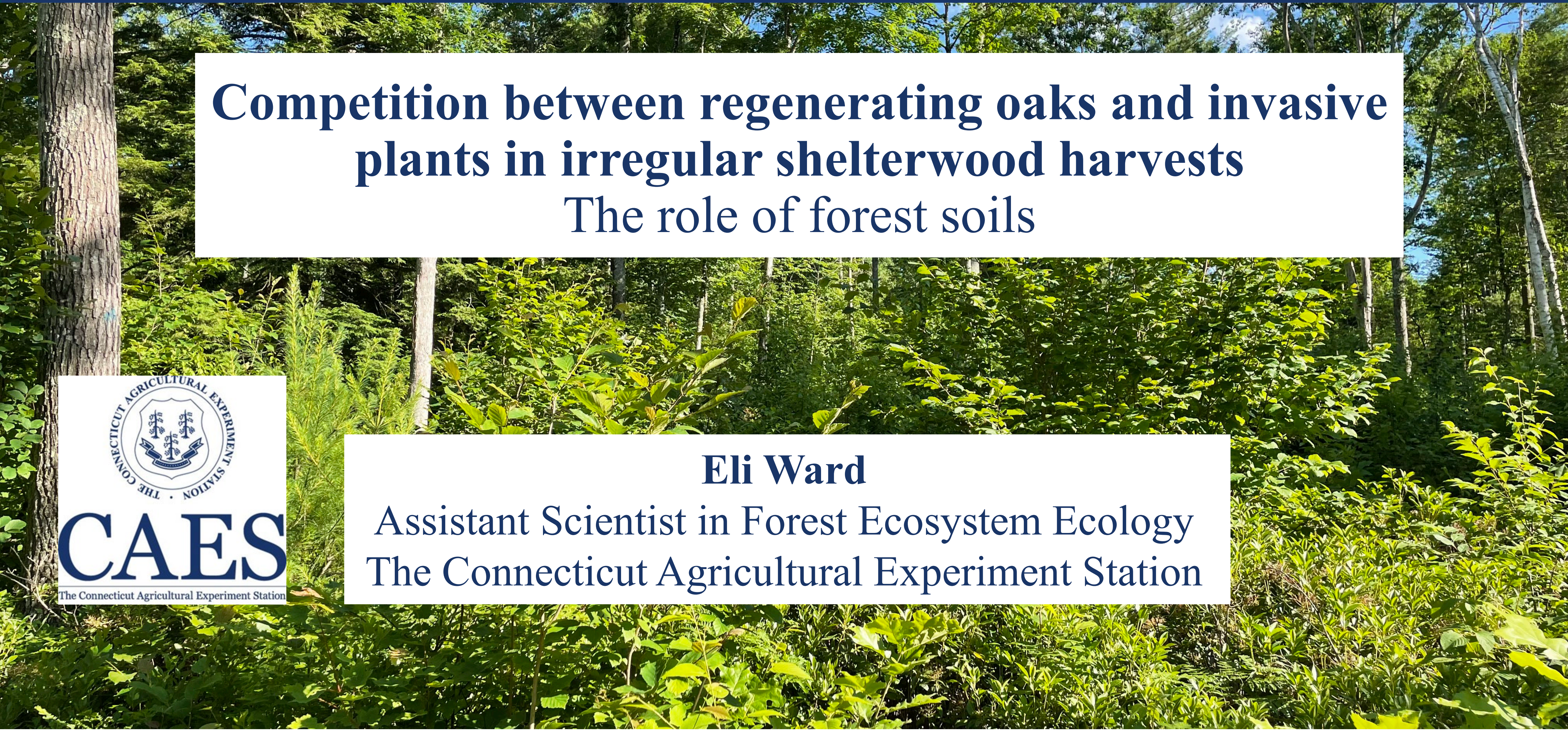


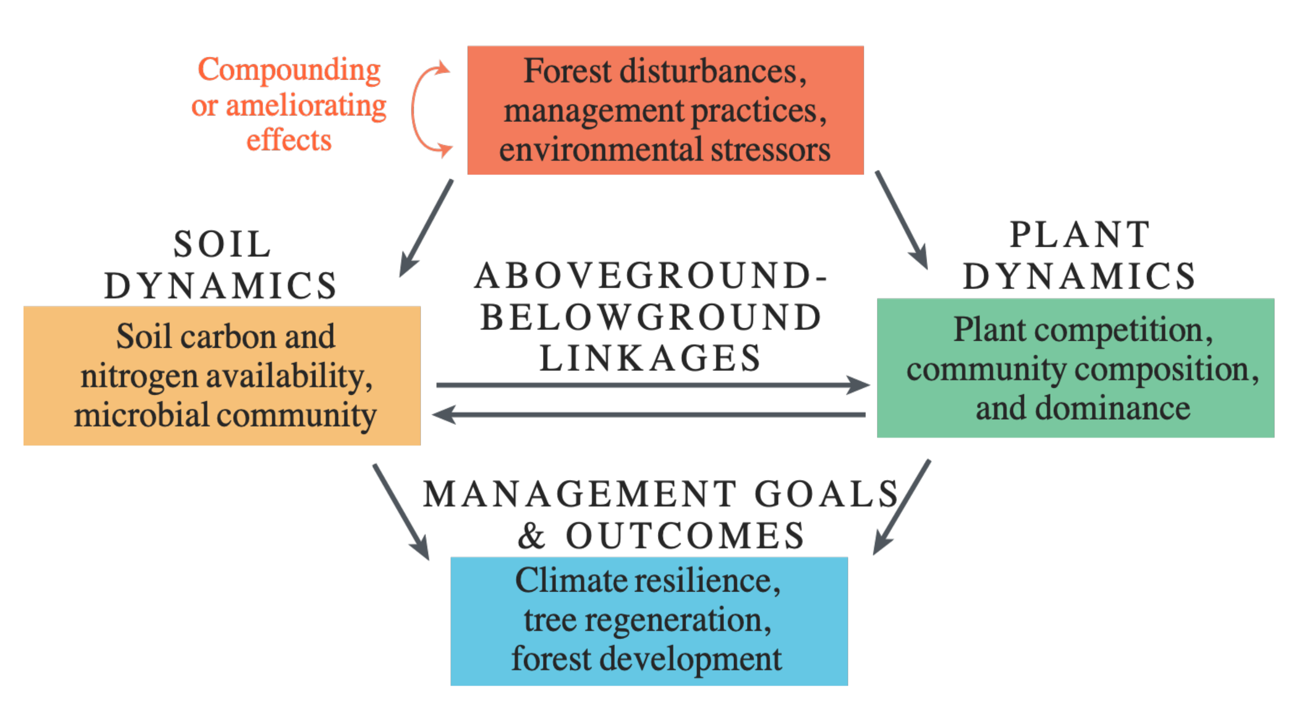
Competition between regenerating oaks and invasive plants in irregular shelterwood harvests

The role of forest soils

Eli Ward
Assistant Scientist in Forest Ecosystem Ecology
The Connecticut Agricultural Experiment Station

How do forest disturbances, management practices, and/or environmental stressors alter the relationships between plant community composition and soil conditions?

Do these changes align with forest management goals?



FOREST MANAGEMENT & ENVIRONMENTAL CHANGE

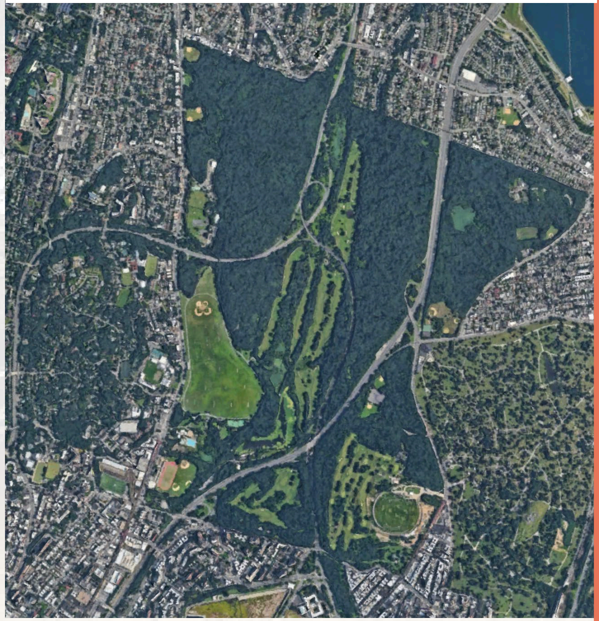
Forest disturbances, management practices, environmental stressors

Urbanization & Urban Forest Restoration	Forest management practices	Forest pest and pathogen invasions
		

FOREST MANAGEMENT & ENVIRONMENTAL CHANGE

Forest disturbances, management practices, environmental stressors

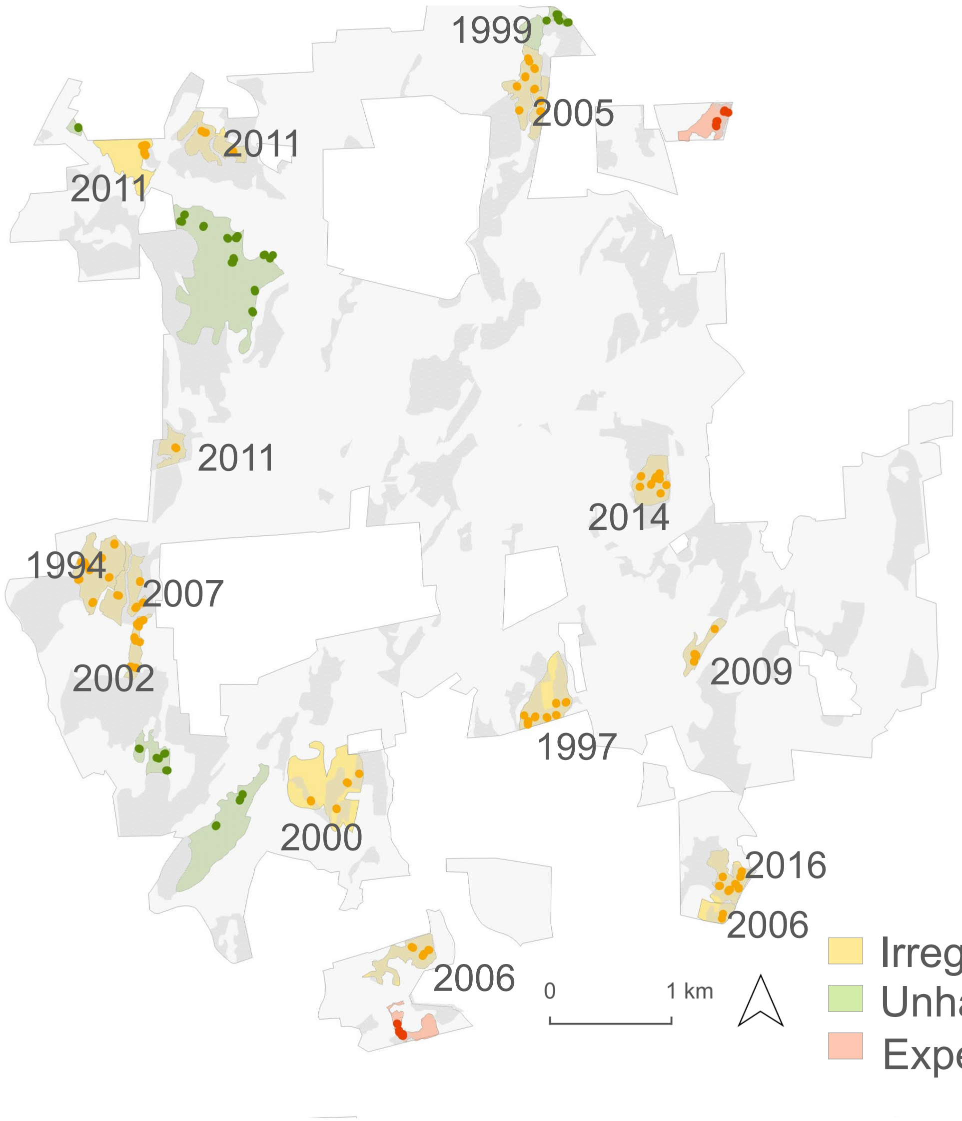
Urbanization & Urban Forest Restoration



Forest management practices

Forest pest and pathogen invasions

Irregular Shelterwood Harvests (Establishment cuts)
Yale-Myers Forest



Irregular shelterwood chronosequence
Unharvested reserve
Experimental plots

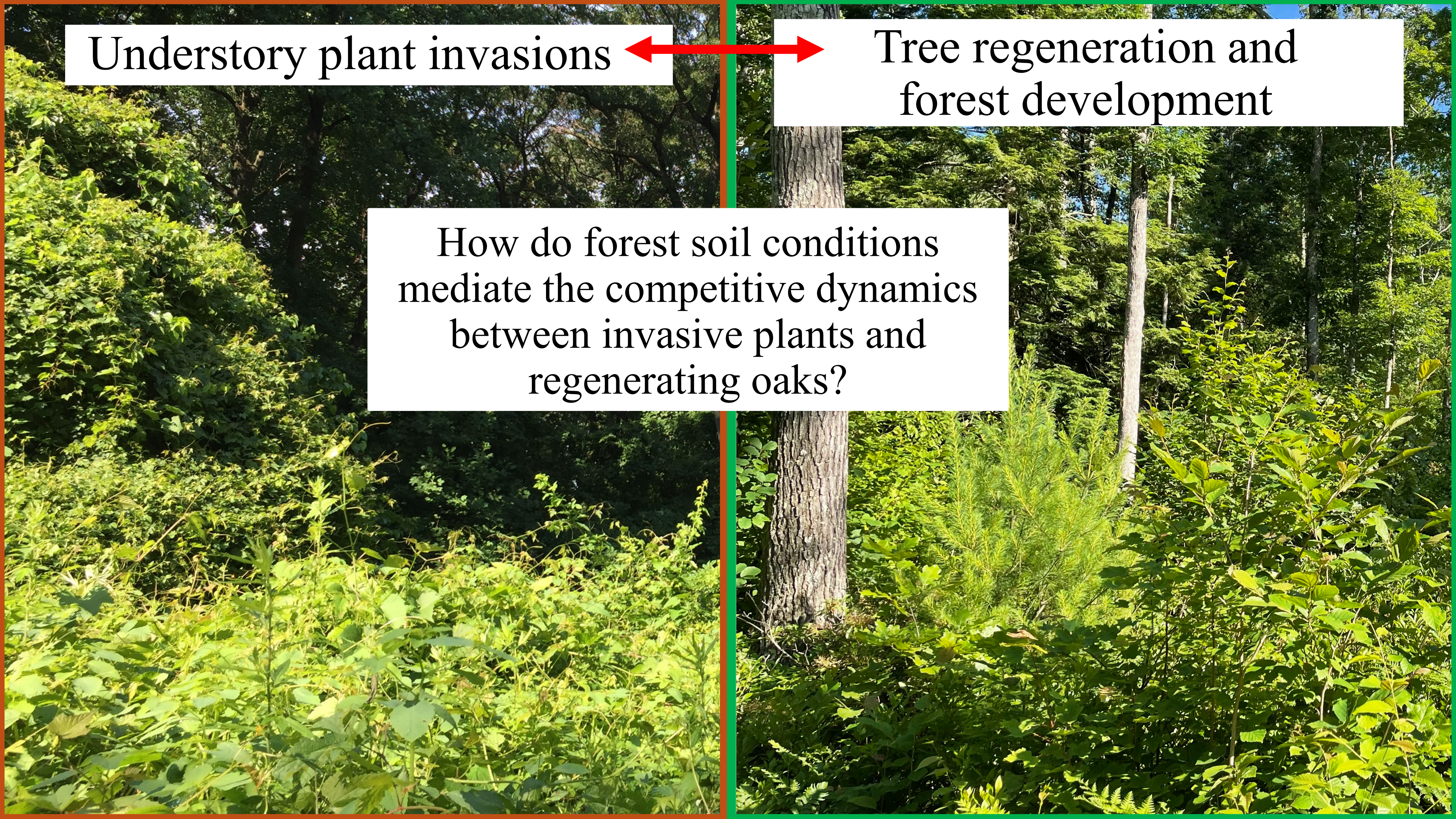
Irregular Shelterwood Harvests (Establishment cuts)
*Regeneration Harvest

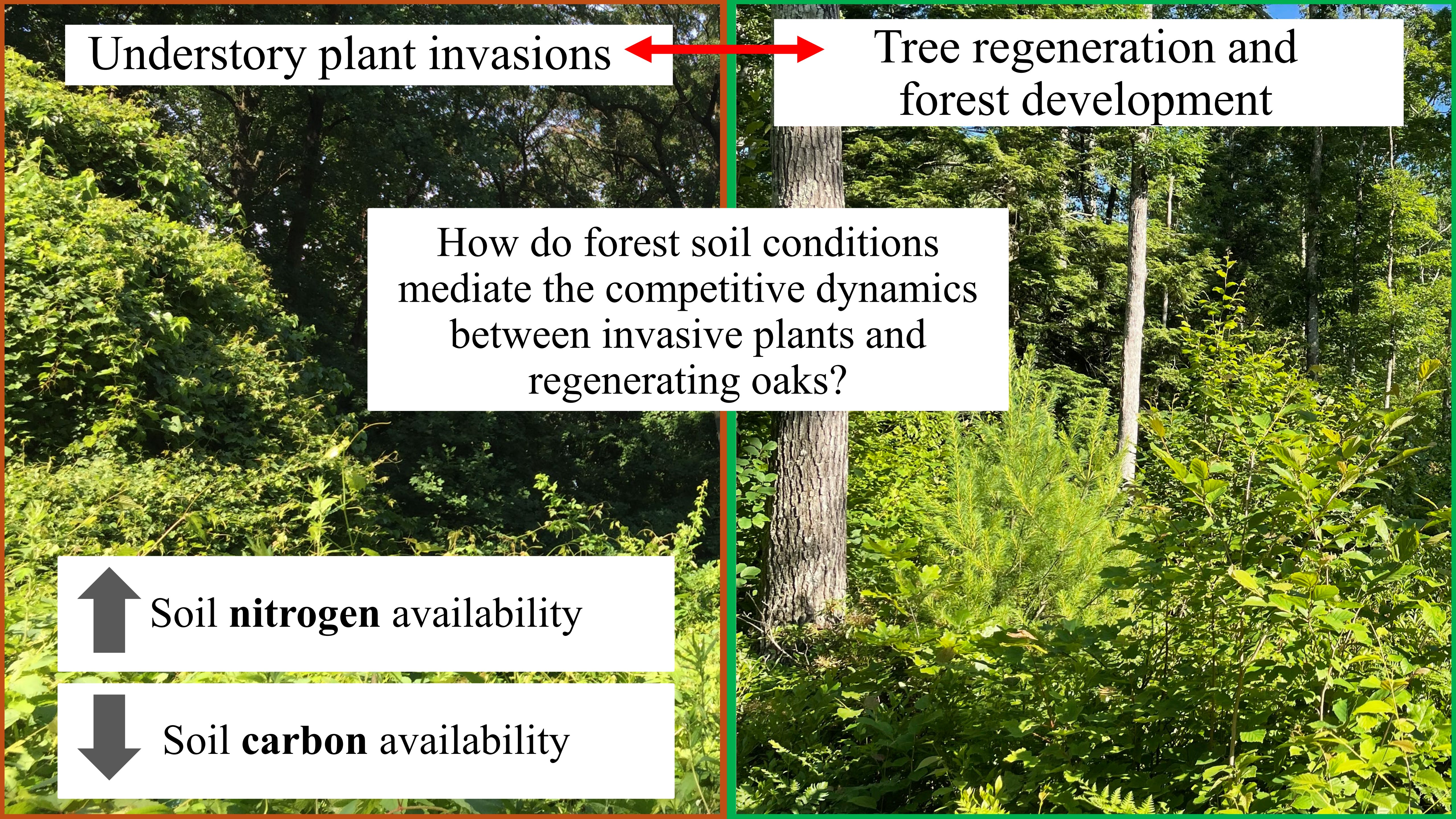
Goals:

- **Regenerate oaks** (and in doing so, other tree species)
- Increase structural and compositional diversity within the stand
- Increase structural and age-class diversity at the landscape scale


Light
Soil resources
Promote diverse assemblages of
regenerating trees, including oaks

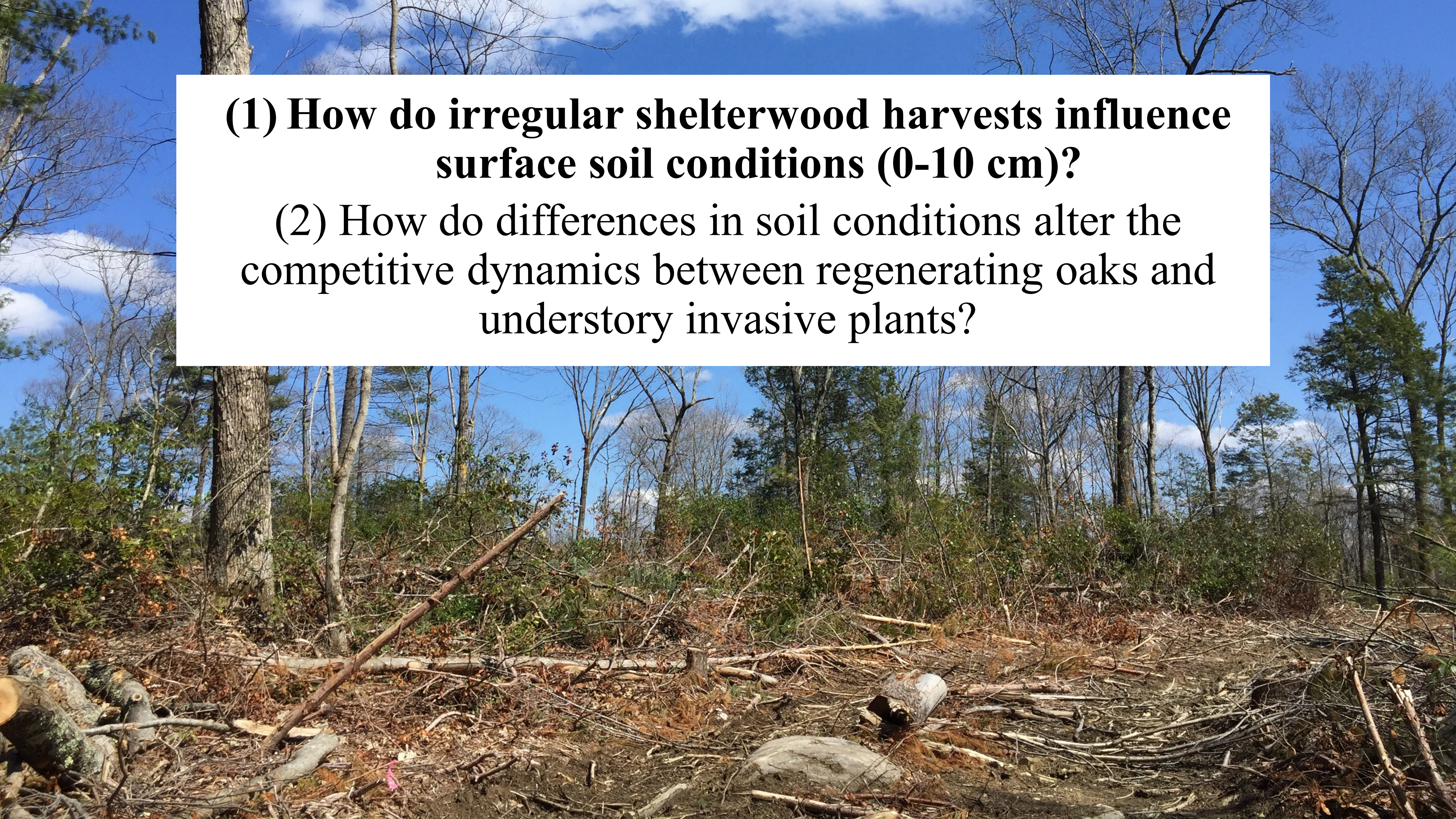

Light
Soil resources
Understory plant invasions*
*When there is sufficient propagule pressure


Understory plant invasions
Tree regeneration and forest development
How do forest soil conditions mediate the competitive dynamics between invasive plants and regenerating oaks?

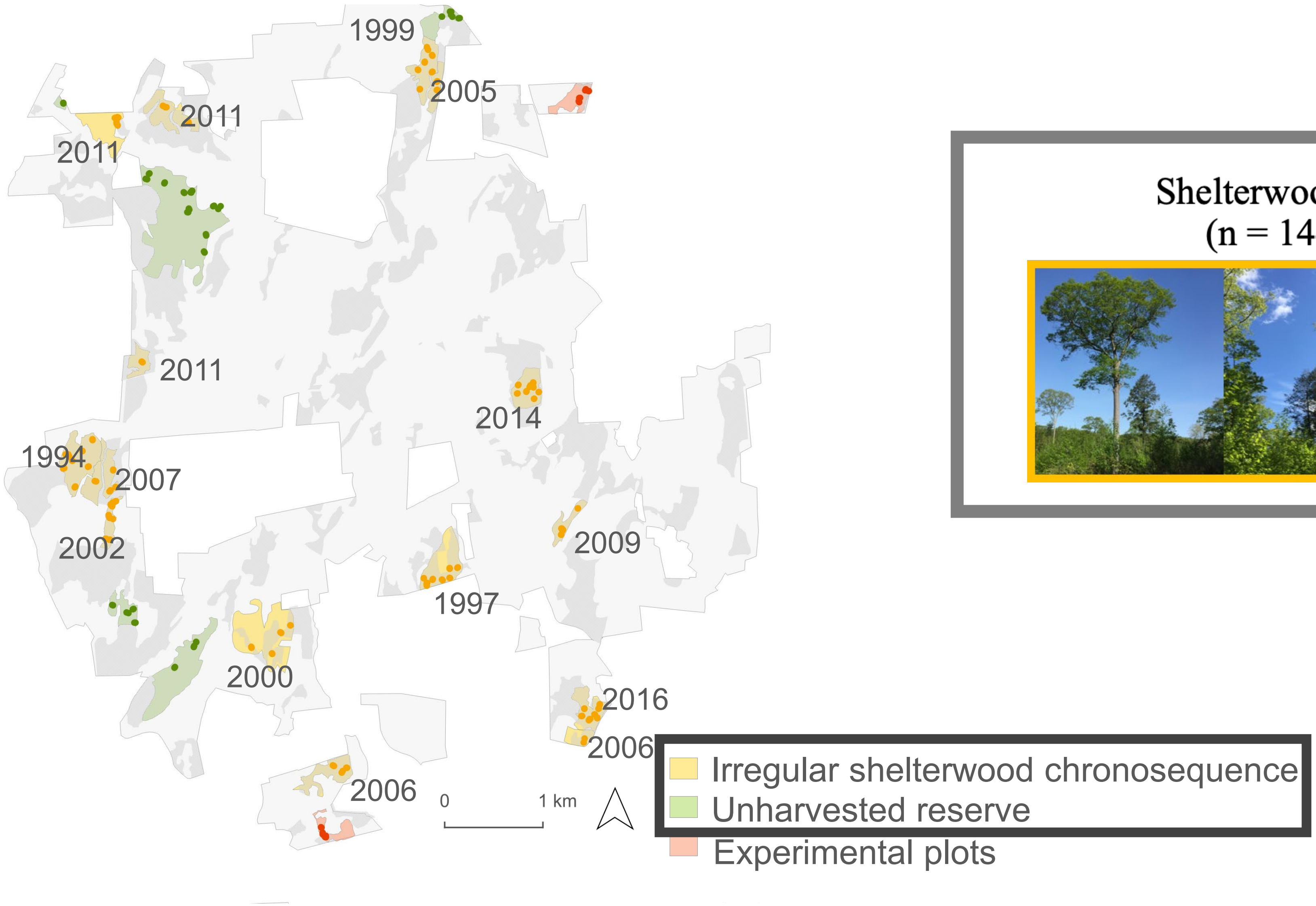

Understory plant invasions
Tree regeneration and forest development
How do forest soil conditions mediate the competitive dynamics between invasive plants and regenerating oaks?
Soil **nitrogen** availability
Soil **carbon** availability

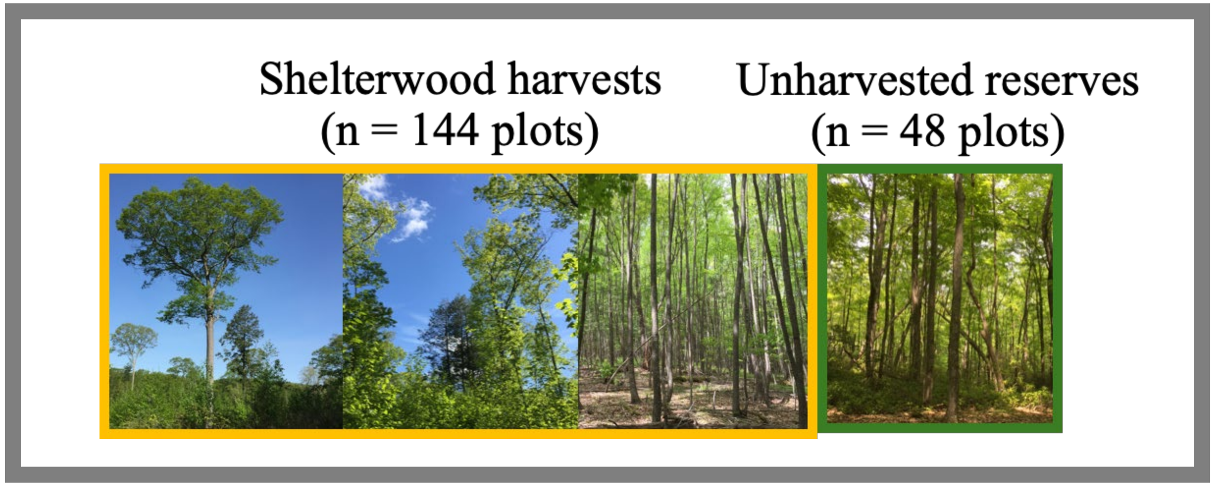
(1) How do irregular shelterwood harvests influence surface soil conditions (0-10 cm)?

(2) How do differences in soil conditions alter the competitive dynamics between regenerating oaks and understory invasive plants?

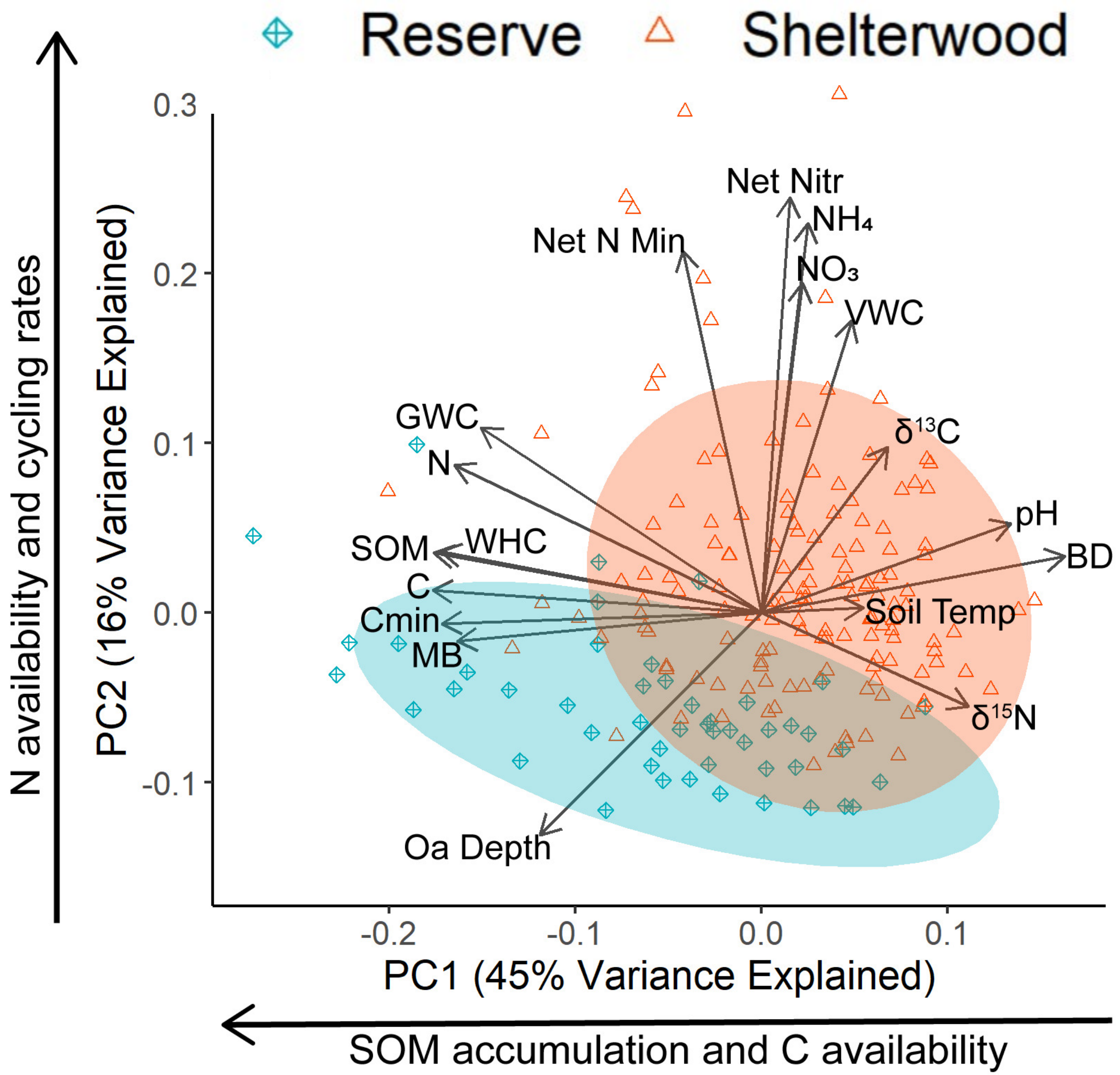


How do irregular shelterwood harvests influence surface soils conditions?

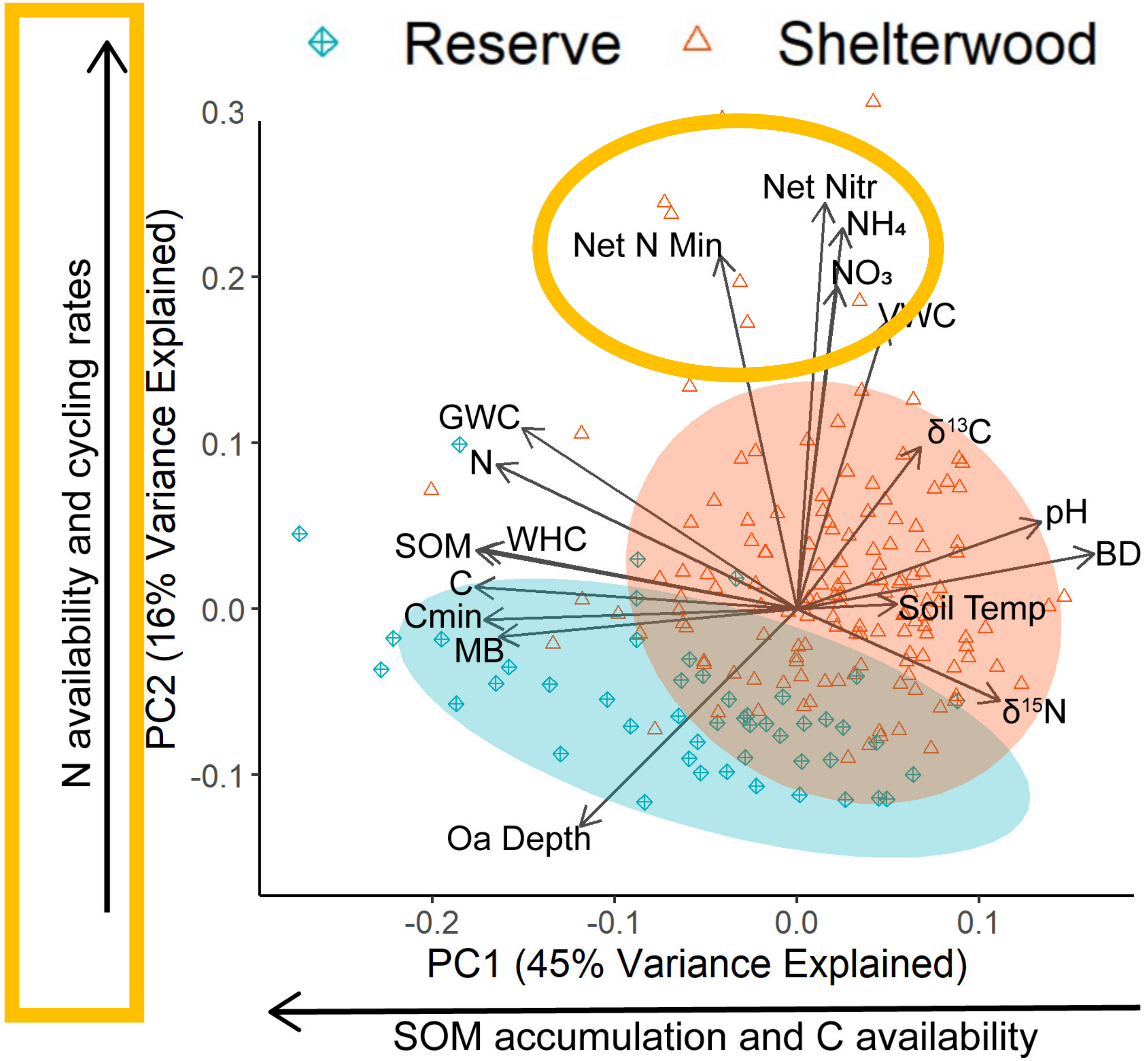


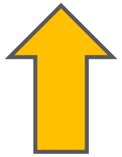


Surface soil conditions in shelterwood harvests vs. unharvested reserves



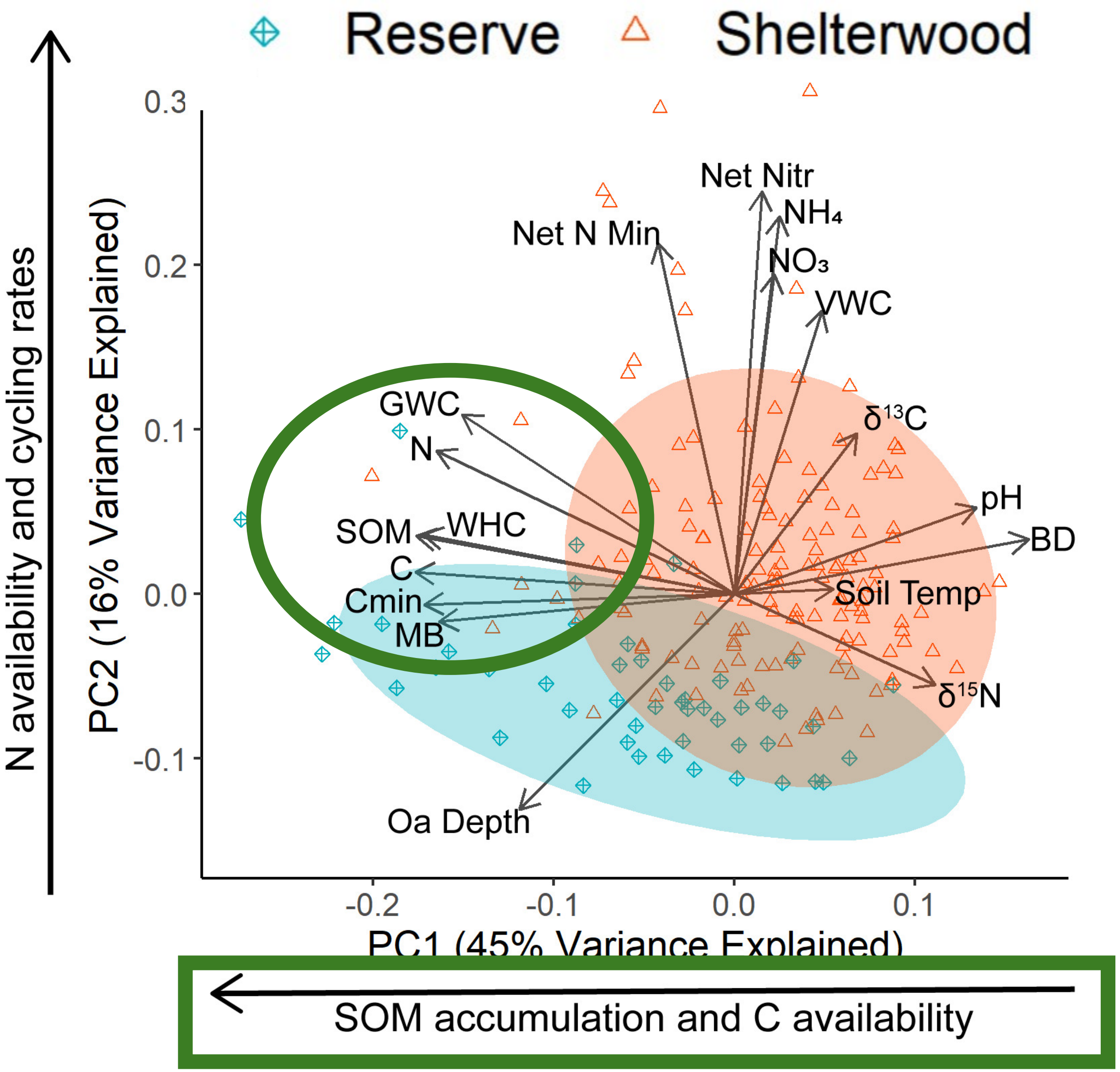
Surface soil conditions in shelterwood harvests vs. unharvested reserves



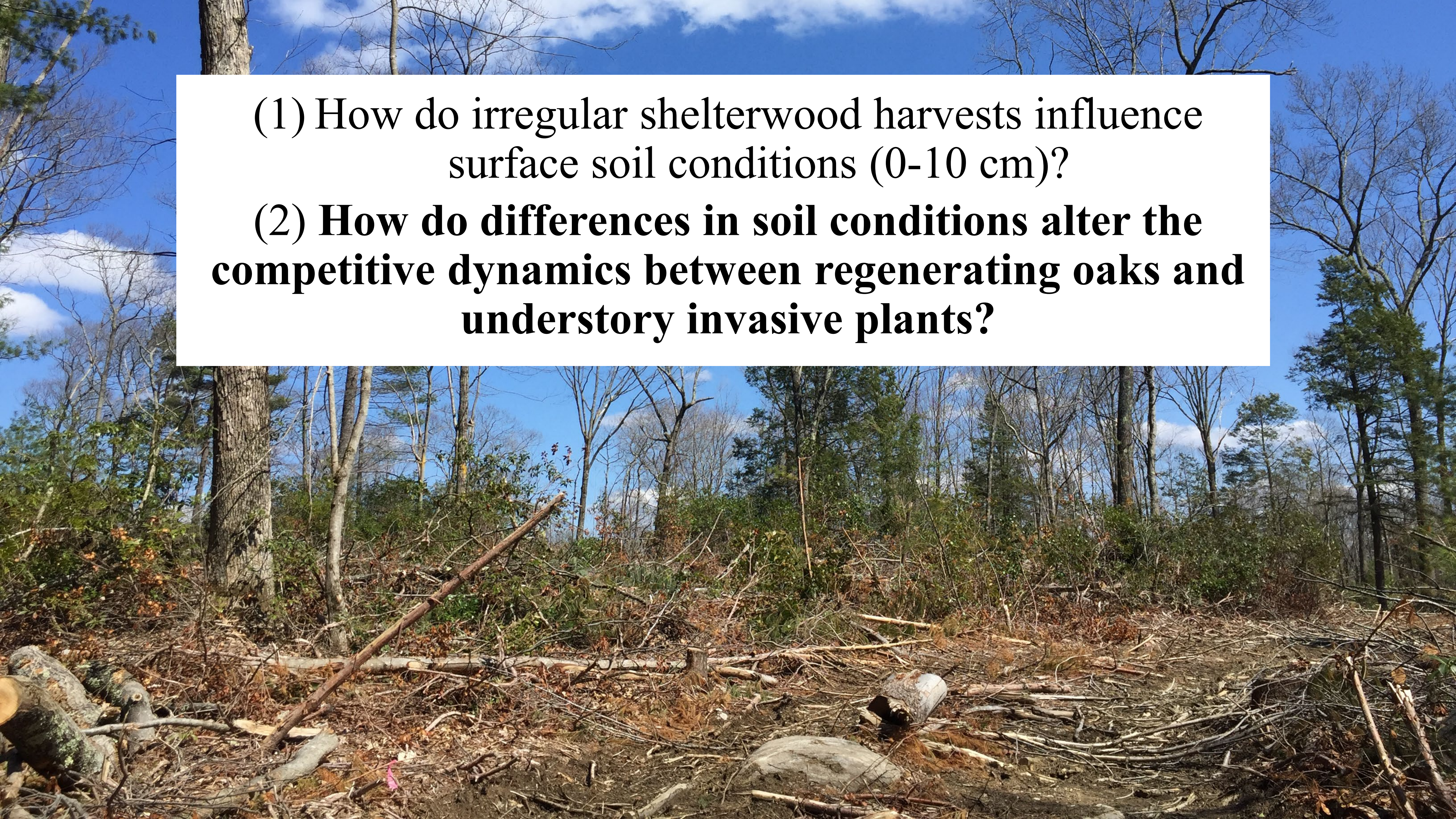


Surface soil nitrogen availability

Surface soil conditions in shelterwood harvests vs. unharvested reserves



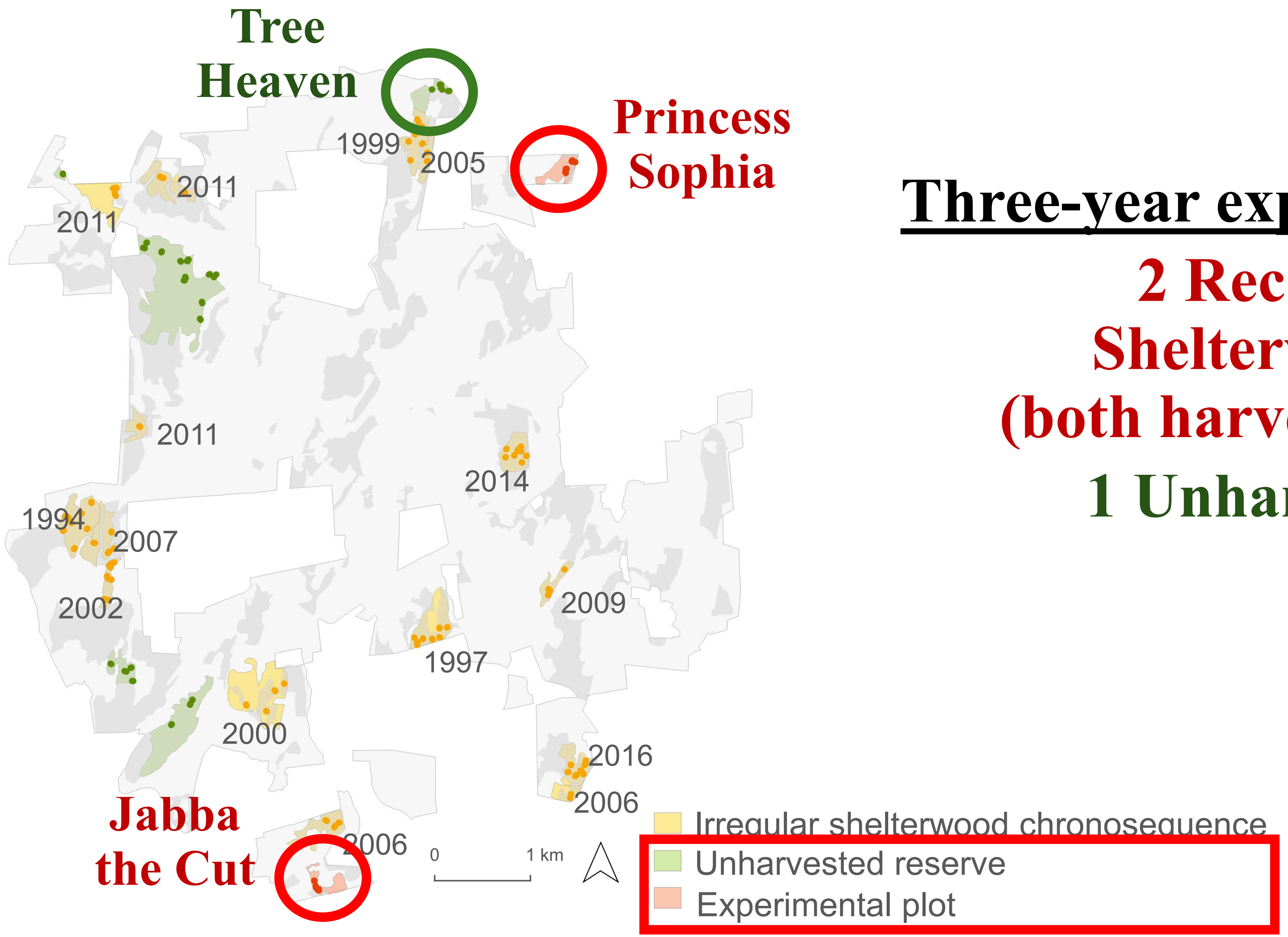
Surface soil carbon availability



(1) How do irregular shelterwood harvests influence surface soil conditions (0-10 cm)?

(2) **How do differences in soil conditions alter the competitive dynamics between regenerating oaks and understory invasive plants?**

How do differences in soil conditions alter the competitive dynamics between regenerating oaks and understory invasive plants?

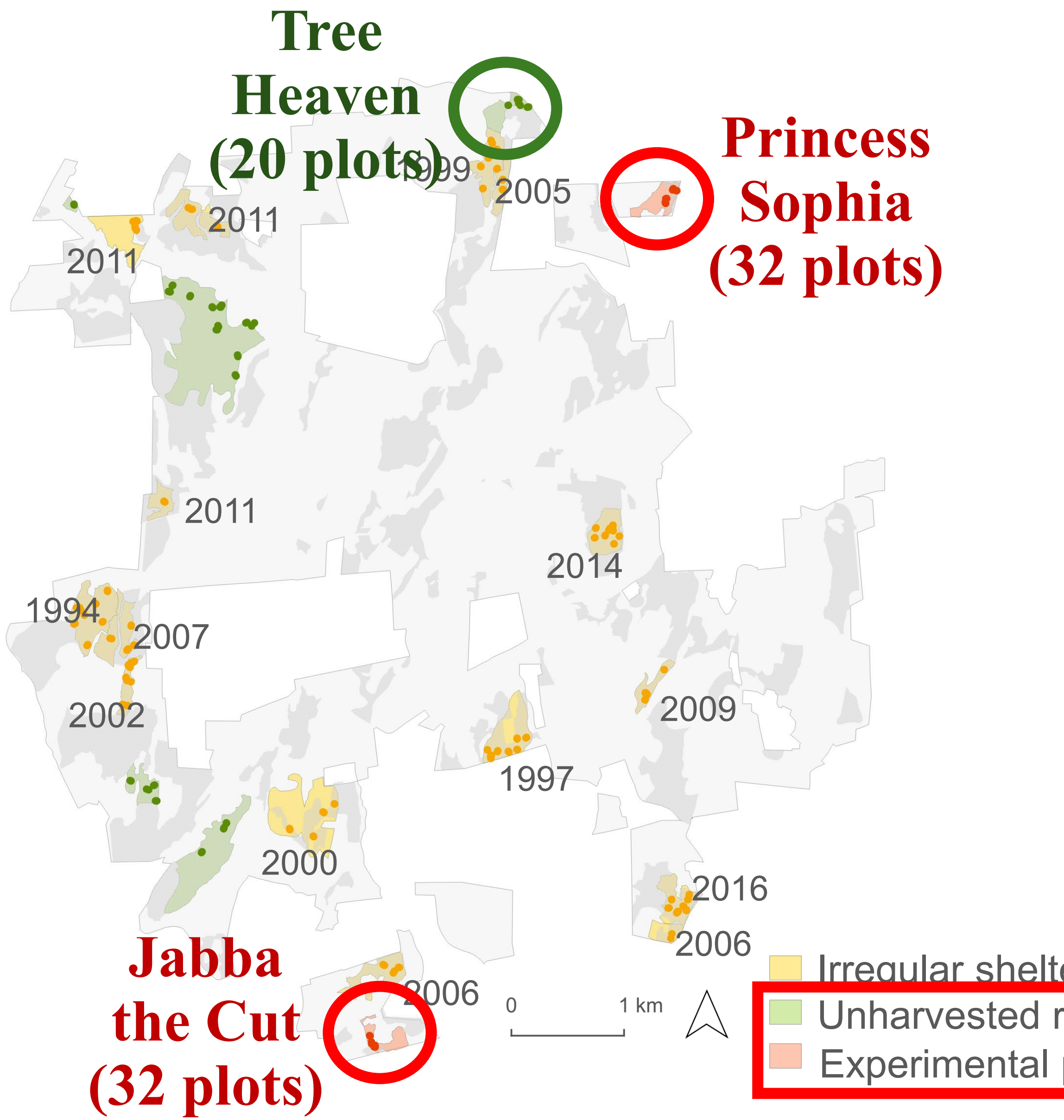


<u>Three-year experiment (2020-2023):</u>

2 Recent Irregular Shelterwood Harvests (both harvested in Fall 2019)

1 Unharvested reserve

How do differences in soil conditions alter the competitive dynamics between regenerating oaks and understory invasive plants?



Red Oak

White Oak

Japanese honeysuckle

Asiatic bittersweet

Multiflora rose

Jabba the Cut

Deeper, moister soils
Surrounded by wet, lowlands
More hemlock and a mixture of black, white, and red oak

Princess Sophia

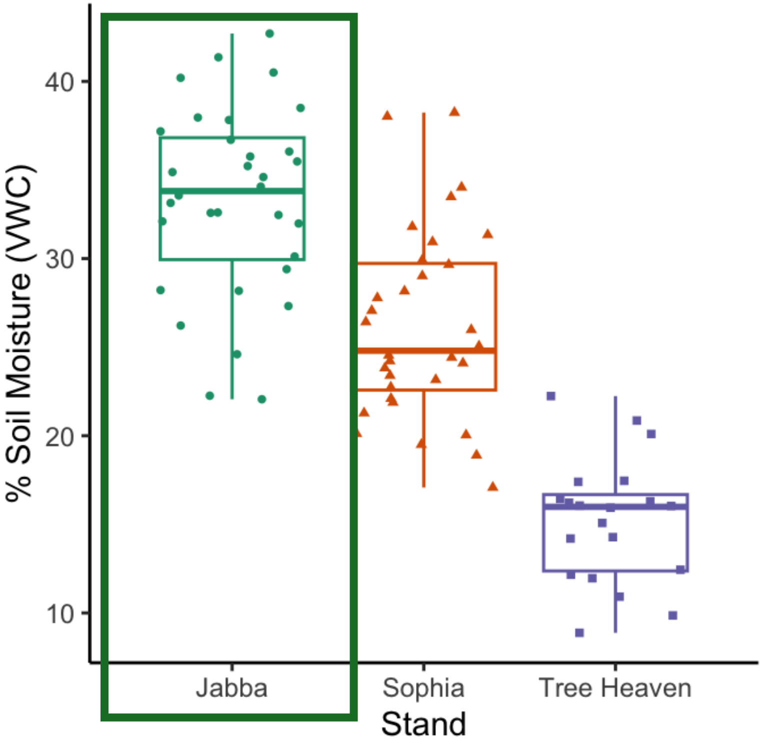
Drier, thinner soils
Rocky outcrops and ravines
Predominantly red oak and hemlock

Differences in initial, post-harvest soil conditions

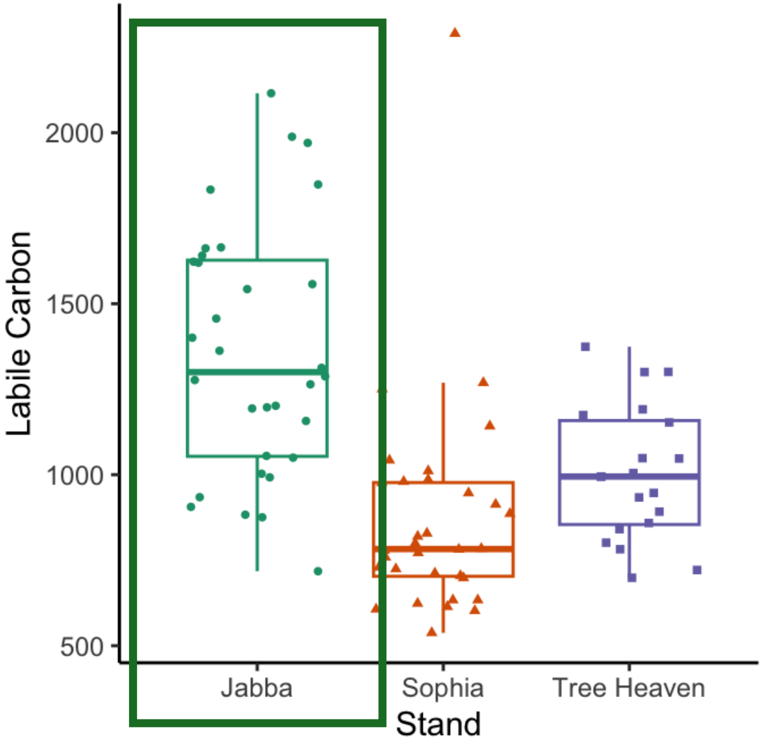
Jabba the Cut

Higher soil moisture and soil carbon availability

Soil Moisture



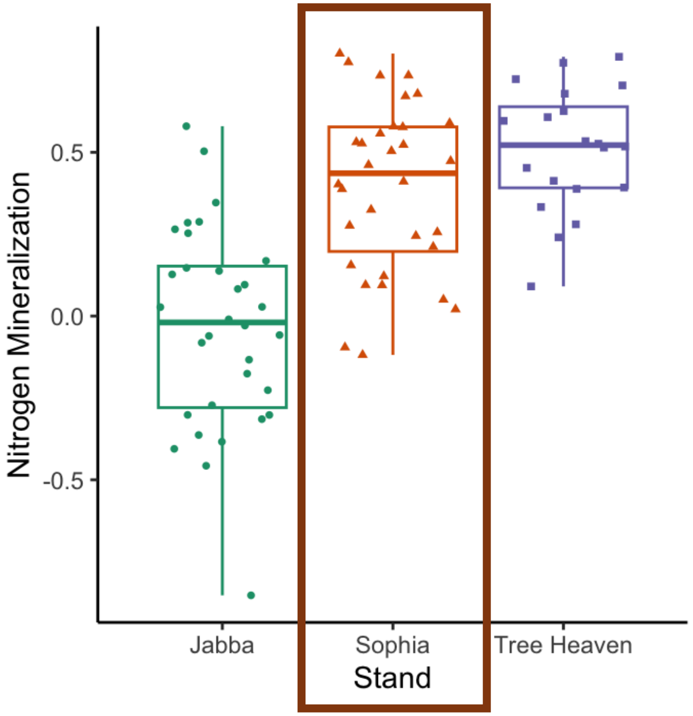
Carbon availability



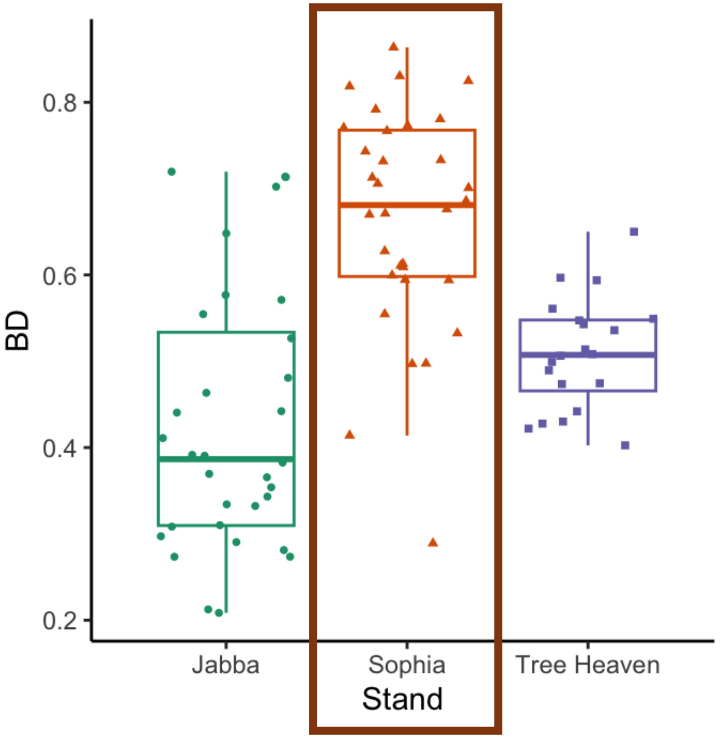
Differences in initial, post-harvest soil conditions

Higher soil disturbance and nitrogen availability

Nitrogen availability

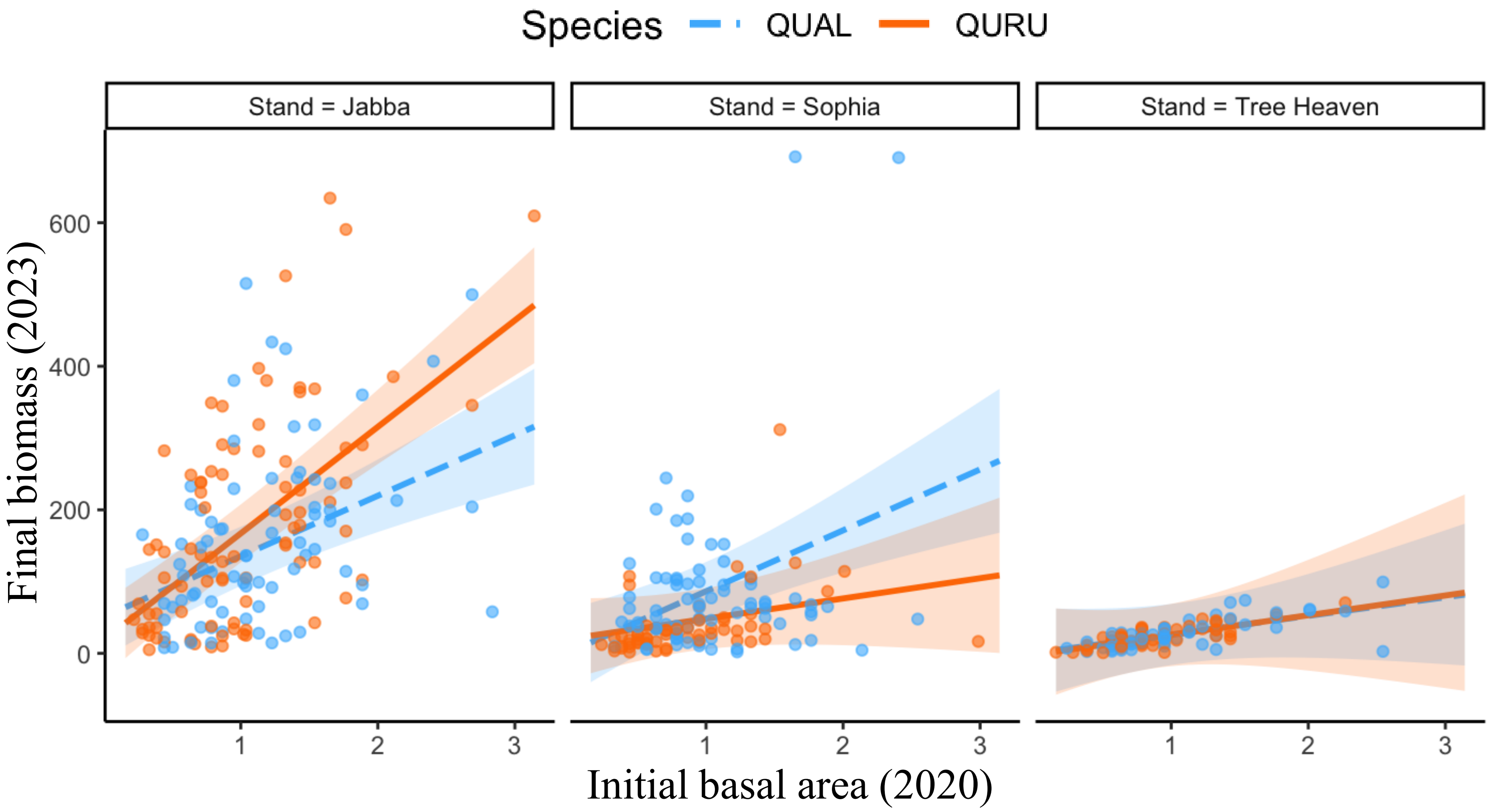


Soil compaction

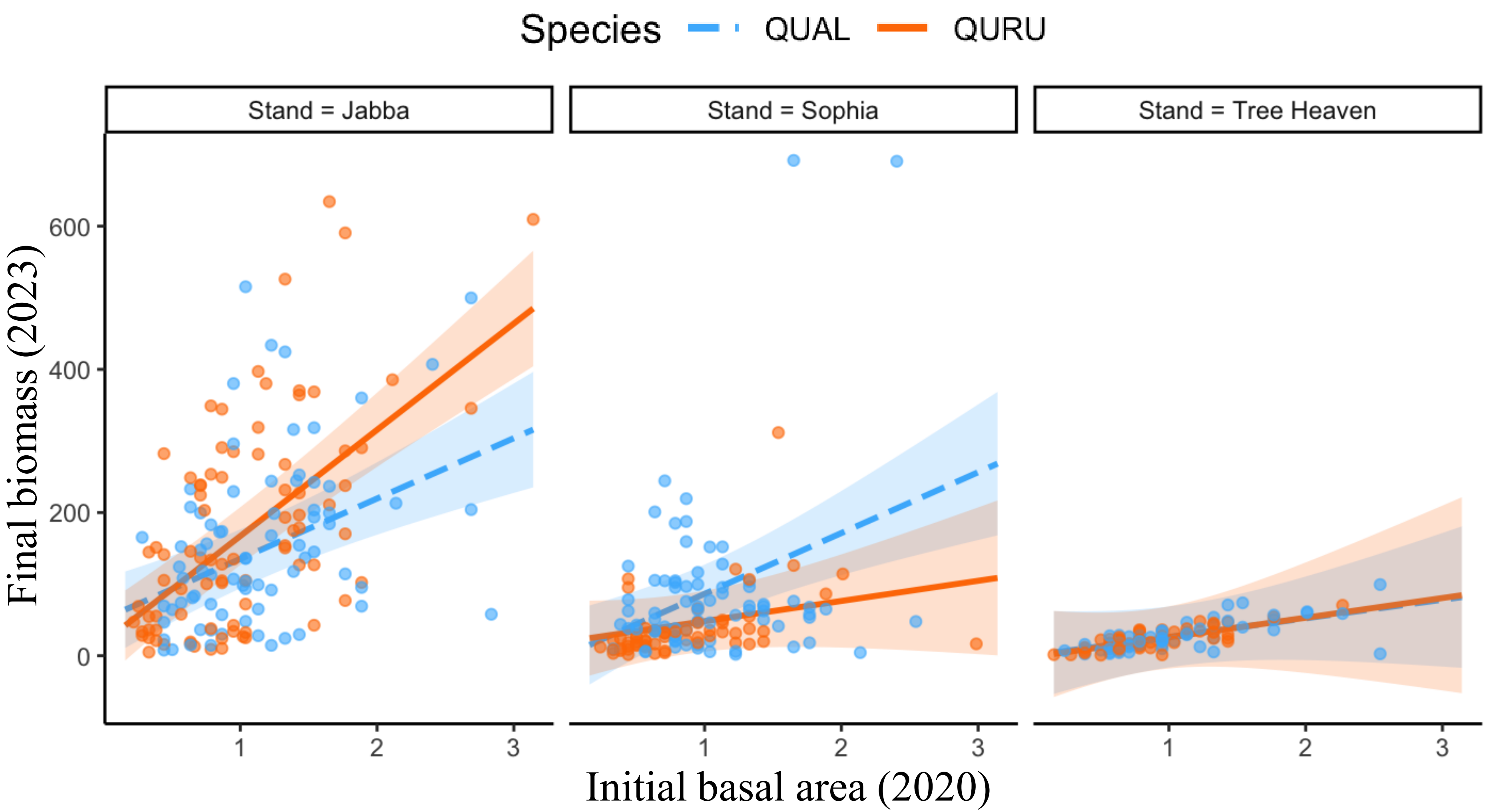


Princess Sophia

Differences in the growth and mortality of the planted oaks



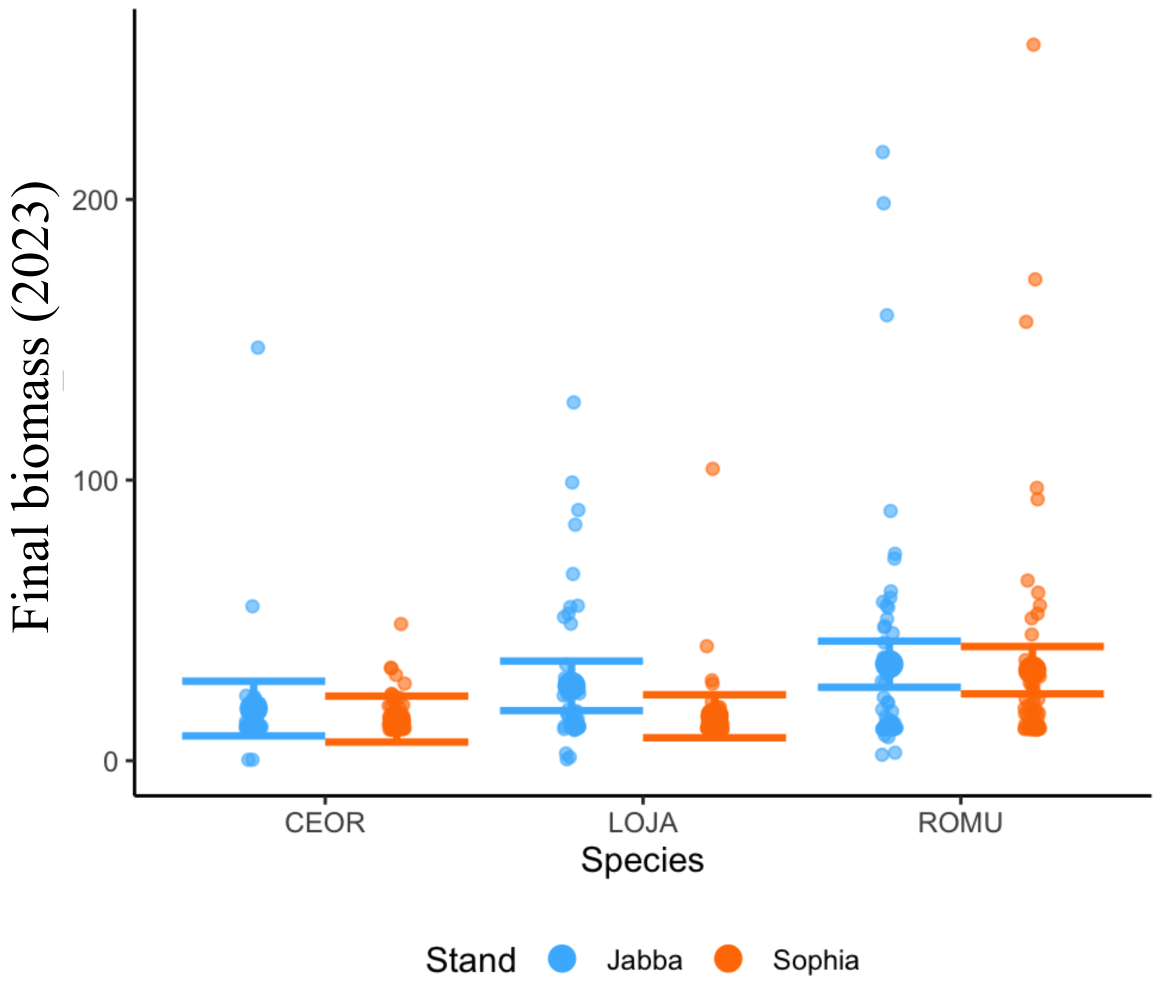
Differences in the growth and mortality of the planted oaks



Survival (%):

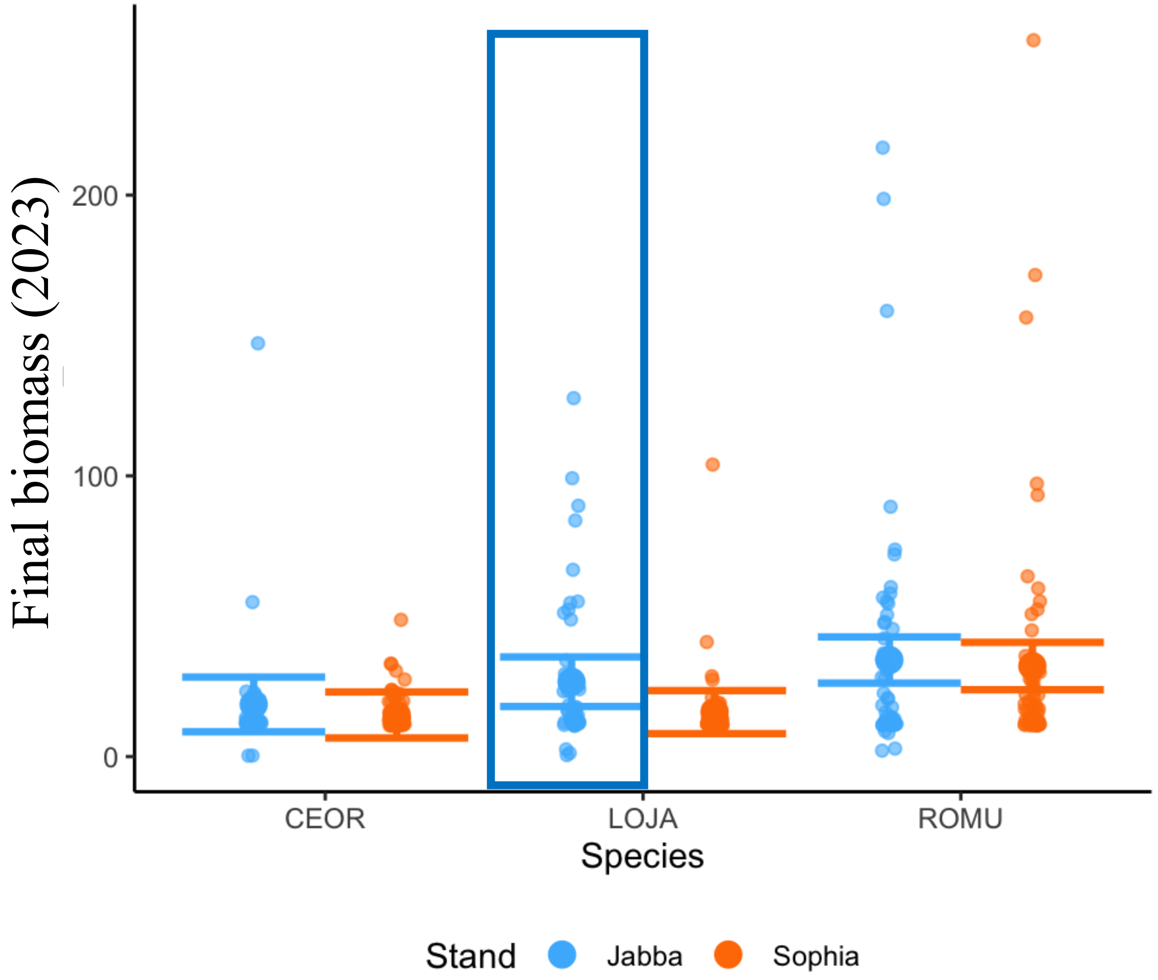
	Jabba	Sophia	Tree Heaven
QUAL	79%	79%	92%
QURU	88%	60%	82%

Differences in the growth and mortality of the invasives



Differences in the growth and mortality of the invasives

Japanese honeysuckle had a higher growth rate in Jabba the Cut, which had higher soil moisture and carbon

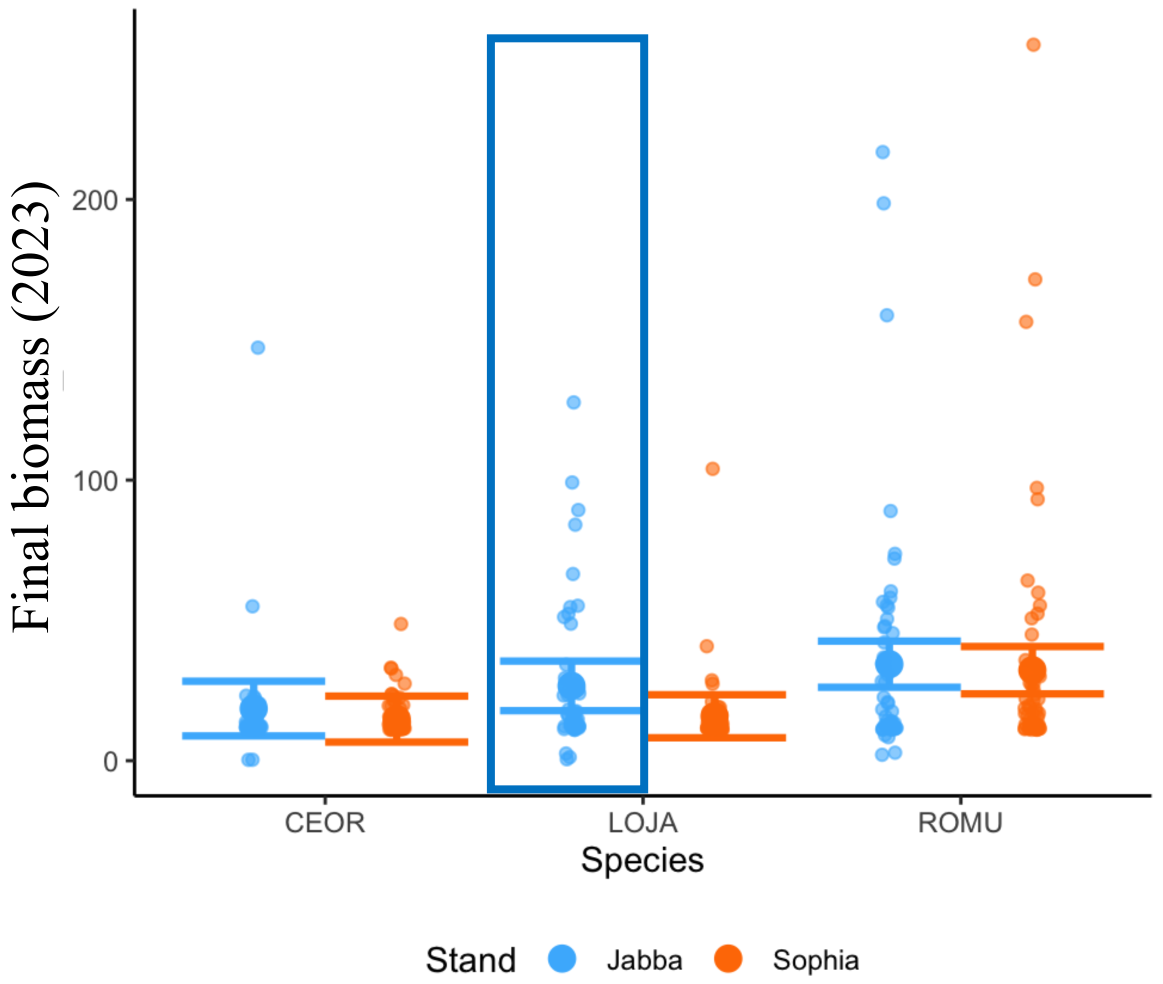


Differences in the growth and mortality of the invasives

However, all the invasive plant species had higher survival rates in Princess Sophia, which had higher levels of soil disturbance and nitrogen availability

Survival (%)

Stand	Species		
	CEOR	LOJA	ROMU
Jabba the Cut	35%	34%	39%
Princess Sophia	**44%**	**49%**	**45%**

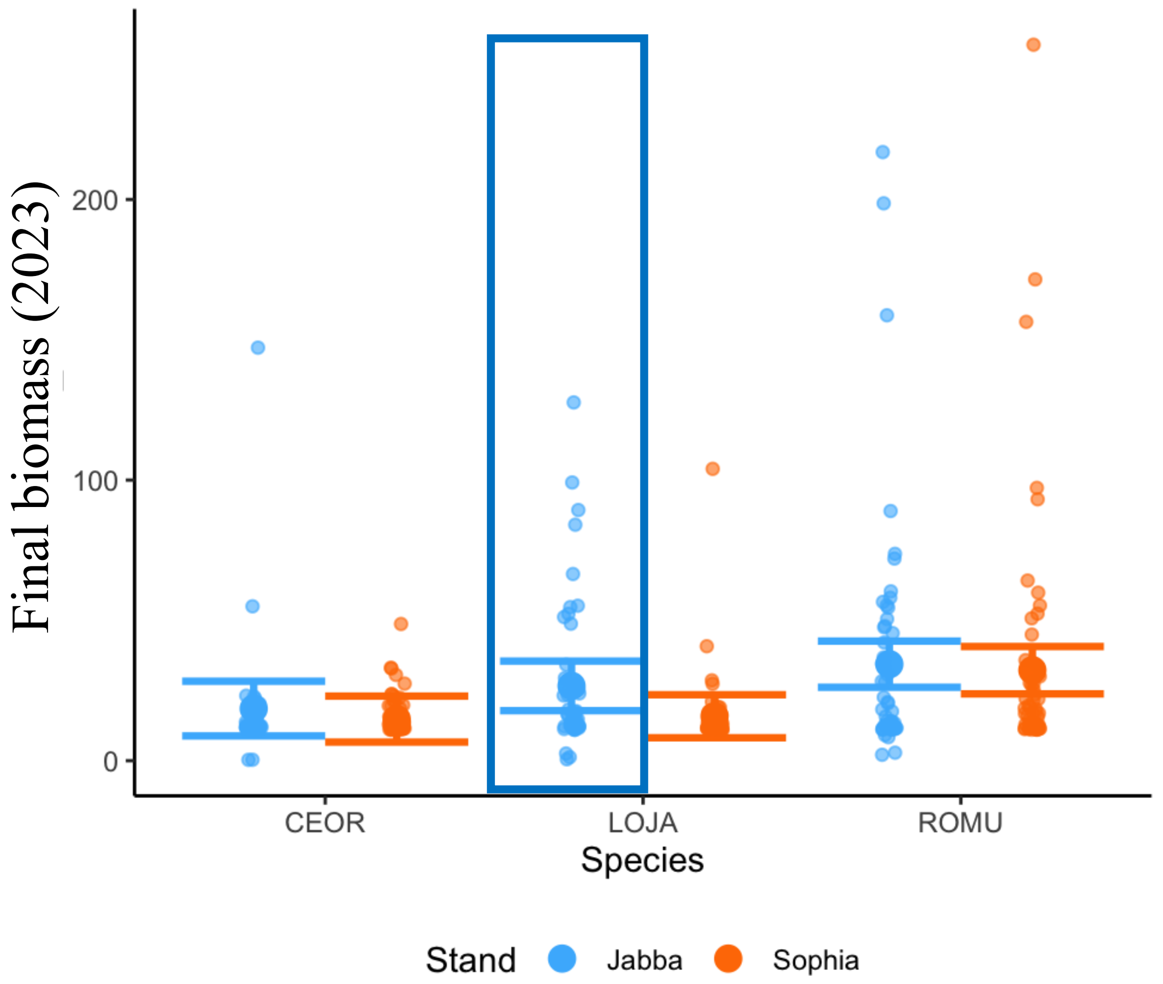


Differences in the growth and mortality of the invasives

Any evidence for the "sit and wait" strategy?

Survival (%)

Stand	Species		
	CEOR	LOJA	ROMU
Jabba the Cut	35%	34%	39%
Princess Sophia	44%	49%	45%
Tree Heaven	**3%**	**10%**	**10%**



Some early conclusions:

- Irregular shelterwoods increased soil nitrogen availability and reduced surface soil carbon
- Both oak species grew better with higher soil moisture and carbon
- Differences between the two stands were more pronounced for red oak
- Red oak had very slow growth and poor survival in the drier stand with higher soil compaction and nitrogen availability
- Japanese honeysuckle also grew better with higher soil moisture and carbon
- The survival rates of the invasive plants were consistently higher in the stand with elevated soil disturbance and nitrogen availability
- **Invasive plants may have a competitive advantage over regenerating oaks in stands with higher soil disturbance and nitrogen availability**

What does ***forest soil health*** mean for promoting tree regeneration?

Thank you!

CAES
The Connecticut Agricultural Experiment Station

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Jabba the Cut

Species	*TPA*	*Total # of Stems*	*Avg. DBH*	*Volume/acre (MBf)*	*Total Volume (MBf)*
Hemlock	15.6	196	18	24.5	45.1
Black Oak	8.7	110	18	14.0	24.6
White Oak	8.7	110	15	9.4	12.6
Red Oak	4.3	54	18	6.5	11.8
White Pine	3.3	41	15	3.9	7.3
Red Maple	6.2	78	14	5.9	6.2
Black Birch	3.3	41	15	3.3	3.7
Yellow Birch	2.3	29	14	2.3	2.1
Ash	0.2	3	15	0.3	0.5
Black Cherry	0.5	6	14	0.4	0.4
Shagbark Hickory	0.1	1	13	0.1	0.1
TOTAL	**53.1**	**669**	**169**	**70.6**	**114.3**

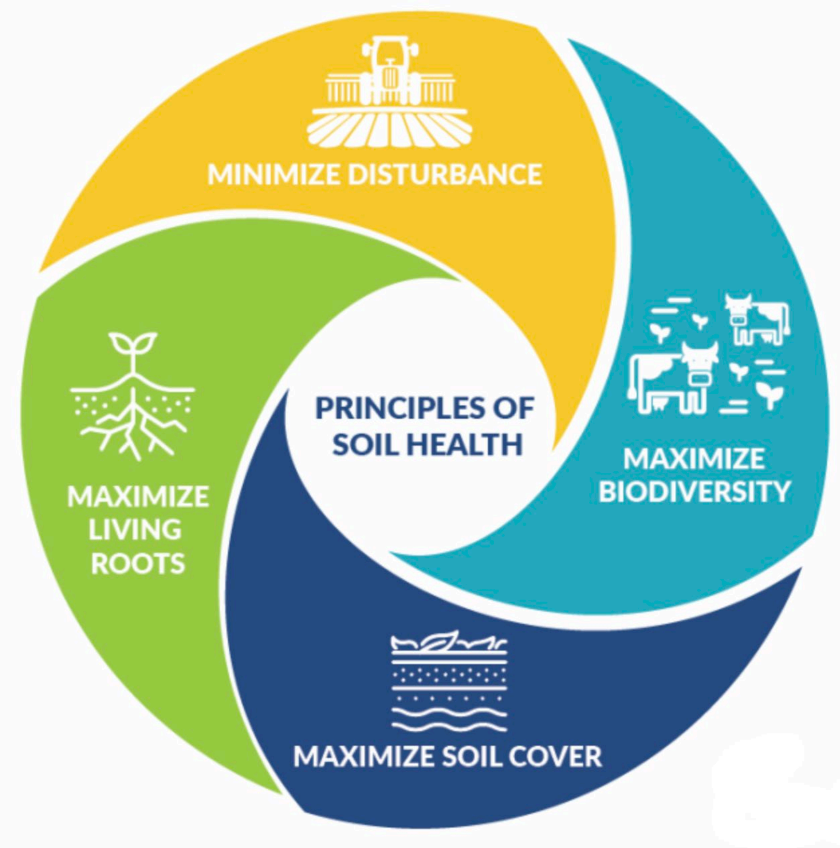
Princess Sophia

Species	# of stems	MBf
Red Oak	238	45.0
Black Oak	49	6.2
Scarlet Oak	0	0.0
White Oak	10	0.9
Sugar Maple	27	2.3
Red Maple	37	3.2
Black Cherry	5	0.3
Ash	4	0.8
Black Birch	44	3.1
Yellow Birch	0	0.0
Paper Birch	2	0.2
Shagbark Hickory	0	0.0
Other Hickory	0	0.0
Beech	4	0.3
Tulip Poplar	1	0.0
White Pine	31	5.5
Red Pine	0	0.0
Hemlock	289	31.9
TOTAL	**741**	**99.84**

What does ***forest soil health*** mean for promoting tree regeneration?

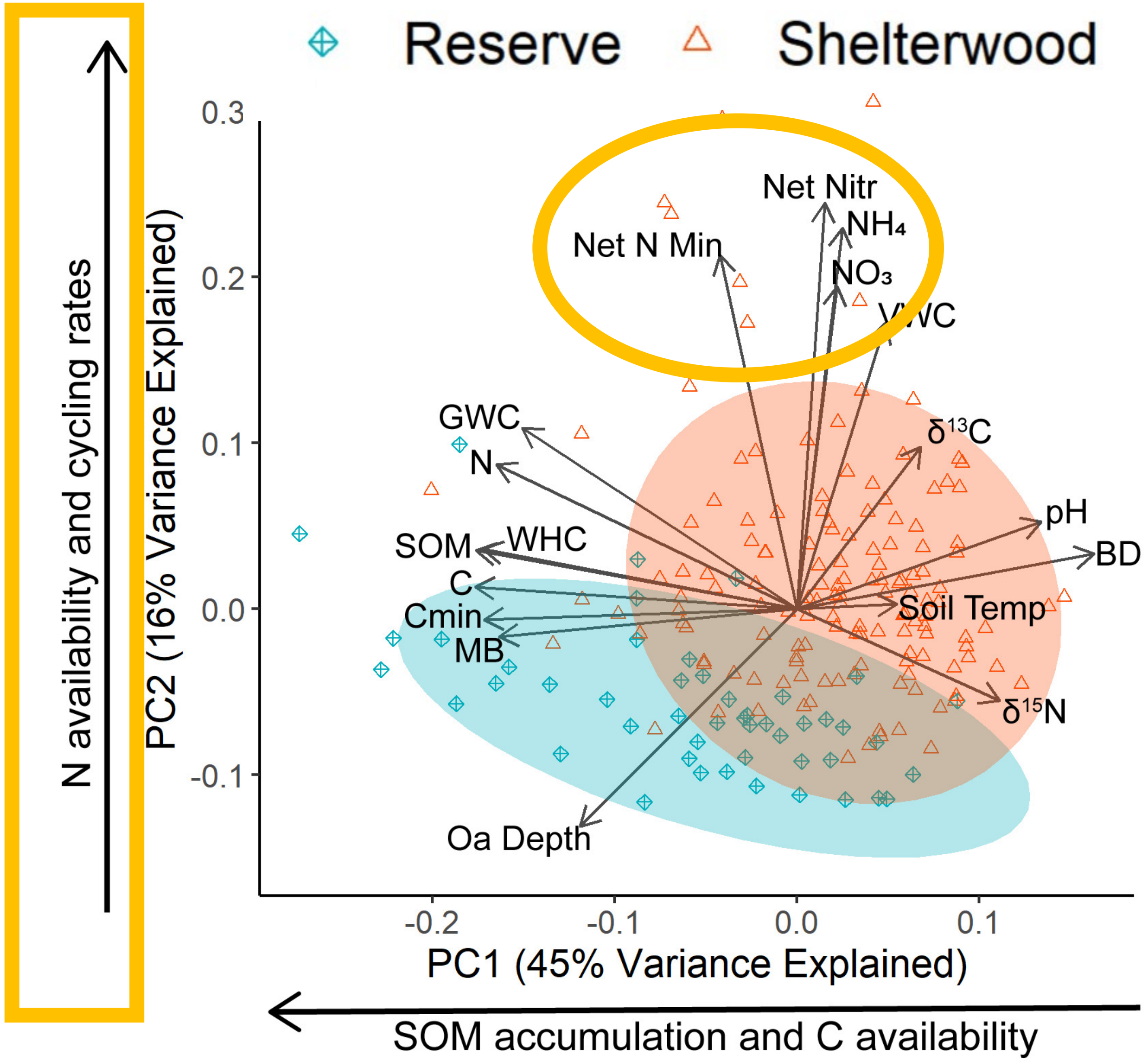
Continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans by performing five essential functions:

- Regulating water
- Sustaining plant and animal life
- Filtering and buffering potential pollutants
- Cycling nutrients
- Providing physical stability and support

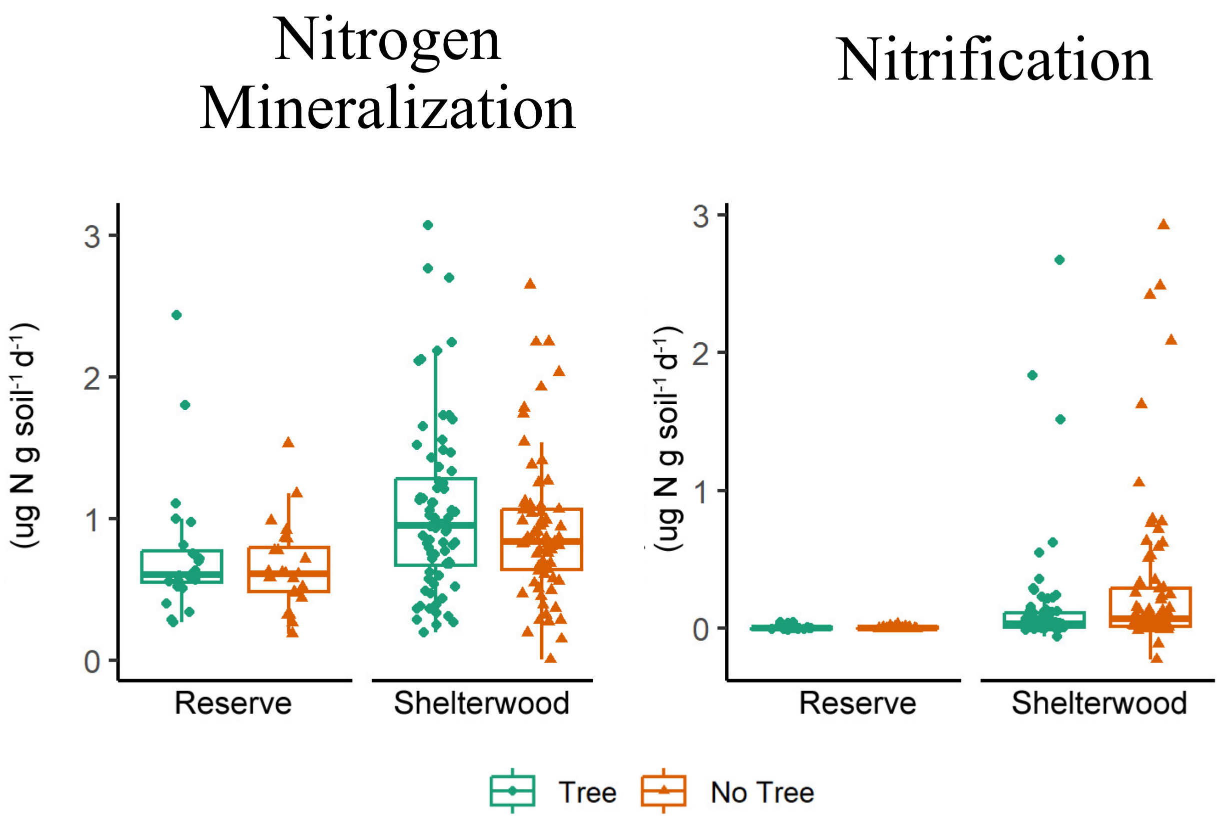


Source: https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health

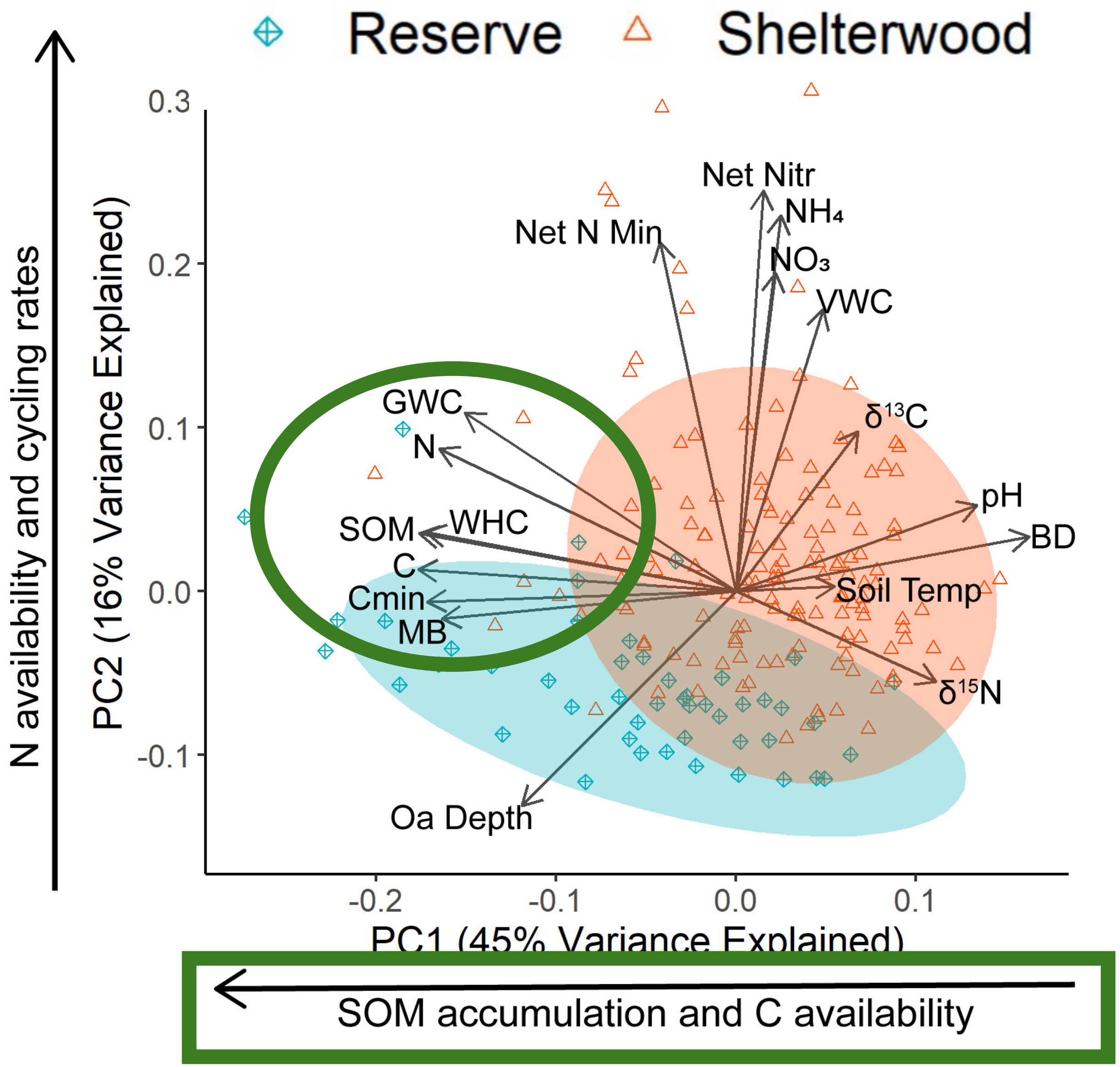
Surface soil conditions in shelterwood harvests vs. unharvested reserves



Surface soil nitrogen availability



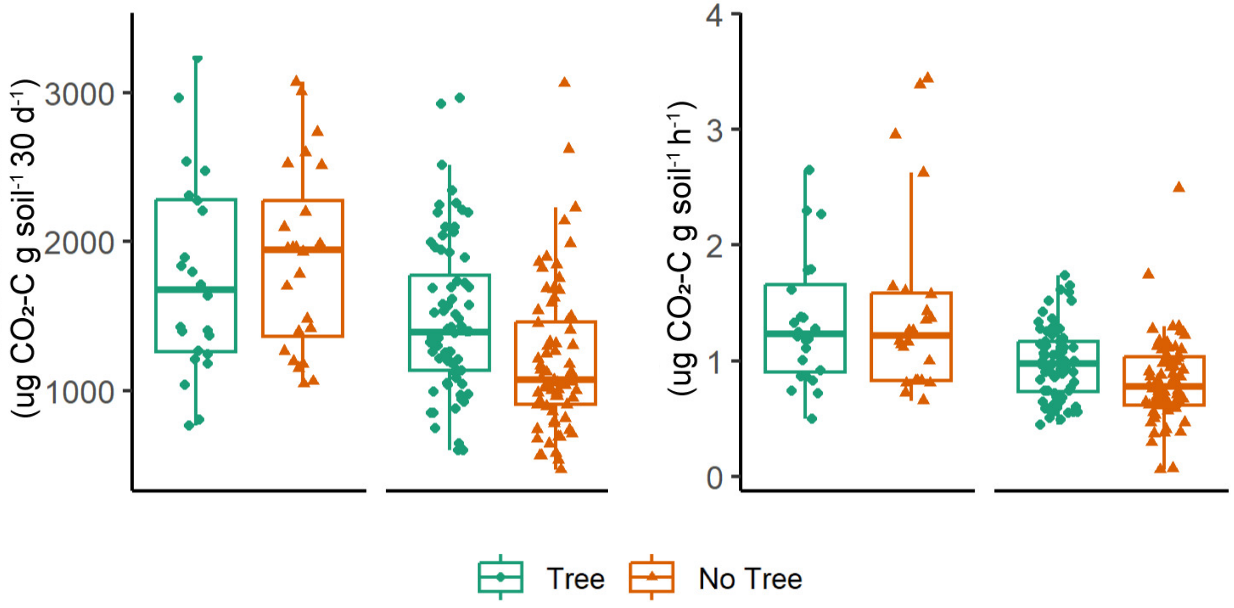
Surface soil conditions in shelterwood harvests vs. unharvested reserves



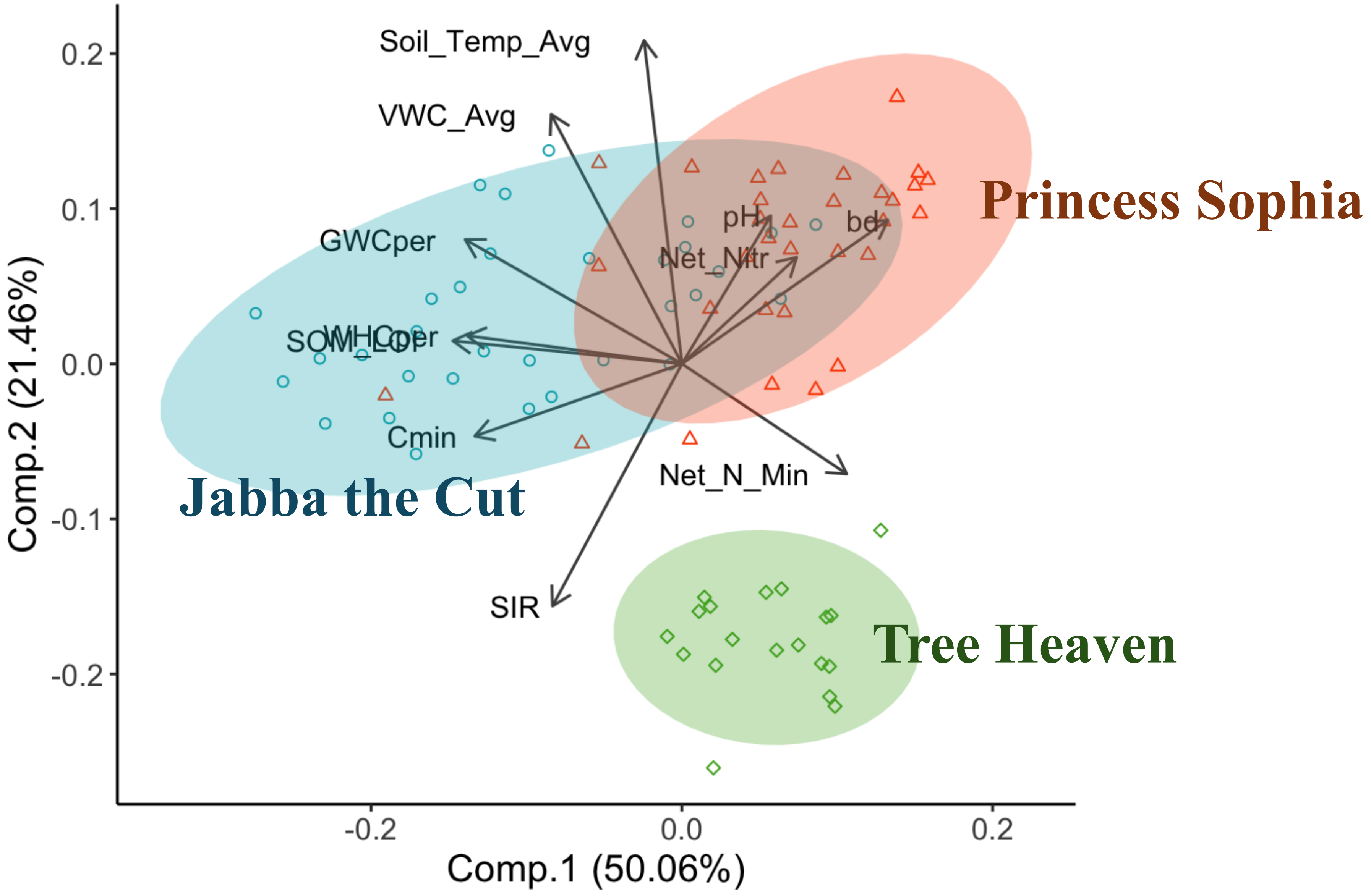
Surface soil carbon availability

Carbon Mineralization

Microbial Biomass



Differences in initial, post-harvest soil conditions between the three stands



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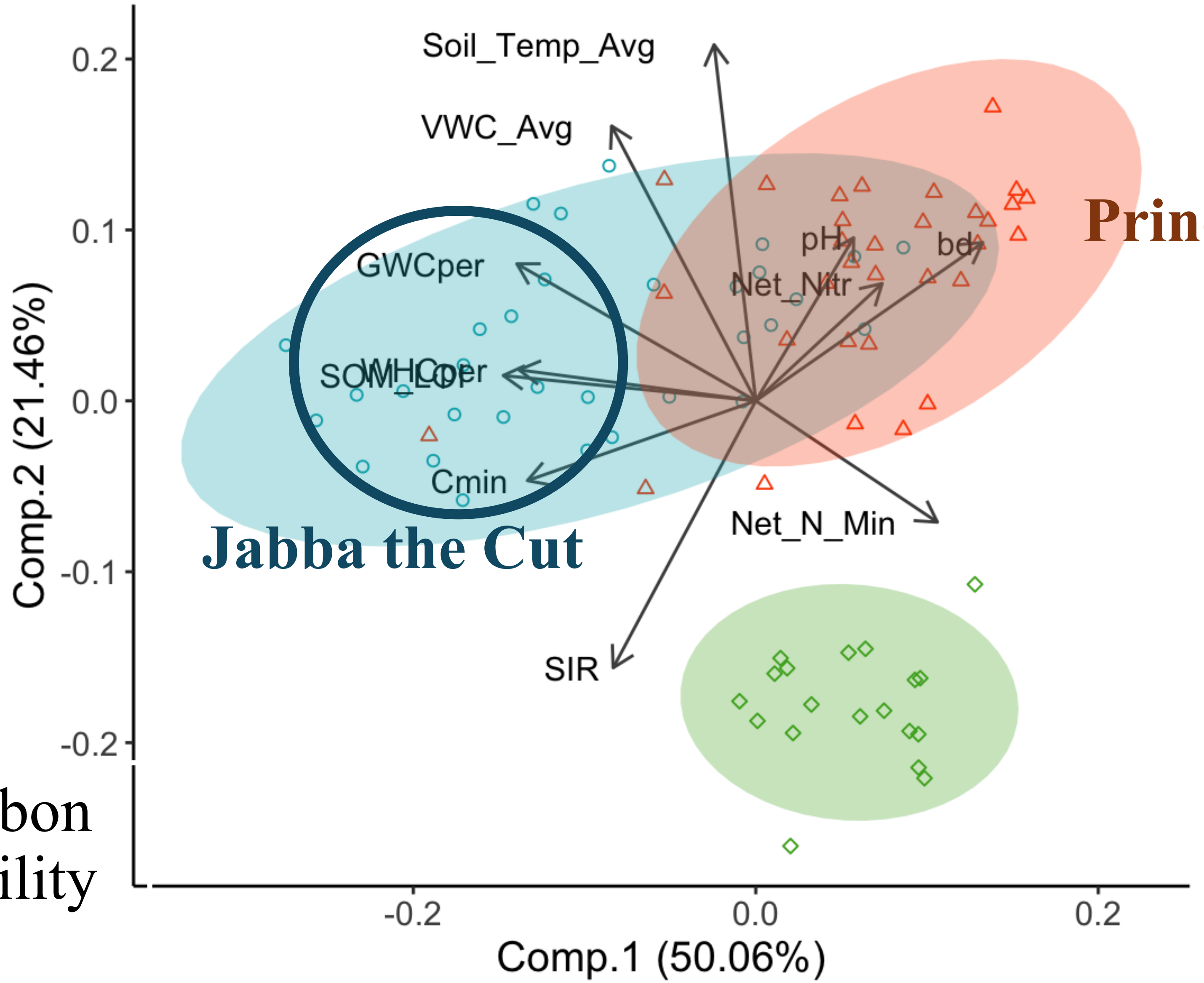
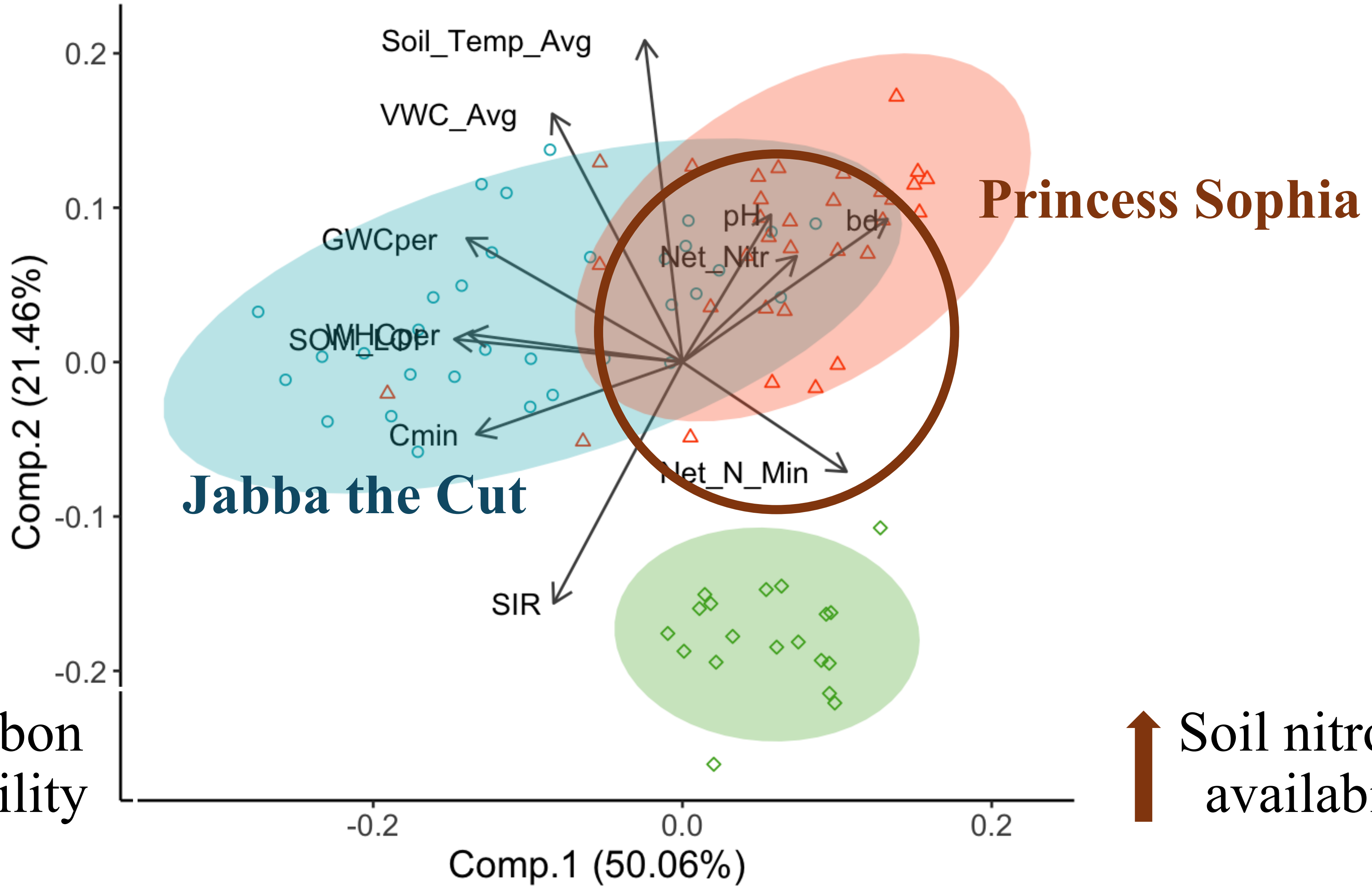


Soil carbon availability

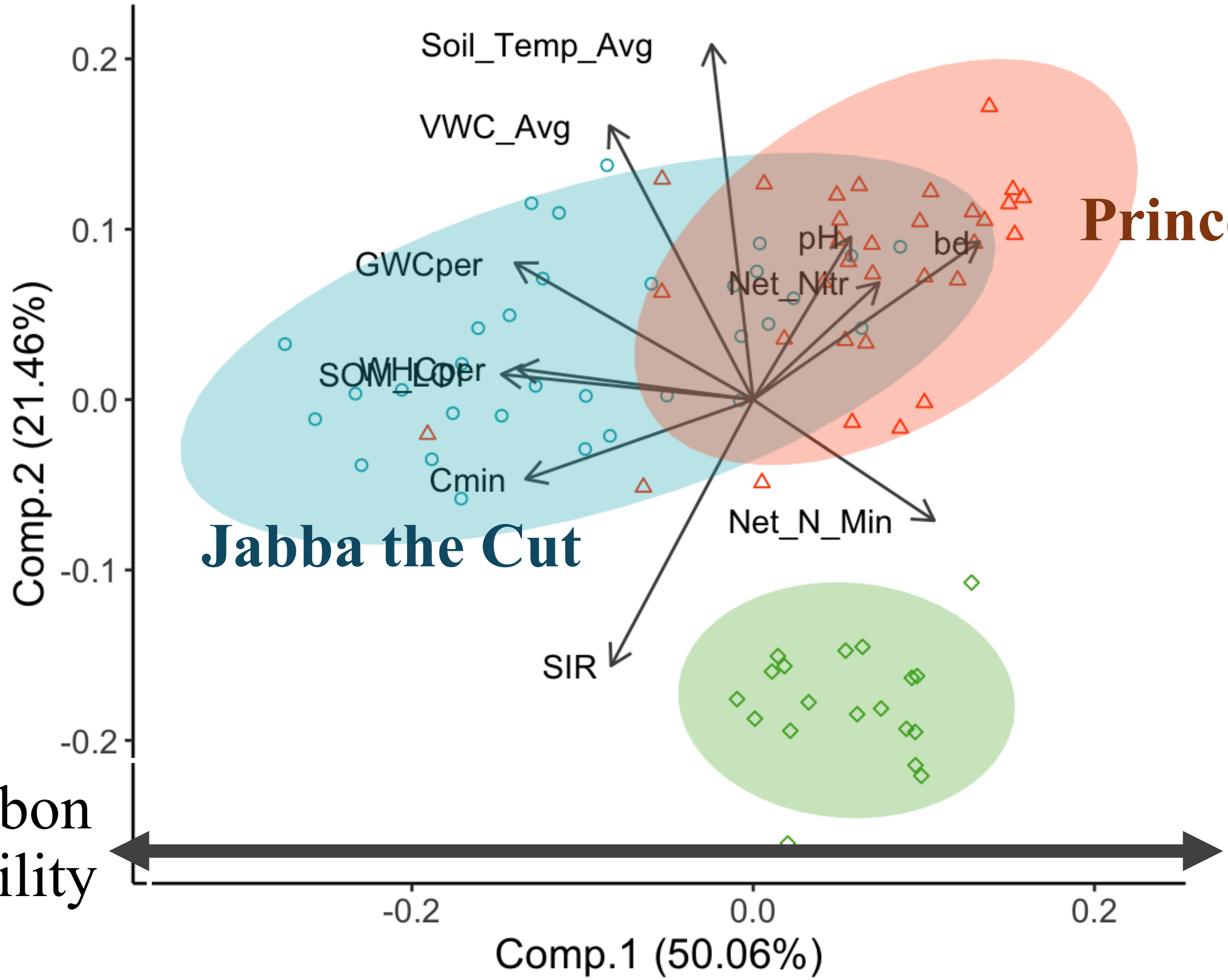
Differences in initial, post-harvest soil conditions between the three stands



↑ Soil carbon availability

↑ Soil nitrogen availability

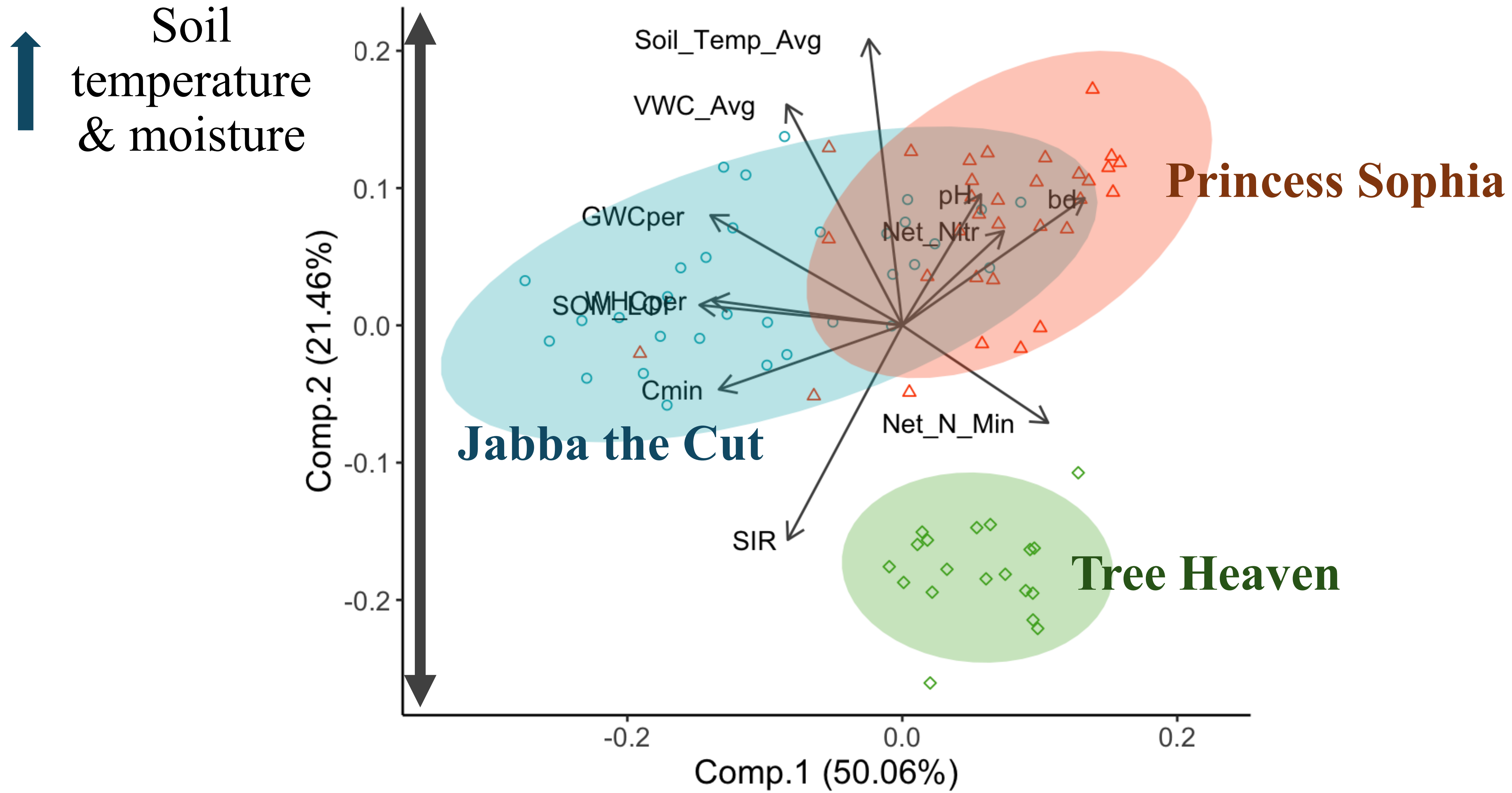
Differences in initial, post-harvest soil conditions between the three stands



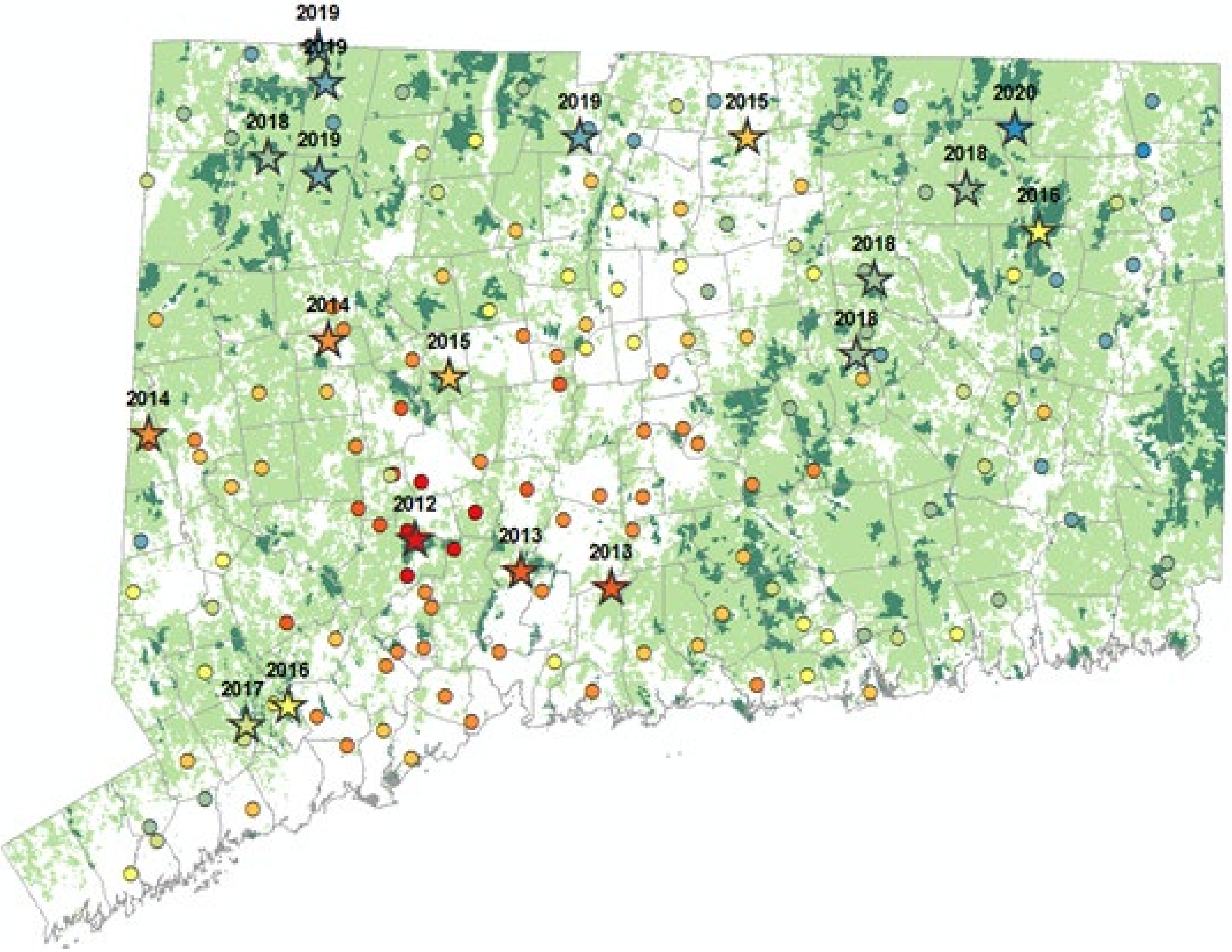
Soil carbon availability

Soil nitrogen availability

Differences in initial, post-harvest soil conditions between the three stands



How will understory plant communities and tree regeneration respond to ash tree mortality from emerald ash borer invasion?



How will overstory tree mortality from forest pest and pathogen invasions alter understory plant composition and tree regeneration?