Climate-adaptive silviculture & Diversity Indices: Is it working?

UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES

ASCC
Adaptive Silviculture for Climate Change

Southern New England Exurban ASCC affiliate site team:

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Anita Morzillo[1] – Landscape Ecology and human Dimensions
Amanda Bunce[1] – Researcher & PhD Candidate
& the UConn Forest Crew [1]
Danial Evans[4] - CT DEEP State Lands Forester
Christopher Riely[5] – Research Associate and Forester @ URI replicate site
& the DEM foresters in RI

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The University of Vermont
University of Minnesota
Michigan Technological University
Dartmouth
Forest and Rangeland Stewardship Colorado State University
NIACS Northern Institute of
The Jones Center at Ichauway
Mississippi Park Connection
Natural Resources Canada / Ressources naturelles Canada

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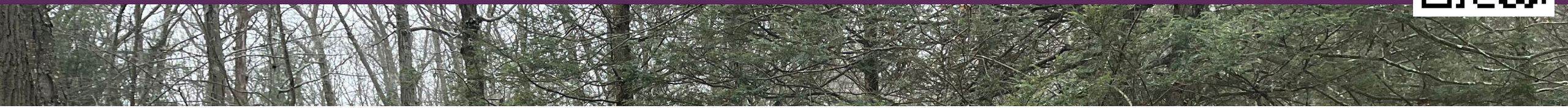
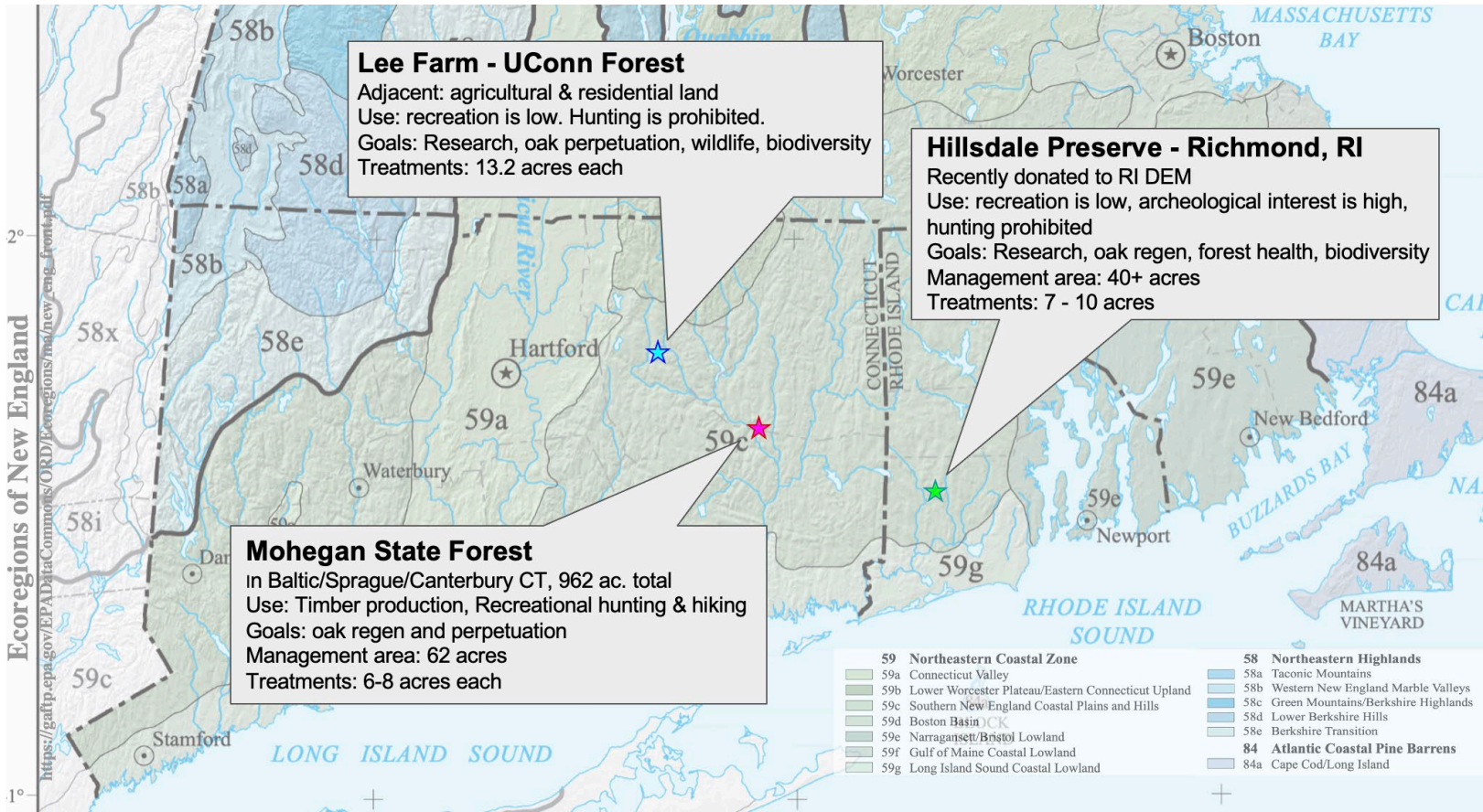


ASCC Network Site Locations, 2023

Framework developed 2010/11; First site, Cutfoot, 2013

Southern New England, Exurban Oak-hickory Site Locations

Initiated Oct., 2020

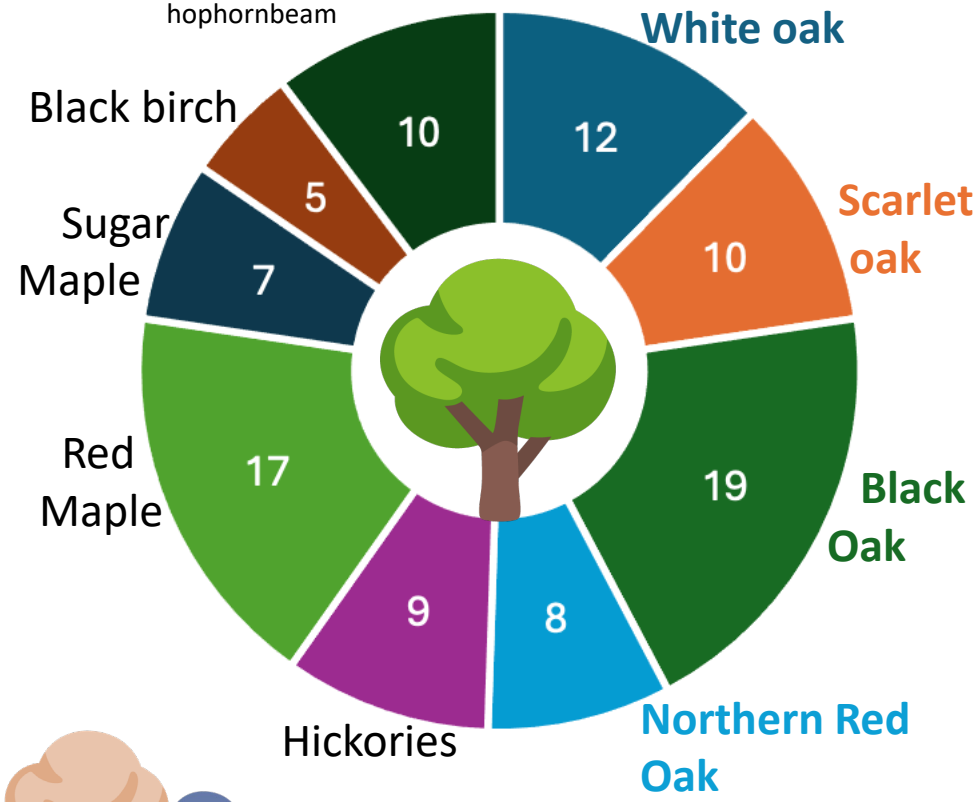


Species Dominance

Over all 3 SNE Exurban Oak-hickory sites

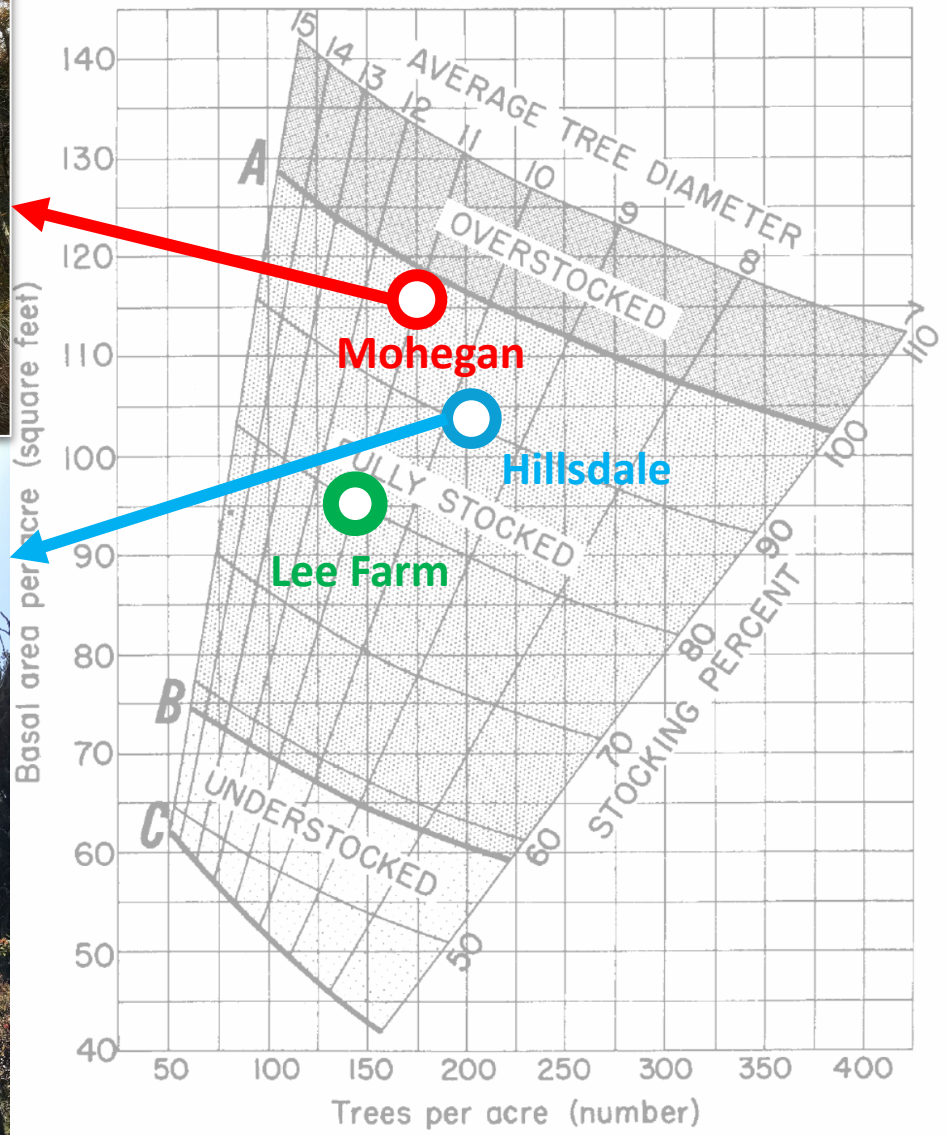
By basal area

Other: Yellow poplar, Yellow birch, red pine, pitch pine, white ash, sassafrass, red cedar, beech, spruce, American hornbeam, hophornbeam



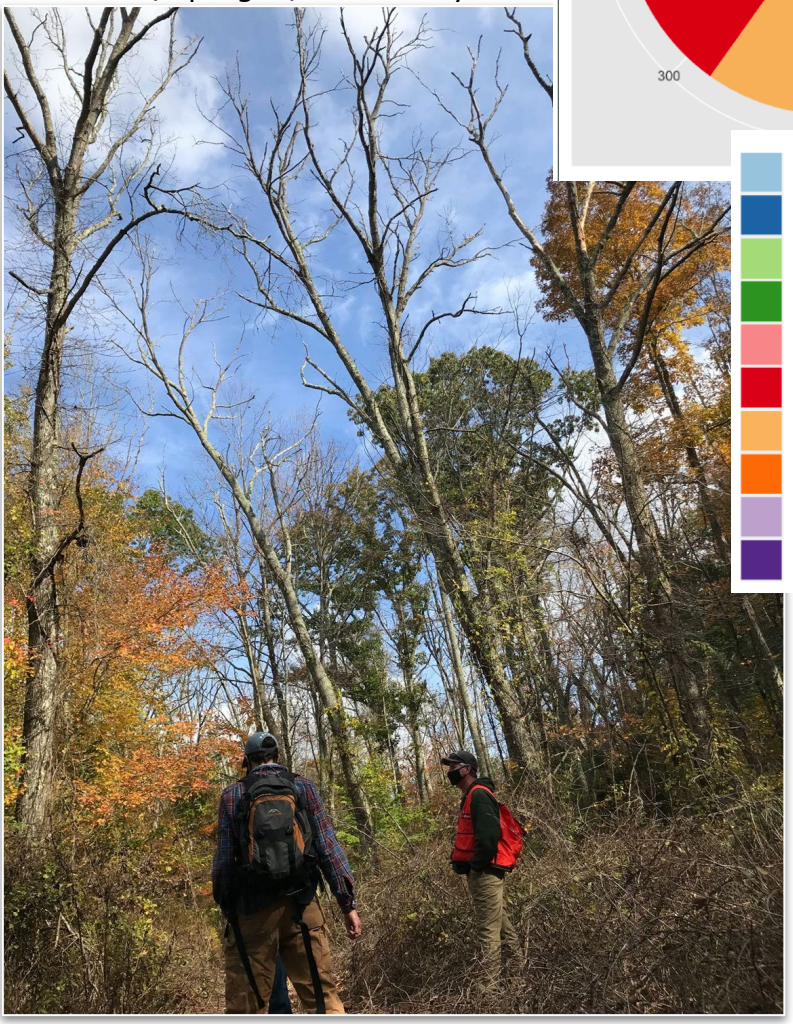
Stocking

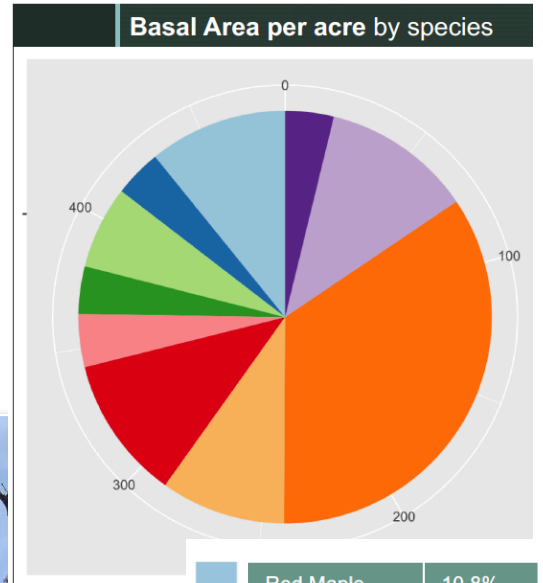
Differing levels of mortality from spongy moth/drought, 2016-1018



We held a workshop of local forest managers and experts to co-develop treatment plans for **Mohegan State Forest**

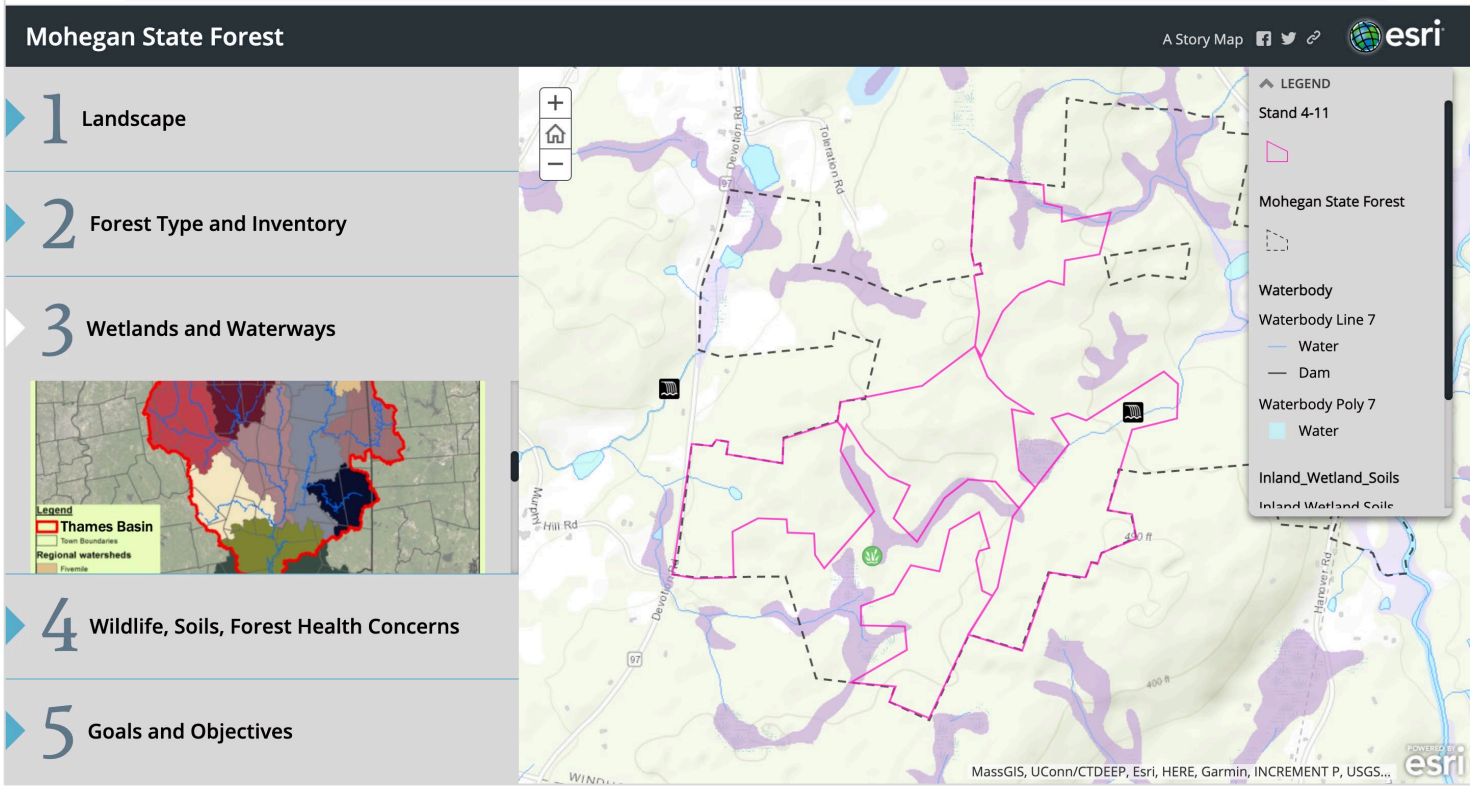
In Baltic/Sprague/Canterbury CT

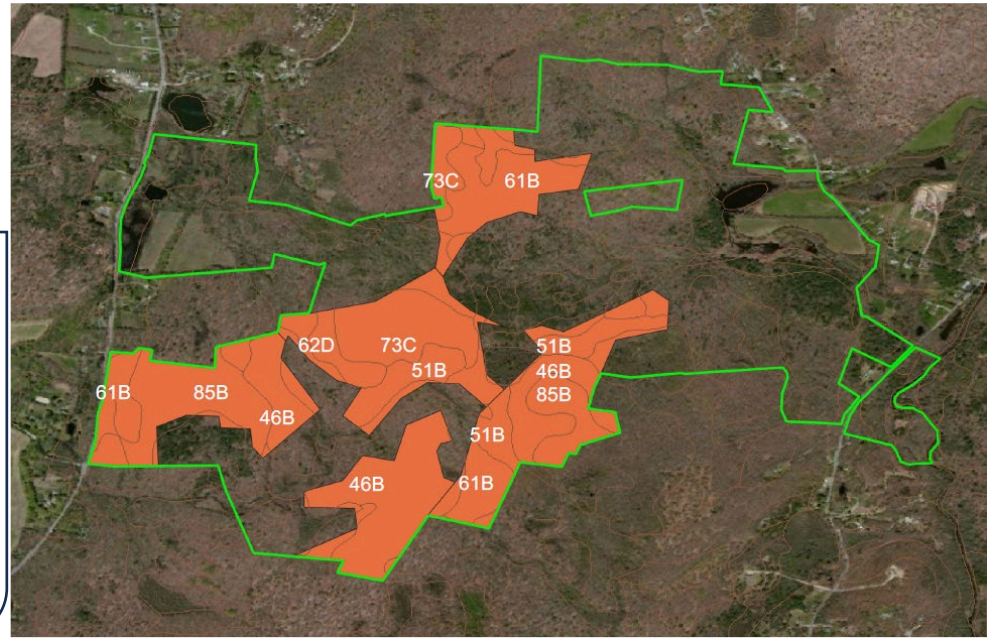




Red Maple	10.8%
Sugar Maple	3.7%
Birch	6.5%
Conifer	3.7%
White Ash	4.1%
Hickory	11.3%
White Oak	9.8%
Red Oak	34.5%
Black Oak	11.7%
Shade tolerant	3.8%

Scan code to check out the story map



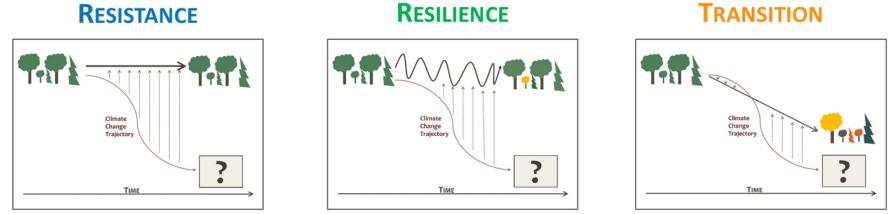


Experimental Treatments developed for **Mohegan State Forest,** Implemented Winter 2022/'23

Adaptation Options

Manage for Persistence
Ecosystems are still recognizable as being the same system (character)

Manage for Change
Ecosystems have fundamentally changed to something different



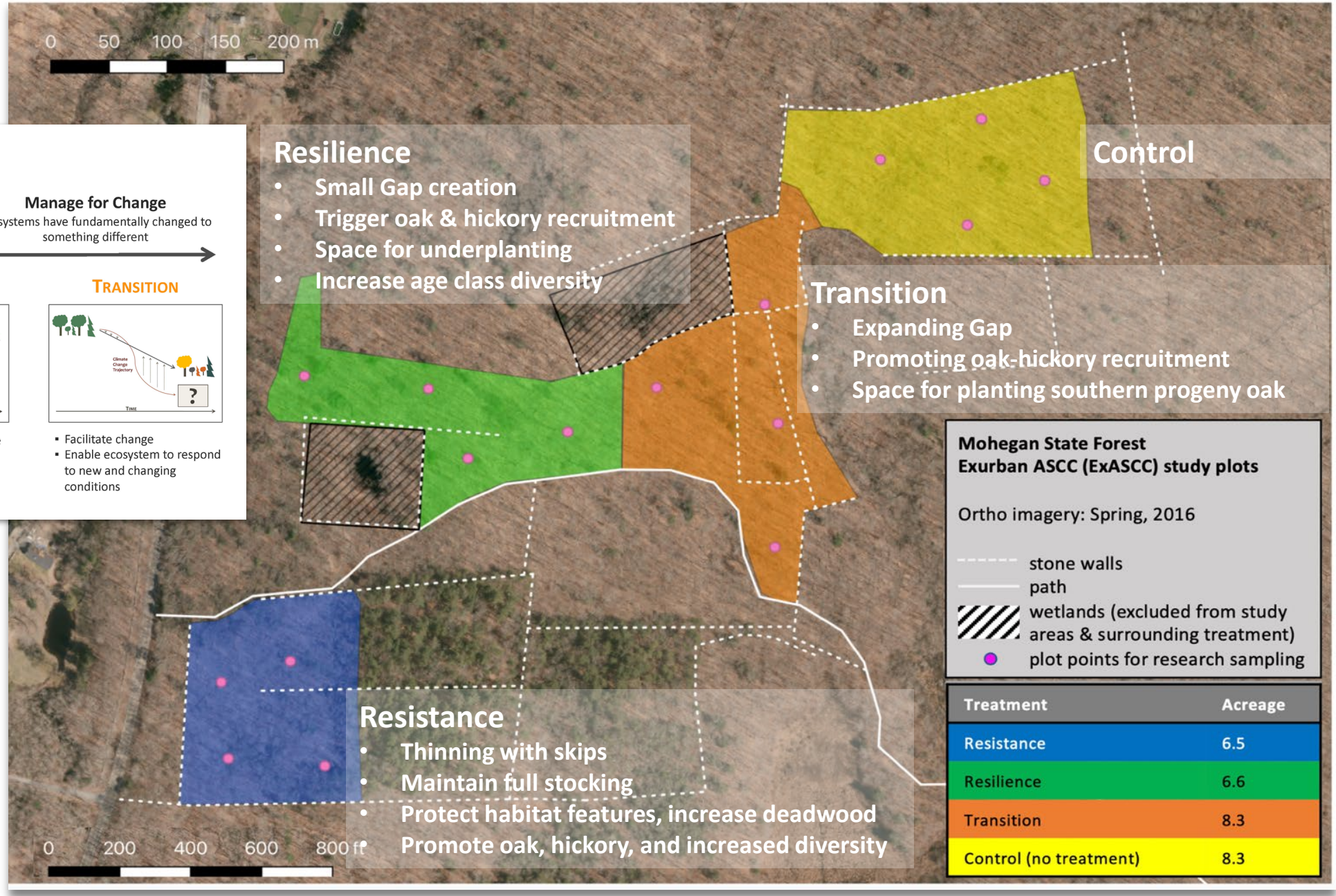
- Improve defenses of forest against change
- Maintain relatively unchanged conditions

- Accommodate some degree of change
- Return to prior condition after disturbance

- Facilitate change
- Enable ecosystem to respond to new and changing conditions

For all treatments:

- Promote Oak-hickory regeneration and recruitment
- Control understory shade-tolerant species (red maple, black birch)
- Control invasive brush (barberry, multiflora rose)



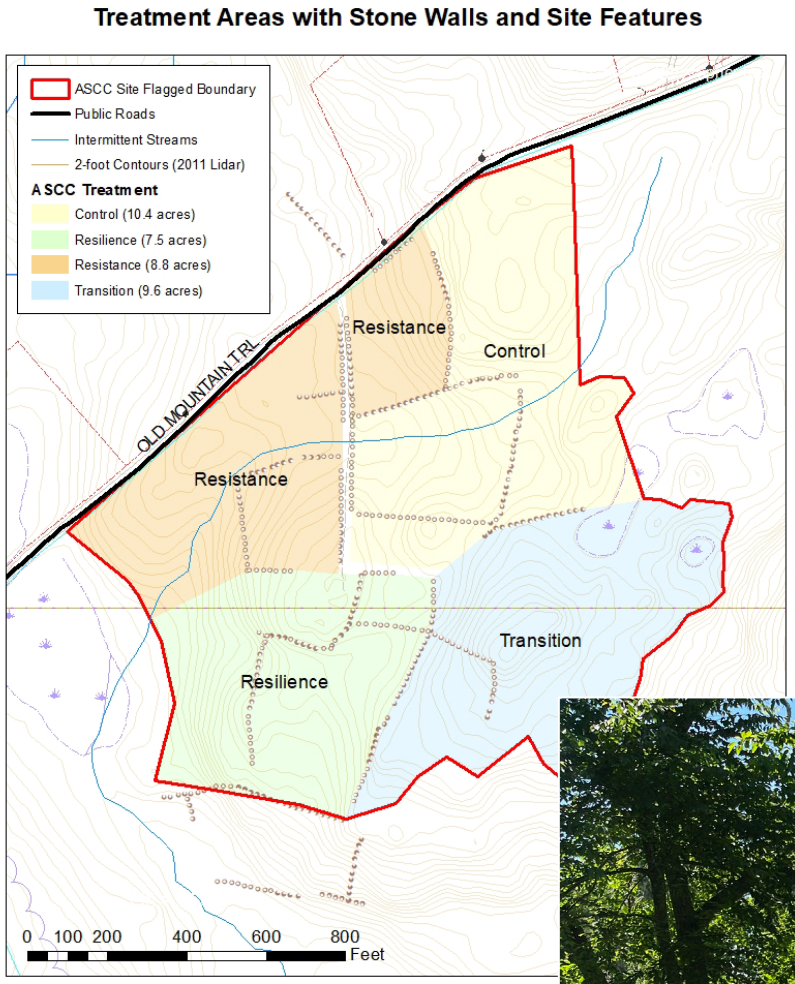
Treatment	Acreage
Resistance	6.5
Resilience	6.6
Transition	8.3
Control (no treatment)	8.3

ASCC Southern New England Replicate Study Area

RI DEM Hillsdale Preserve

Richmond, RI.

Treatment area ~ 40 acres



Resistance

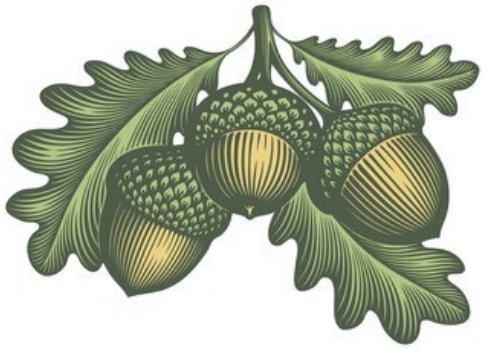
- Species to preserve: tulip poplar, yellow birch, white ash
- Retain stream & wetland buffer
- Leave deadwood for habitat & logging slash to deter deer

Resilience

- Crush competitive greenbriar and huckleberry
- Retain cover in rocky areas, remove cover near wetland for bird habitat
- Deadwood for habitat, logging slash to deter deer
- Planting chestnut

Transition

- Planting southern progeny oak & “future adapted species”
- Tree shelters, animal repellent & logging slash to mitigate deer browse



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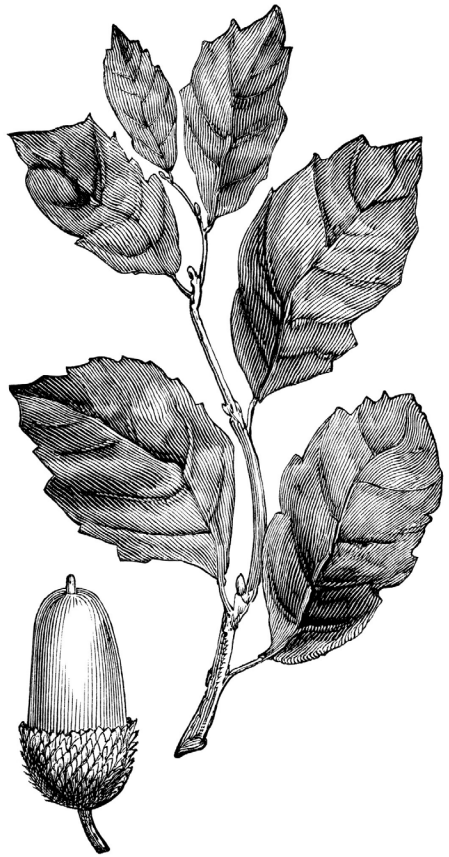


FIG. 344. FRUIT AND LEAVES OF QUERCUS SUBER.

Quantifying Diversity in Climate-adaptive management

Increased diversity is a ubiquitous climate-adaptive management goal:

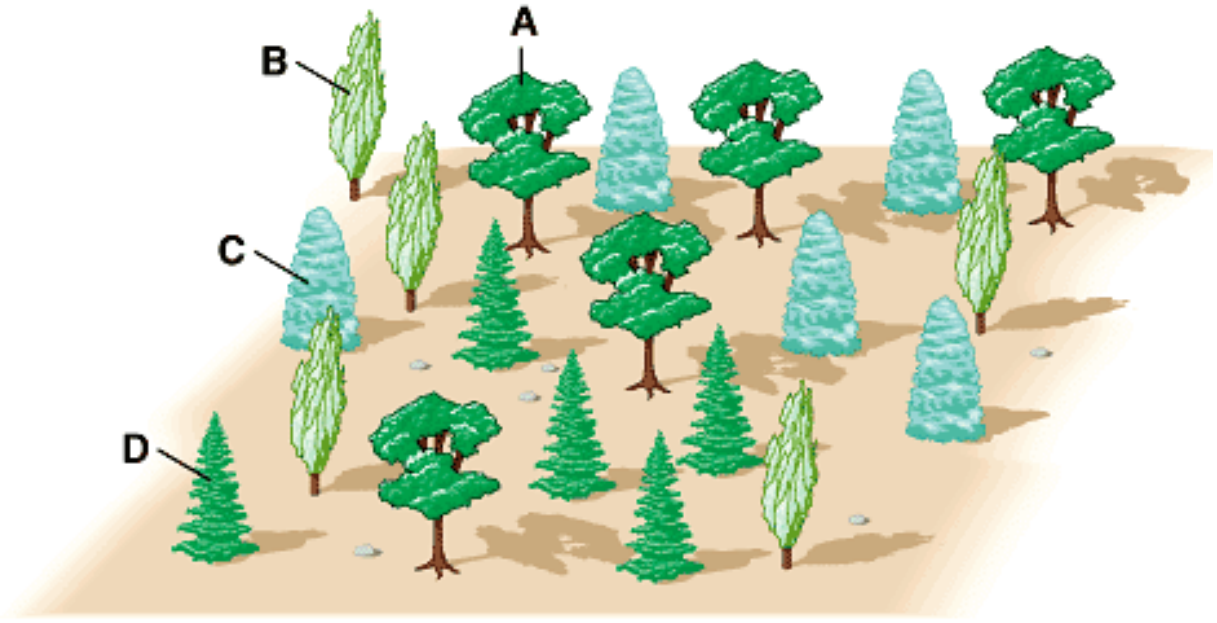
- Diversity and variety equate to less vulnerability to any one disturbance, & options for recovery post-disturbance
- Lack of diversity is a legacy of southern New England historical management & overharvesting

Species diversity
&
Structural Diversity

Part of all 3 SNE treatments.
Part of All other ASCC network treatments.

Quantifying Species Diversity

1) **Species richness** – the number of species within a defined region
2) **Species relative abundance** – how common or rare species are, compared to other species in the region



Community 1

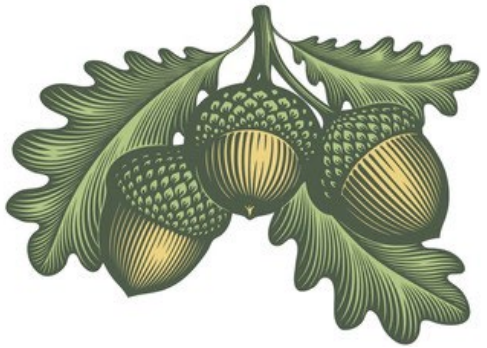
A: 25% B: 25% C: 25% D: 25%

Community 2

A: 80% B: 5% C: 5% D: 10%

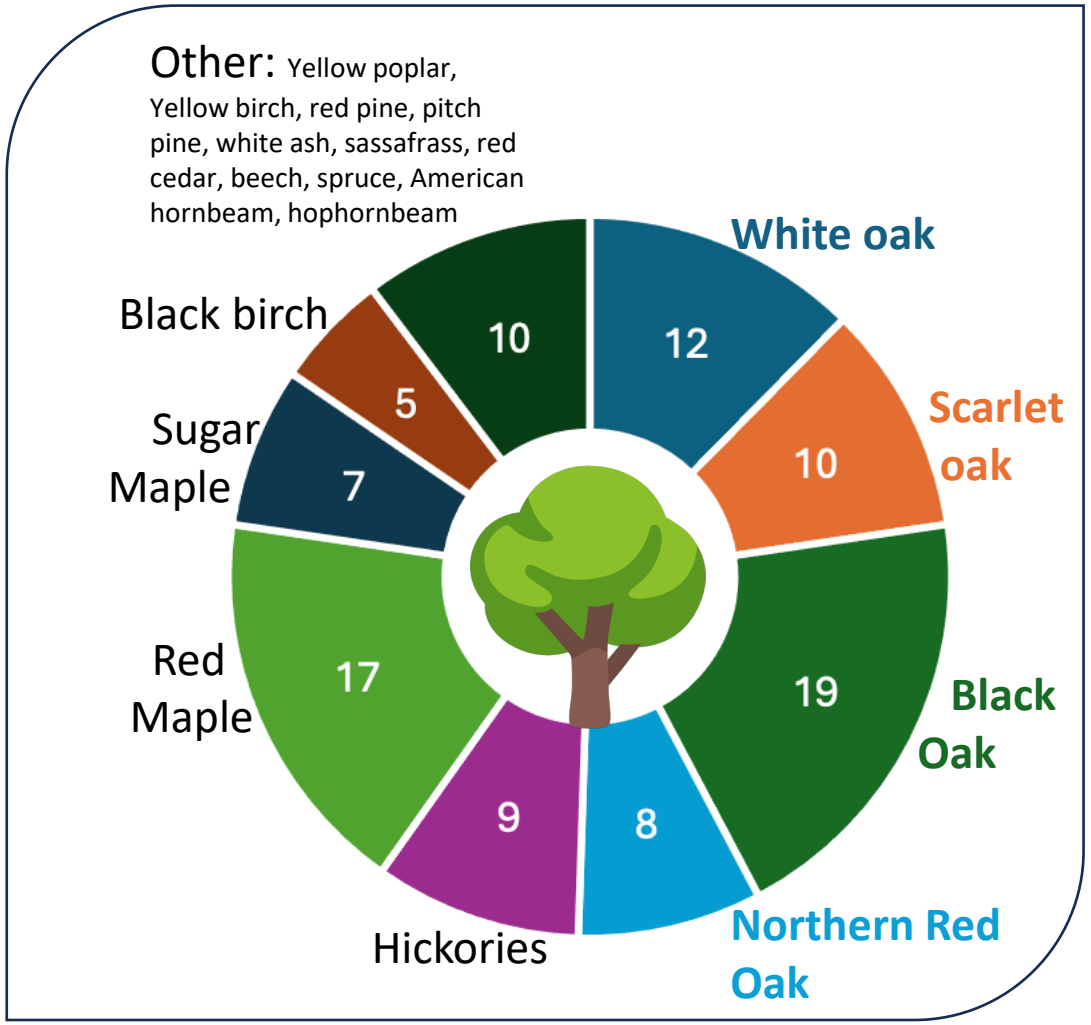
Community 1 has greater Species Richness

Species A has a high relative abundance

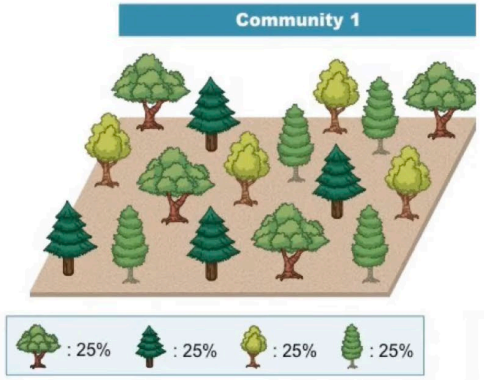


Quantifying Species Diversity

Shannon Diversity index takes into account **species richness & relative**



Sample calculation for community 1

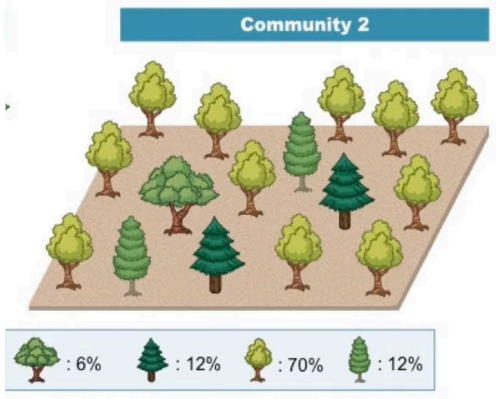


- Proportions:
  - $P_1 = 0.25$
  - $P_2 = 0.25$
  - $P_3 = 0.25$
  - $P_4 = 0.25$

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

- H = - [(.25 ln.25) + (.25 ln.25) + (.25 ln.25) + (.25 ln.25)]
- H = 1.39

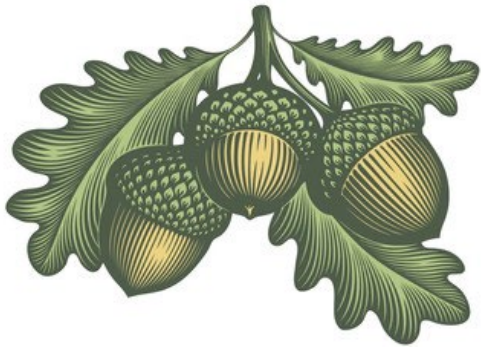
Sample calculation for community 2



- Proportions:
  - $P_1 = 0.06$
  - $P_2 = 0.12$
  - $P_3 = 0.70$
  - $P_4 = 0.12$

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

- H = - [(.06 ln.06) + (.12 ln.12) + (.7 ln.7) + (.12 ln.12)]
- H = 1.06



Quantifying Structural Diversity

We can make a Shannon Index for **structures** too

But we need to use the data to make categories…

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Diversity Index

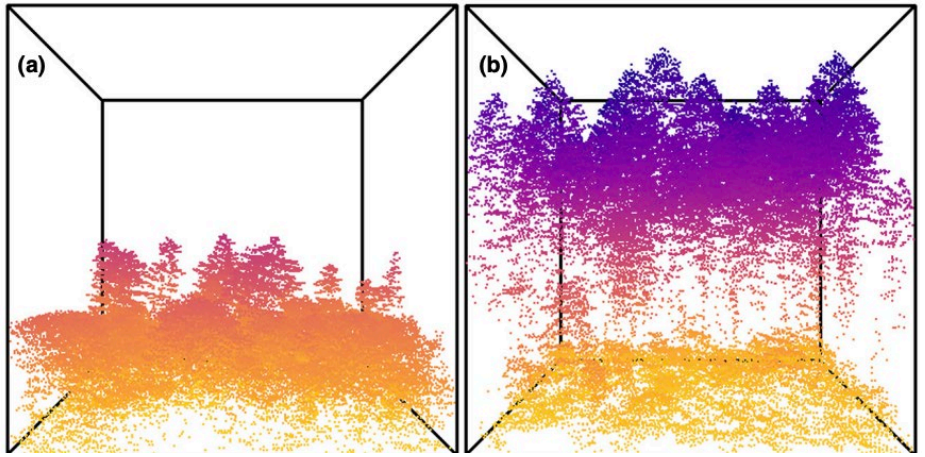
Sum of the proportion of stems in each category

The natural log of the proportion for that category

Forest structure variables

Aerial imagery or TLS	Inventory-based studies
Height of tallest trees (a)(d)	Stem density (b)
Height of most dense vegetation (d)	• Dead tree density (b)
Stem density (a)	• Pole density (b)
Vertical density (d)	• Sapling density (b)
Vertical variation in vegetation density (d)	Basal area (b)
Total plant area (Aboveground biomass) (d)	Avg. height (b)
Dominant species (a)	Clumping pattern (from stem maps) (c)
Successional stage (a)	Spacing pattern (from stem maps) (c)

(a) Martin et al., 2020
(b) Sourza et al., 2012
(c) Wikle et al., 2023
(d) Wang et al., 2024



LiDAR canopy height model of (a) young forest and (b) late successional forest

LaRue, Elizabeth A., et al. "A theoretical framework for the ecological role of three-dimensional structural diversity." *Frontiers in Ecology and the Environment* 21.1 (2023): 4-13.

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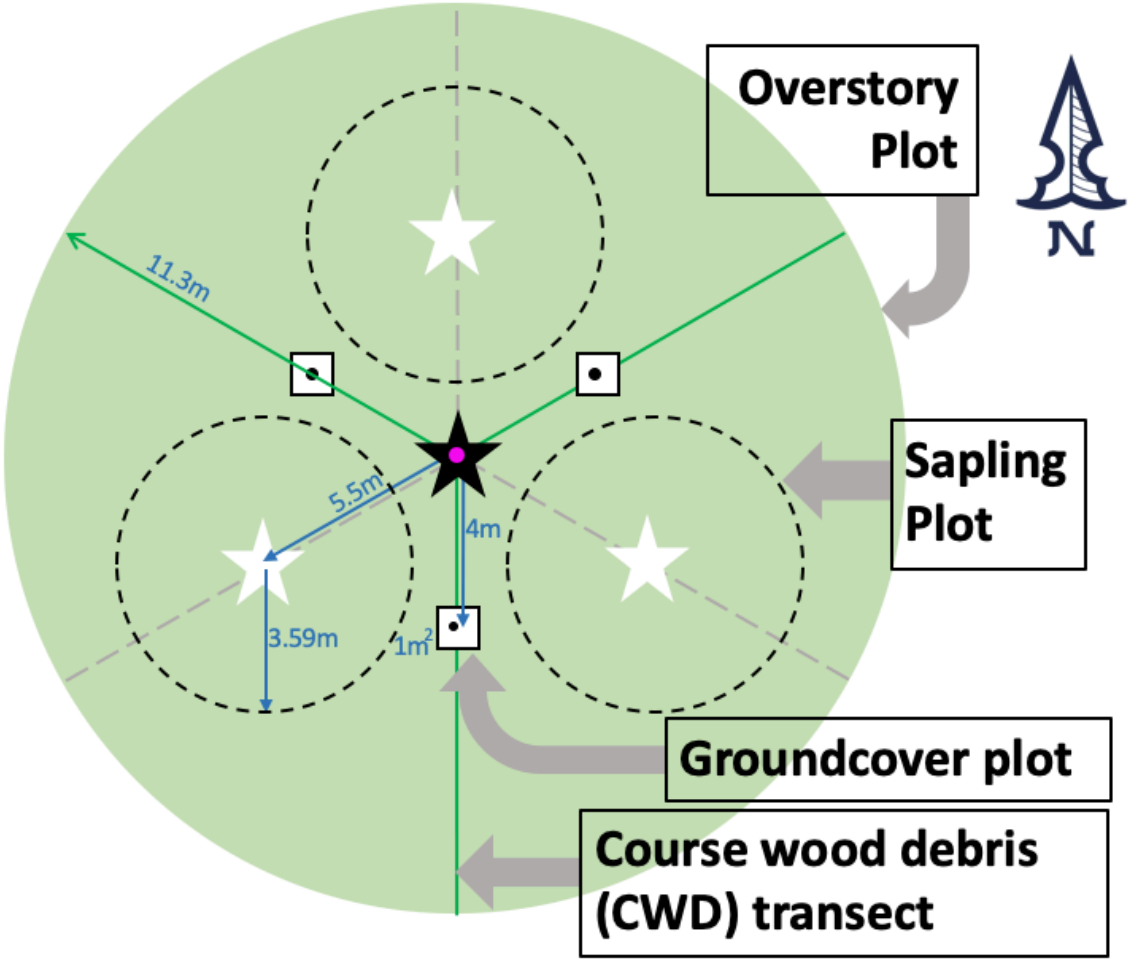


Quantifying Structural Diversity

Shannon Diversity index takes into account **species richness & relative abundance**

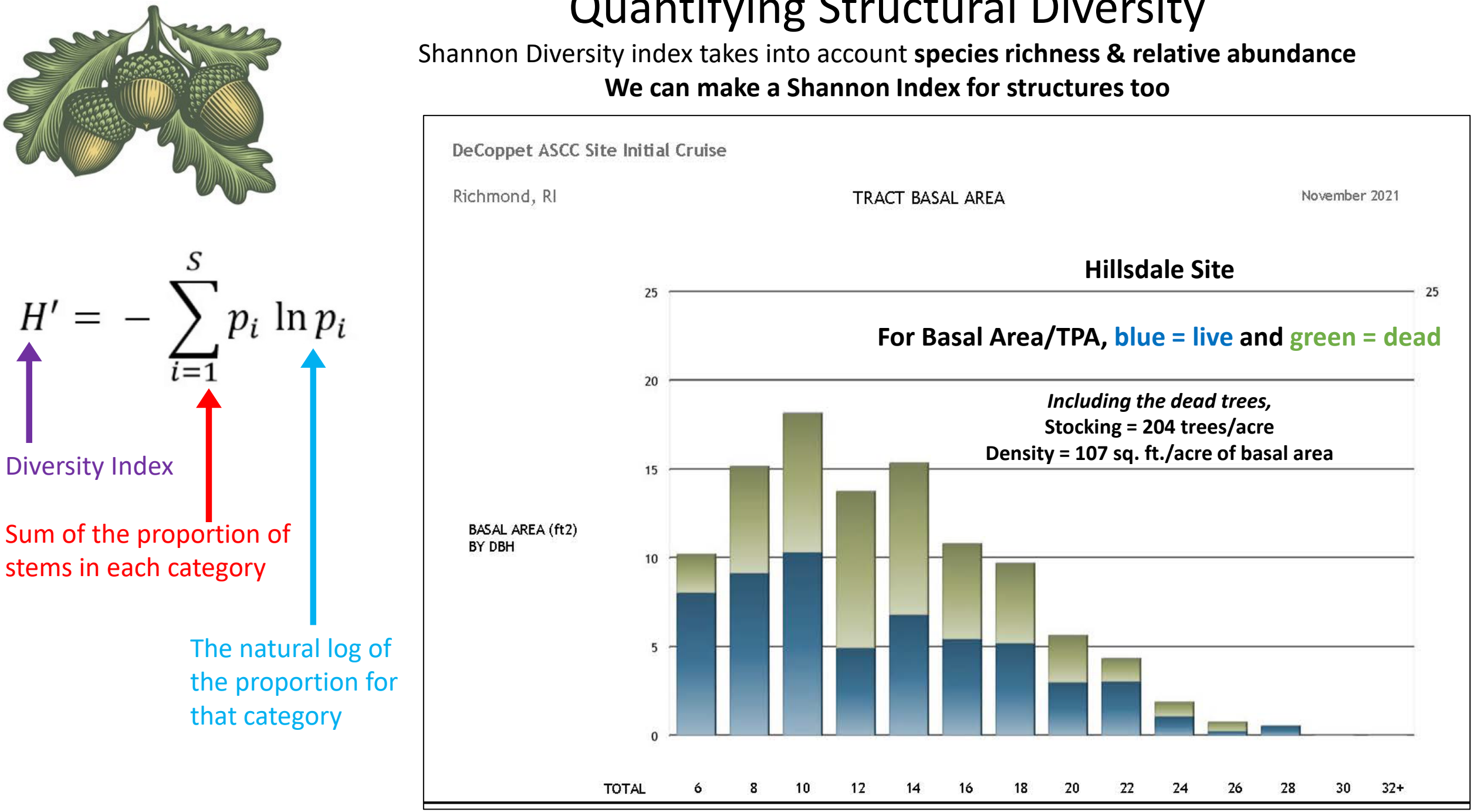
We can make a Shannon Index for structures too

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Diversity Index

Sum of the proportion of stems in each category

The natural log of the proportion for that category



Quantifying Structural Diversity

Shannon Diversity index takes into account **species richness & relative abundance**

We can make a Shannon Index for structures too

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Structure categories:

DBH = 4-8”

DBH = 8-12”

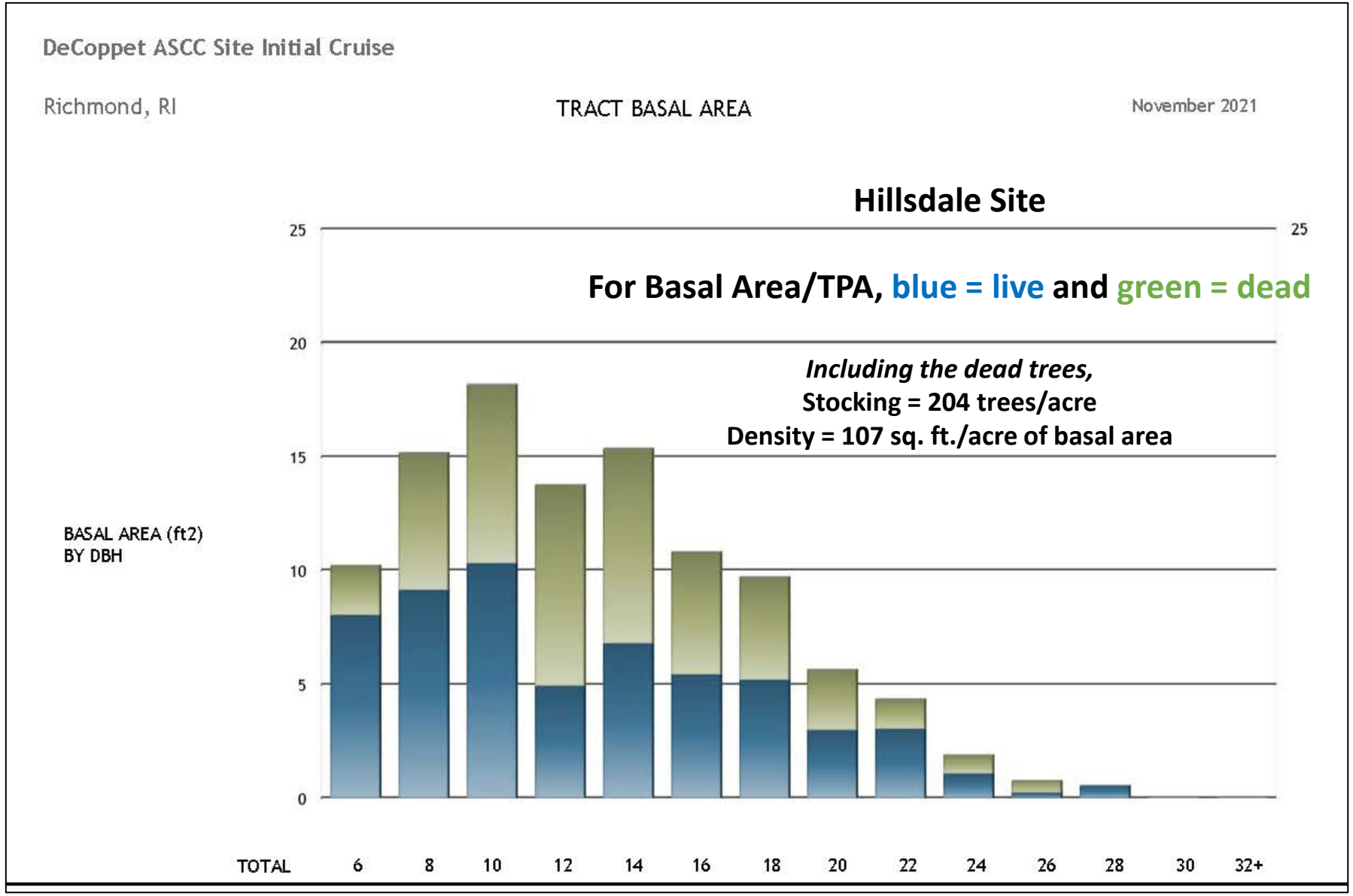
DBH = 12-16”

DBH = 16-20”

DBH = 20—24”

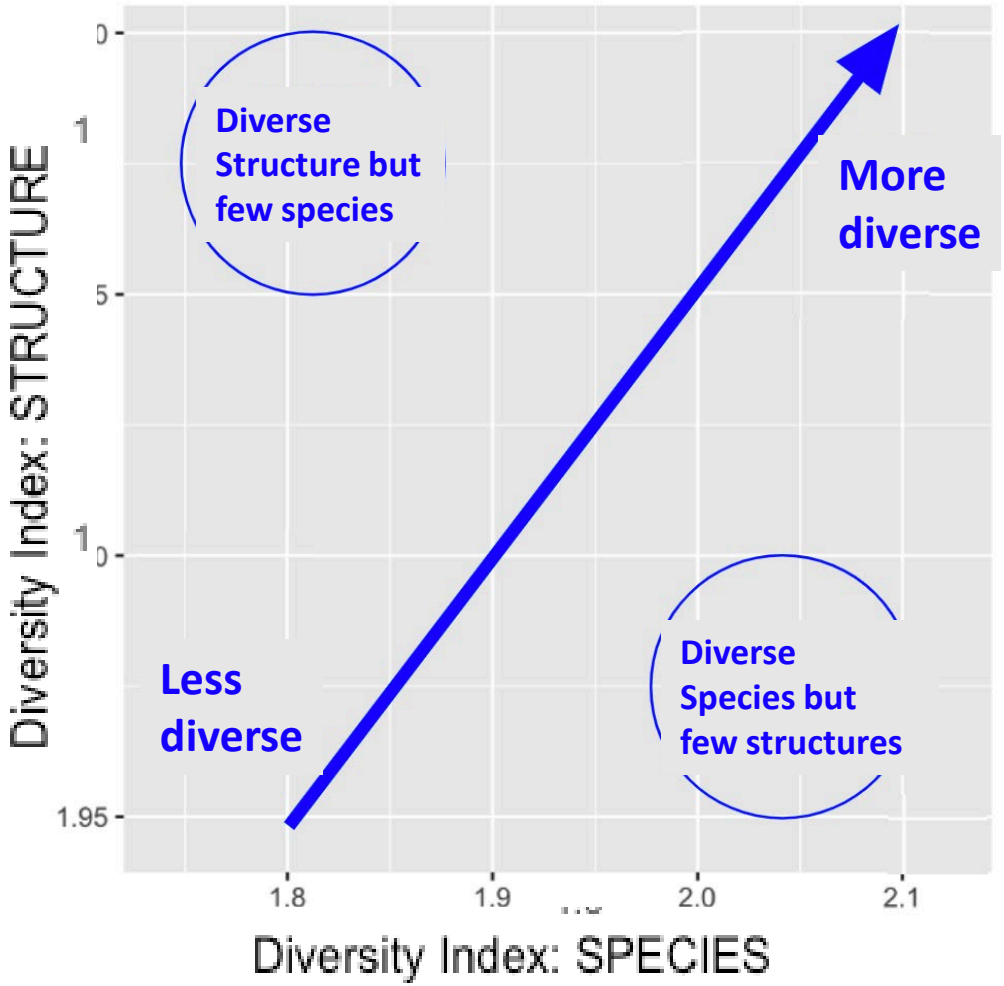
DBH = 24-28”

DBH = 28-32”



Plotting Species + Structural Diversity

Comparing 3 SNE sites, pre-treatment



Plotting Species + Structural Diversity

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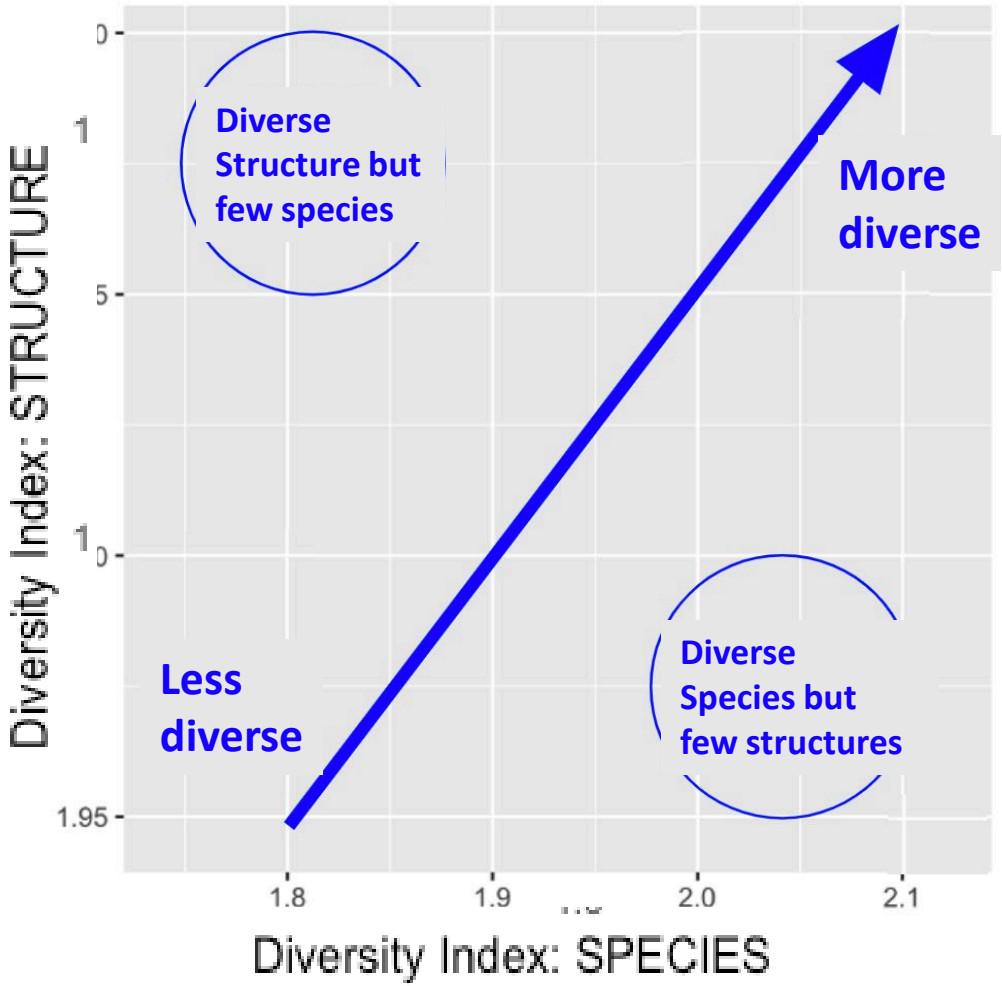

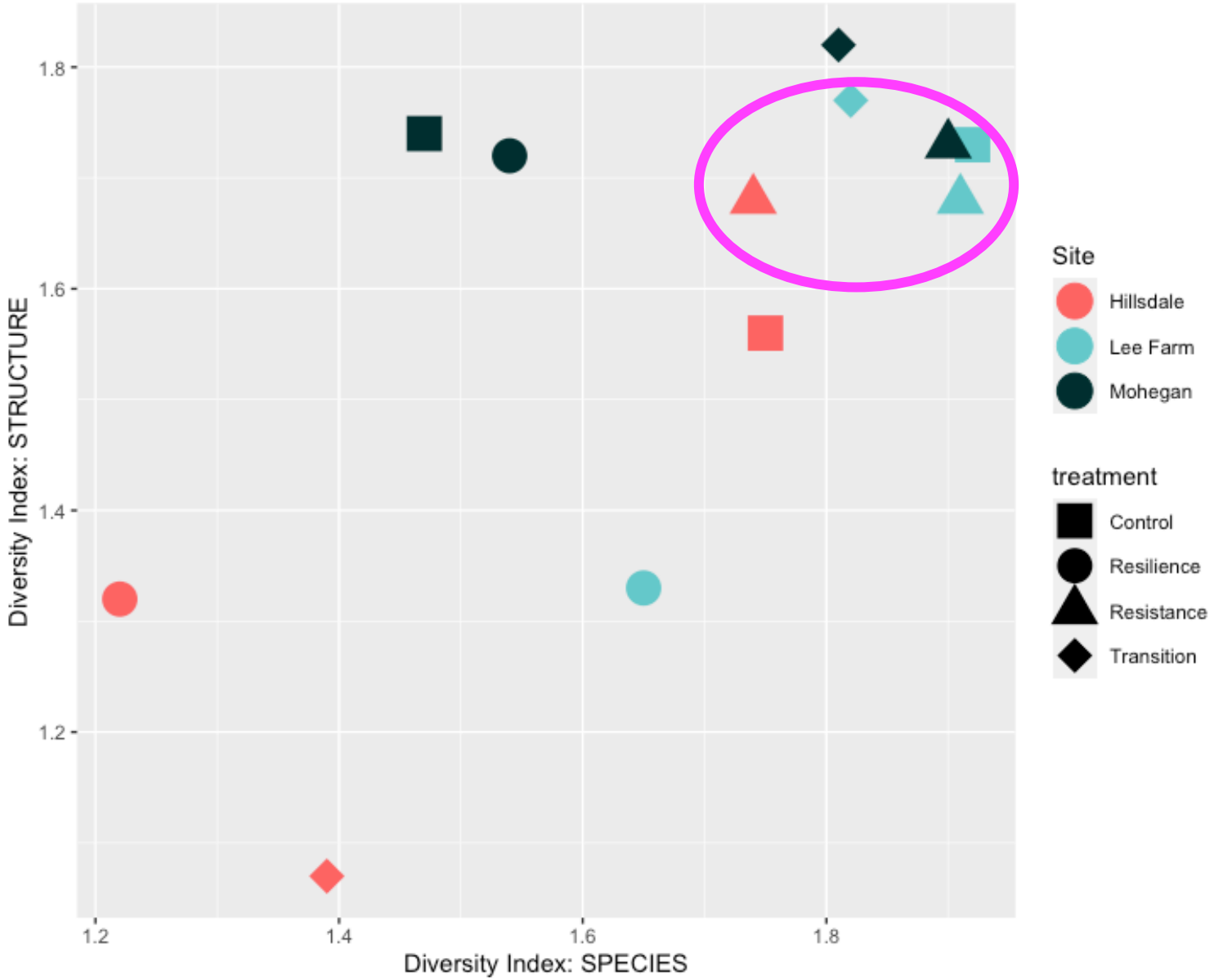

Plotting Species + Structural Diversity

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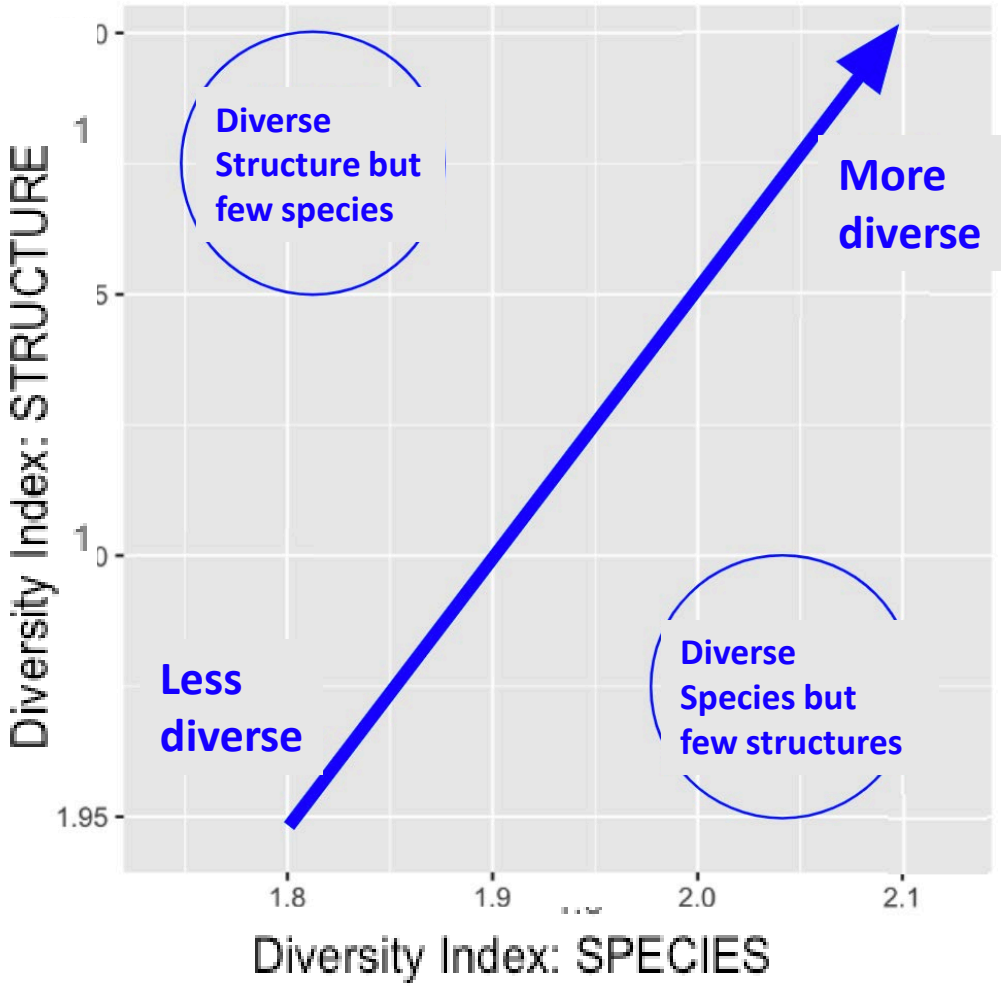
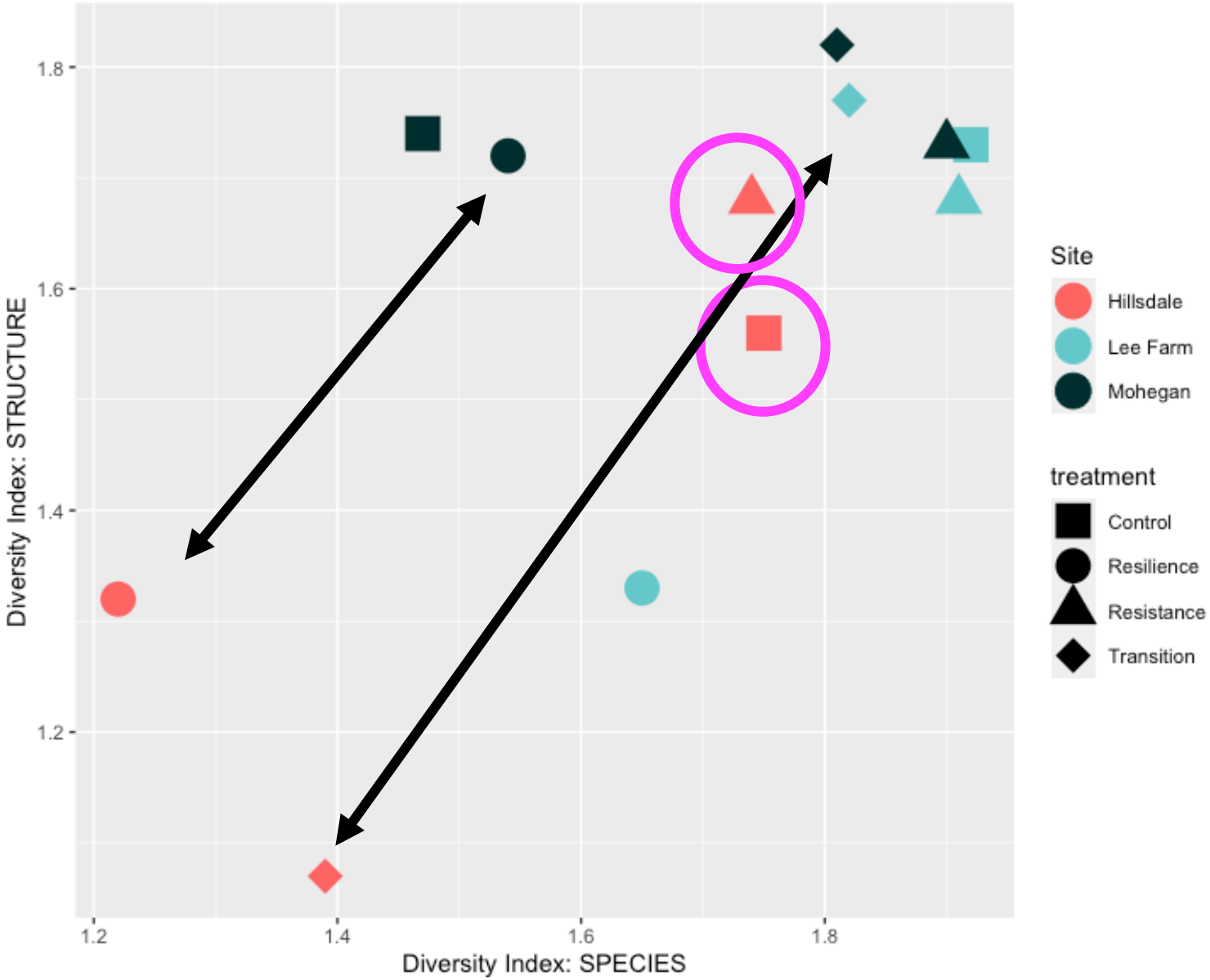
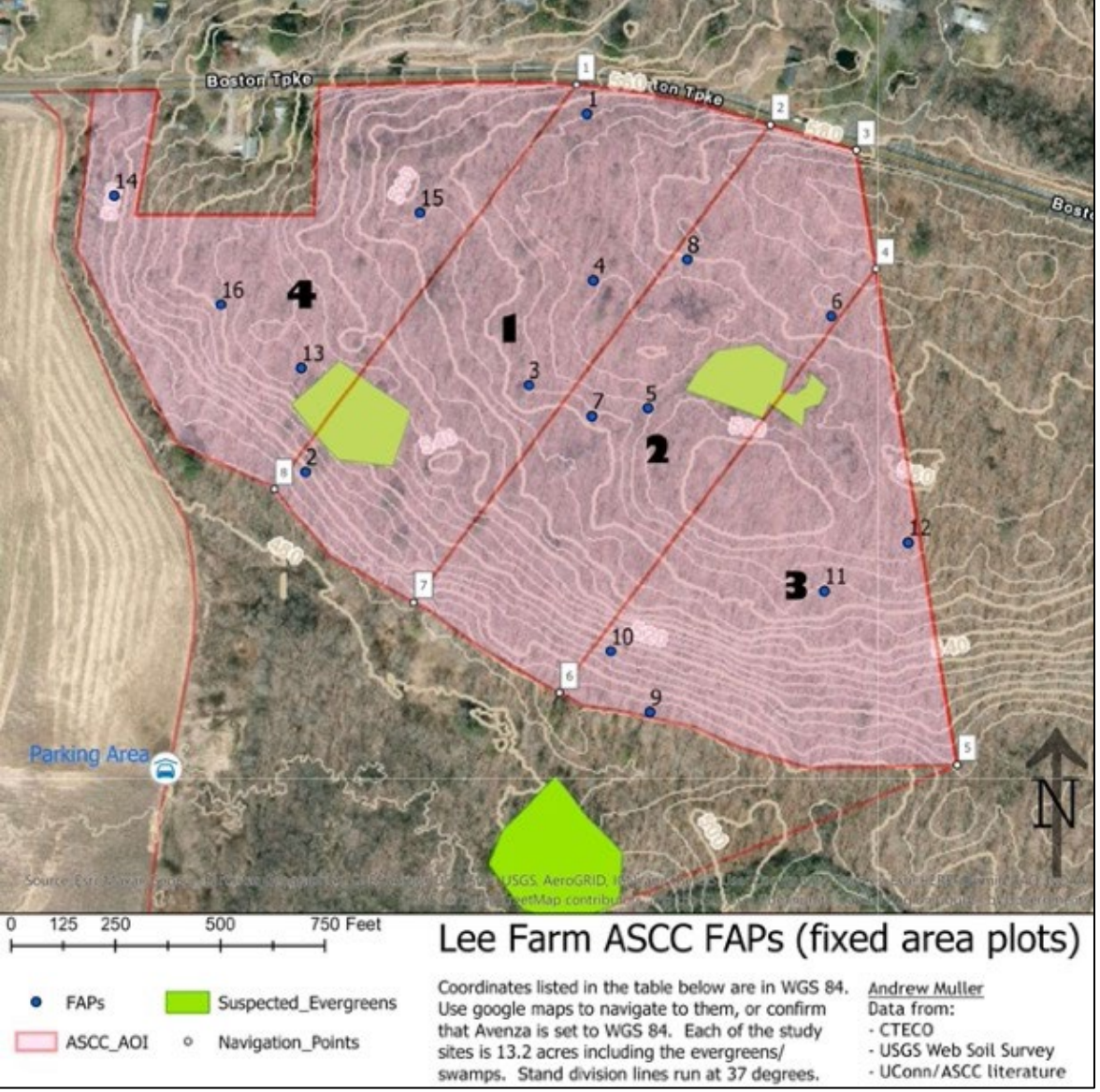
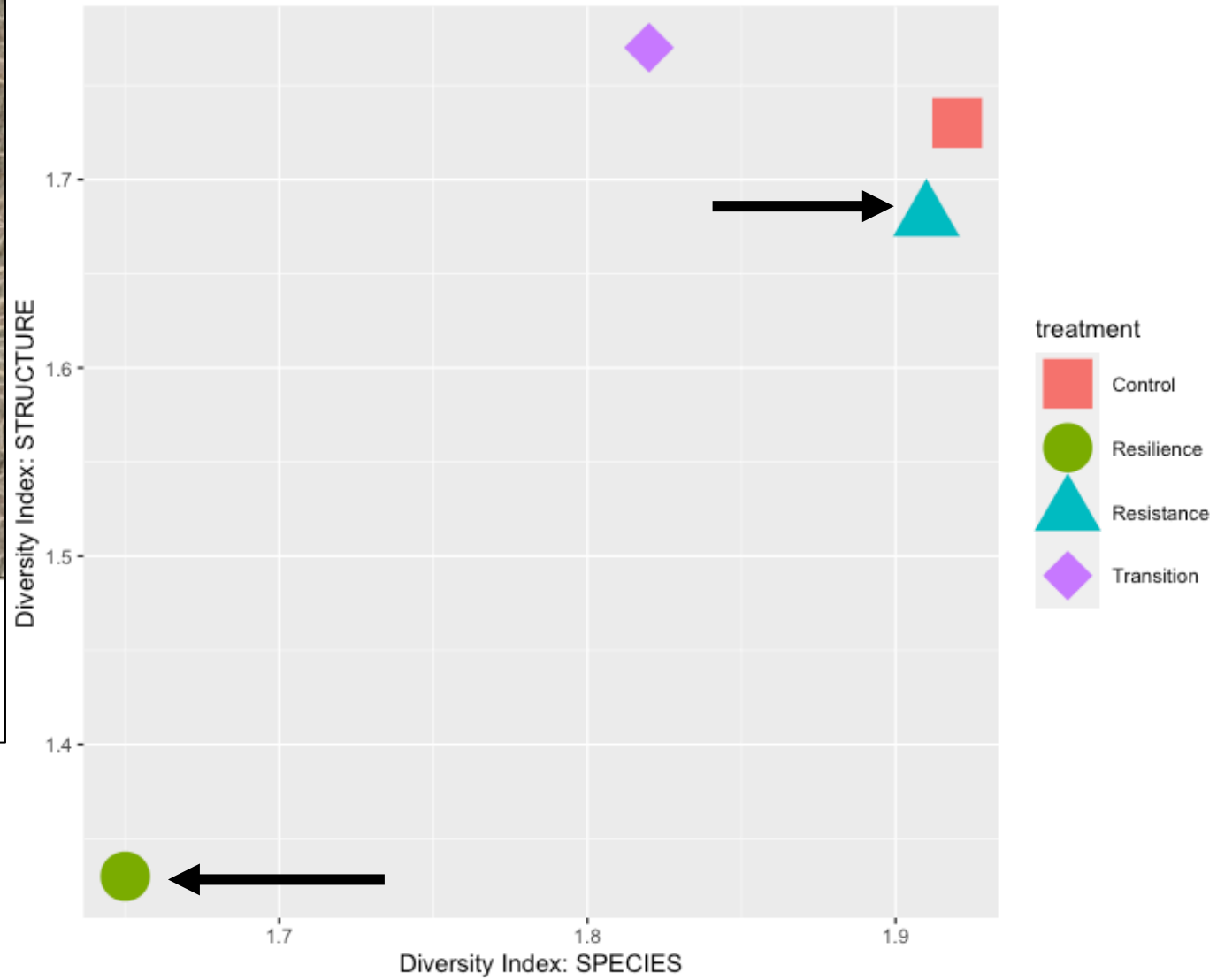






Plotting Species + Structural Diversity

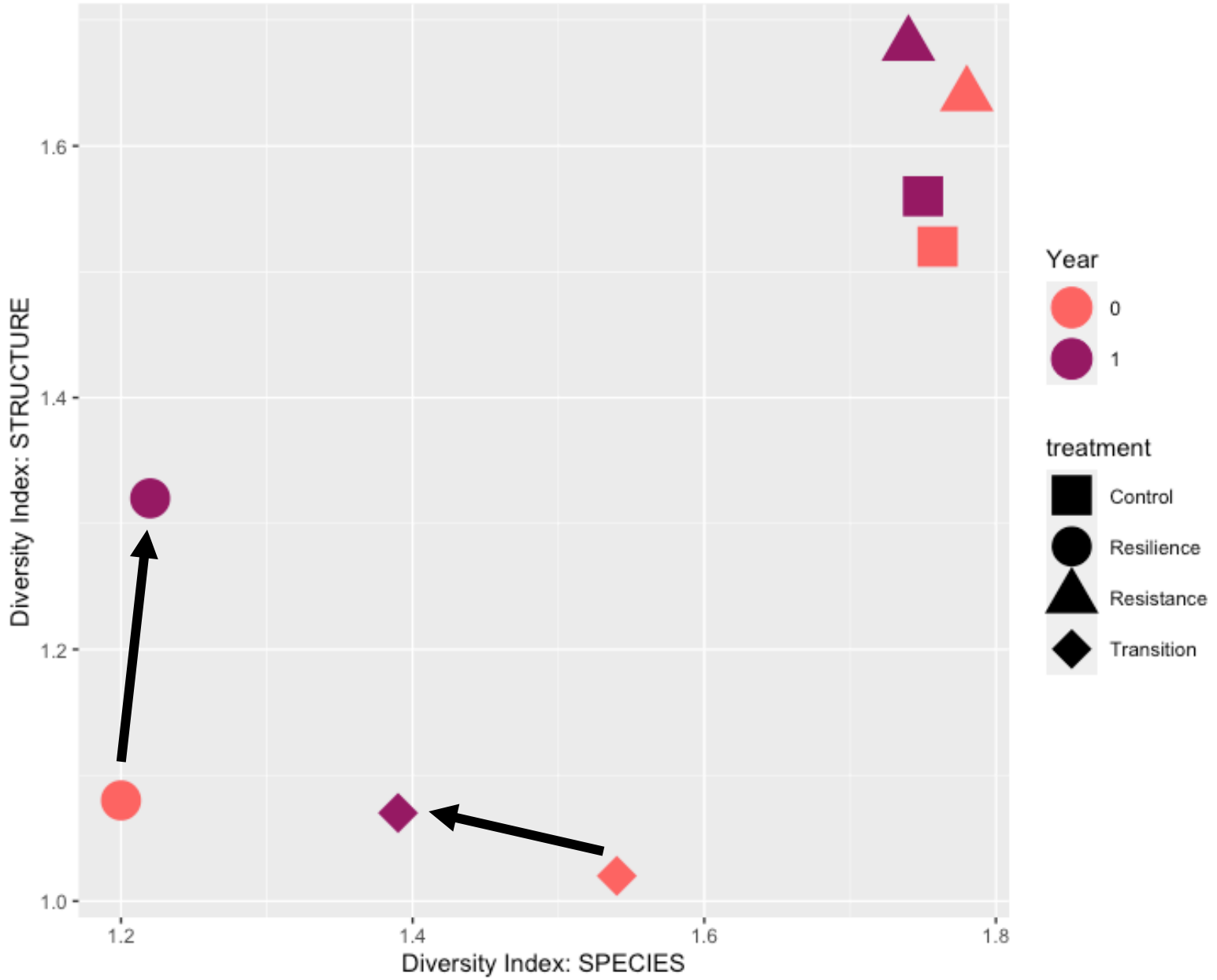
Lee Farm, pre-treatment



URI Forestry Specialist Christopher Riely is co-directing Rhode Island's component of a U.S.-Canada forest ecosystem project. David DelPoio/The Providence Journal

Plotting Species + Structural Diversity

Hillsdale Site, 2 years of pre-treatment data



Southern New England Exurban Oak ASCC Affiliate Site – Hillsdale Replicate

"Planting to assess survival and growth of future-adapted oaks"

Experimental Design Proposal 1.1 By Christopher Riely

Chrsitopher Riely of URI, William Walker & Tee Jay Boudreau of RI DEM David DelPoio/The Providence Journal

Current first choice oak and other tree species for planting

Resistance Treatment Area	Transition Treatment Area
black oak	blackjack oak*
chestnut oak	chinkapin oak*
scarlet oak	post oak*
white oak	Southern red oak*

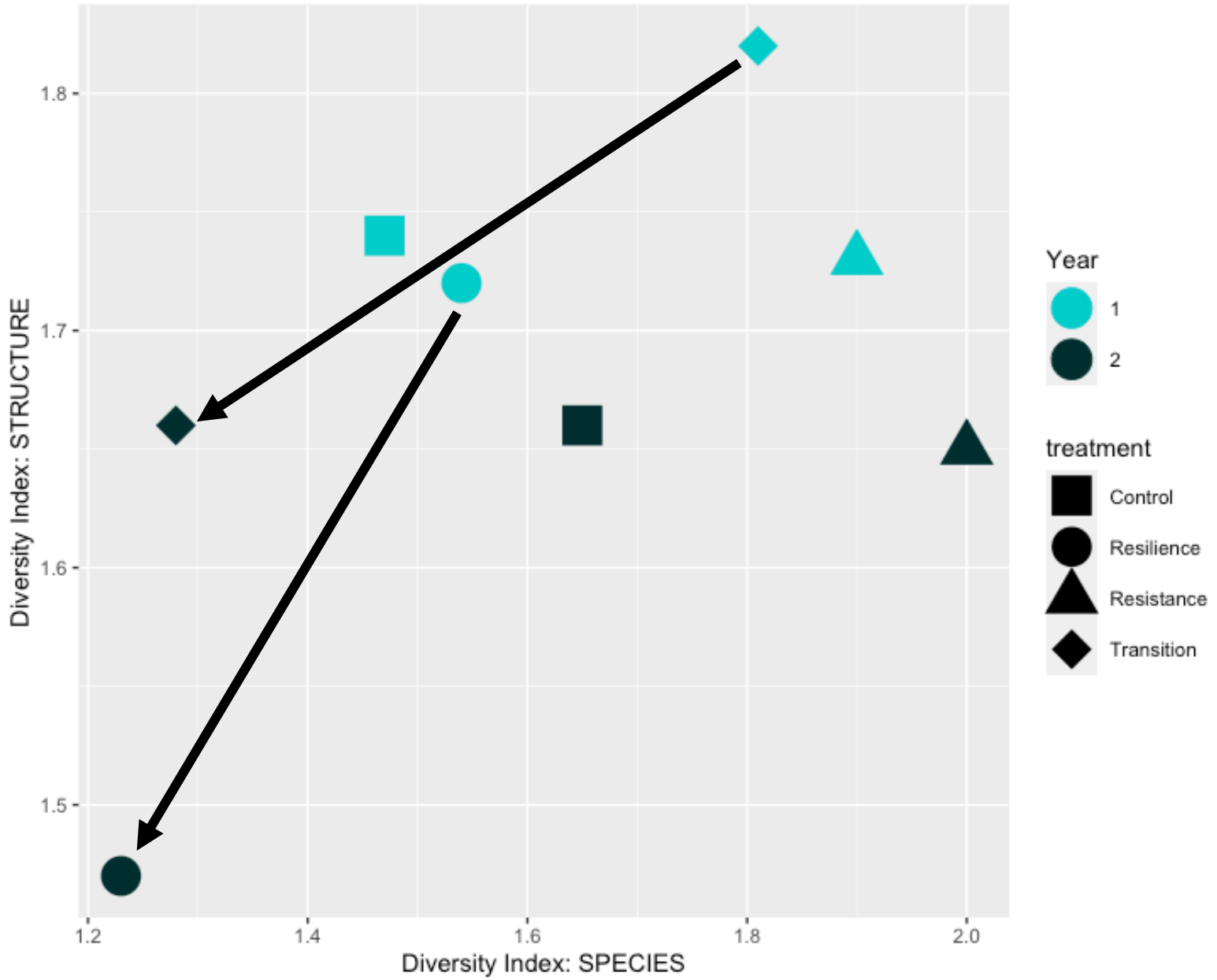
Other candidate oak tree species for planting if first choices are unavailable

Resistance Treatment Area	Transition Treatment Area
bear oak	chestnut oak
Northern red oak	other AM oaks?
native hickories	hickories

*new habitat/assisted migration potential

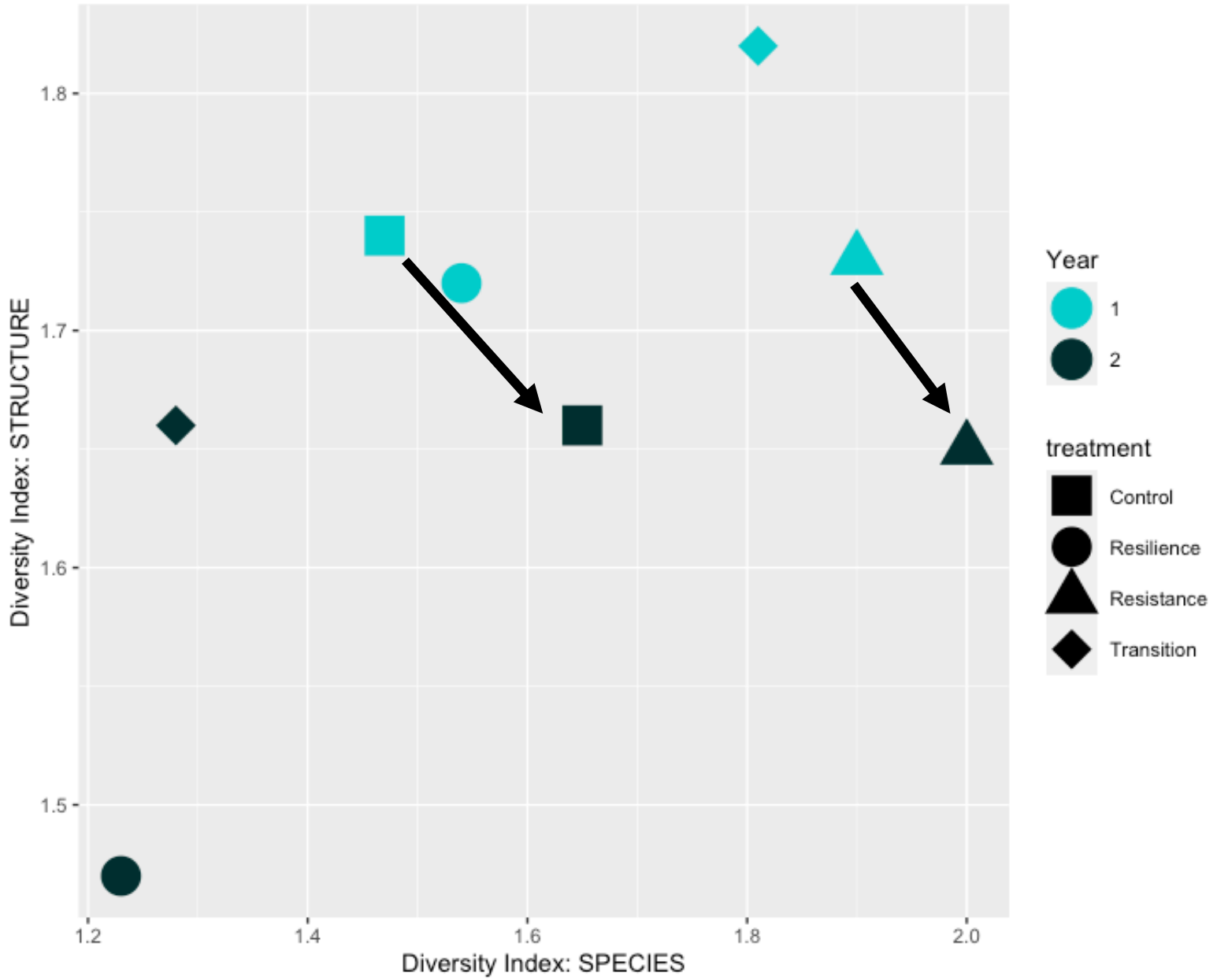
Plotting Species + Structural Diversity

Mohegan State Forest, Pre- and Post-treatment



Plotting Species + Structural Diversity

Mohegan State Forest, Pre- and Post-treatment



Plotting Species + Structural Diversity

Mohegan State Forest, Pre- and Post-treatment

Using unstable structure categories…

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Structure categories are:

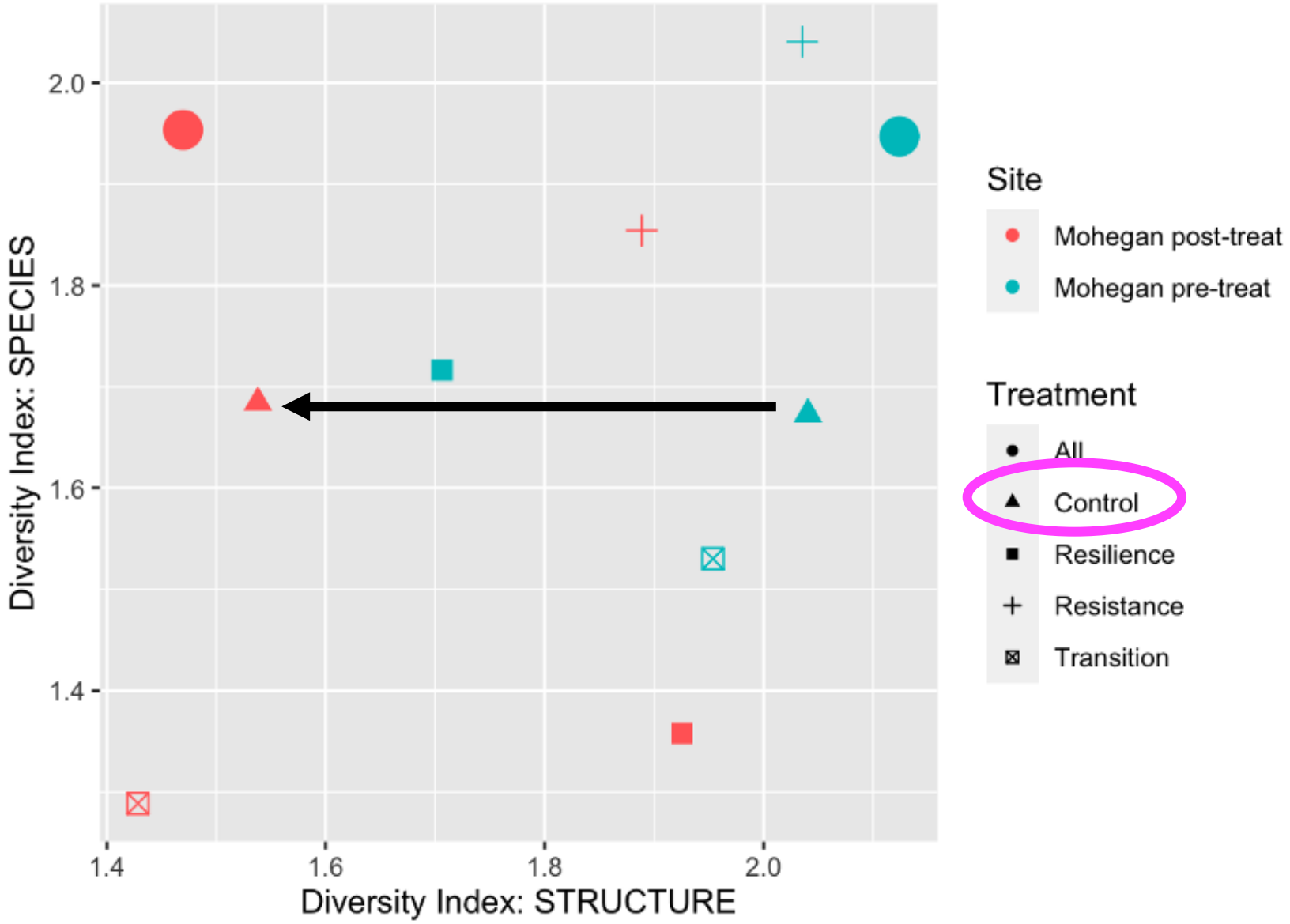
4-8” intermediate

4-8 co-dominant

8-12” co-dominant

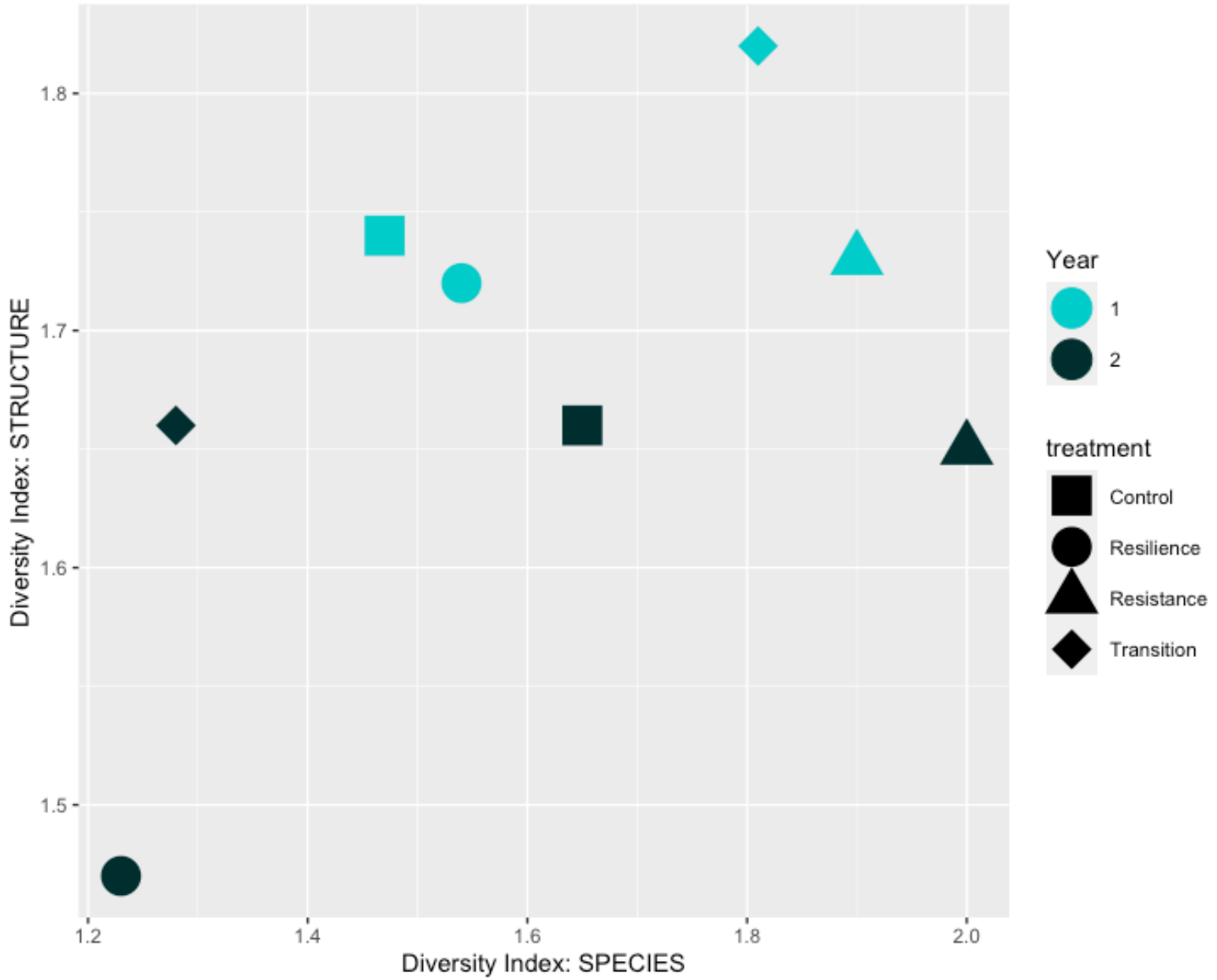
8-12” dominant

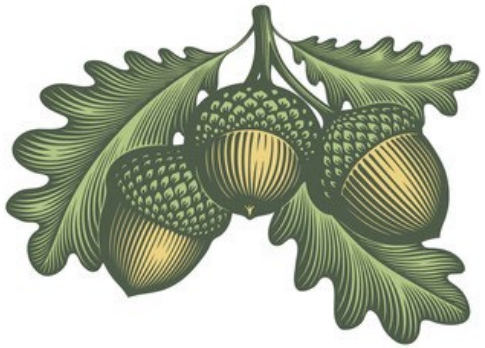
And so on…



Plotting Species + Structural Diversity

Mohegan State Forest, Pre- and Post-treatment





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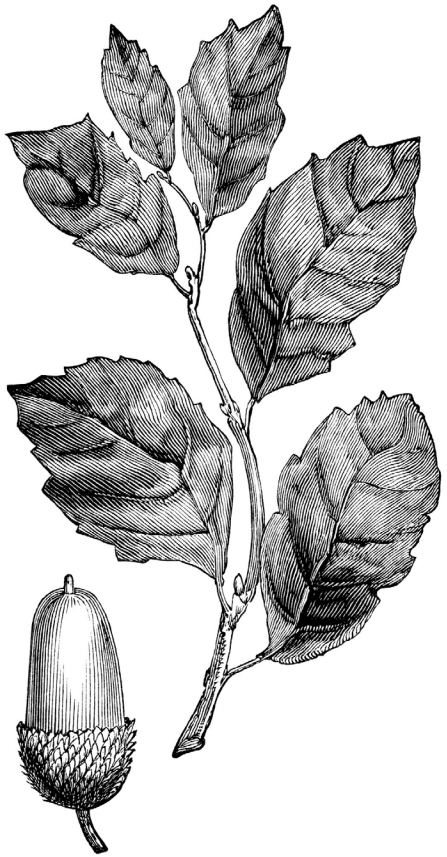

FIG. 344. FRUIT AND LEAVES OF QUERCUS SUBER.

Ask us about taking a tour!

Thanks for your attention!

Check out the ASCC research network at Adaptivesilvicultre.org

Reach me at Amanda.bunce@uconn.edu