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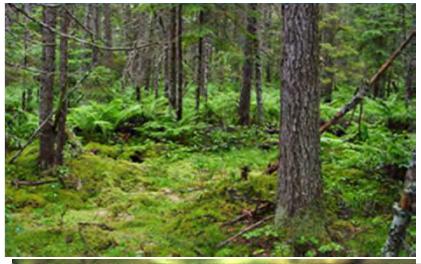
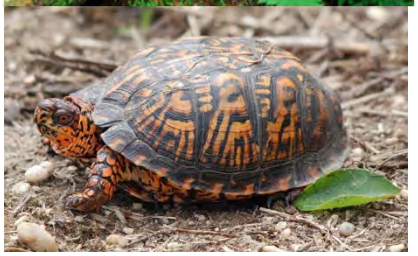




Promoting Forest Resilience:

Biological legacies and other considerations for managed forests

Mark Anderson PhD.

Director of Conservation Science

The Nature Conservancy

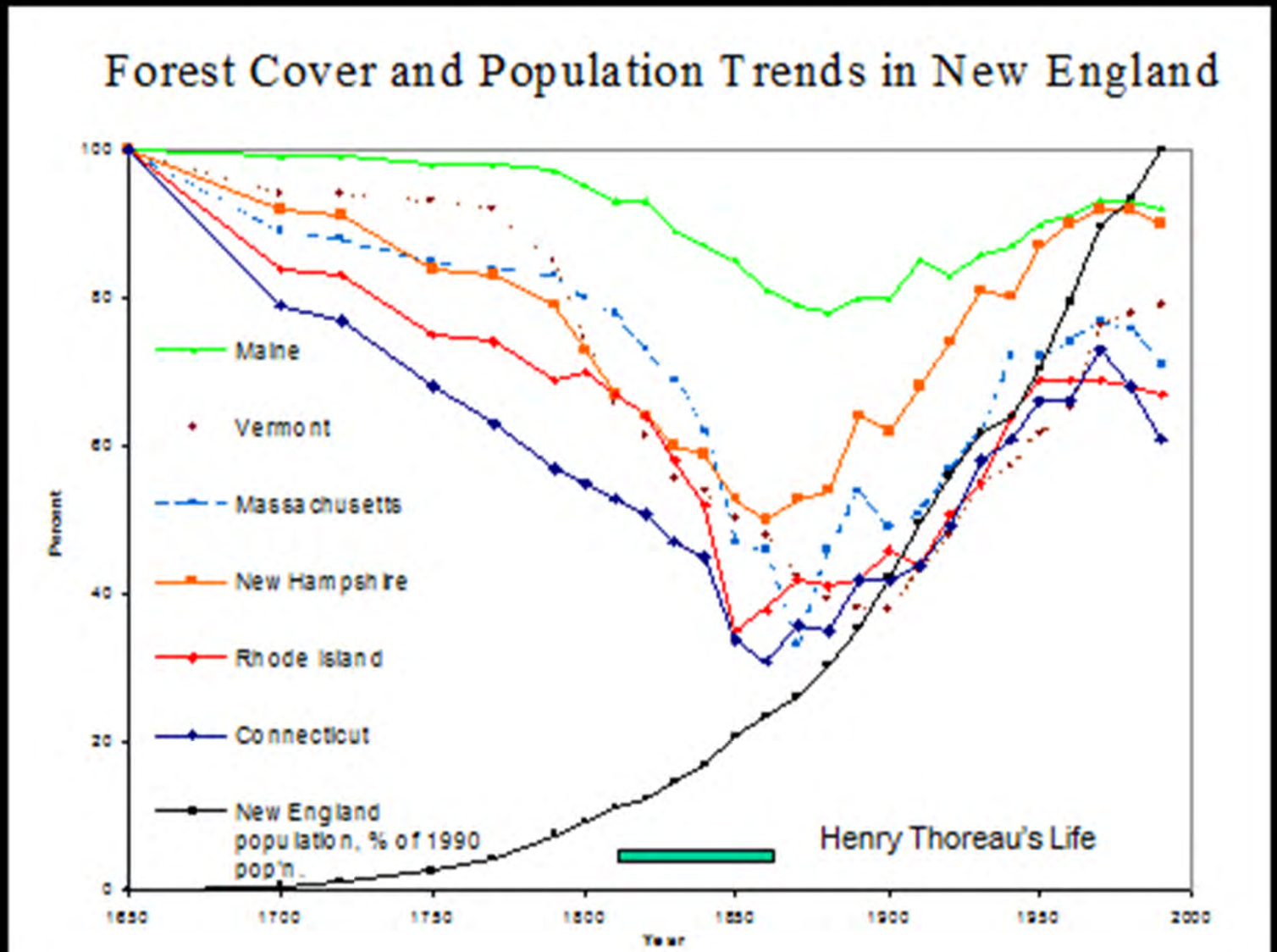
Eastern North America Division

Overview

- ❖Changing Forests, Changing Climate
- ❖The Science of Recovery
- ❖Resilience at the Site Scale
- ❖Resilience at the Regional Scale

Eastern Forests

Forests have Returned! But....



Source: David Foster

PEOPLE

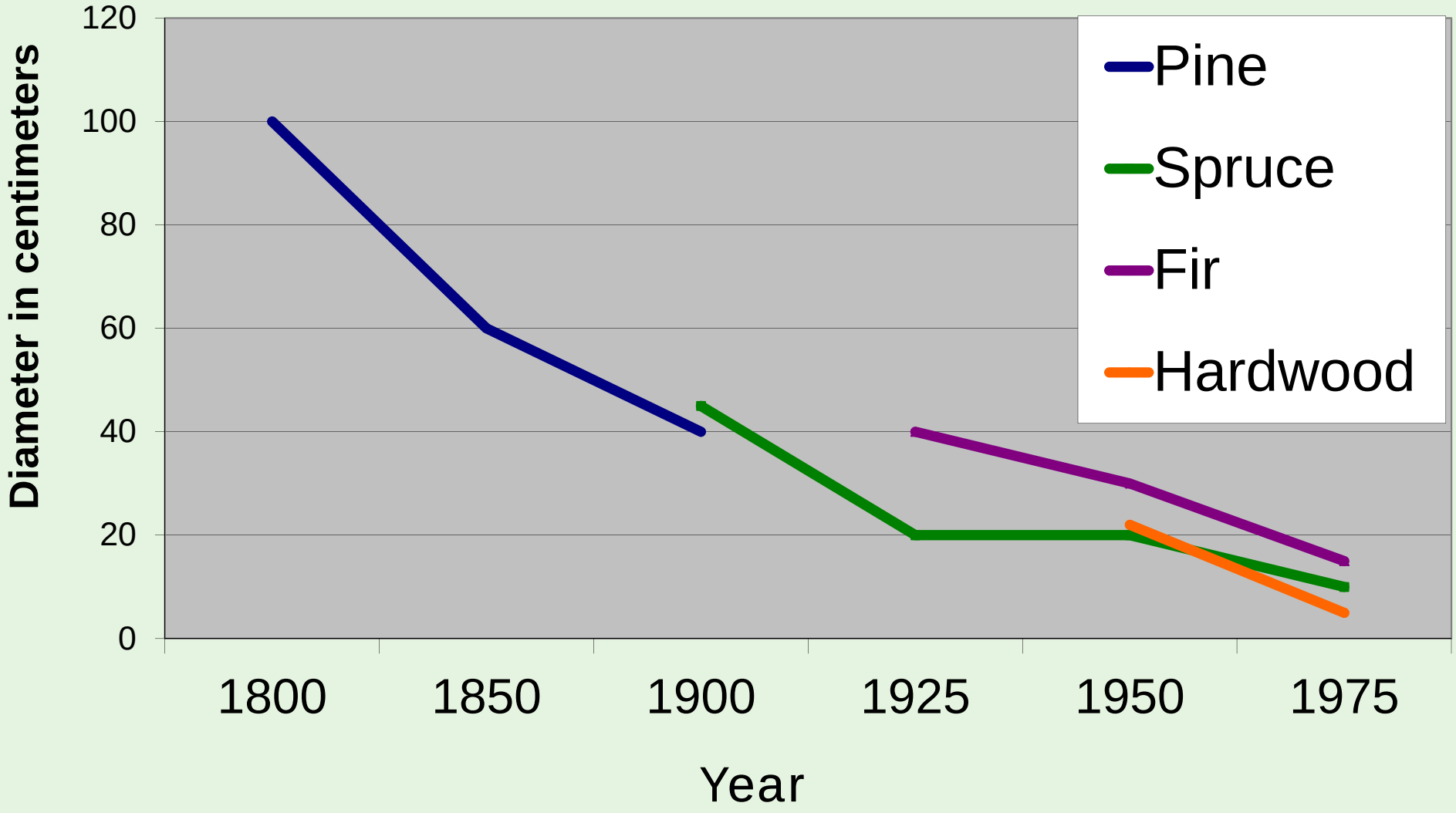
Have increased to over 71 Million

ROADS

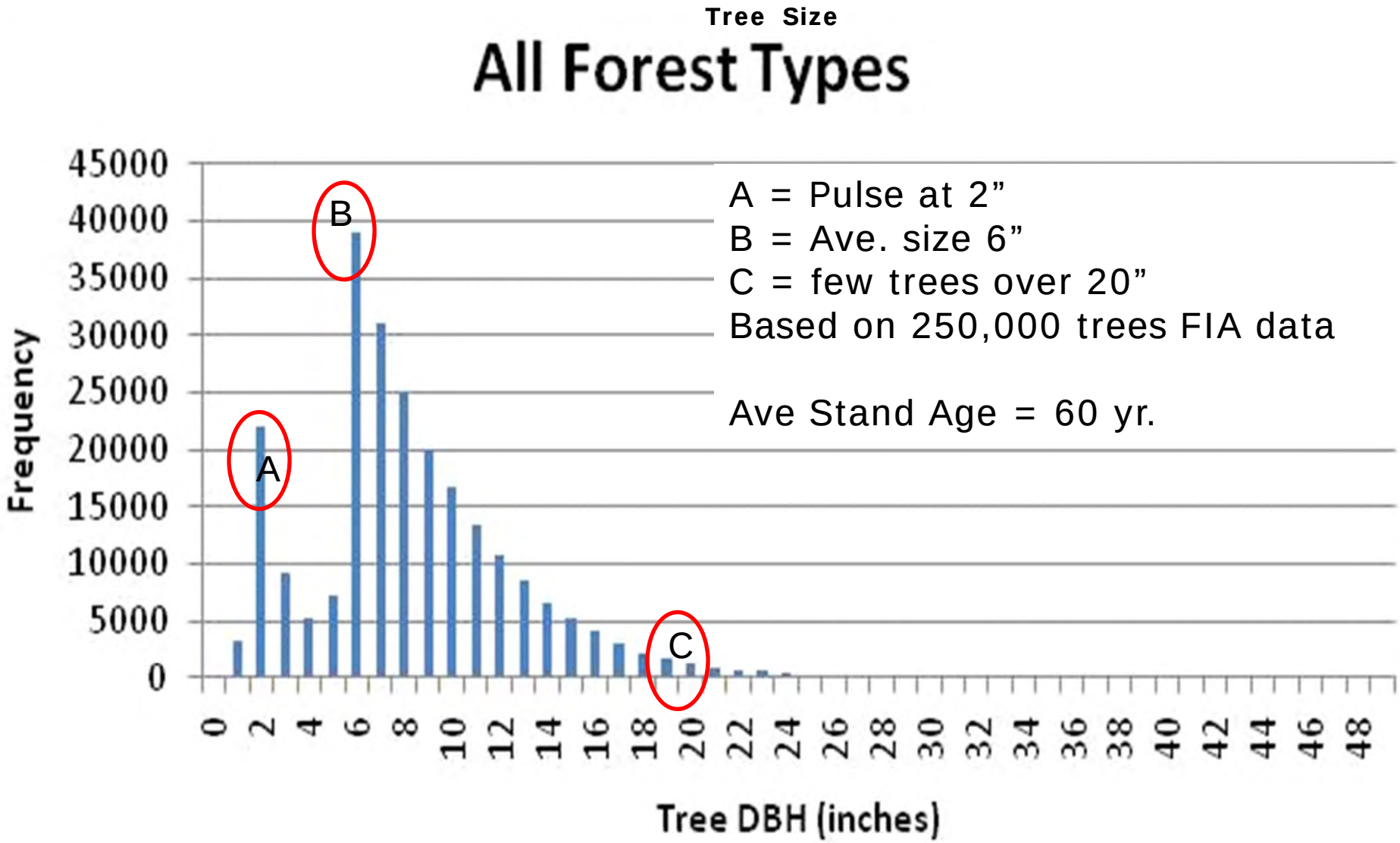
Have increased from 0 to 732,000 miles, enough to circle the earth 29 times

Gradual changes in Wood Resource Base

New Brunswick, Canada (Regier & Baskerville 1986)



Current Size and Age Structure (FIA)

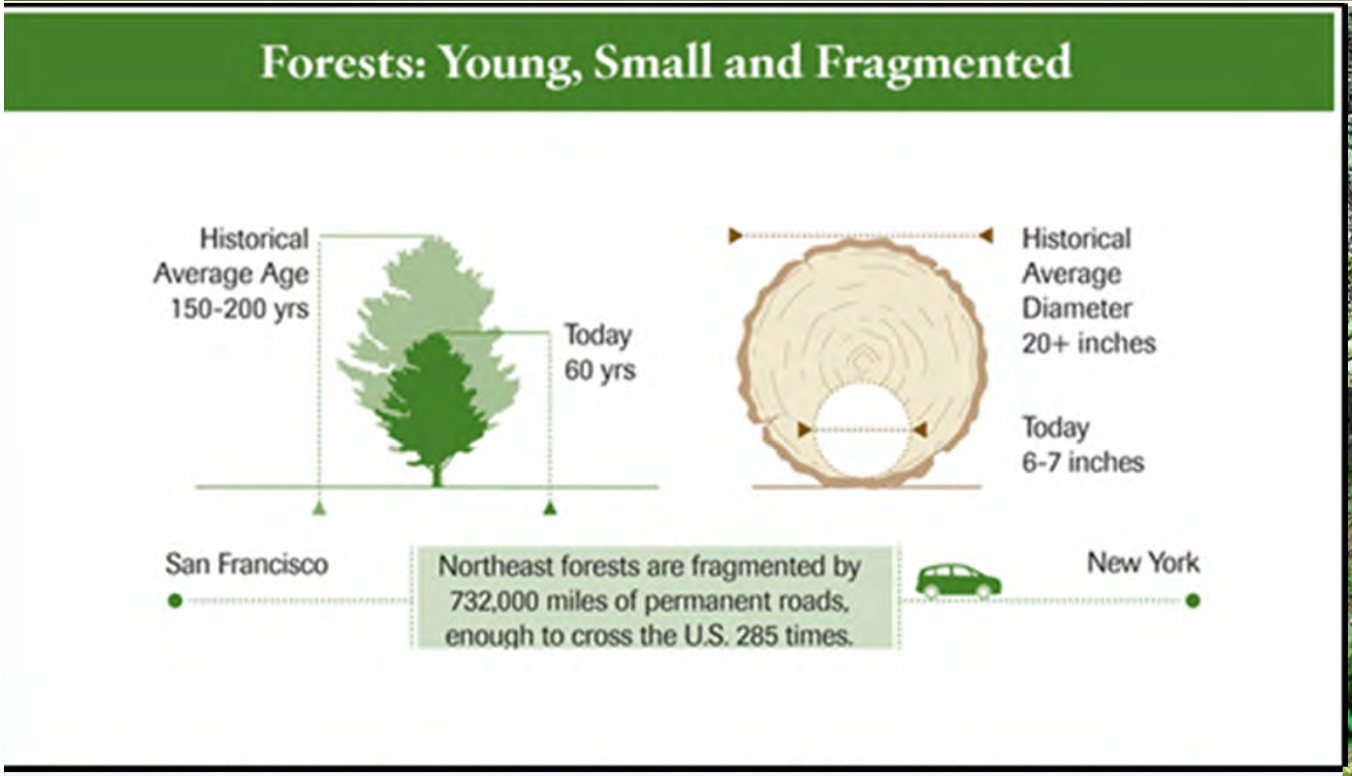


A = Pulse at 2”
B = Ave. size 6”
C = few trees over 20”
Based on 250,000 trees FIA data

Ave Stand Age = 60 yr.

Based on 11,000 FIA plots. Anderson and Olivero 2010

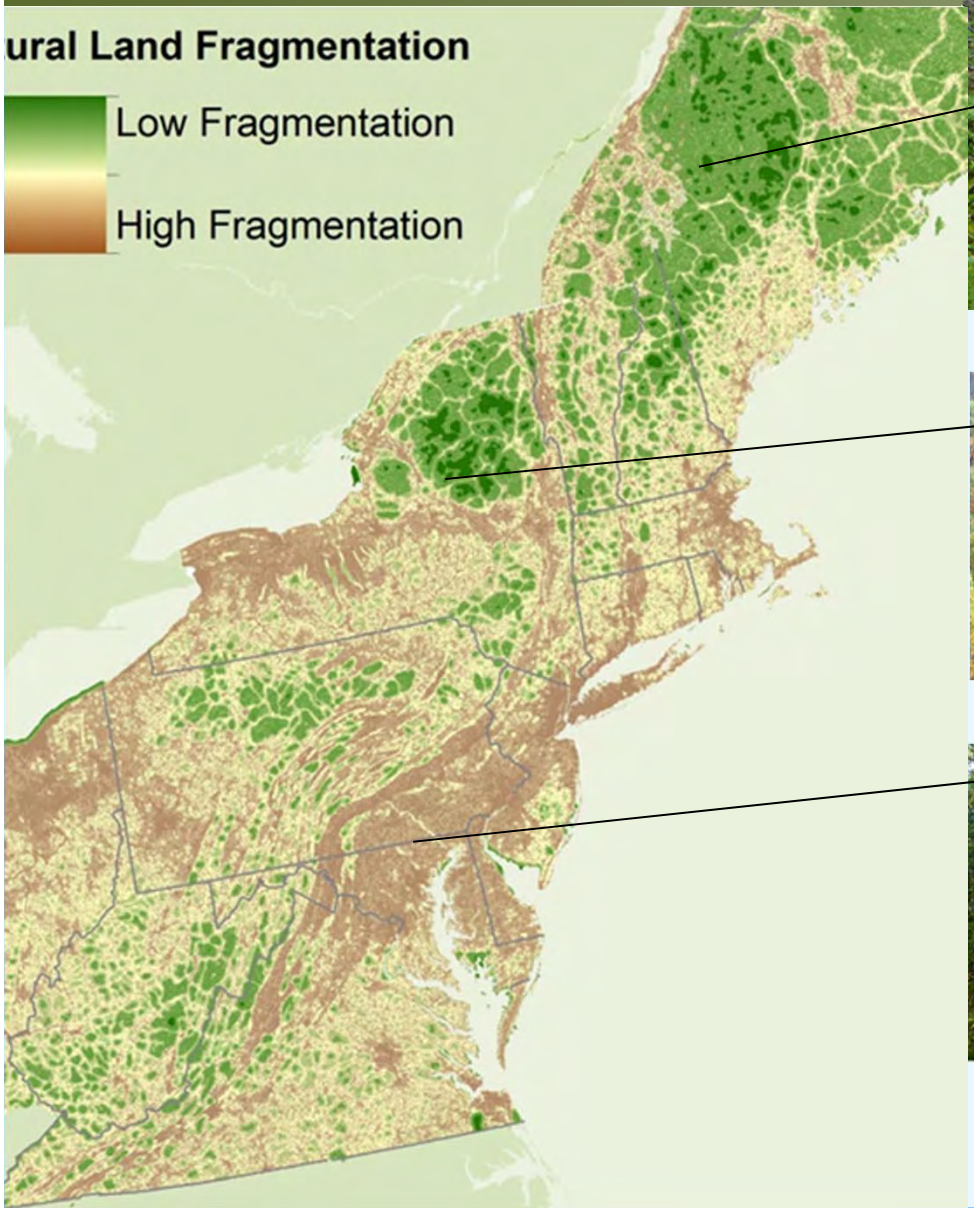
Forever Young?



Current forest stands average 60 years old, 6-7 inches diameter. This appears to be a perpetual state.

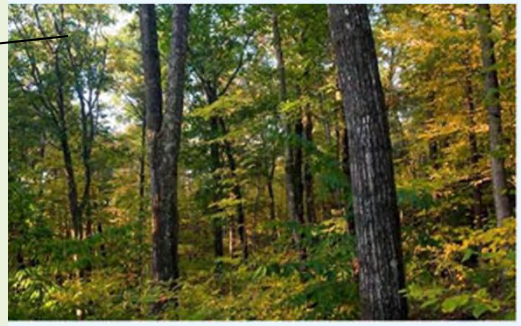
Old forests develop characteristic features like large fallen trees, mossy nurse logs, thick organic soils.

Forest Fragmentation



Upland Boreal

Northern Hardwood



Oak-Pine

Oak-Pine

Least Secured = 17%

Most Fragmented = 69

Fewest Large Blocks

Most Change

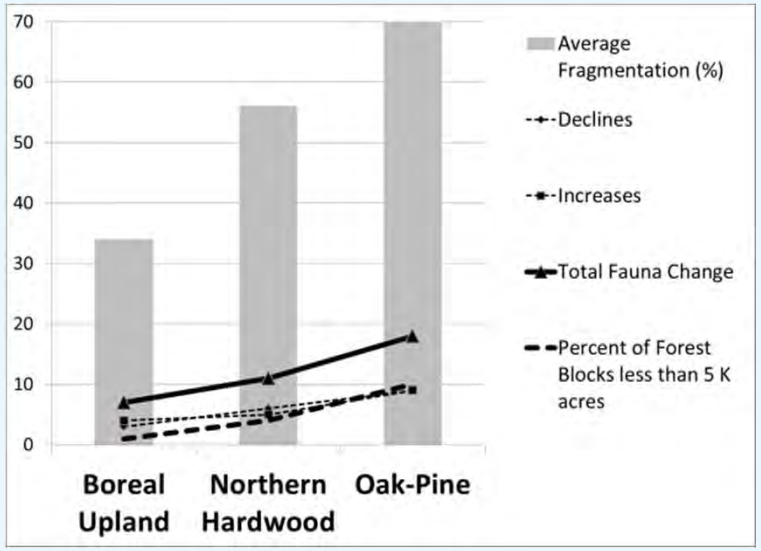
Oak Forests: Breeding Birds

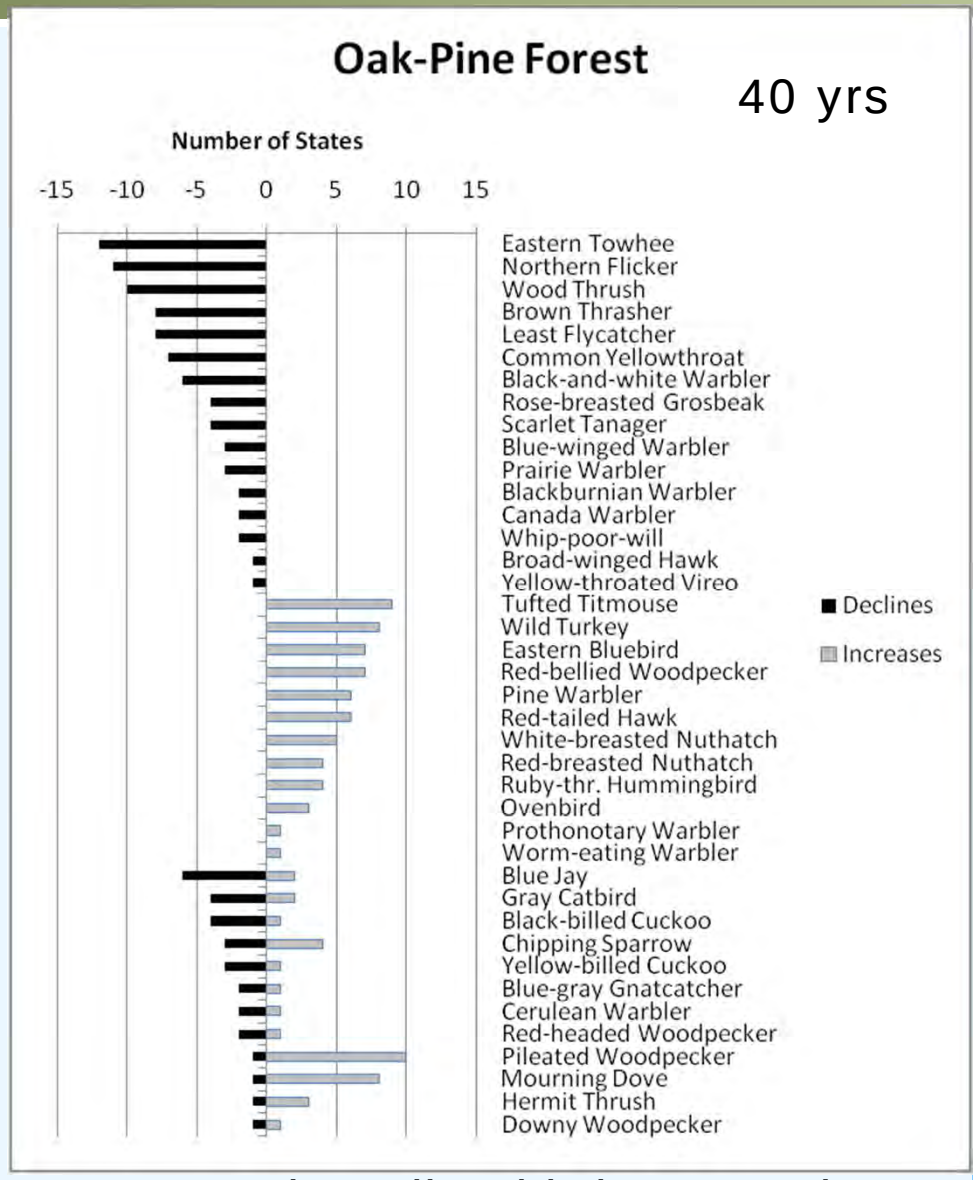
Steep Declines*

eastern towhee
northern flicker
brown thrasher
whip-poor-will
Canada warbler

Steep Increases*

wild turkey
red-bellied woodpecker
pileated woodpecker
white-breasted nuthatch





Source: breeding bird survey data

Remarkably Resilient - all things considered

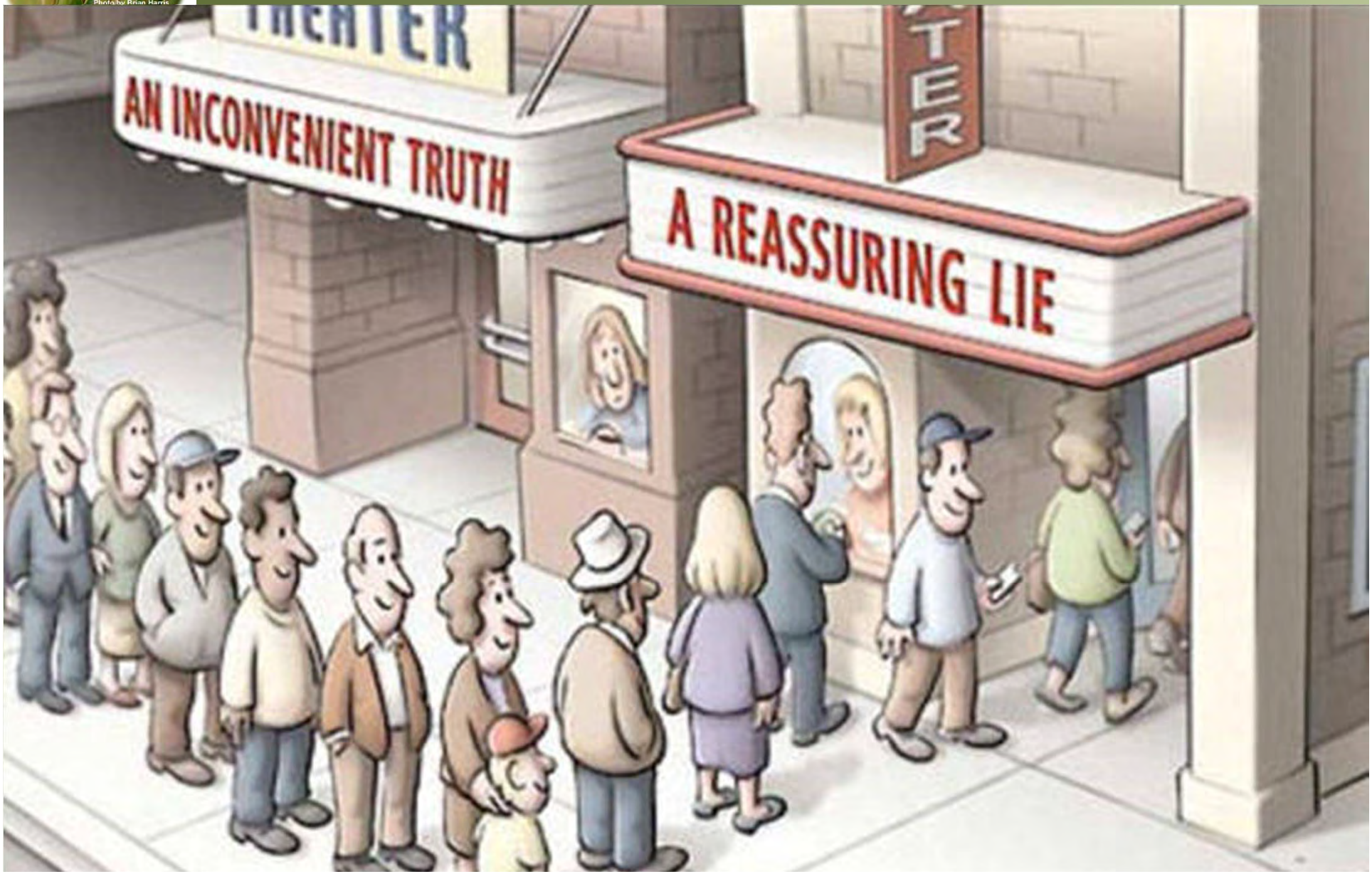
-functional extinction: chestnut, wolf, cougar, woodland caribou

-presently 31% of flora and 10% of vertebrate fauna are exotic

-hundreds of species range shifts, declines in grassland birds and early successional species

A forested landscape that supports 13,530 species (8,223 plants, 5,307 animals) including 523 vulnerable species

CLIMATE CHANGE



Forest Resilience

What makes the forest so resilient?
Can we enhance those characteristics?

Disturbance

Foster, 1988. Disturbance History, Community Organization and Vegetations Dynamics of the Old-Growth Pisgah Forest, South-Western New Hampshire, U.S.A. J. of ecology 76(1) 105-134

Pisgah Forest over 300 years

- 15 Fires
- 4 Hurricanes
- 7 Windstorms
- Infestations
- Blight

Disturbance the rule not the exception

How do Forests Recover from Disturbance?

Mt St. Helens May 18 1980

In 3 years 90% of the plant species were found

Biological Legacies

An organism, a reproductive portion of an organism, or a biologically derived structure or pattern inherited from a previous ecosystem: such as large trees, snags, and down logs that provide refugia and structurally enriches the new stand

Franklin, Jerry F.; Mitchell, Robert J.; Palik, Brian J. 2007. **Natural disturbance and stand development principles for ecological forestry**. Gen. Tech. Rep. NRS-19. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 44 p.

Categories and examples of biological legacies

Organisms

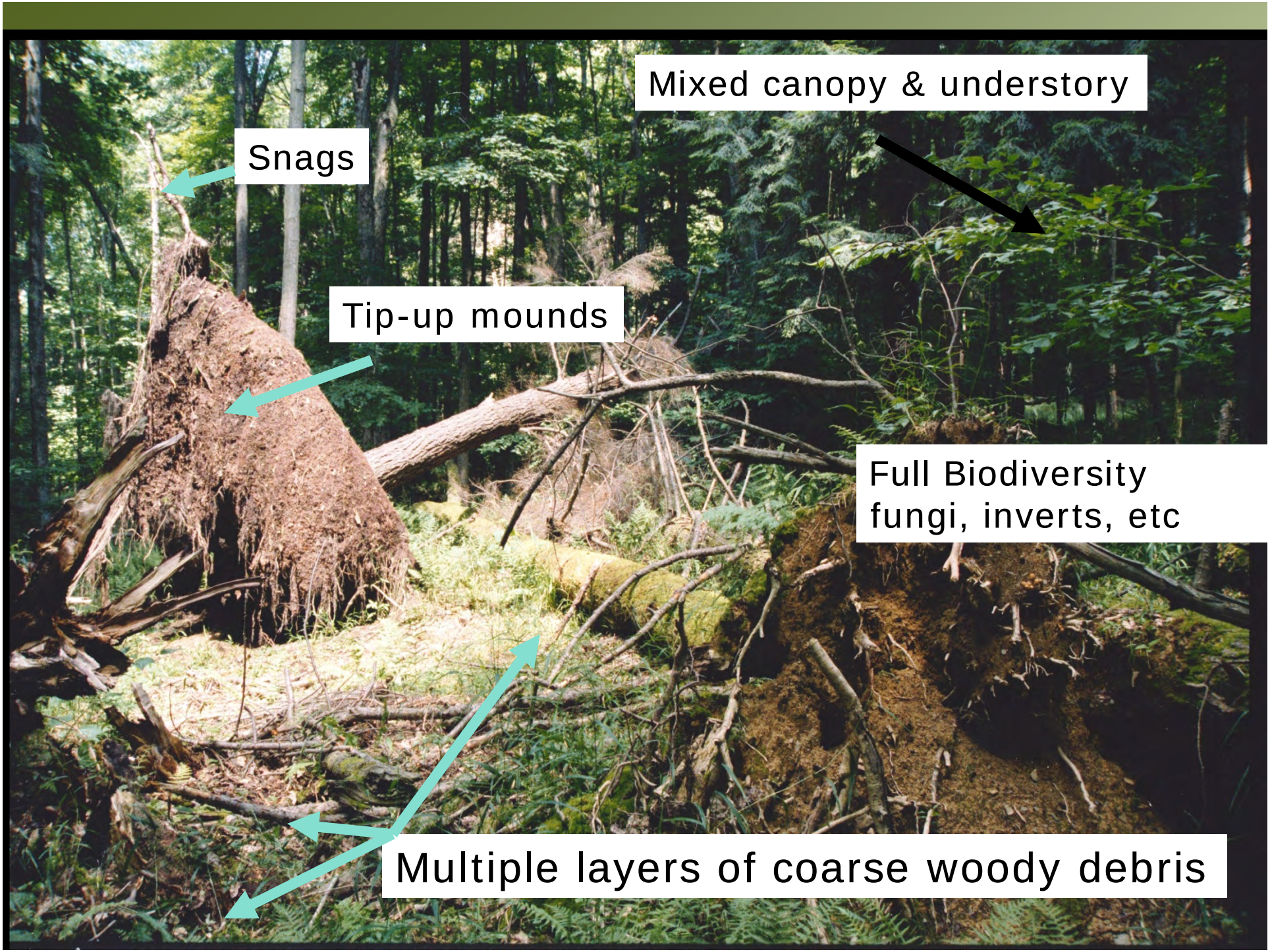
- Sexually mature and intact live trees
- Tree reproduction (seedling and sapling banks)
- Vegetatively reproducing parts (e.g., roots)
- Seed banks
- Shrub, herb, bryophyte species
- Mature and immature animals and microbes

Organic matter

- Fine litter, Particulate material
- Organically derived structures
  - -Standing dead trees
- Downed trees and other coarse woody debris
- Root wads and pits from uprooted trees

Organically derived patterns

- Soil chemical, physical, microbial properties
- Forest understory composition and distribution


Mixed canopy & understory
Snags
Tip-up mounds
Full Biodiversity
fungi, inverts, etc
Multiple layers of coarse woody debris

Legacies Matter to Biodiversity

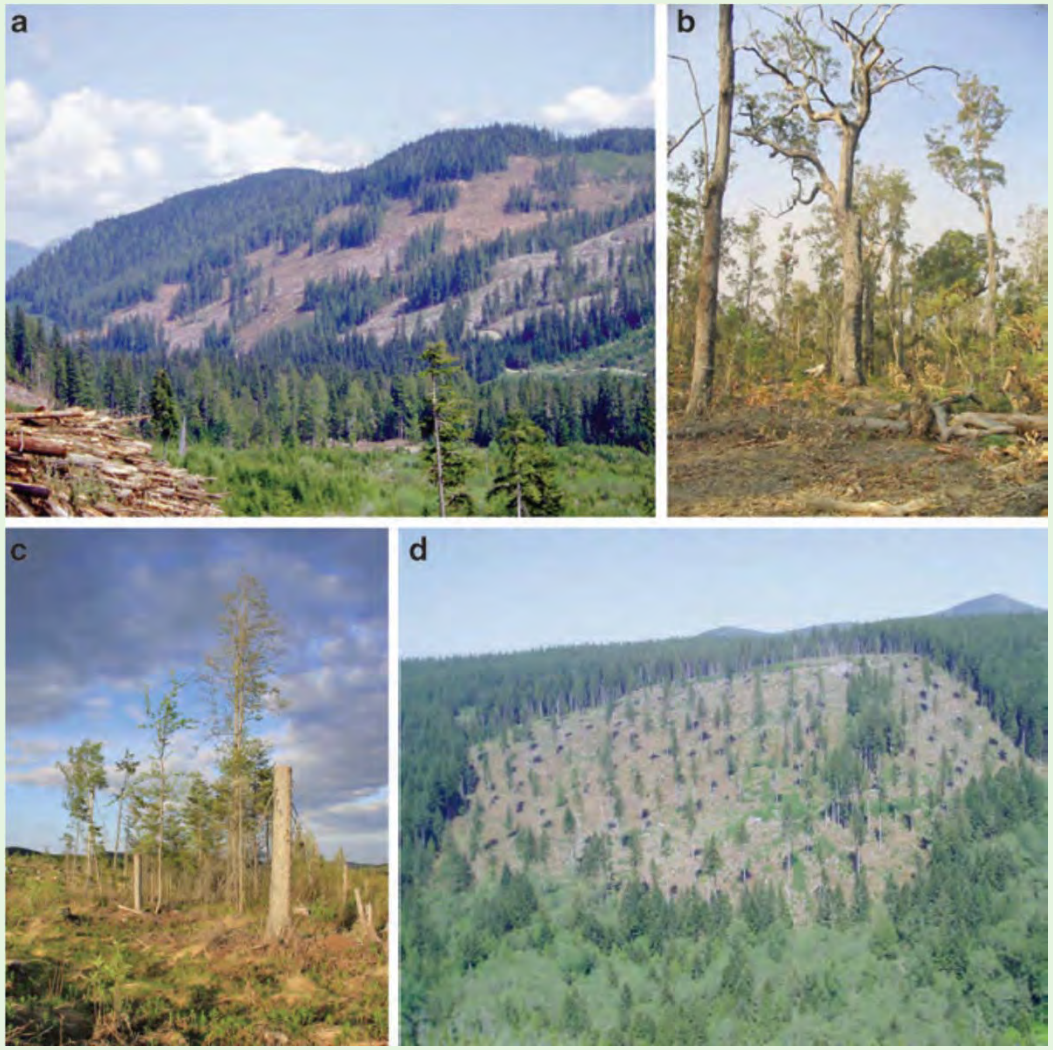
- Epiphitic lichens, 30+ (Selva 1996)
- Bryophytes 19/7 (Cooper-Ellis 1998)
- Ant-like litter beetle (Chandler 1986)
- Breeding birds 2-40x (Haney & Schaats 1996)
- CWD 2-5(Goodburn & Lorimer 1998)
- Marten dens >40 dbh (Wynne & Shelborne)
- Pileated wdpkr >55cm
- (Evans & Conner 1979)
- Amphibians 130 x west (Hansen et al. 1991)
- LWD increased macro-inverts and fish (Nislow et al. 2001)

Legacies matter to Aquatics

Dissipates energy, traps litter, creates pools, releases nutrients. Higher biodiversity & higher quality spawning habitat.dd

Magilligan et al. 2006 The geomorphic function and characteristics of large woody debris in low gradient rivers, coastal Maine, USA. Geomorphology 97

Retention Forestry



A scientifically validated management approach that is modeled on natural processes. A portion of the original stand is left unlogged to maintain the continuity of structural and compositional diversity.

Represents bottom-up conservation through forest manager involvement.

Gustafsson et al. 2012, Retention Forestry to MaintainMultifunctional Forests: A World Perspective

a. British Columbia b. Australia c. Sweden d. Pacific Northwest

Legacies: Natural Quantities

Structural Attributes	Structural Feature	Quantity per Acre
Live Trees		200
	Large trees (>50 cm DBH)	25
	Trees with distictive featur	?
Dead Snags		30
	Large >50 cm	9
	Medium 25-50 cm	10
	Small <25 cm	11
Logs		61
	Large >50 cm	10
	Medium 25-50 cm	30
	Small <25 cm	21
Leaf Litter		1.5 tons
Soil Organisms	All decomposers	5 tons
	Snails and slugs	400 lbs
	Earthworms	900 lbs
	Nematodes	8-24 billion indiv.
Fungi		0.5 tons

? Largely unknown for Northeastern Forests

Adapted from Kohm and Franklin 1997. Data sources: McGee 1999, Marchand 2000, Bray and Gorham 1964, Cleve et al. 1983 etc

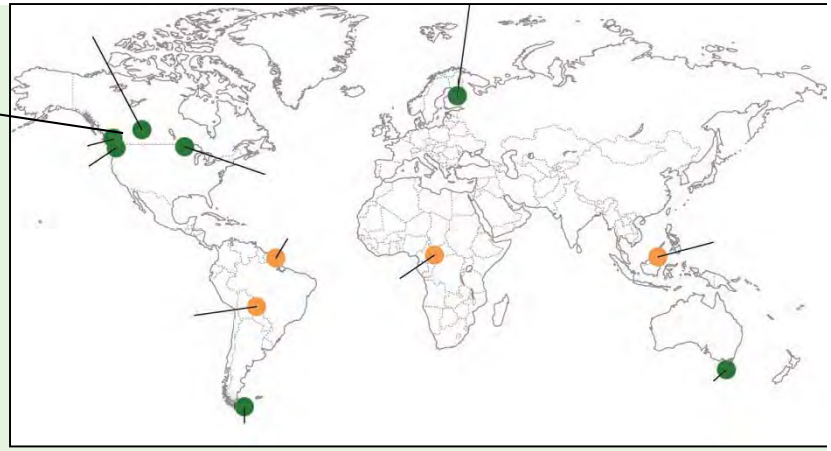
Legacies: How Much is Needed?

DEMO

(Demonstration of Ecosystem Management Options)

- Unharvested control
- 75% aggregated retention
- 40% aggregated retention
- 40% dispersed retention
- 15% aggregated retention
- 15% dispersed retention

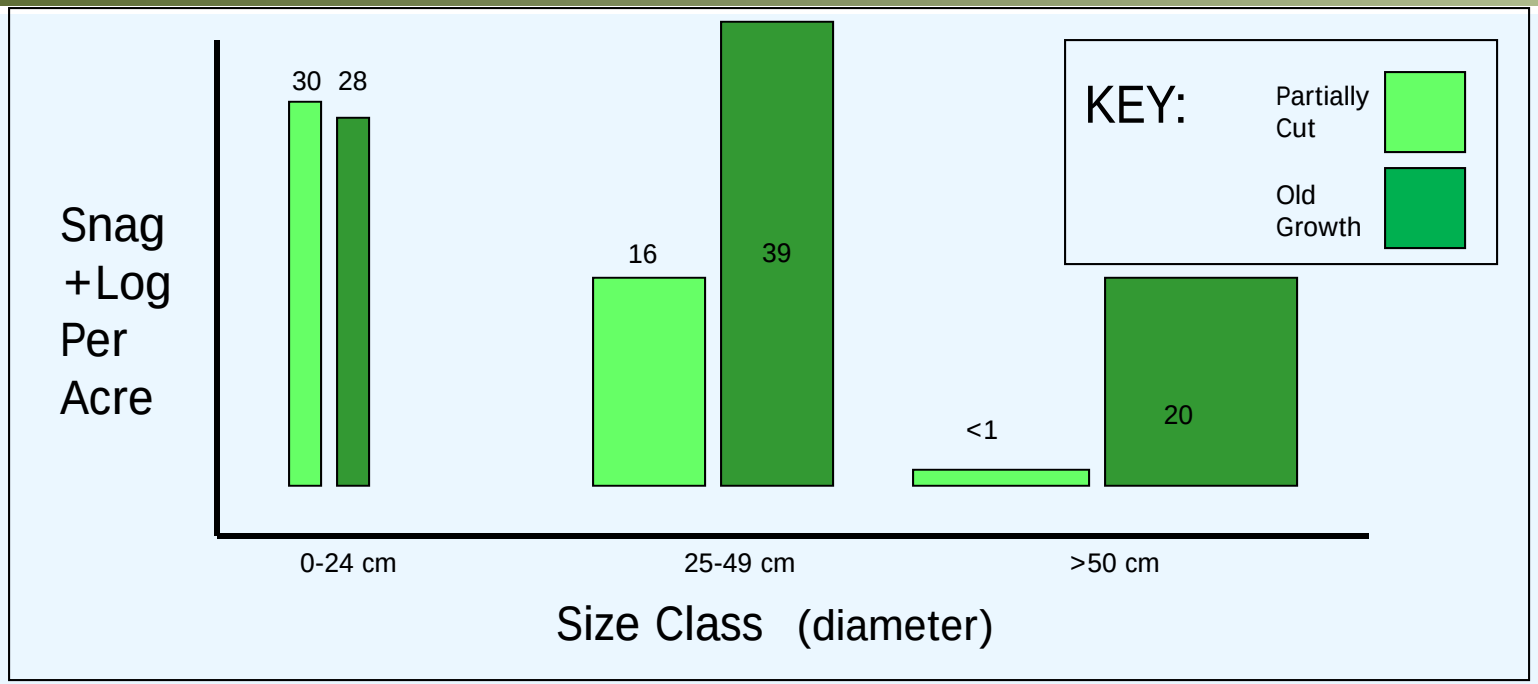
Aubry KB, Halpern CB, Peterson CE. 2009. Variable-retention harvests in the Pacific Northwest: A review of short-term findings from the DEMO study. Forest Ecology and Management 258: 398–408.



At 15% retention:
- no difference from clearcut in microclimate, ecological responses, and public perception

Aggregate pattern (1ha):
- Reduced damage/mortality to residual trees
- Refugia for forest organisms

Quality and Types of Legacies Matter: Coarse Woody Debris



0-24 cm	25-49 cm	>50 cm	
Downy Woodpecker	Grey squirrel	Pileated woodpecker	Amphipods
Swallows	Saw-whet owl	Barred owl	Salamanders
Creeper	Screech Owl	Martin/Fisher/Raccoon	Snakes
Chickadee	3-toed woodpecker	Nurse Logs	Small mammals
Titmouse	Flicker	Lichens & Mosses	
Wren	RB & WB Nuthatches	Bryophytes & Fungi	
Bluebird	Black backed woodpecker	Water Storage	

Central Appalachians TNC and USFS Efforts

Implementation

Strategies

Broad adaptation responses and overarching goals

Approaches

More detailed adaptation responses considering site conditions

Tactics

Prescriptive actions

Example: Legacies

Maintain or enhance structural diversity

Retain and replenish biological legacies

Apply aggregated retention harvest at 30%

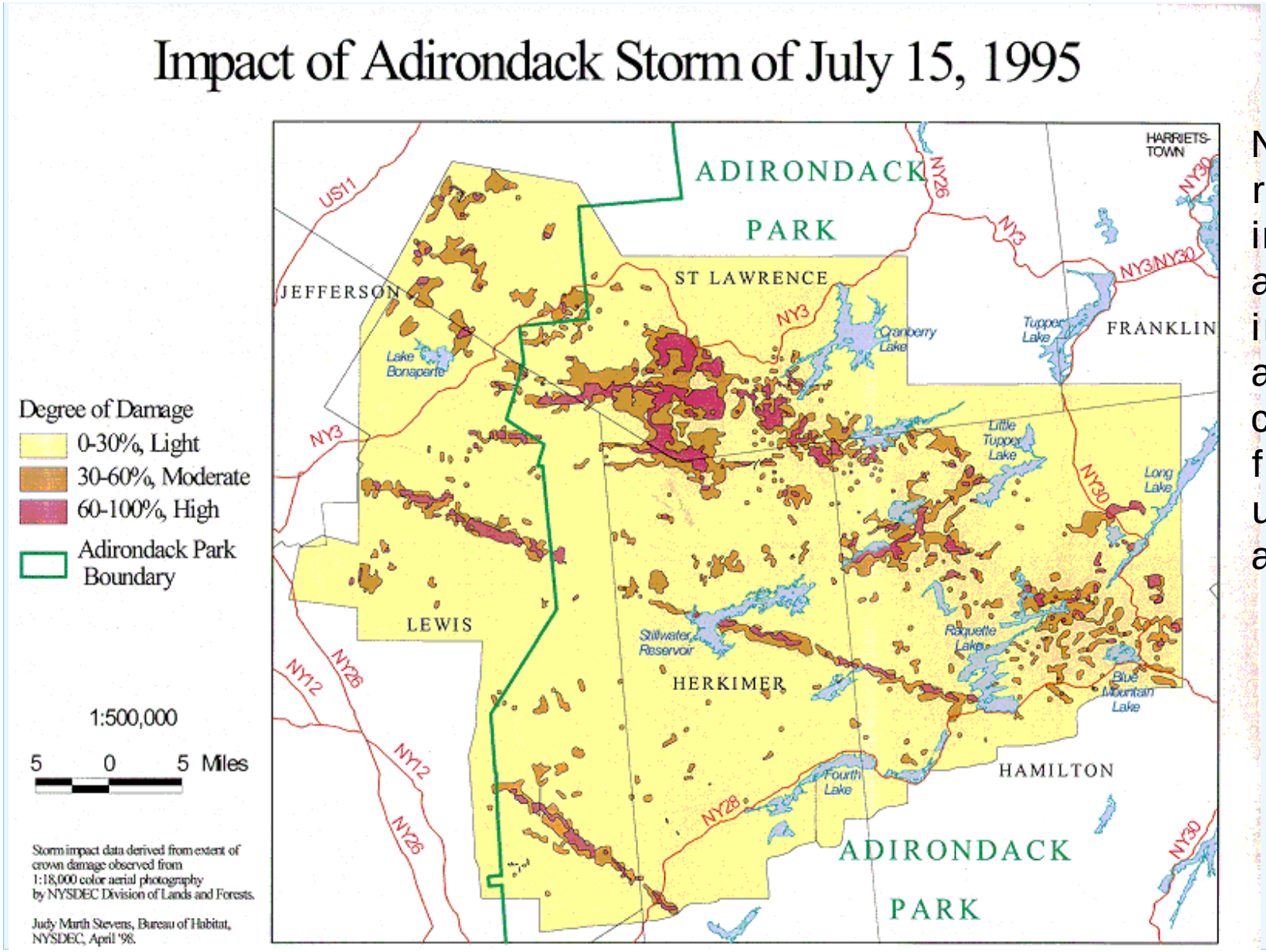
Central Appalachian
Forest Planning Goals

Strategy	Approaches
Sustain fundamental ecological function	Maintain or restore soil quality and nutrient cycling
	Maintain or restore hydology
	Maintain or restore reparian areas
	Restore fire to fire-adapted systems
Reduce the impact of existing biological stressors	Maintain or improve the ability of forests to resist pests and pathogens
	Prevent the introduction and establishment of invasive plants species
	Manage herbivory to protect and promote regeneration
Maintain and enhance species or structural diversity	Promote diverse age-classes
	Maintain and restore diversity of native tree species
	Retain and replenish biological legacies

From Bearer et al. 2014

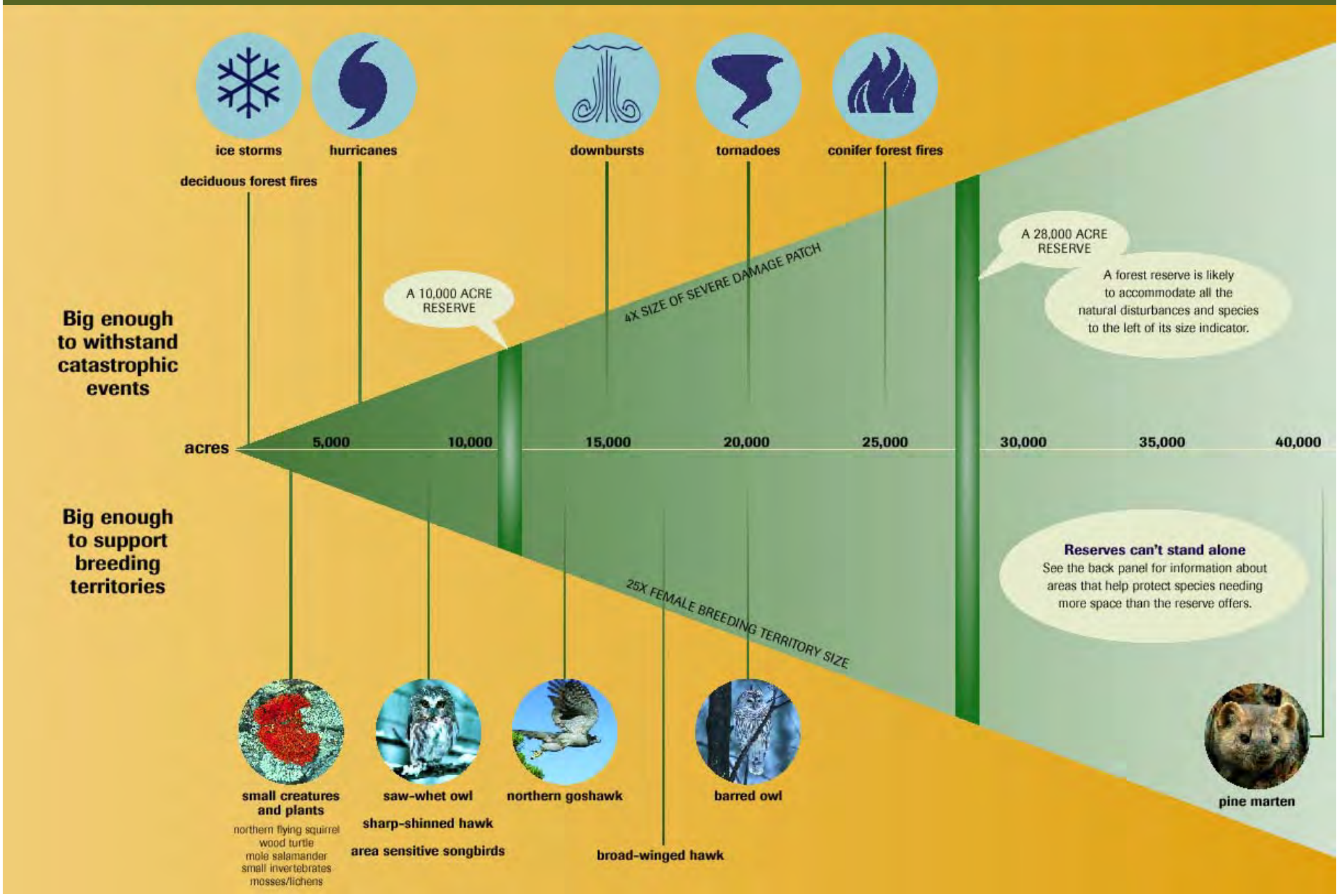
Resilience at the Regional Scale

Accommodating the Scale and Pattern of Disturbances



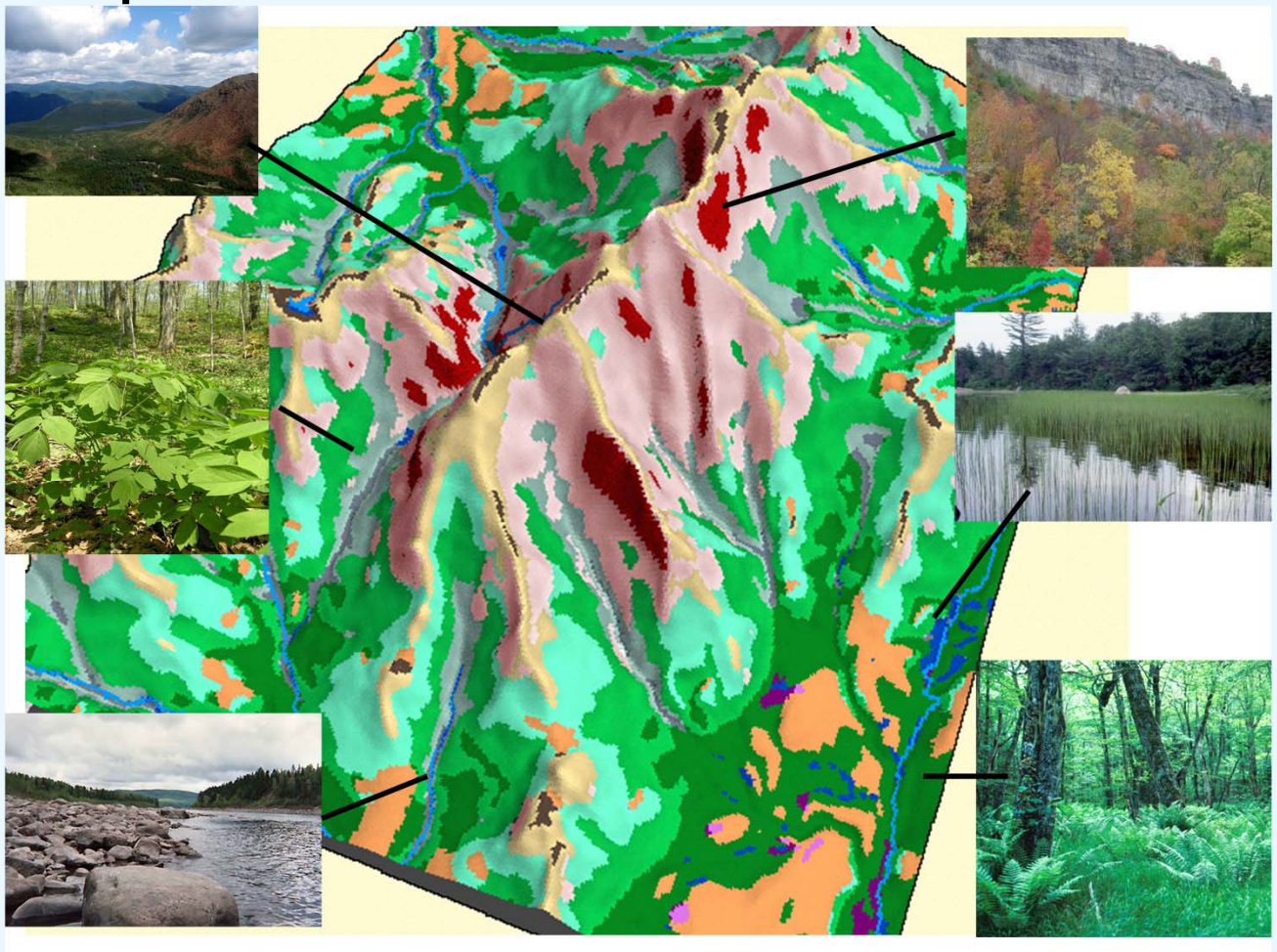
Not all recovery is in situ also immigration and colonization from undisturbed areas

How Big: Allow for Dynamics



Landscape Diversity - Microclimates

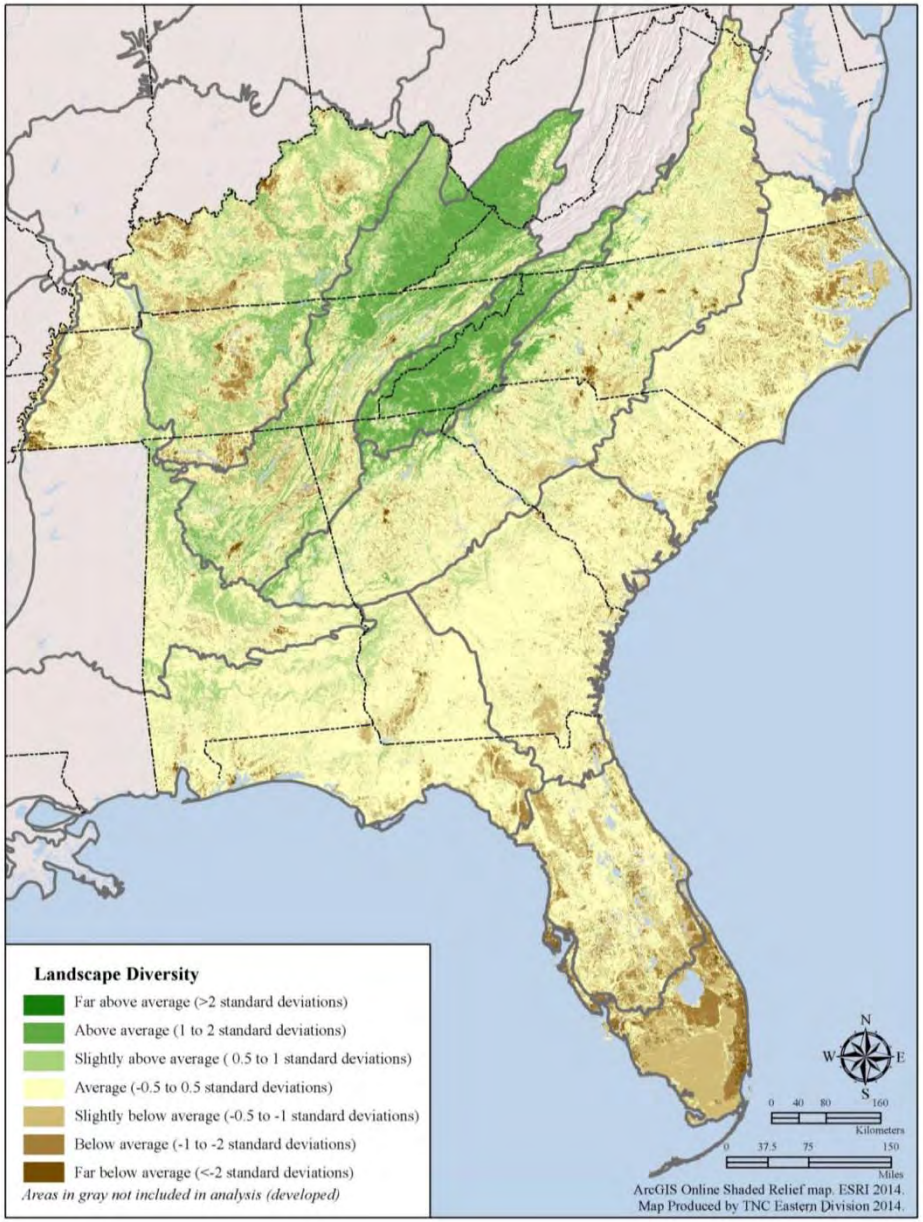
More Heterogeneity = more options for species

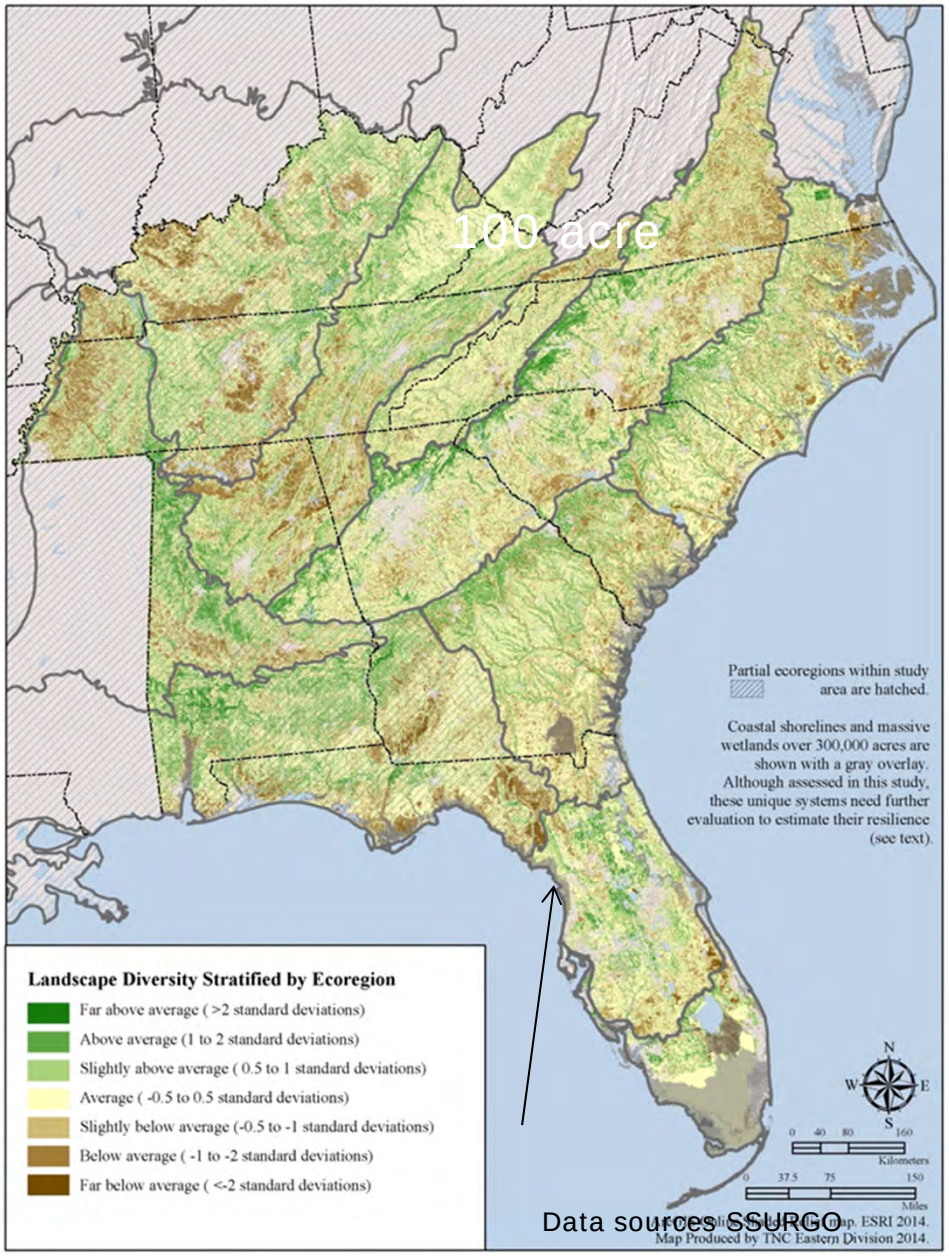


Landforms and topography split the regional climate into a number of micro-climates and these are what most species actually experience.

Willis and Bhagwat, 2009. **Biodiversity and Climate Change**. Science , Loarie et.al. 2009. **The velocity of Climate**

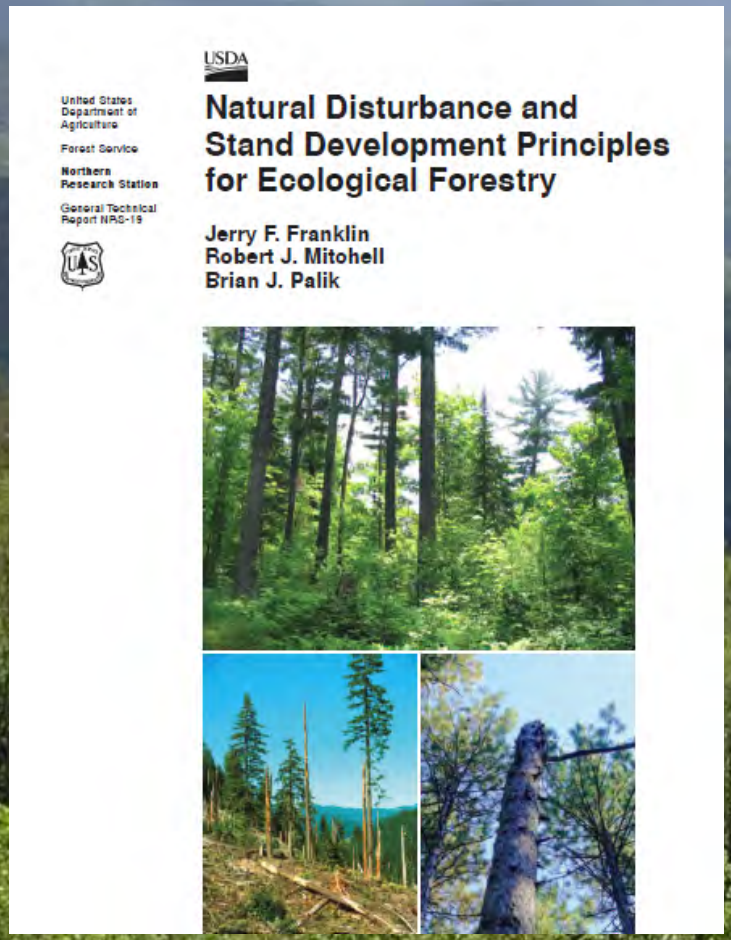
Landscape Diversity





Data sources SSURGO

Ecological Forestry



Many questions but powerful new tools and insights for managing forests and retaining diversity in a dynamic world.

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Thank You

This research has been supported by the Northeast Association of Fish and Wildlife Agencies, Sweet Water Trust, the Doris Duke Foundation and The Nature Conservancy