Mycorrhizae in the nursery: what do they mean for transplanting success

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University of Wisconsin-Madison

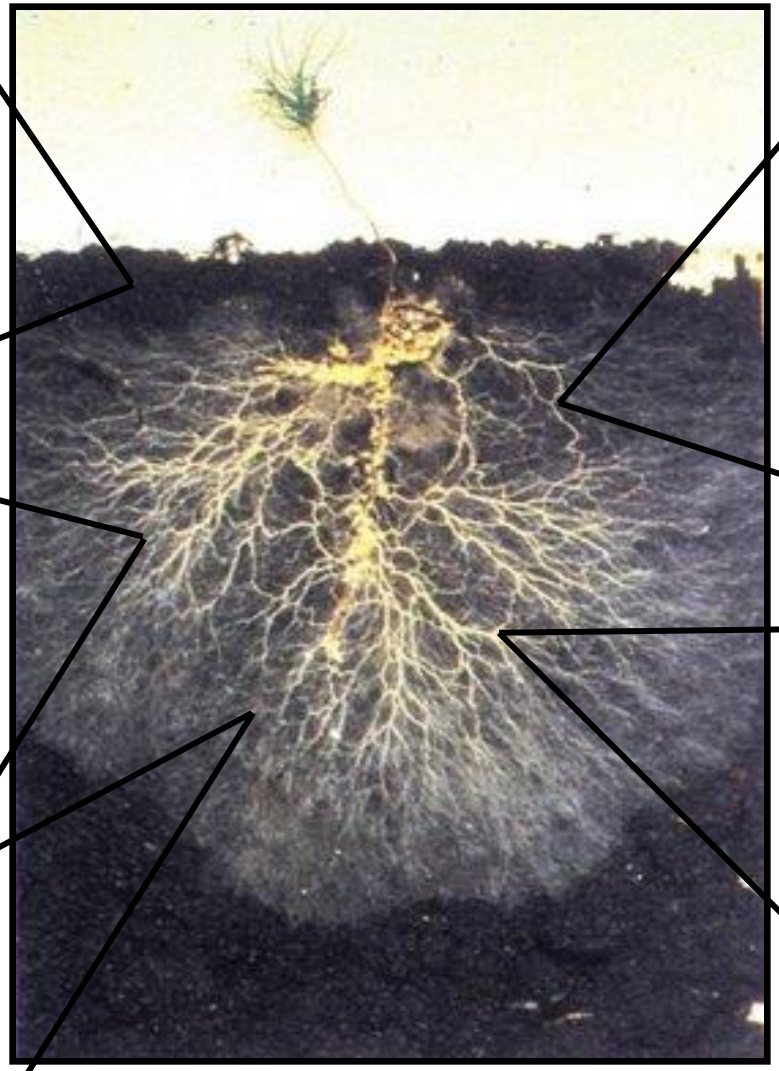
No Plant is an Island

Saprotrophs

George Knaphus

Ectomycorrhizal Fungi

Endophytes



Arbuscular Mycorrhizal Fungi

Pathogens

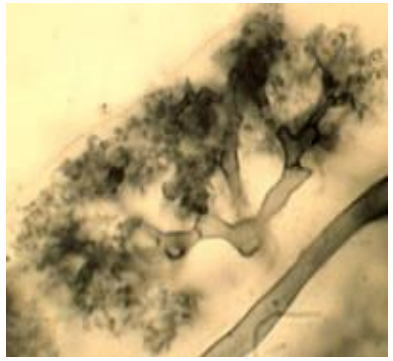
http://ohioline.osu.edu/

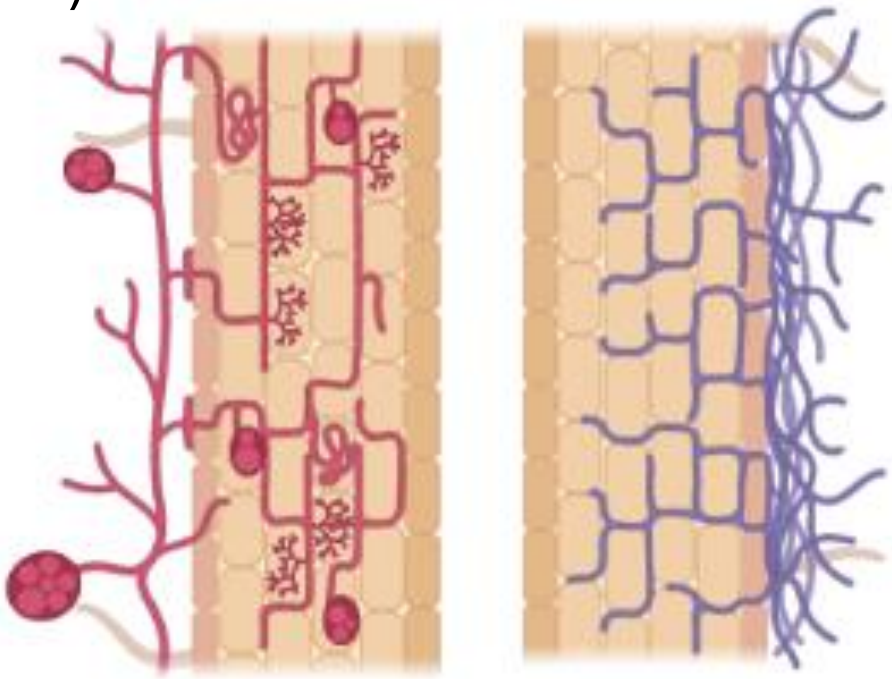
Mycorrhizal Fungi

Tree species tend to form one of two types of mycorrhizal symbiosis

Arbuscular Mycorrhizae (AM)

- Fungi *scavenge* for mineral nutrients
- Forage close to root systems
- Highly generalized





Ectomycorrhizae (EM)

- Fungi *scavenge* for mineral nutrients or *mine* organic matter
- Can foraging near or far from root and can connect host trees through networks
- Range from generalized to specialized

Arbuscular Mycorrhizal Fungi

Vast majority of plants

- Almost all herbaceous plants (including crops)
- Many important temperate forest trees

Ashes

Walnut

Maples

Elms

Cherries

Cedars

Ectomycorrhizal Fungi

Select groups of woody plants

Many of important temperate forest trees

Oaks

Hickories

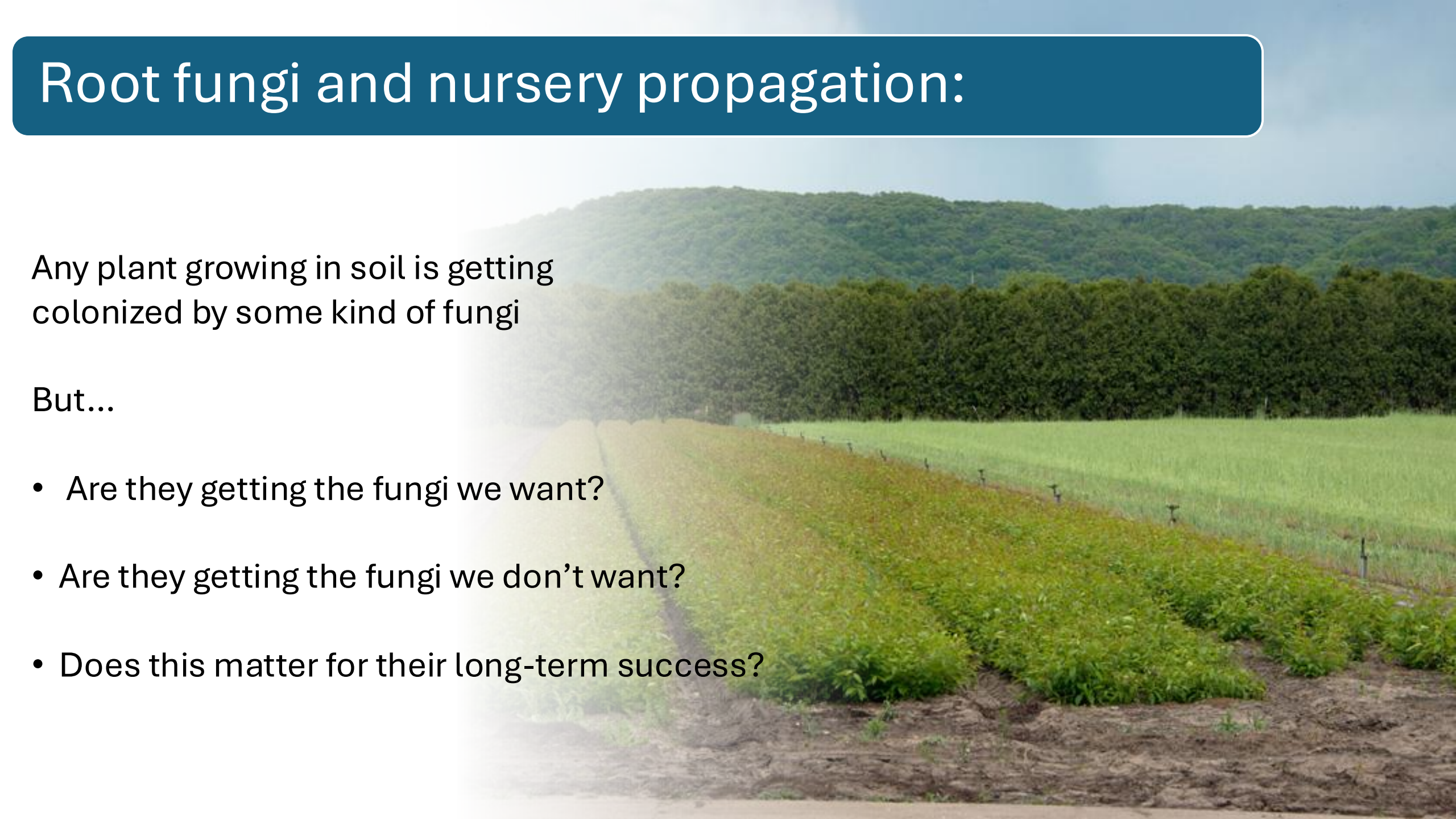
Cottonwood/aspen

Spruce/fir

Basswood

Pines

Root fungi and nursery propagation:



Any plant growing in soil is getting colonized by some kind of fungi

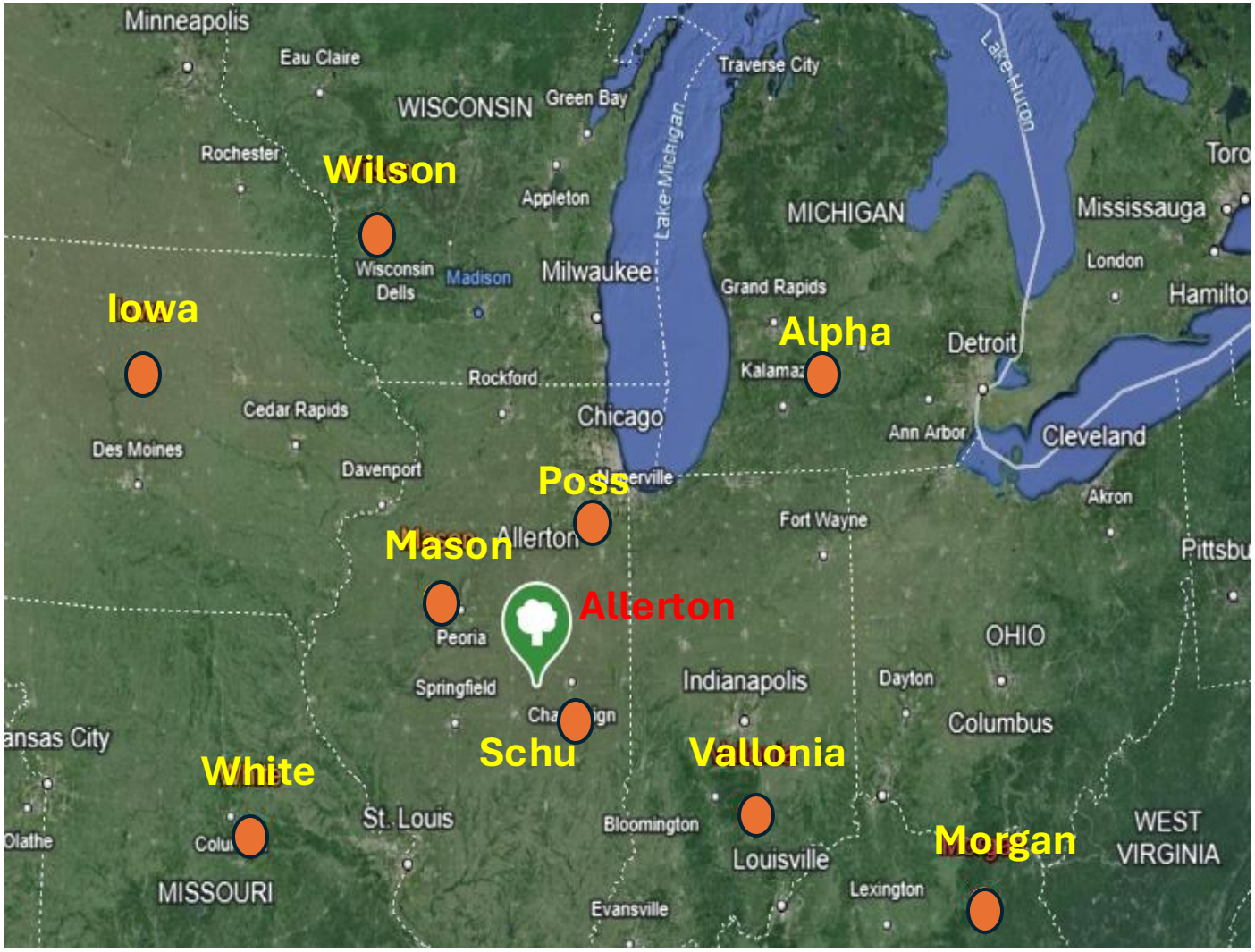
But…

- Are they getting the fungi we want?
- Are they getting the fungi we don’t want?
- Does this matter for their long-term success?

Research Questions:

- Do tree seedlings develop different fungal associations between nurseries?
- Do fungal differences persist after transplanting?
- Do fungal differences affect the success of tree establishment?
- Can nursery management shape fungal associations in desirable ways?

Do tree seedlings develop different fungal associations between nurseries?



Obtained seedlings from 9 nurseries around the Midwest

Matched species as much as possible:

Tree	Genus	Mycorrhizal Type	# of Nurseries
Maple	Acer	AM	5
Walnut	Juglans	AM	3
Sycamore	Platanus	AM	4
Cherry	Prunus	AM	5
Locust	Robinia	AM	1
Cedar	Taxodium	AM	2
Elm	Ulmus	AM	1
Birch	Betula	EM	1
Hickory	Carya	EM	6
Pine	Pinus	EM	8
Oak	Quercus	EM	9

Do tree seedlings develop different fungal associations between nurseries?

Methods

Collect root samples from seedlings lifted from nursery beds

↓

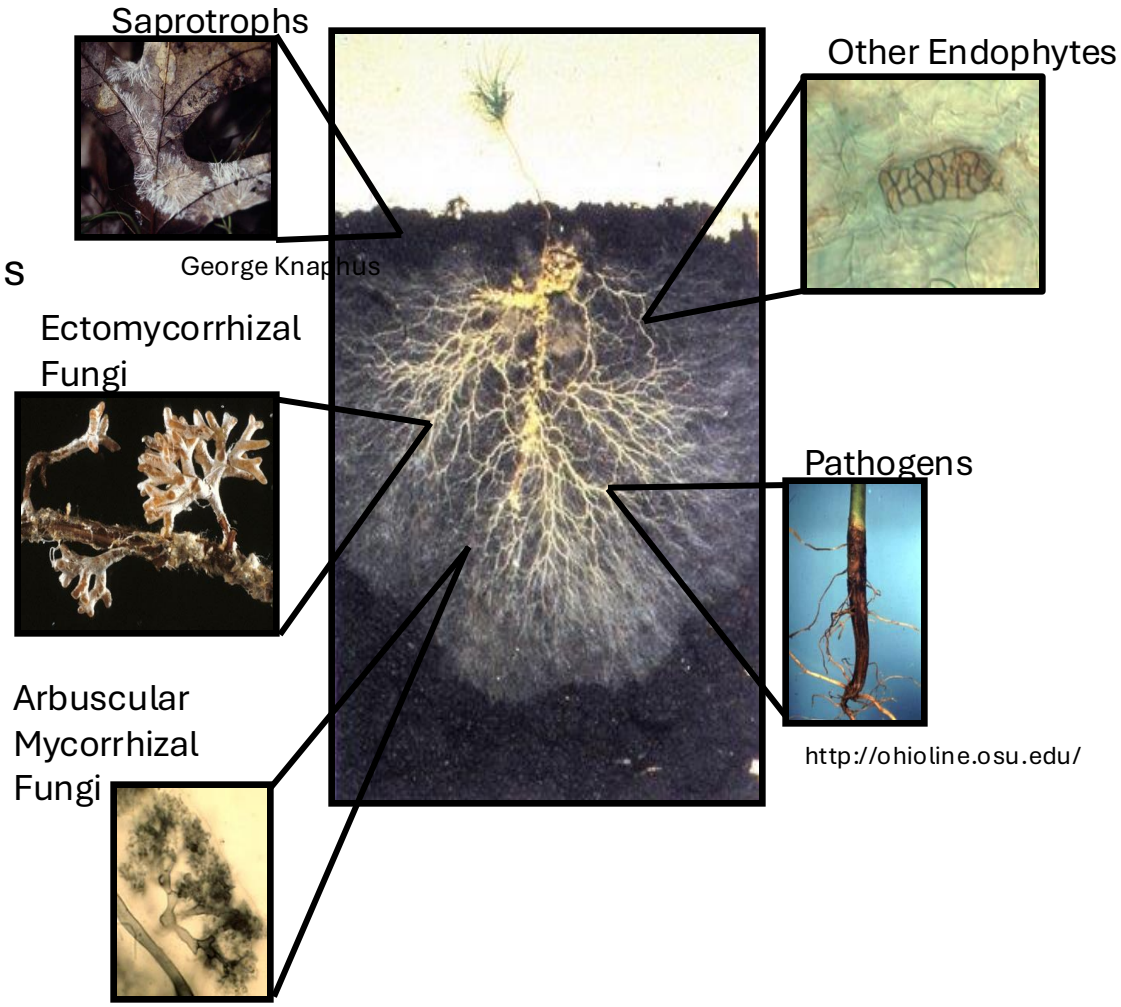
DNA extracted from non-sterile root fragments

↓

Amplify the fungal ITS2 gene sequence with PCR

↓

Fungal taxa identified via high-throughput sequencing



Fungal taxa assigned to guilds via FungalTraits Database

Arbuscular Mycorrhial Fungi

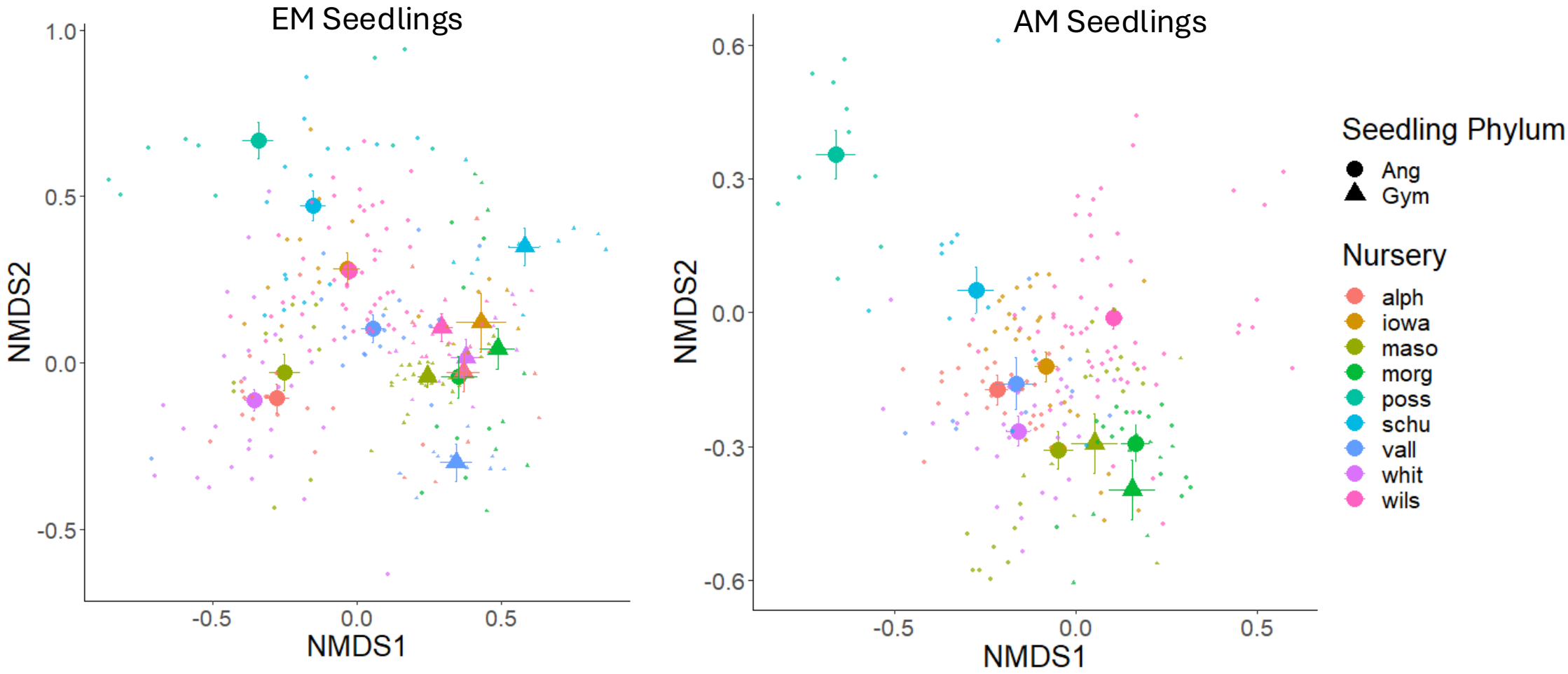
Ectomycorrhizal Fungi

Saprotrophs

Potential Pathogens and Endophtyes

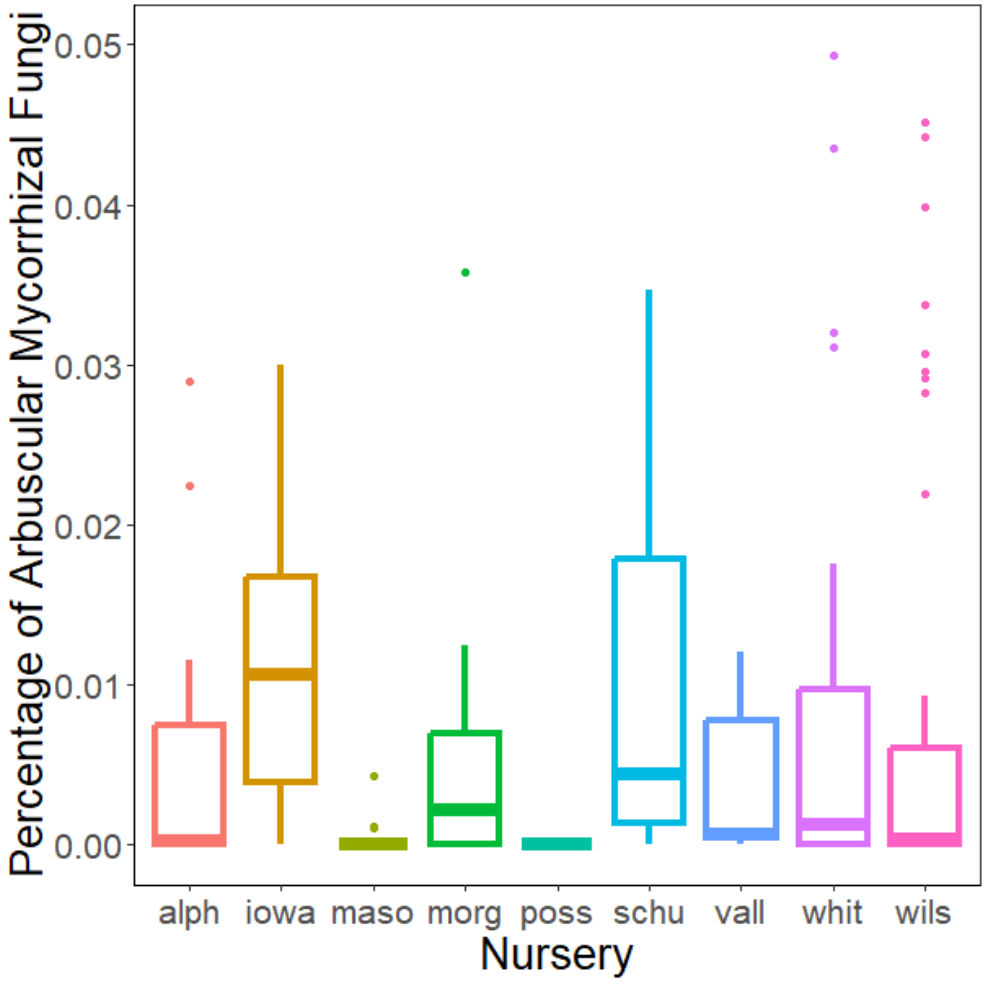
- Do not attempt to separate pathogenic from non-pathogenic endophytic genera
- Potentially includes mutualistic, commensal, or parasitic interactions even within same fungal species

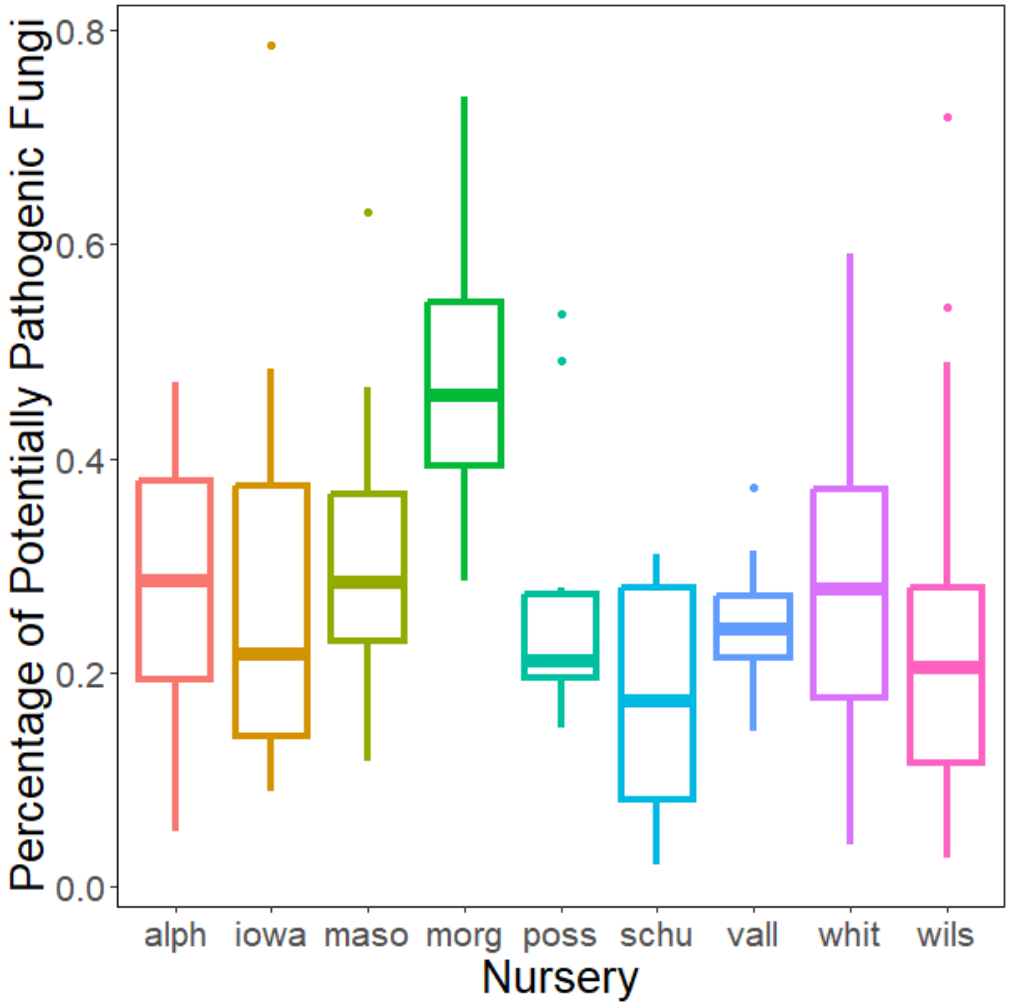
Do tree seedlings develop different fungal associations between nurseries?



Nurseries form distinct clusters, indicating divergent fungal communities on seedling roots

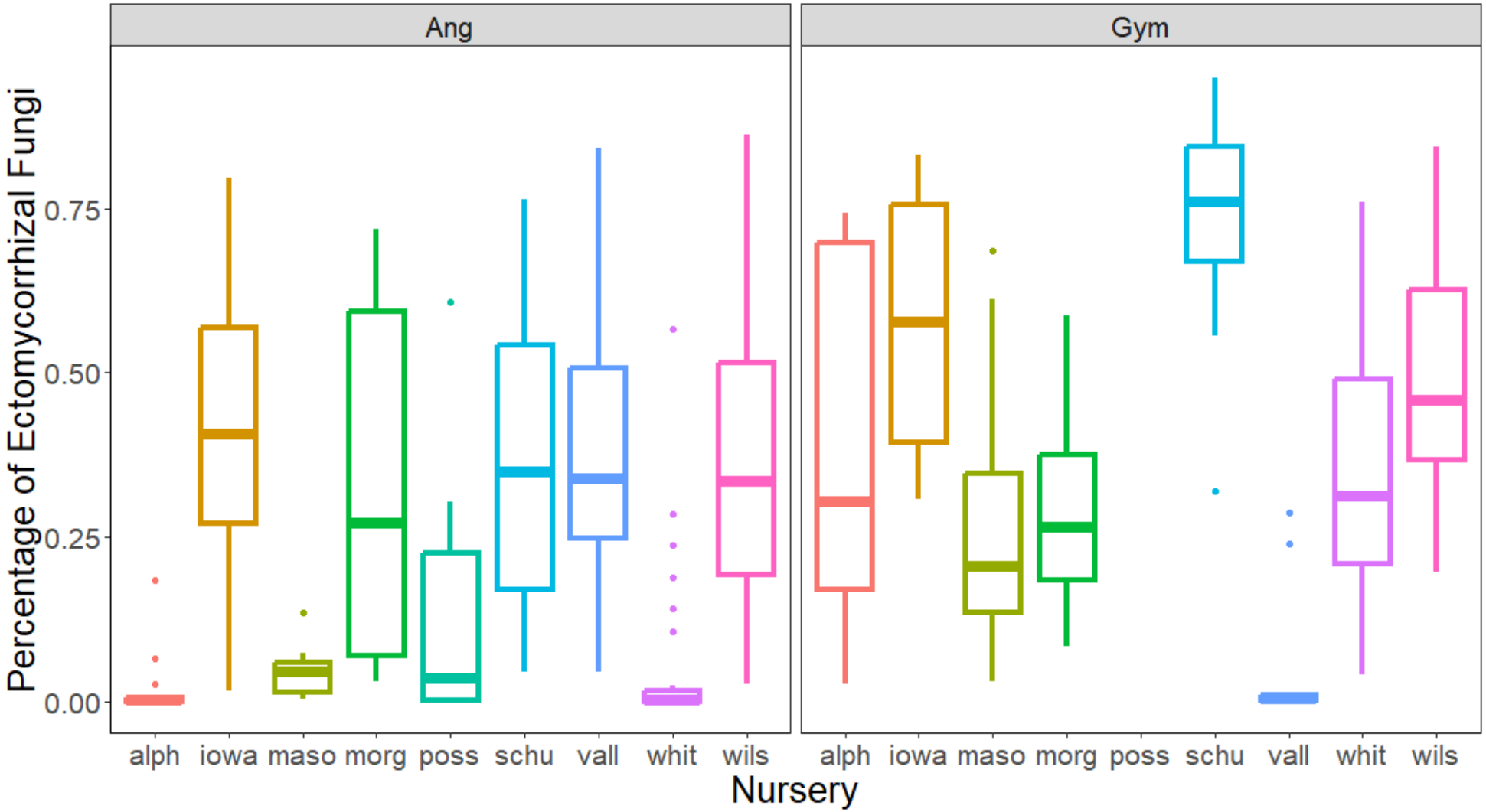
Do tree seedlings develop different fungal associations between nurseries?





Nurseries differ in the colonization of arbuscular mycorrhizal and potentially pathogenic fungi on AM seedling roots

Do tree seedlings develop different fungal associations between nurseries?

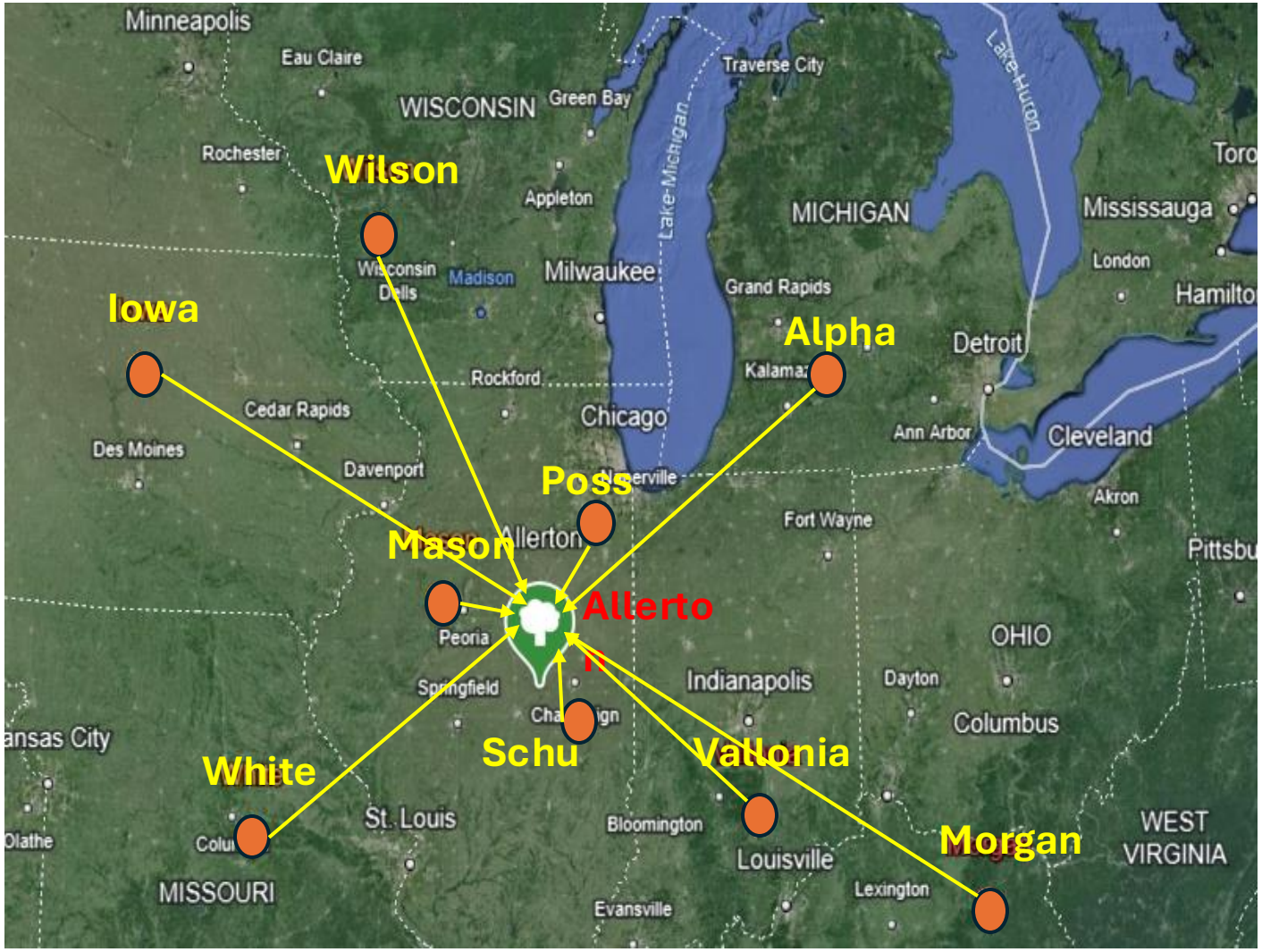


Nurseries differ in the colonization of ectomycorrhizal fungi on both hardwood and softwood seedlings

Do tree seedlings develop different fungal associations between nurseries?

Nurseries differ in the colonization of potentially pathogenic fungi on both hardwood and softwood seedlings

Do fungal differences persist after transplanting?



Obtained seedlings from 9 nurseries around the Midwest

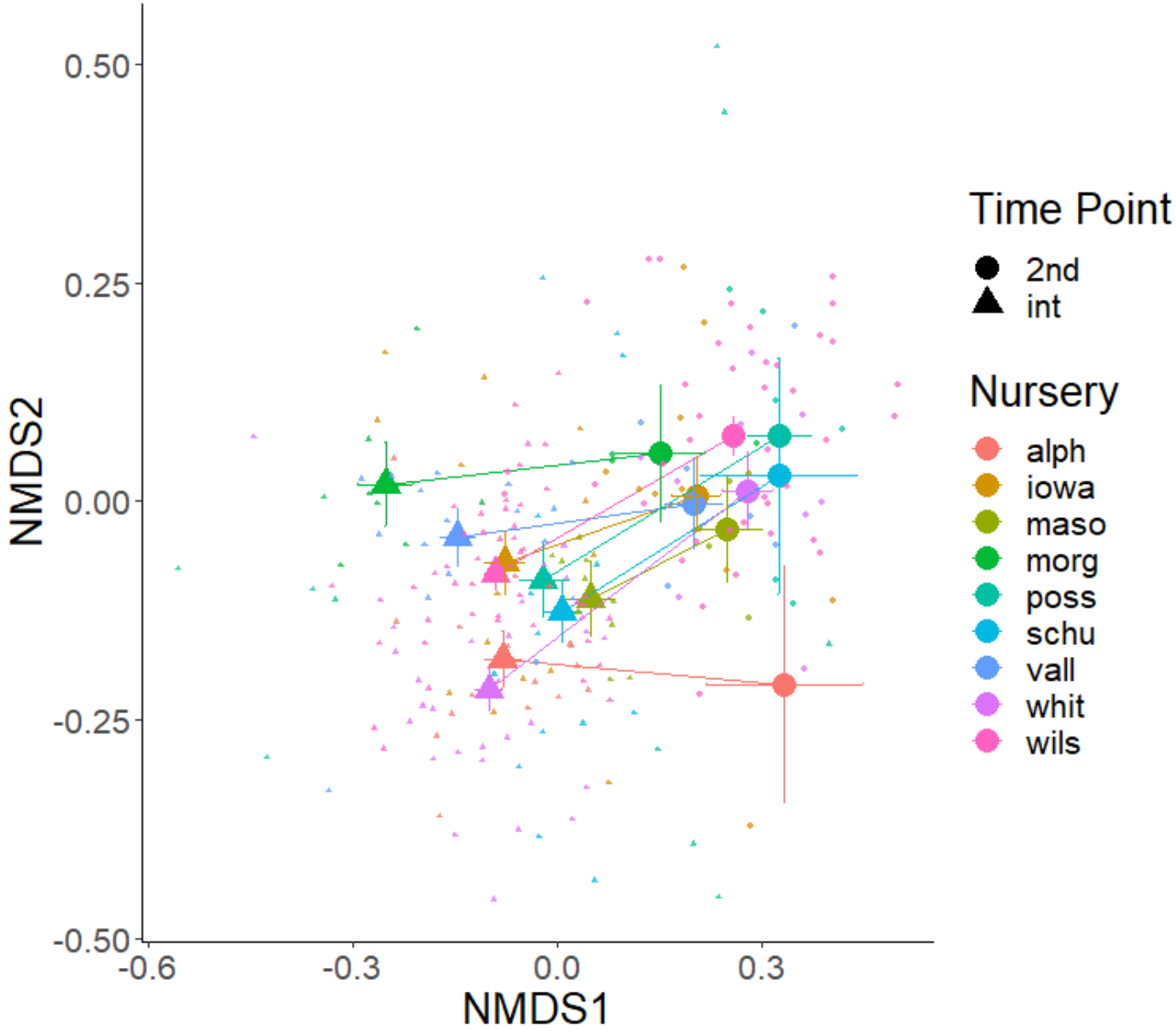
Matched species as much as possible:

Transplanted seedlings from each nursery into field plots at the Allerton Park and Recreation Center

Harvested some seedlings after one full growing season to recharacterize fungal communities

Harvested additional seedlings after two full growing season to recharacterize fungal communities

Do fungal differences persist after transplanting?

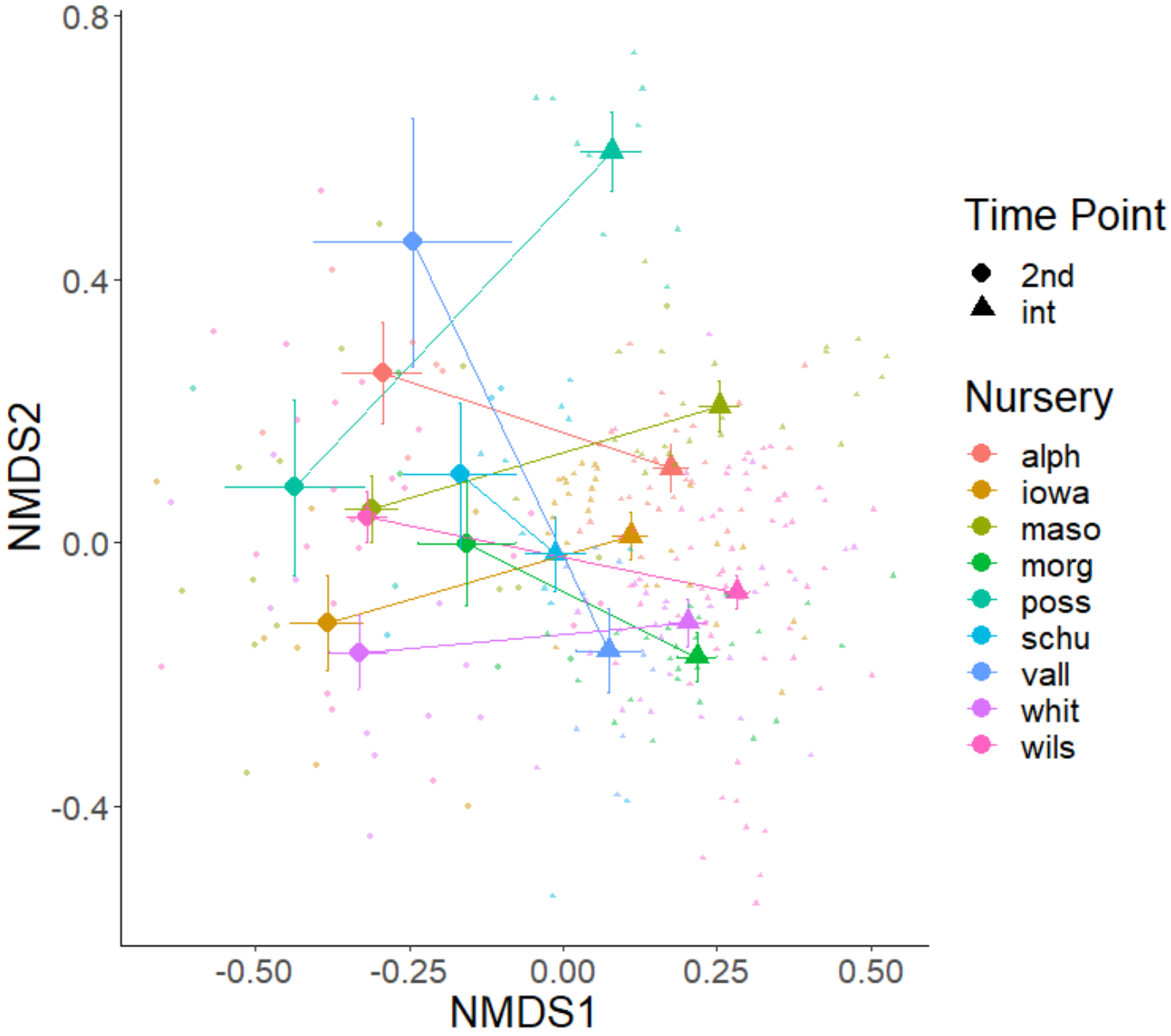


Ectomycorrhizal
Hardwoods (Angiosperms)

After 2 seasons
Initial (pre-planting)

Two years after planting, all fungal communities shift, but they still retain distinctions due to their nursery of origin

Do fungal differences persist after transplanting?



Arbuscular mycorrhizal
Hardwoods (Angiosperms)

After 2 seasons
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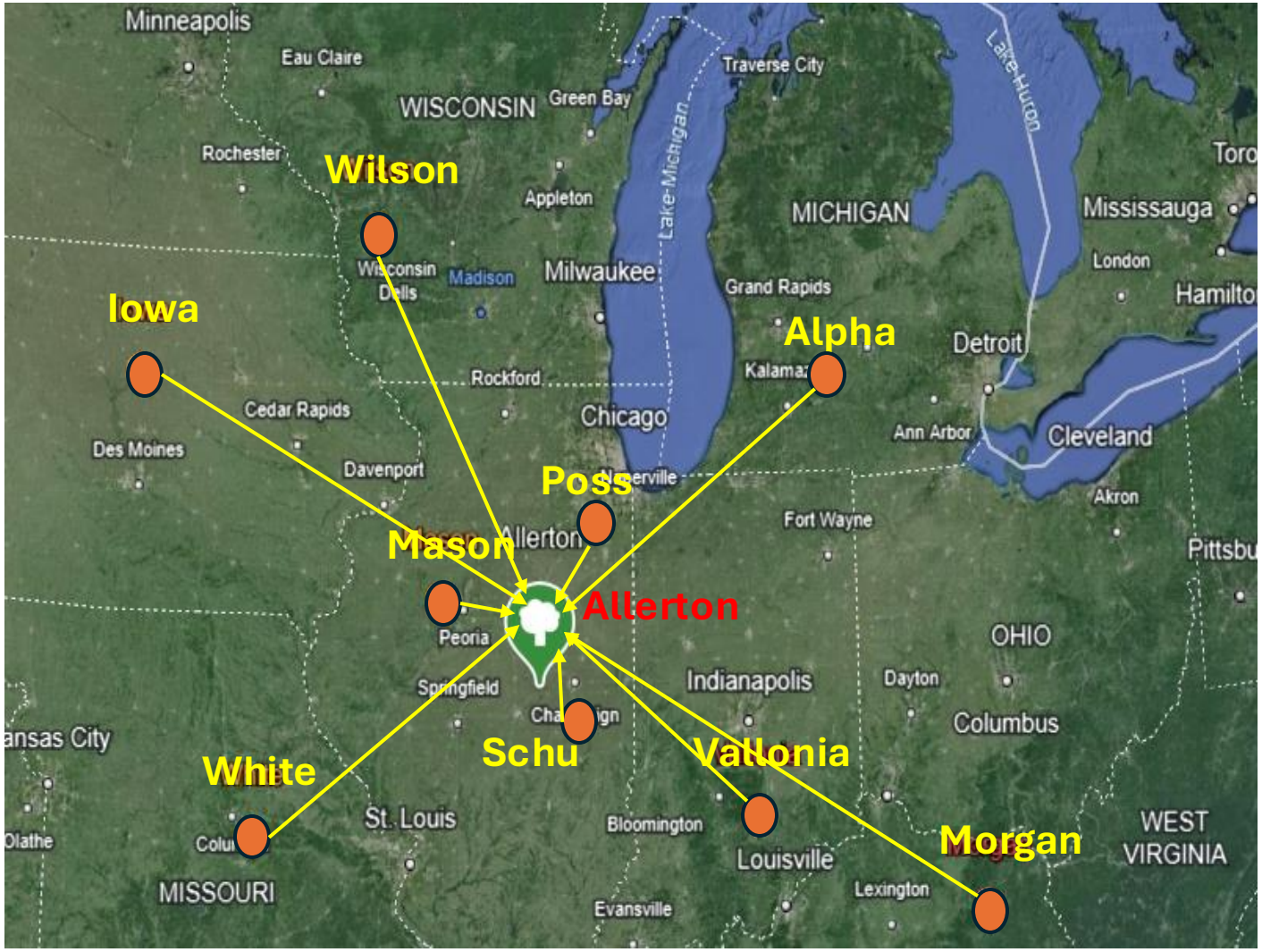
Two years after planting, all fungal communities shift, but they still retain distinctions due to their nursery of origin

Do fungal differences affect the success of tree establishment?



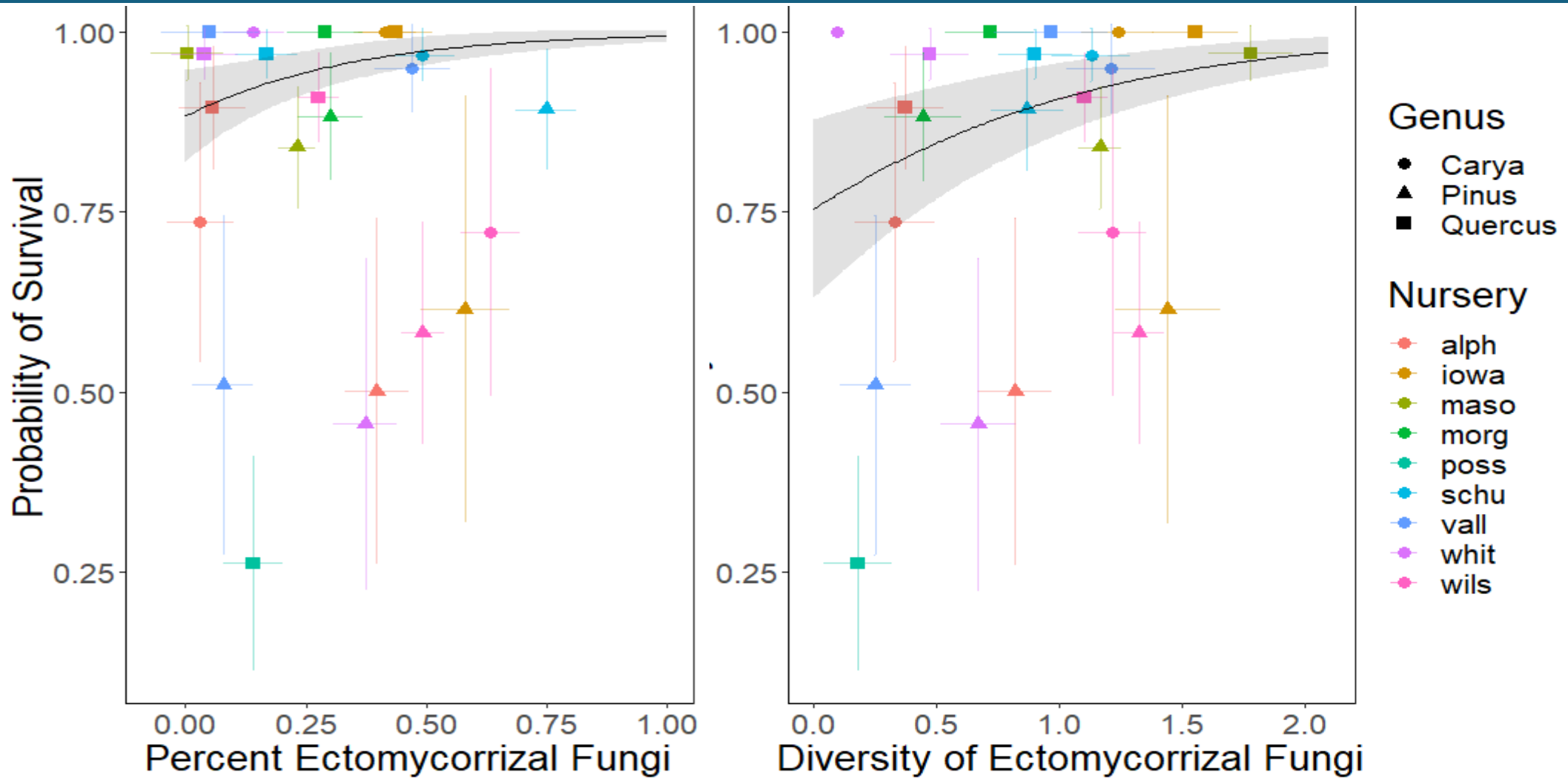
Obtained seedlings from 9 nurseries around the Midwest

Matched species as much as possible:

Transplanted seedlings from each nursery into field plots at the Allerton Park and Recreation Center

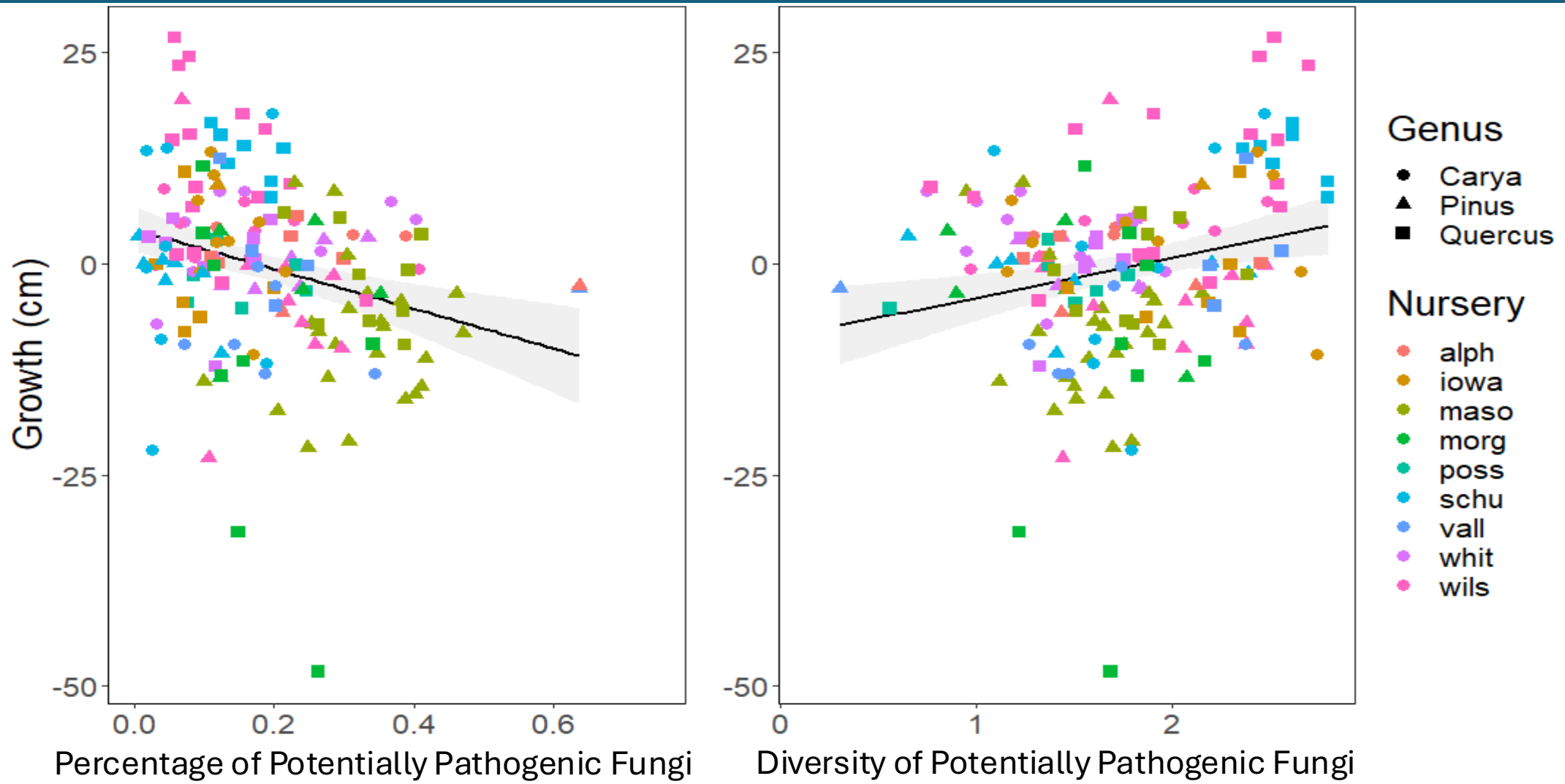
Followed growth (change in height) and survival over two growing seasons

Do fungal differences affect the success of tree establishment?



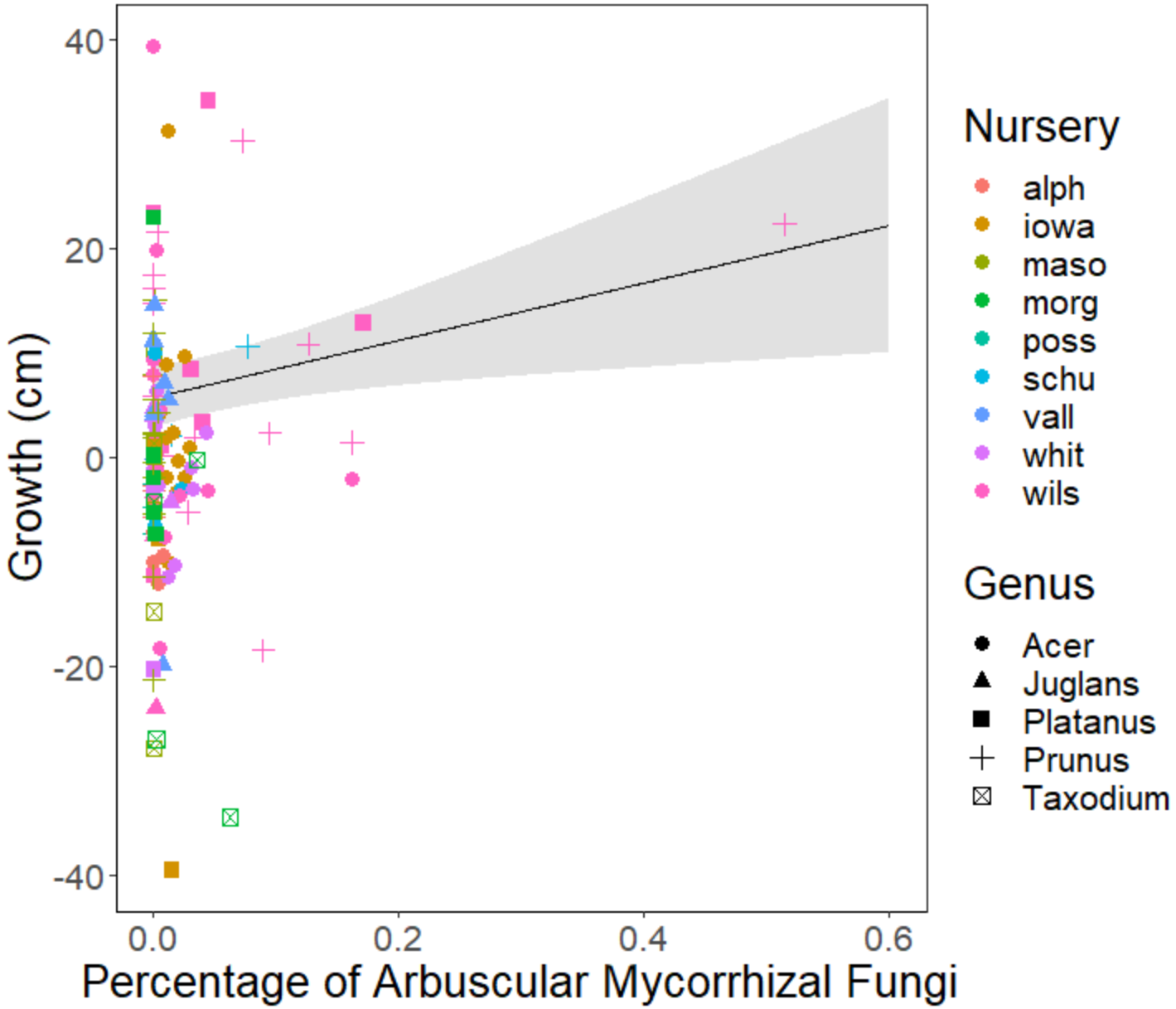
Survival is higher for seedlings with more (and more diverse) ectomycorrhizal colonization from the nursery

Do fungal differences affect the success of tree establishment?



Growth is higher for seedlings with lower colonization (but higher diversity) of putative pathogens from the nursery

Do fungal differences affect the success of tree establishment?



Growth, but not survival, increased for seedlings with a higher colonization of arbuscular mycorrhizal fungi from the nursery

Research Questions:

- Do tree seedlings develop different fungal associations between nurseries?
- Do fungal differences persist after transplanting?
- Do fungal differences affect the success of tree establishment?

Major caveat: Each nursery used different seed sources, so results may reflect genetic differences among tree populations

Do fungal differences affect the success of tree establishment?

Grow a common southern and northern seed population at 3 nurseries spanning climate gradient for 1 year

Transplant seedlings into northern and southern field sites

Nursery Source

Control for genetic differences

Pre-plant Treatment

Untreated

X

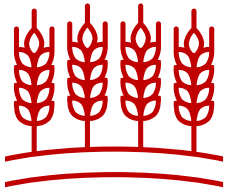
Fungicided

Control for non-fungal effects

Outplanting Site

Forested

X



Post-Agricultural

Test in different soil backgrounds

Do fungal differences affect the success of tree establishment?

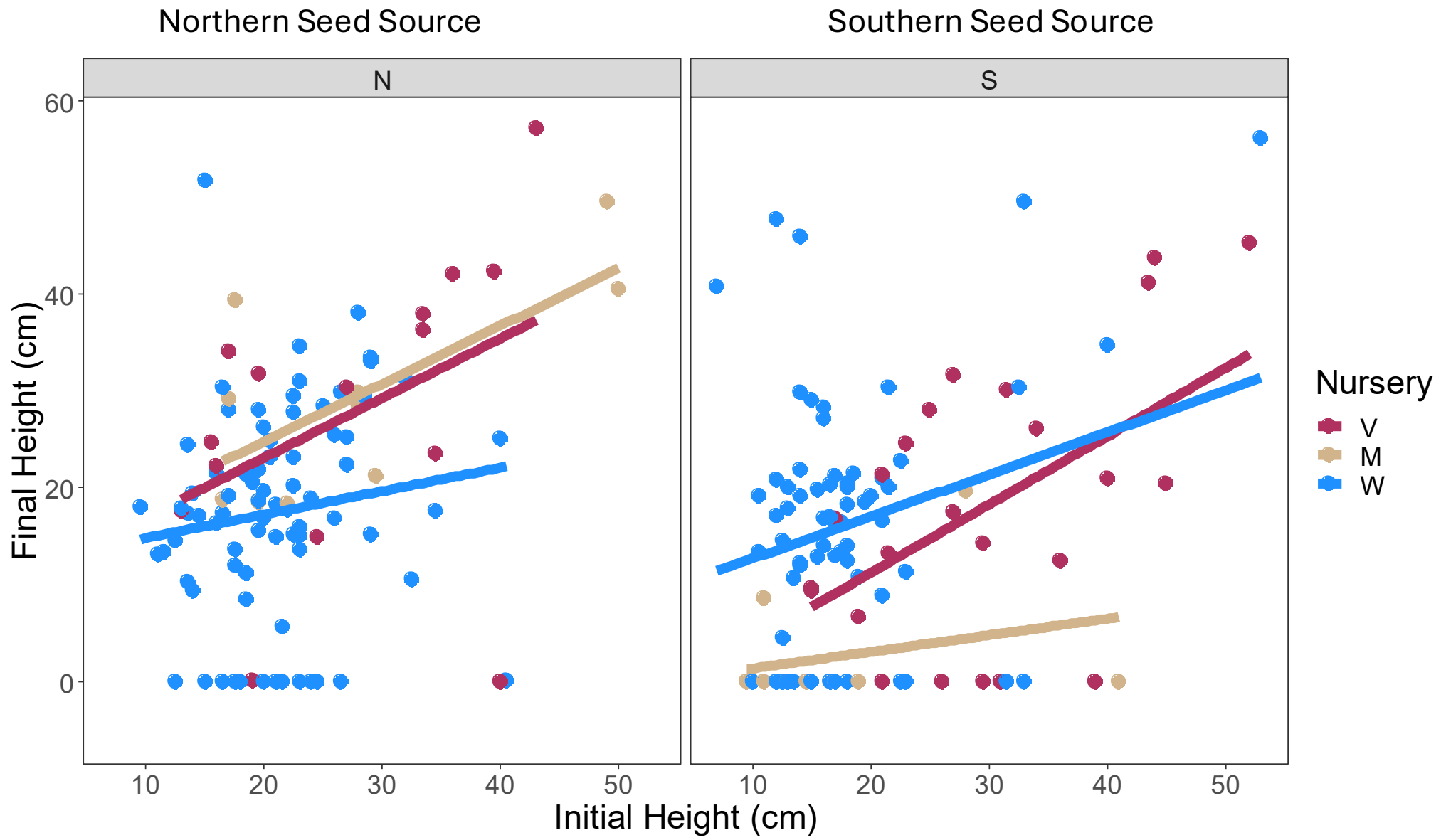
Preliminary Results:

Growth of Oak seedlings after one summer

Southern site, post-agricultural

For northern population, growing in a southern nursery promoted growth in the restoration site

Effects were weaker when treated with fungicide pre-planting



Can nursery management shape fungal associations in desirable ways?

Year 1: Wilson State Nursery (Boscobel, WI)

Year 2-3: KCI, Technologies Inc.

Seed source

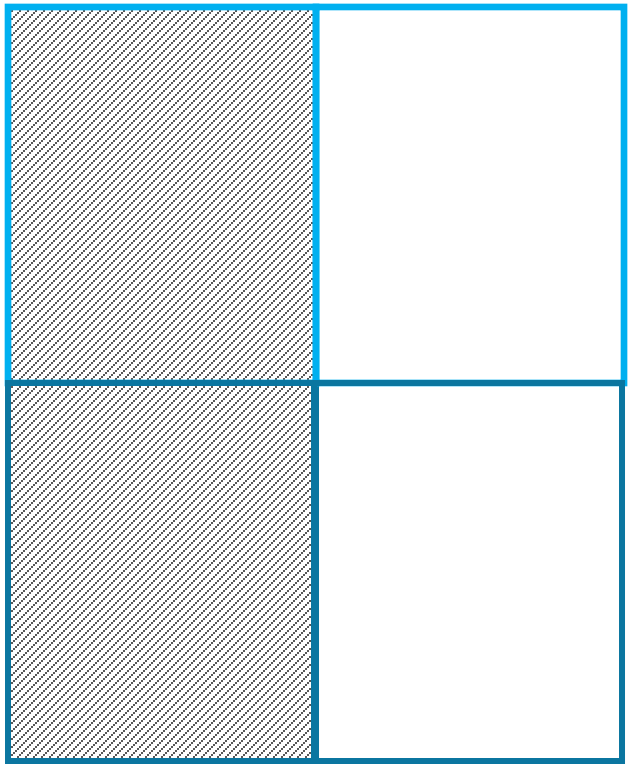
Nursery Management

Pre-plant Treatment

Outplanting Site

Species	Source
White Oak	WI
White Oak	IN
Black Cherry	WI
Black Cherry	IN

X



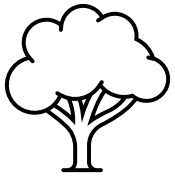
X

Untreated

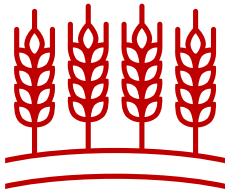
Fungicided

X

Forested



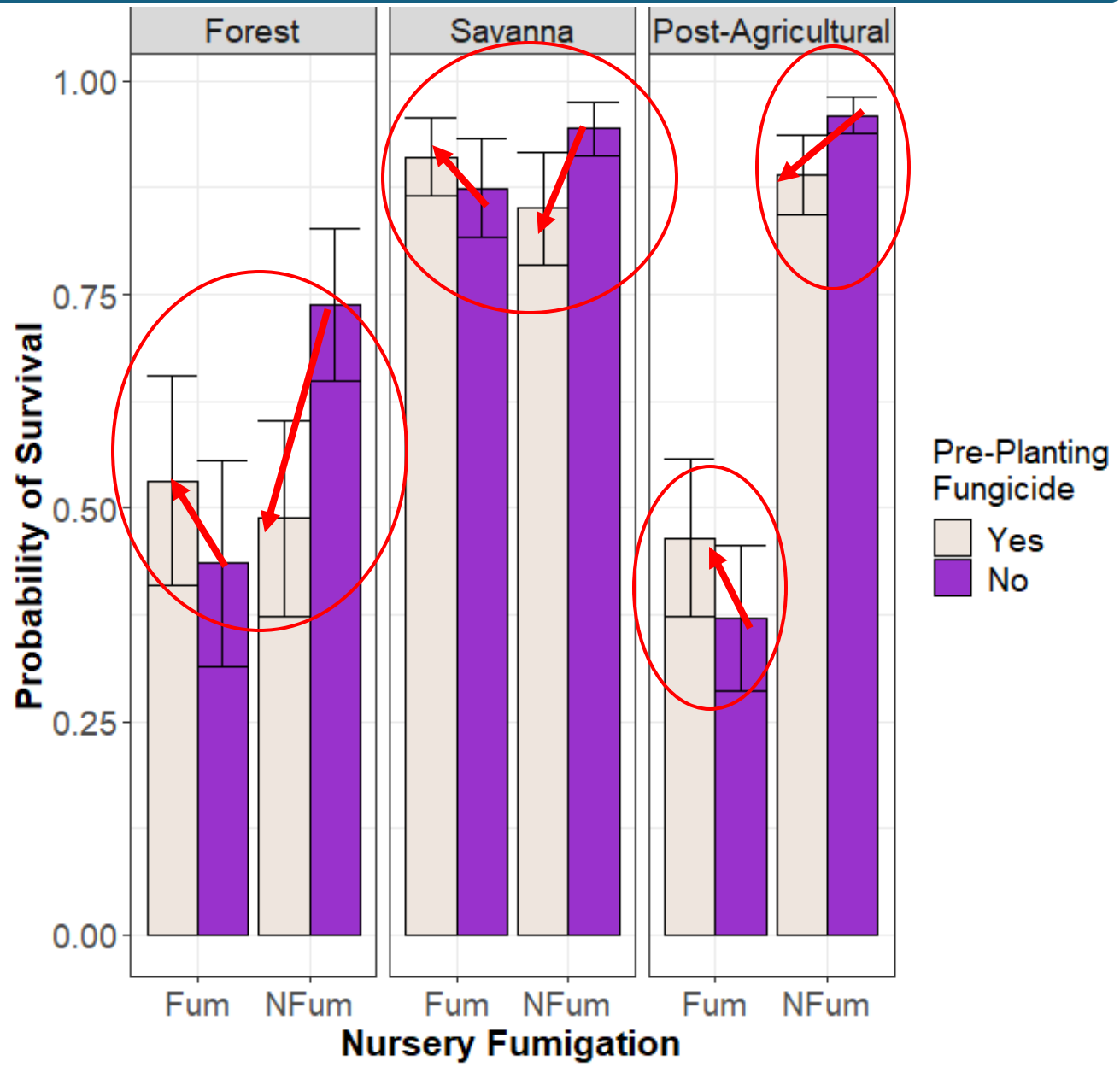
Savanna



Post-Agricultural

Can nursery management shape fungal associations in desirable ways?

- Survival was poor in the shaded forest and high in the savanna
- In post-agricultural soil, non-fumigated seedlings had higher survival
- Fungicide treatment tended to increase survival for seedlings from fumigated plots
- Fungicide treatment tended to decrease survival for seedlings from non-fumigated plots



Research Questions:

- Do tree seedlings develop different fungal associations between nurseries?
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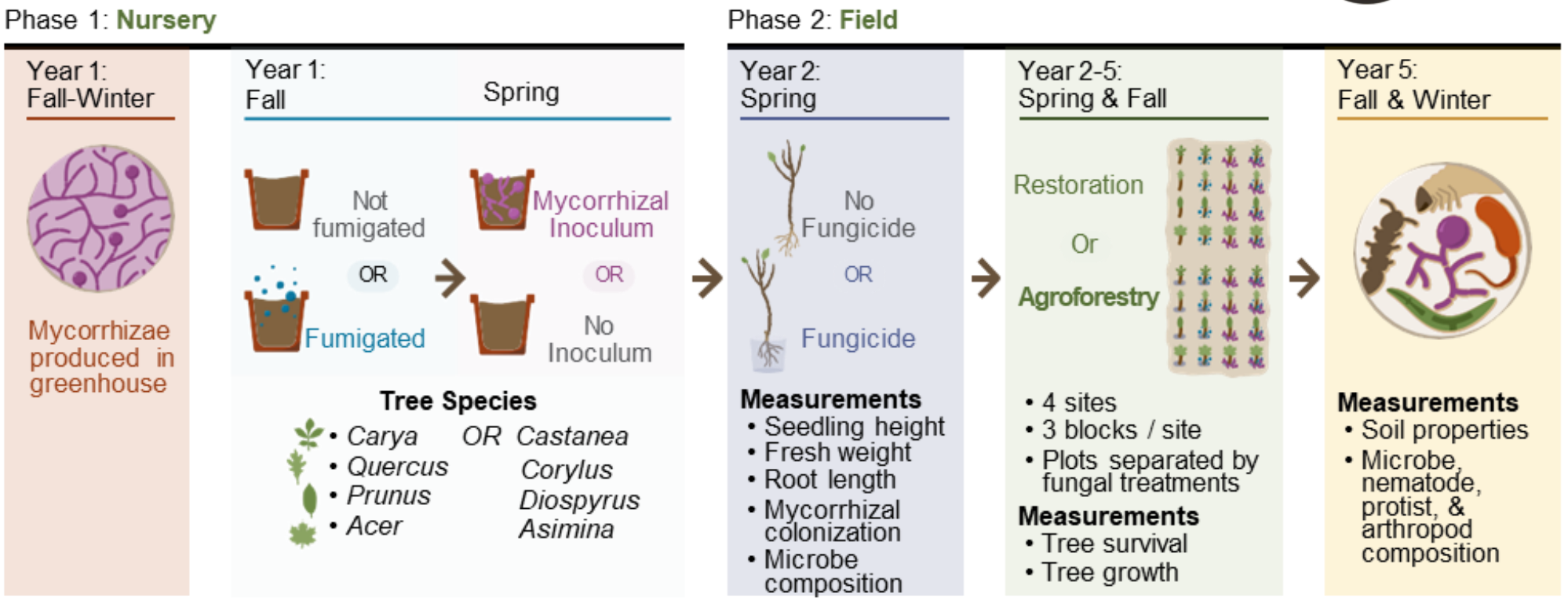
Next Steps:

- Investigating other nursery management practices – especially mycorrhizal inoculation
- Partnering with more nurseries and restoration sites for on-site experimentation
- Expanding into agroforestry operations

SAVANNA INSTITUTE



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Mason State Tree Nursery, Illinois DNR

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