



SMITHSONIAN
ENVIRONMENTAL
RESEARCH CENTER

Smithsonian

Better Reforestation: *BiodiversiTREE* (est. 2013) & *Functional Forests* (2026)

John D. Parker & Justin Nowakowski (SERC PIs)

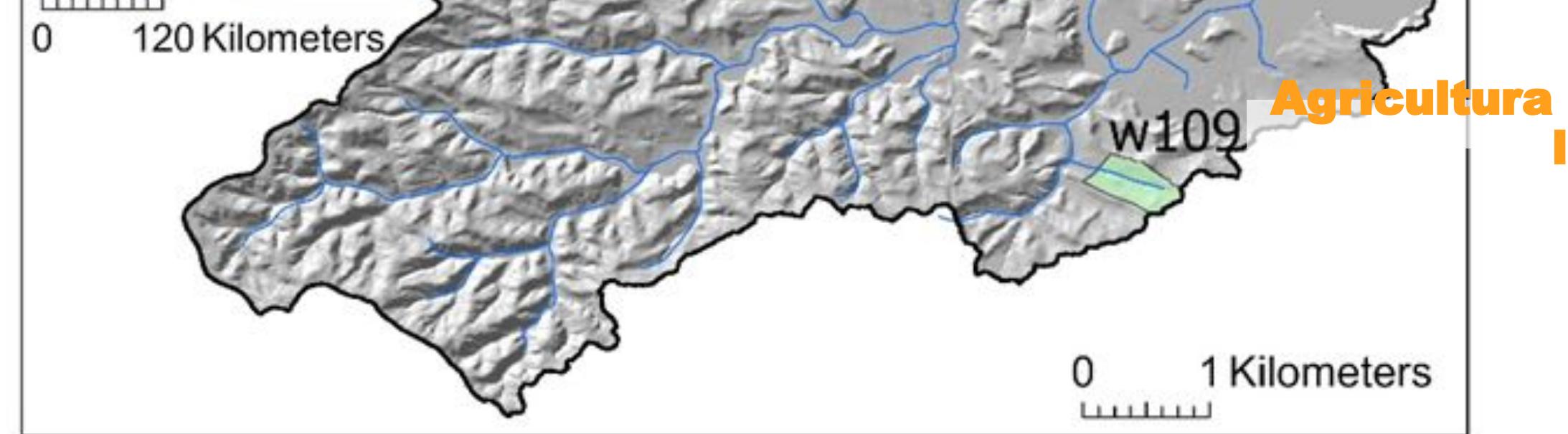
4+ sq miles, 15+ miles of shoreline, farmland, forests, marshes, streams...

A 'living laboratory' for environmental research since 1965



SERC RESEARCH PRIORITY: IMPACTS OF LANDCOVER ON WATER QUALITY





Watershed 109: 40yrs of riparian buffer strip research

ECOLOGY
ECOLOGICAL SOCIETY OF AMERICA



Article

Nutrient Dynamics in an Agricultural Watershed: Observations on the Role of A Riparian Forest

William T. Peterjohn, David L. Correll

First published:

1979

DOI:

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Page

After ~40yrs as corn, how can we learn something different from watershed 109?

Plant trees (for \$\$\$)!!!



**NEARLY ALL FOREST PLANTATIONS ARE
MONOCULTURES
(7% *global total*)**



REFORESTATION AS NATURAL CLIMATE SOLUTION

~1 TRILLION
NEW TREES
PLEDGED

ALMOST NO
MONITORING,
MANY FAIL,
MAJORITY ARE
MONOCULTURE
S

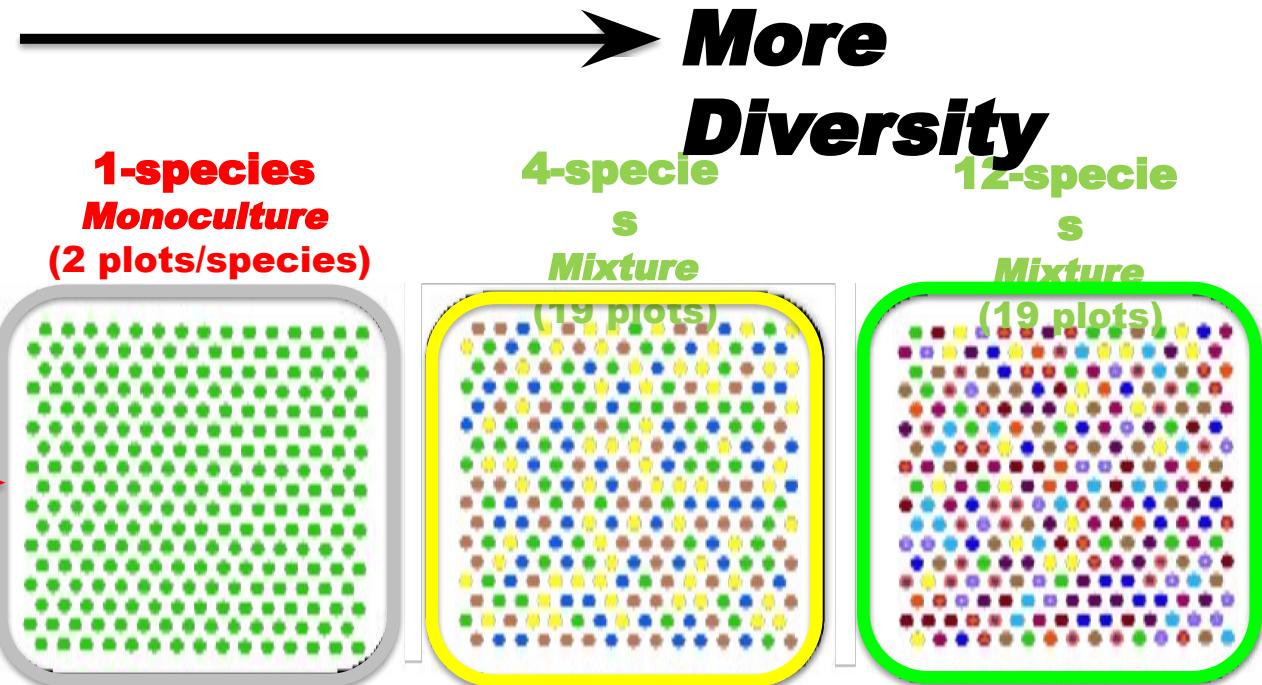
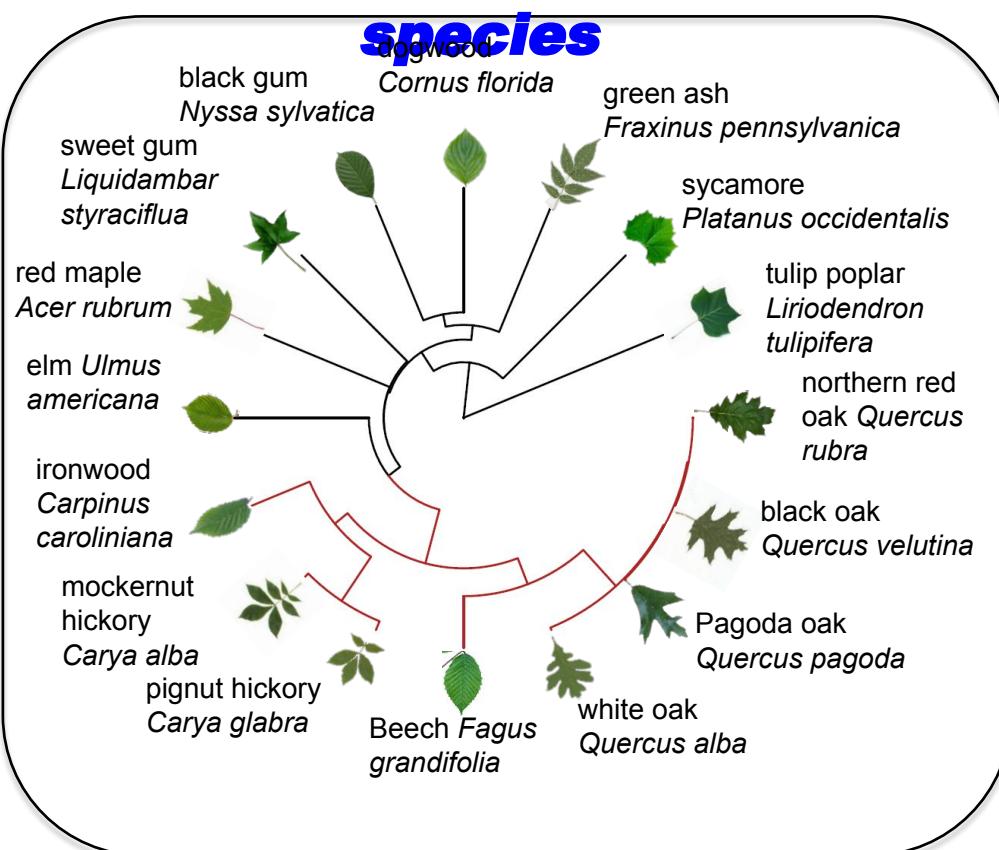




IS TREE *DIVERSITY* IMPORTANT TO RESTORATION SUCCESS?

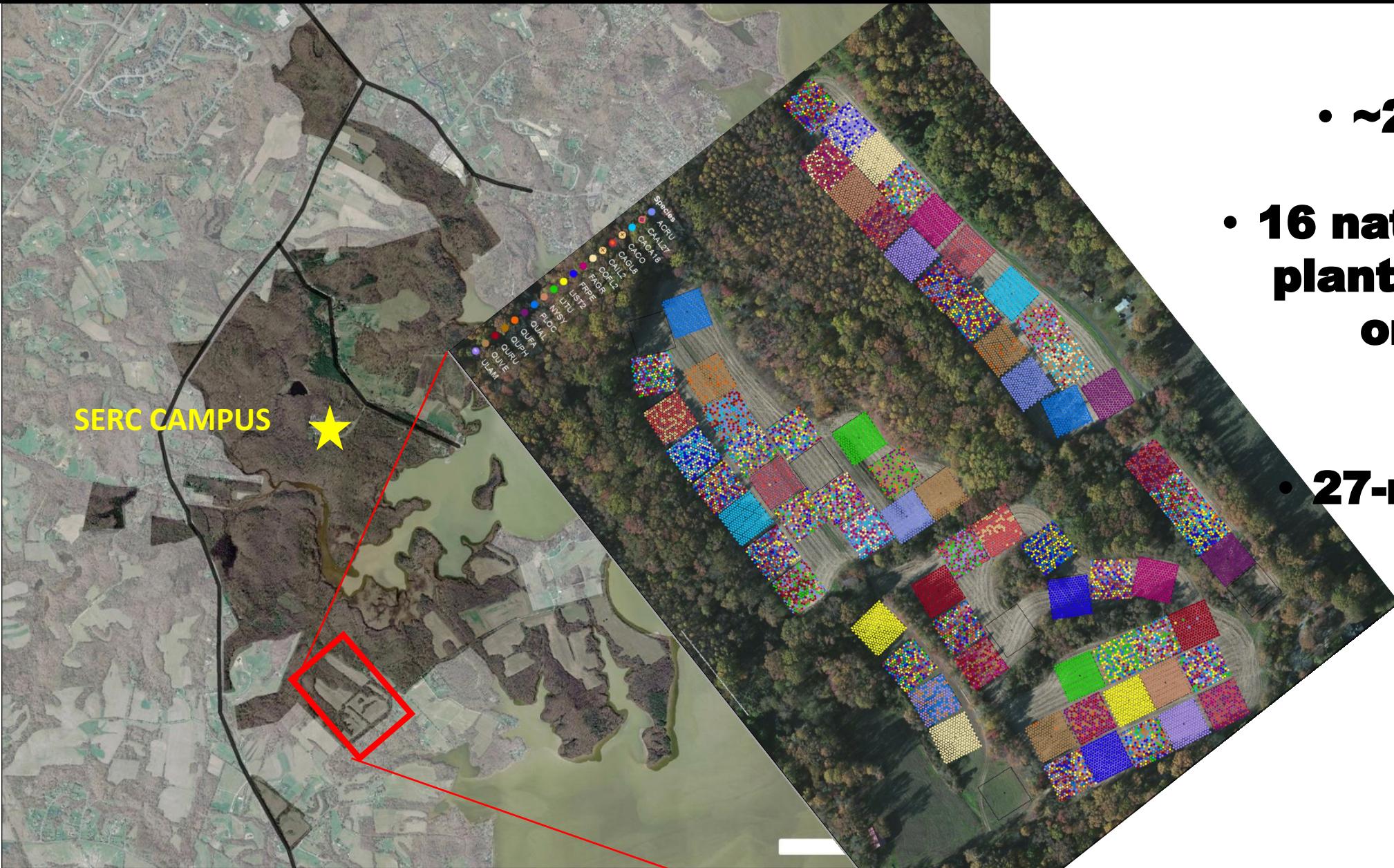


16 native tree species



+ N = 5 UNPLANTED NATURAL REGENERATION CONTROL PLOTS

Biodiversi **TREE**: Tree-Diversity Ecosystem-Function Experiment, est. 2013



- 60 acres
- ~20,000 trees
- 16 native species planted into 1, 4, or 12-species mixtures
- 27-mile walk to every tree

Is tree diversity important to restoration success?

Tree Survival

Tree Growth

Deer Damage

Stand Complexity

Soil Carbon

Soil Microbes

Leaf Insects

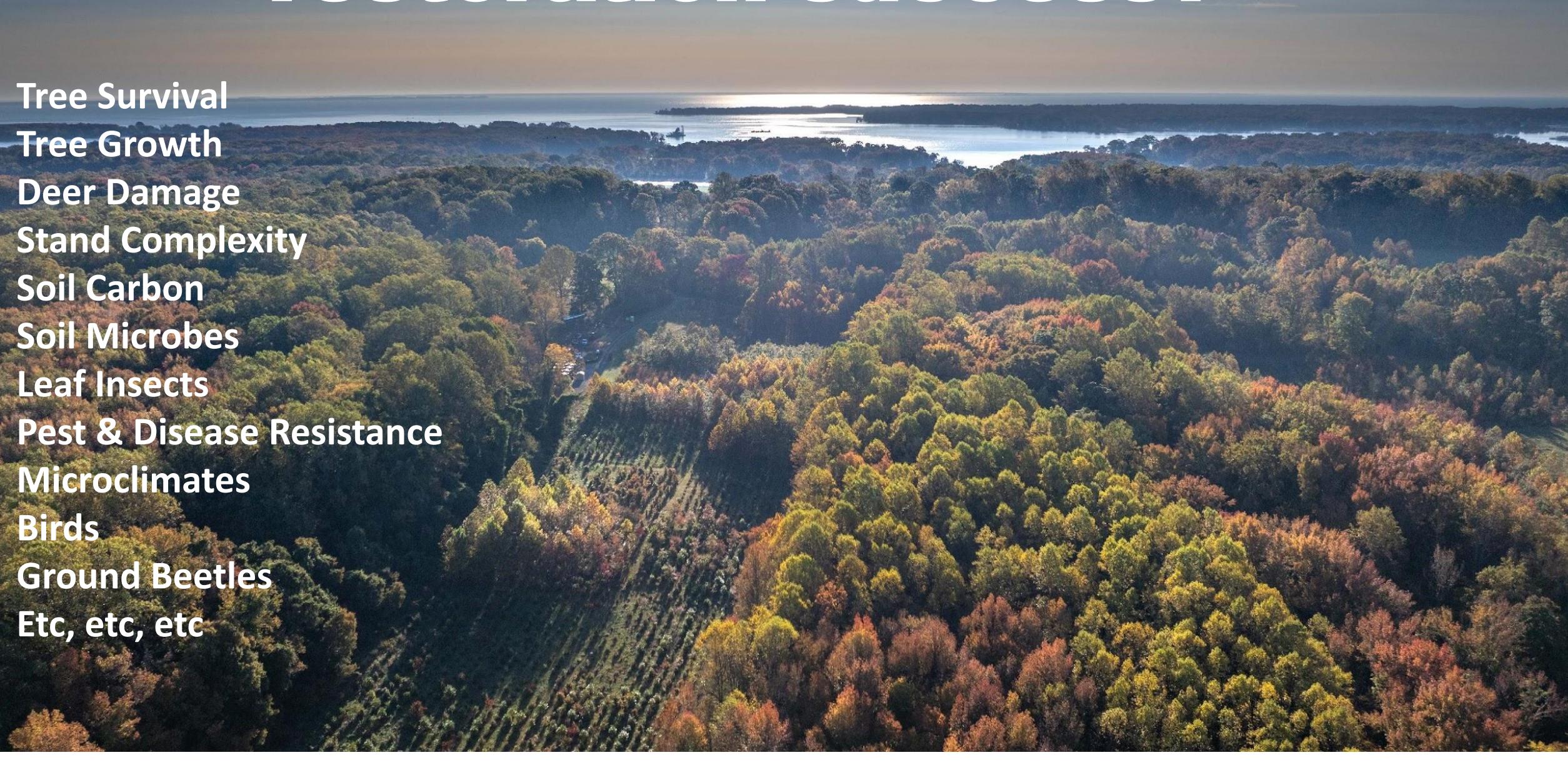
Pest & Disease Resistance

Microclimates

Birds

Ground Beetles

Etc, etc, etc



Does diversity
↑survival & growth?

2013

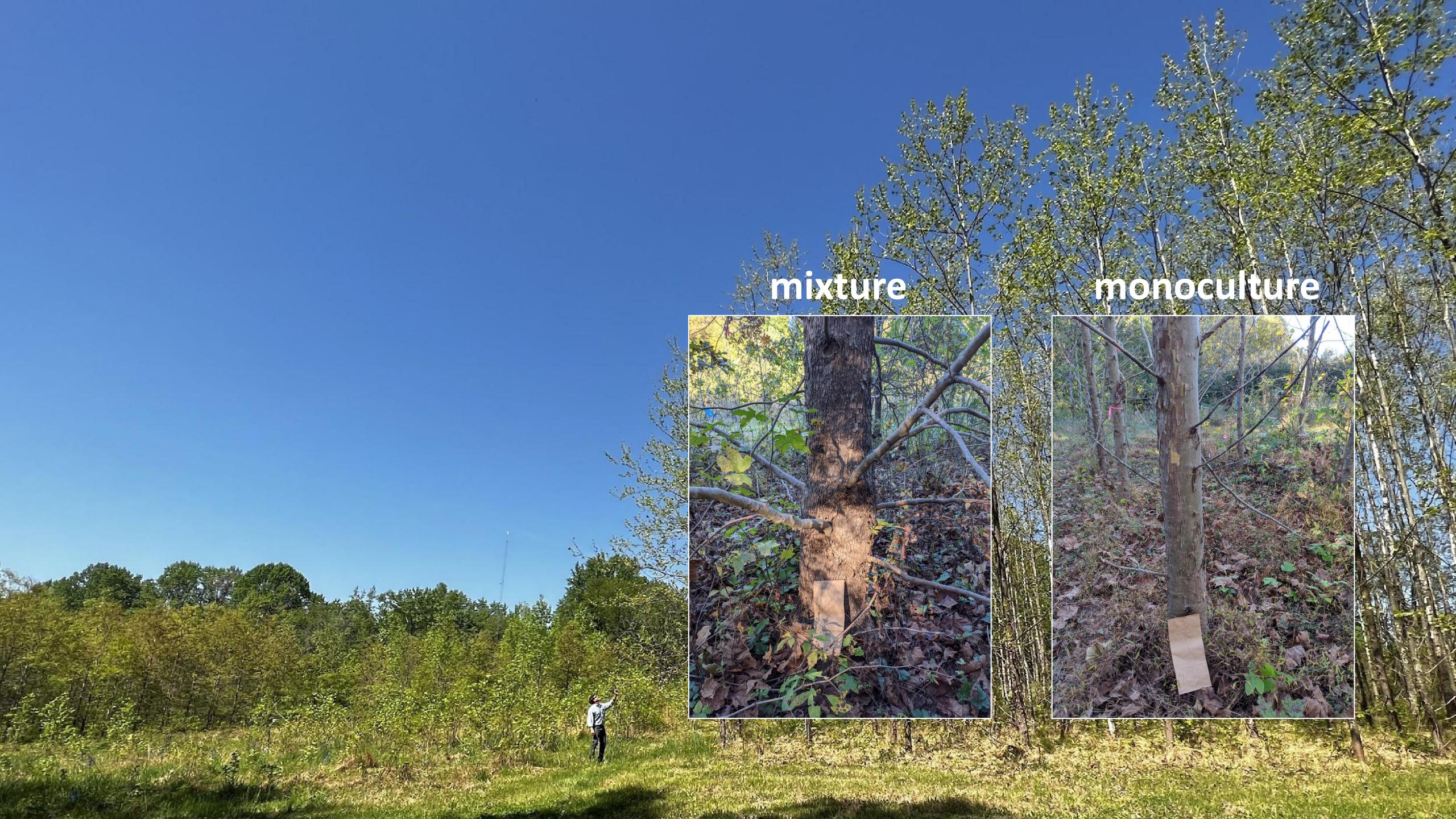


2015



2023





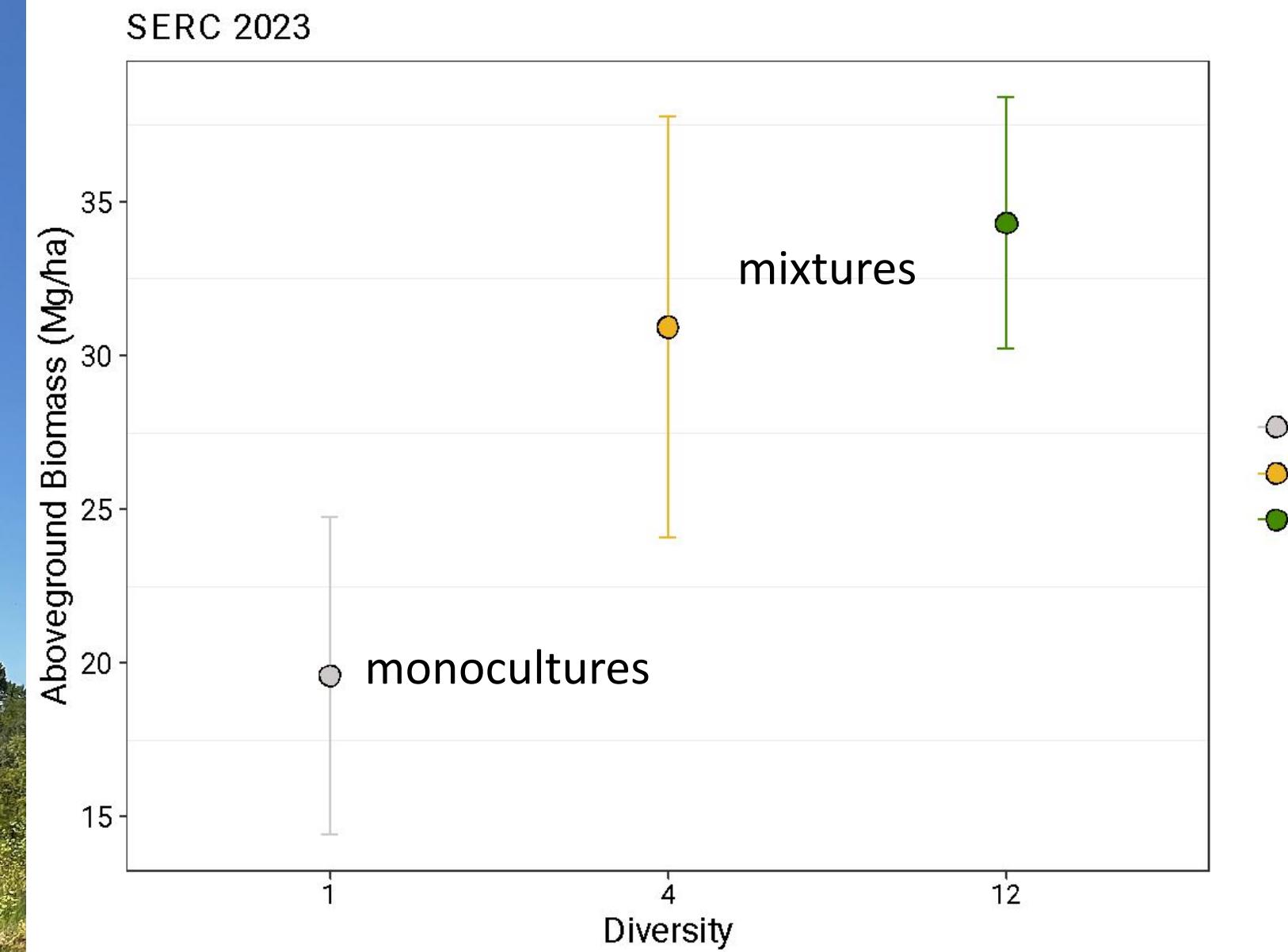
mixture



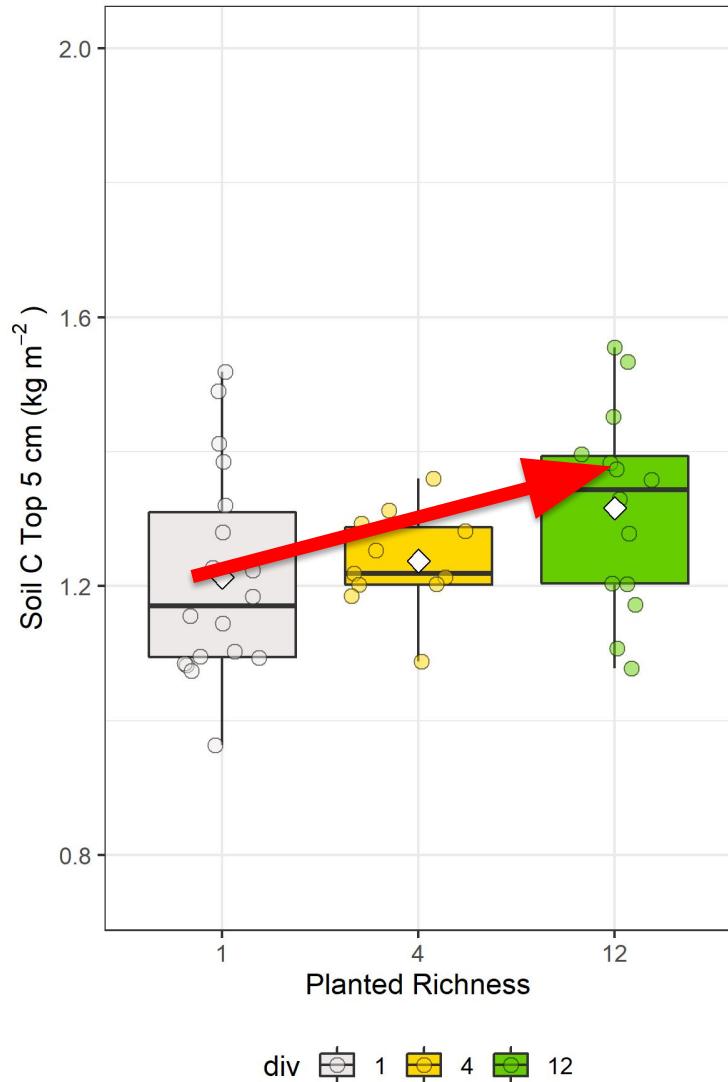
monoculture



Diversity ↑ FOREST BIOMASS by 78%



Diversity \uparrow soil C content by 15% in upper soil layers



Right core from diverse tree mixtures is enriched with carbon



INSECT DIVERSITY (+45%)



If you build it, they will come: did tree diversity help resist cicada outbreak?



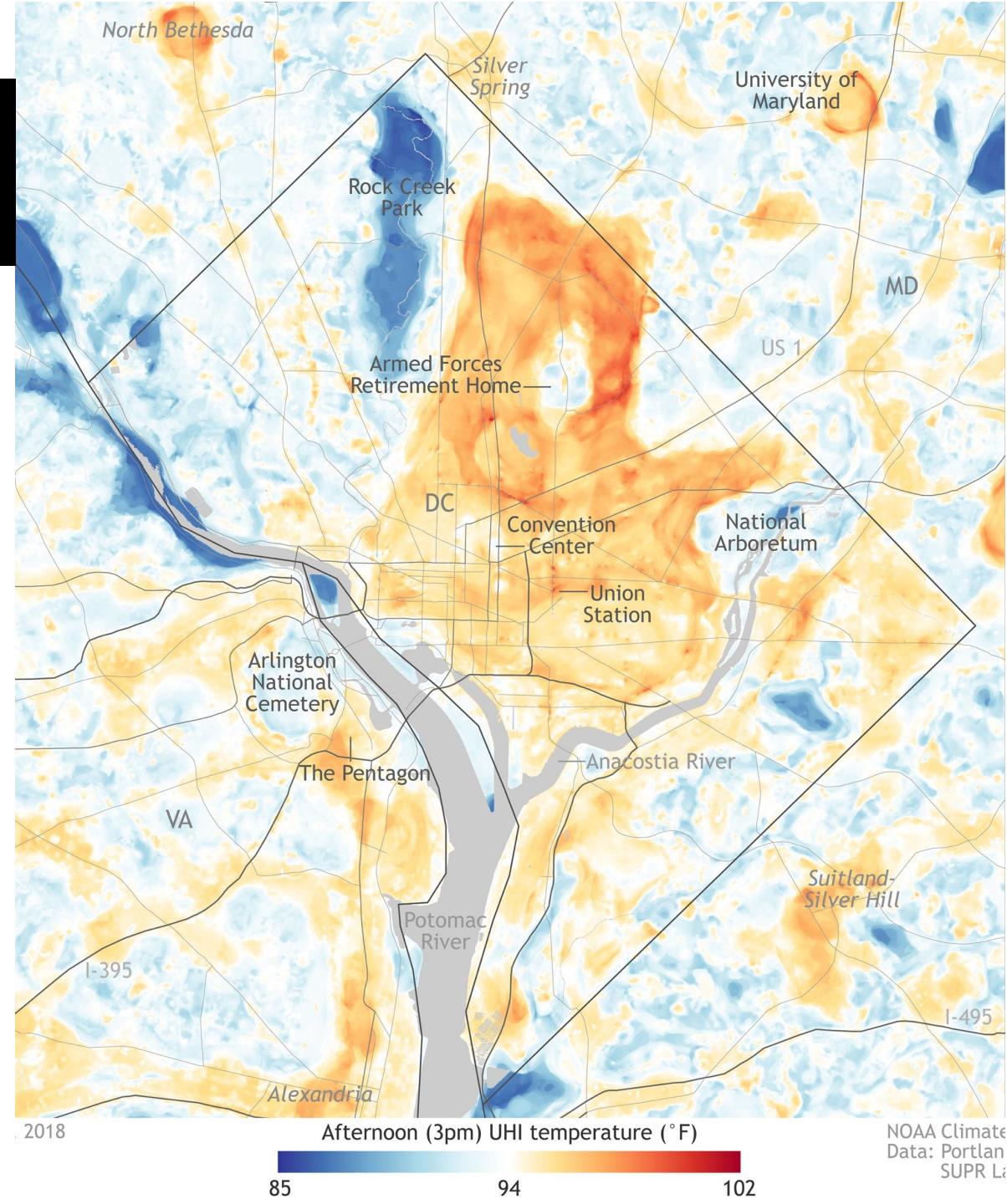
THEY'RE
www.cicadainvasion.com
COMING!



DIVERSE PLOTS: 85% LOWER CICADA DAMAGE



**Trees ↑ shade, ↓ heat
(better microclimates)**



DIVERSE MIXTURES = BETTER MICROCLIMATES

**Cooler in day
Warmer at night
Higher humidity
Wetter soil**



Dr. Justin
Nowakowski

Tree diversity enhances cooling through canopy packing



1 species plot

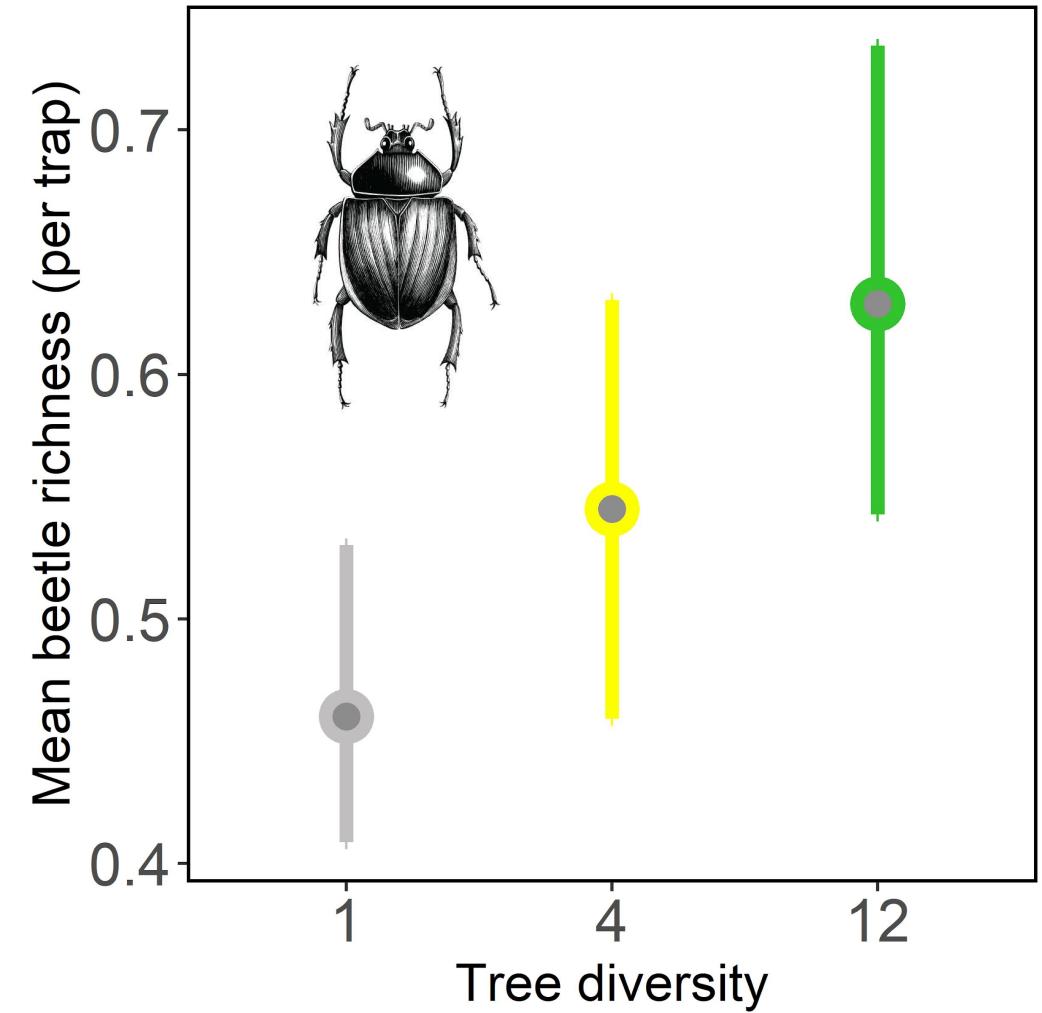


12 species plot

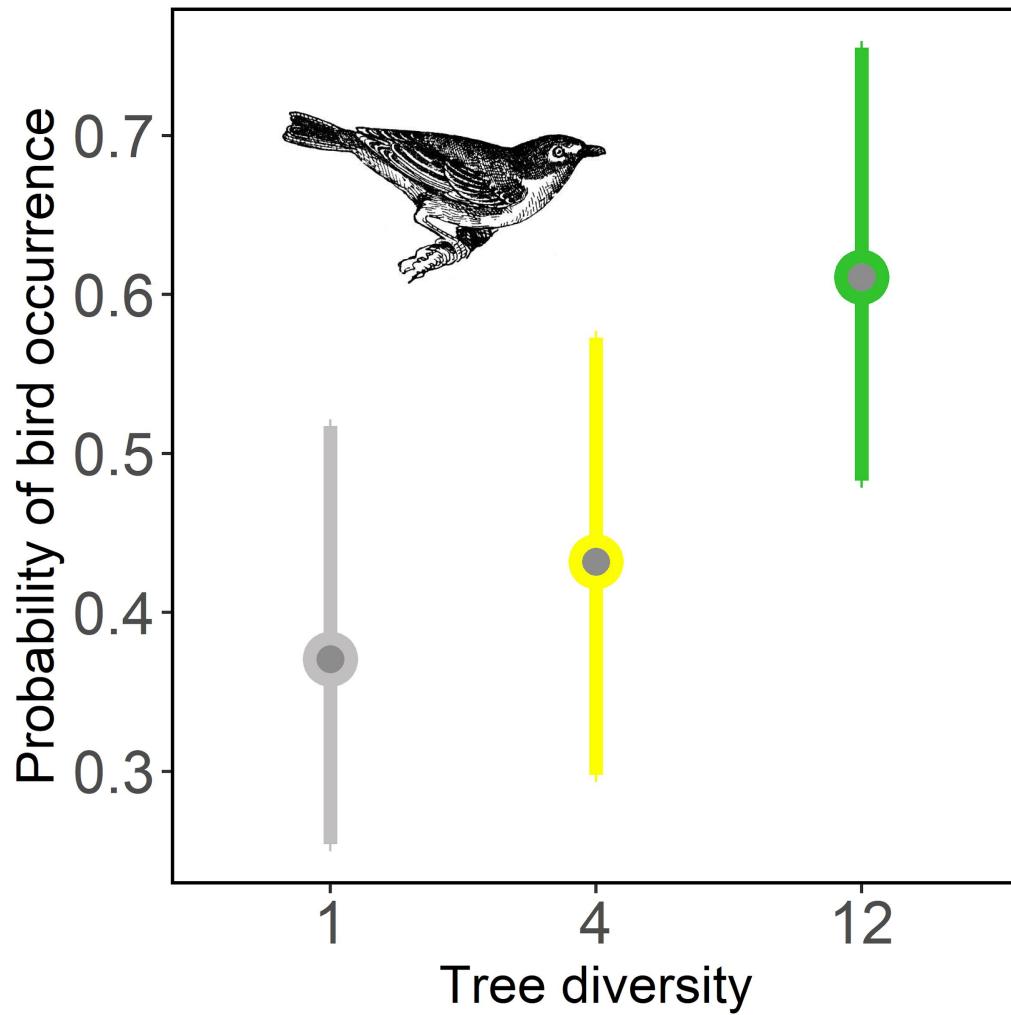
Tree diversity ↑ the beetles



Dr. Justin
Nowakowski



Tree diversity ↑ the birds



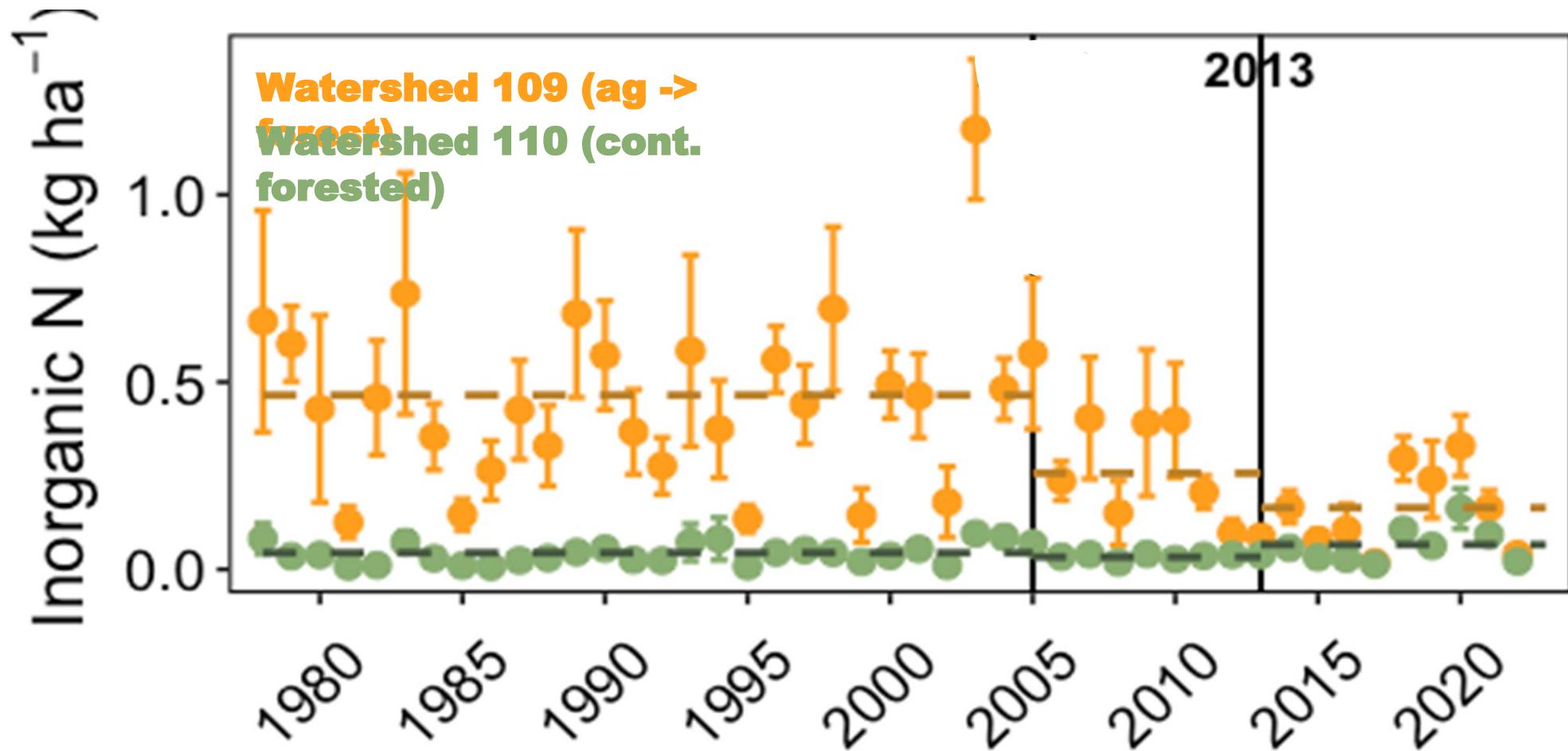
Watershed
109



REFORESTATION DRAMATICALLY ↑ N RETENTION



Rebecca Hale,
SERC



Is tree diversity important to restoration success?

Tree Survival

Tree Growth***

Deer Damage

Stand Complexity***

Soil Carbon*

Soil Microbes**

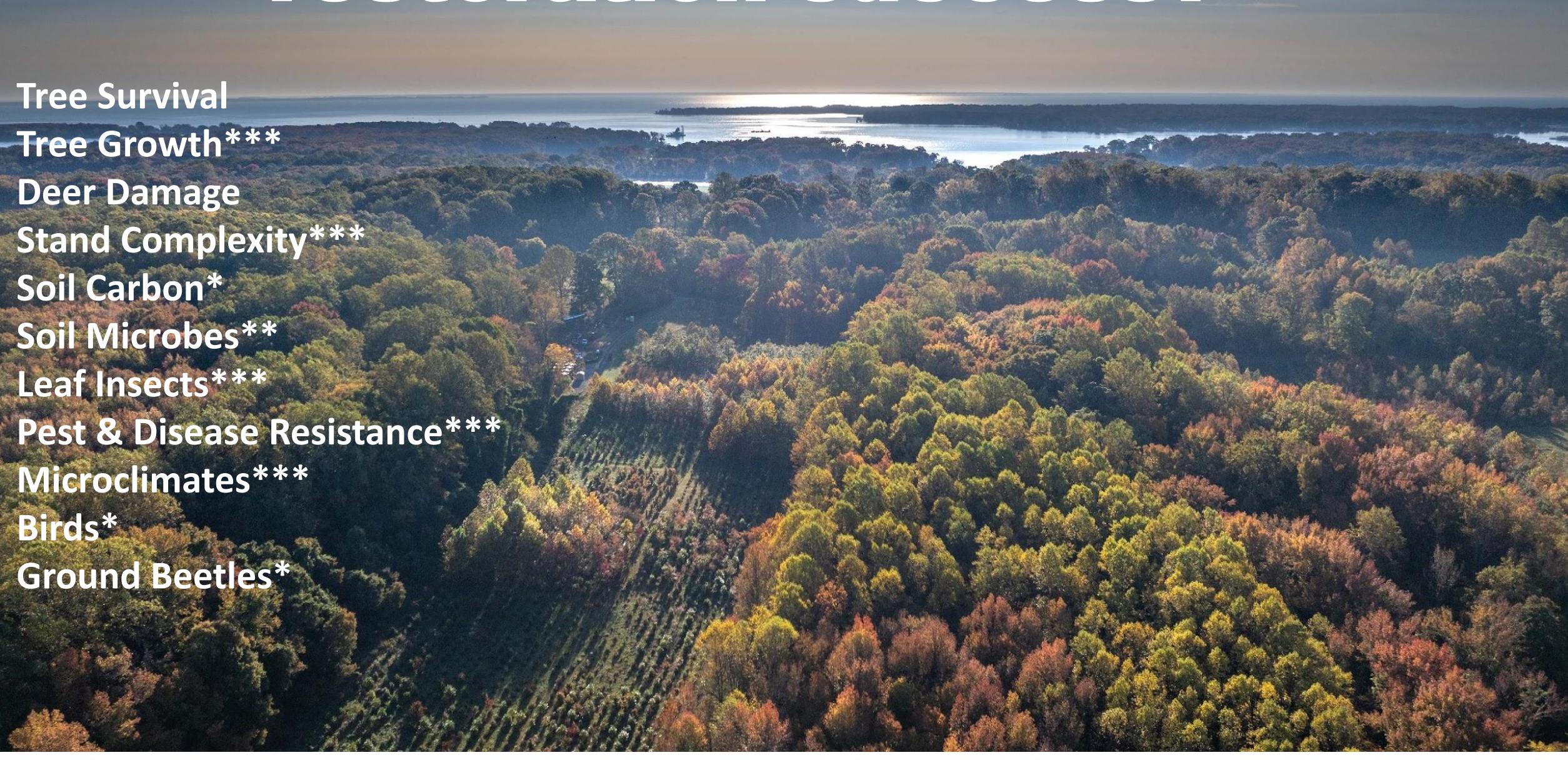
Leaf Insects***

Pest & Disease Resistance***

Microclimates***

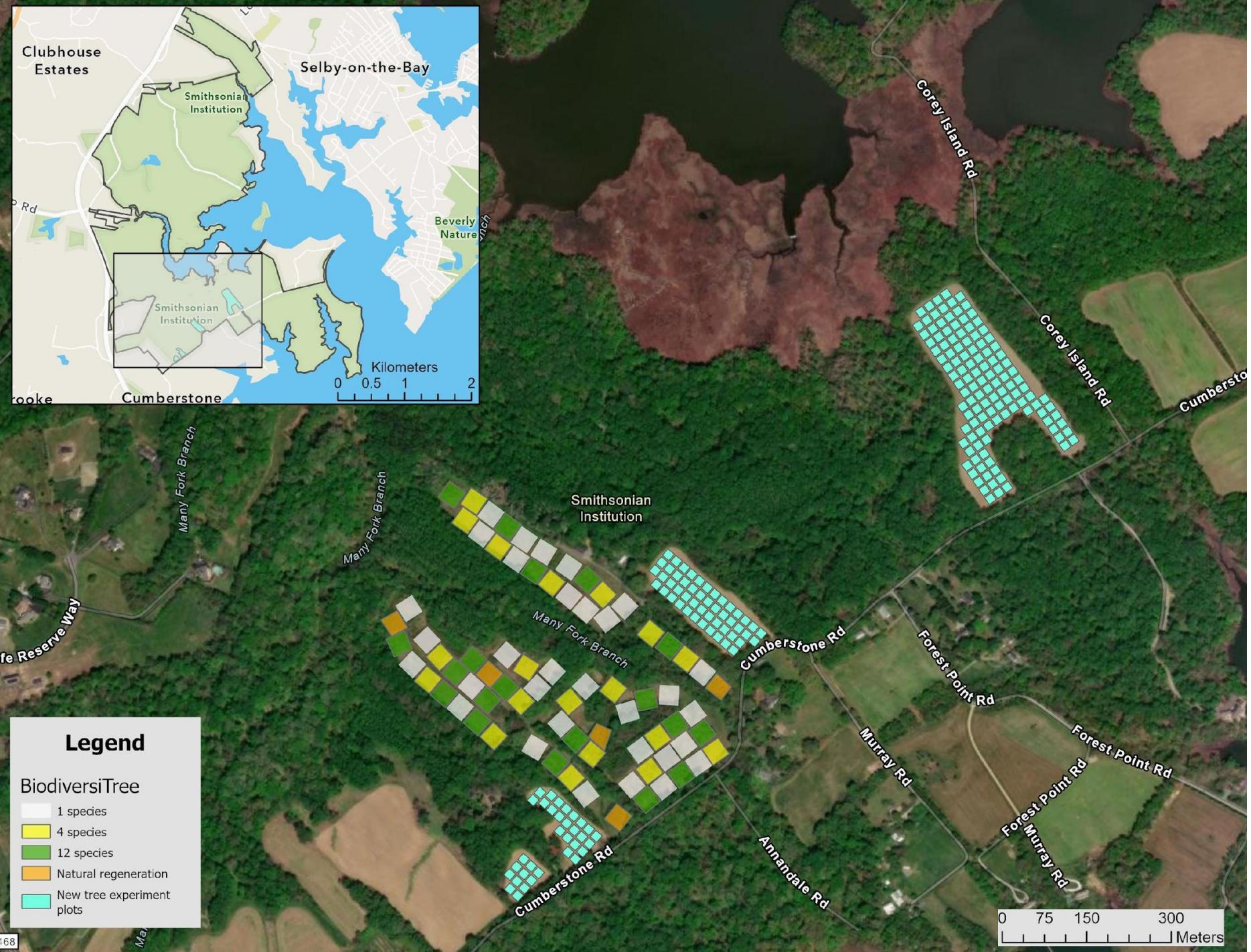
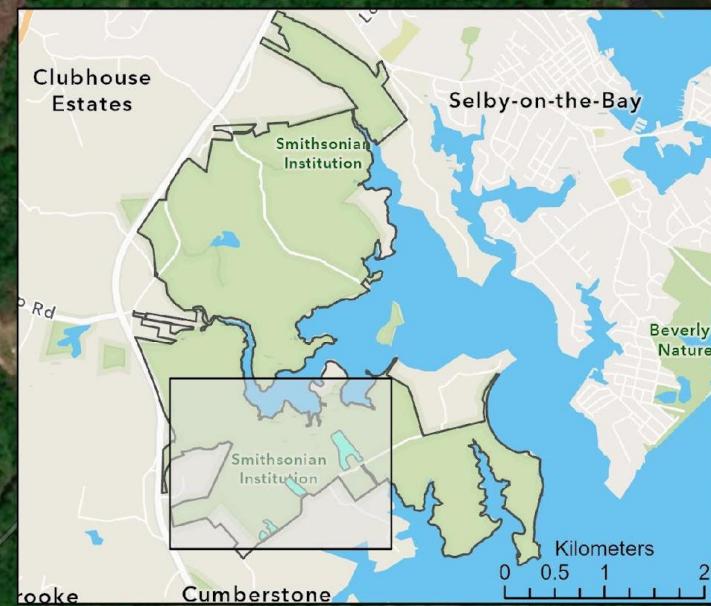
Birds*

Ground Beetles*



"FUNCTIONAL FORESTS"

New tree planting in the Chesapeake Bay critical zone (spring 2026)



Monocultures vs 5-spp mixtures (seed packet analogy)

Low density

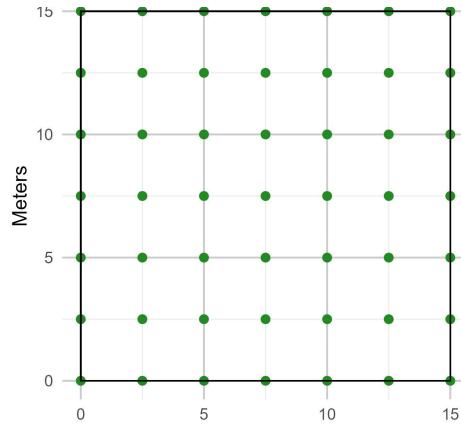
(2.5m spacing)
2177 trees/ha
~30yr old forest

High density

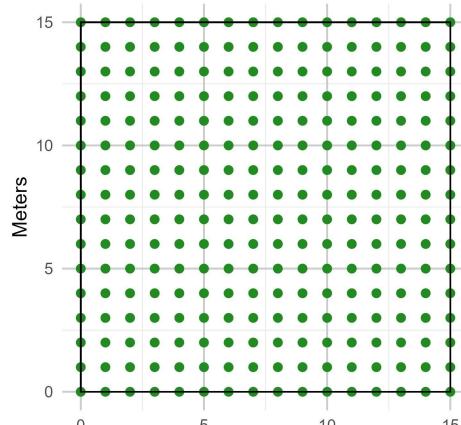
(1m spacing)
11,380 trees/ha
~1yr old forest

Low diversity

Monocultures
2/species x 20 species

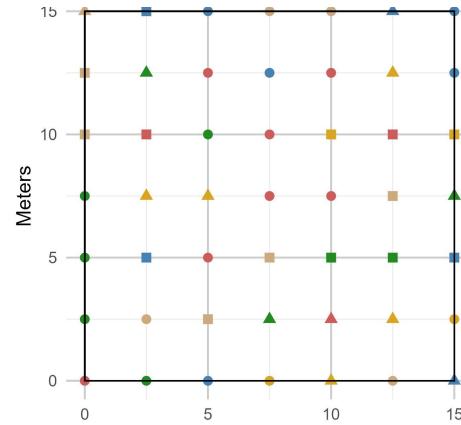


Single species monocultures
(n=2/species x 20 species)

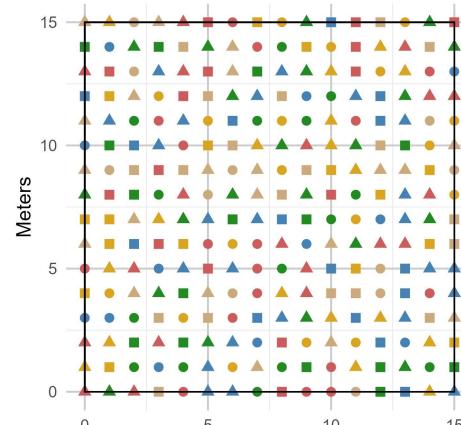


5-spp mixtures

Gradient low->high
multifunctionality



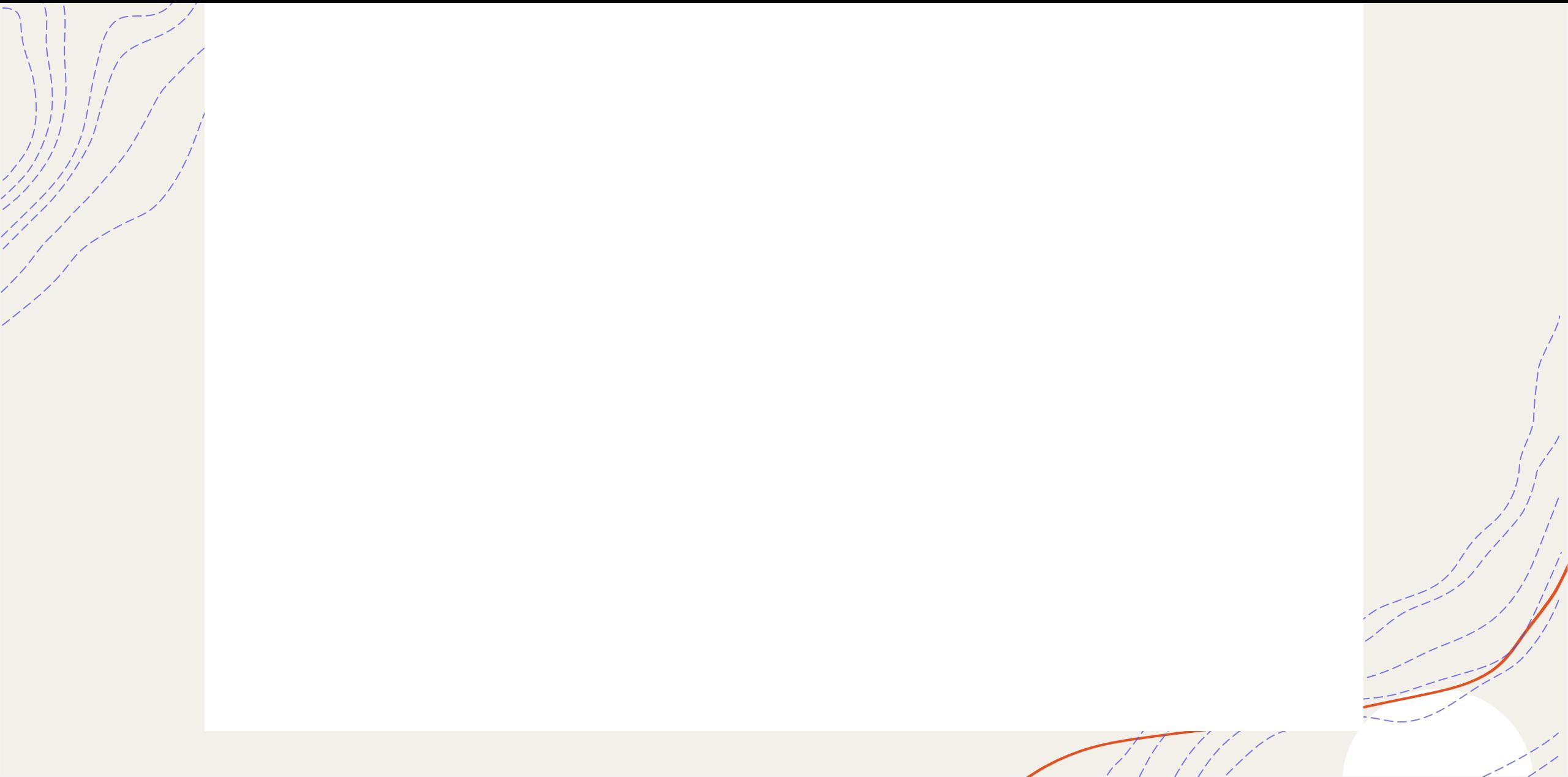
5-species mixtures (n=38)
Gradient: low → high multifunctionality



Function

- Timber production
- Wildlife value
- Food forest value
- Deer resistance
- Climate resilience

Low tree density ~30yr or older forest



Low tree density = lots of maintenance!



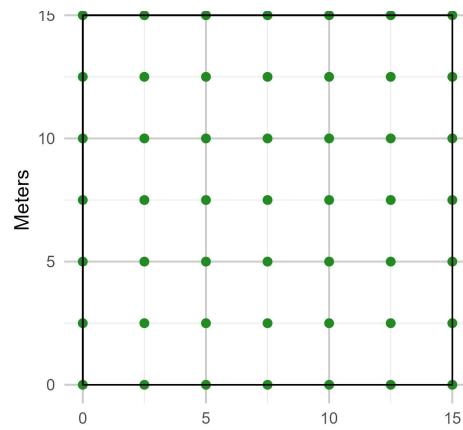
Monocultures vs 5-spp mixtures (seed packet analogy)

Low density
(2.5m spacing)
2177 trees/ha
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Low diversity

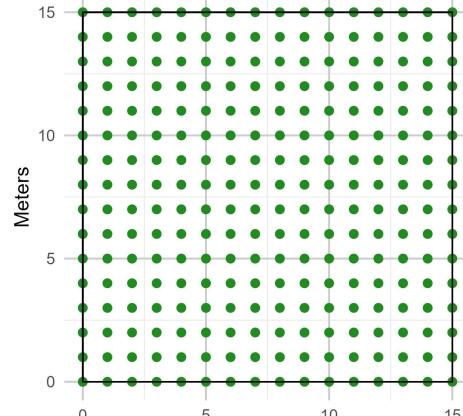
Monocultures

2/species x 20 species



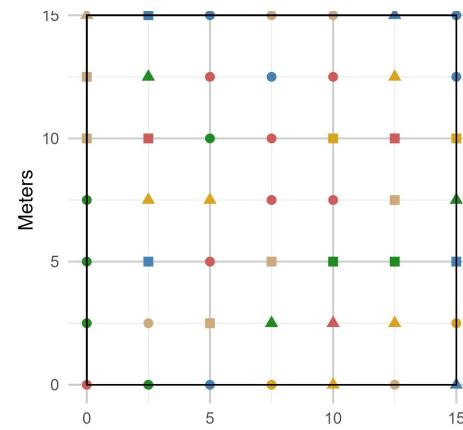
High density
(1m spacing)
11,380 trees/ha
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Single species monocultures (n=2/species x 20 species)



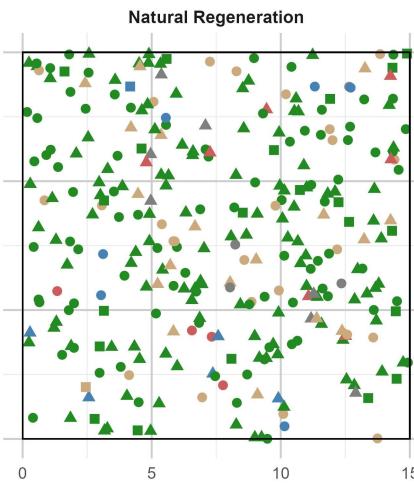
5-spp mixtures

Gradient low->high multifunctionality

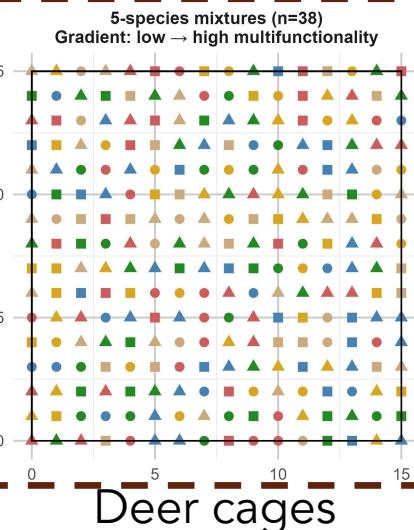
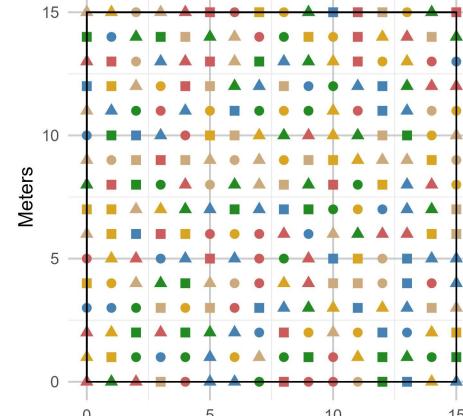


Function

- Timber production
- Wildlife value
- Food forest value
- Deer resistance
- Climate resilience



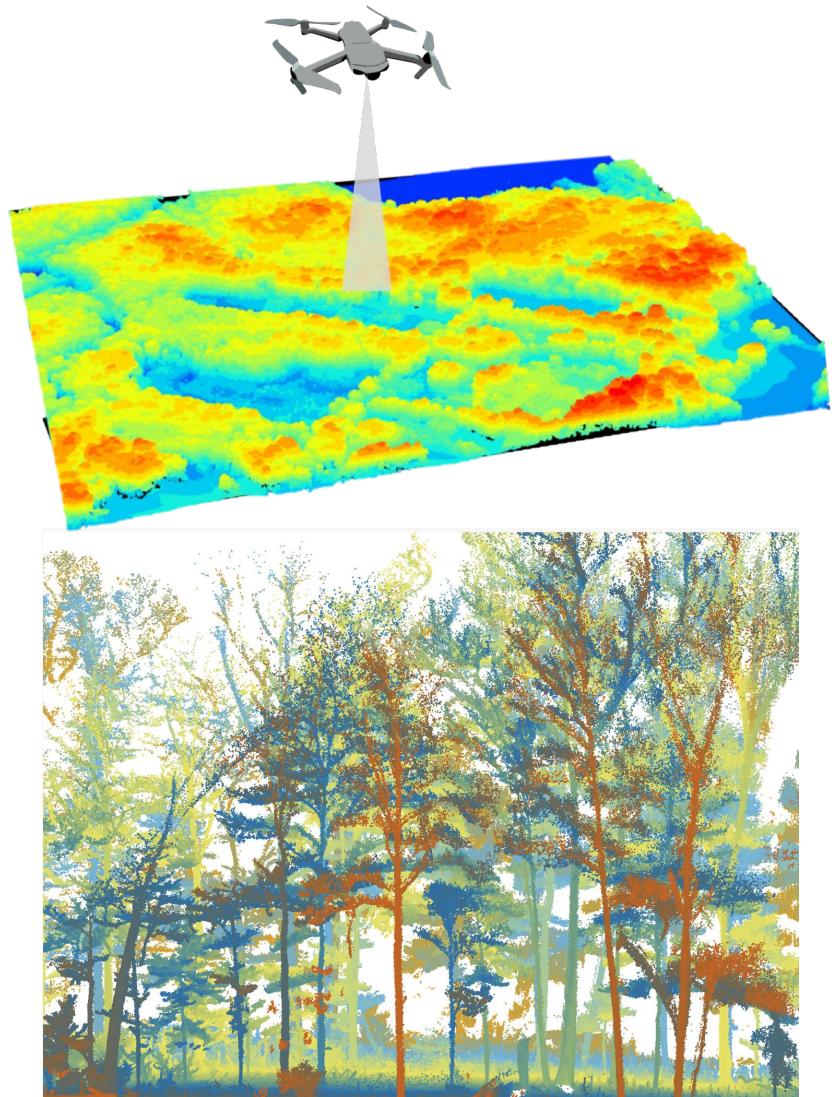
5-species mixtures (n=38) Gradient: low → high multifunctionality





Long-term monitoring of outcomes

- Tree survival, growth, recruitment
- Microclimate sensor arrays
- Passive and active monitoring of wildlife (insects, birds, etc)
- Remote sensing models for monitoring stress and biomass change



200 plots & 33,519 trees....

+ Spending 5 minutes in each plot =
16.6 hours

+ Minimum 2 workdays to do
ANYTHING in each plot.

+ 30 seconds at each tree = 279
hours! (35 workdays)

+ We need collaborators!

