The effects of timber harvesting on tick densities and small mammal foraging behavior and abundance

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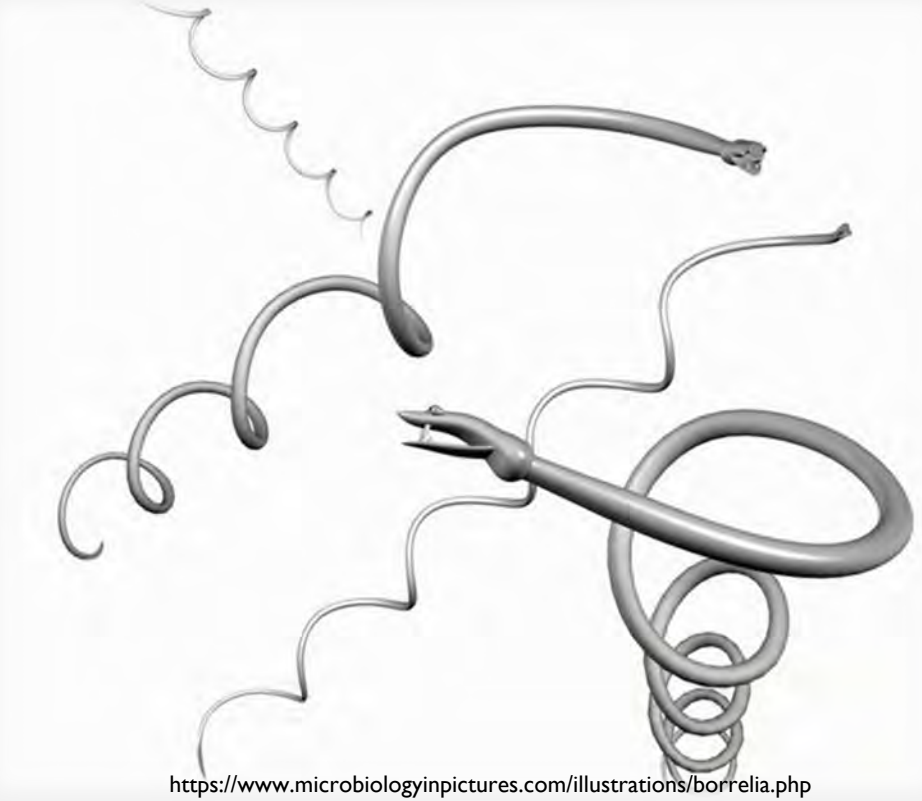
ACKNOWLEDGEMENTS

I would like to thank Dr. Allison Gardner and all members of the Gardner Lab for their help and support, including the invaluable Alyssa Marini and my exceptional technicians, Rose Crispin, Jocelyn Ferraro, Danielle Donadio, and Braedon Stevens. I would also like to thank the landowners and foresters in southern Maine for granting me access to their land and providing me with land management histories. I am also grateful for my sources of funding from USDA-NIFA award #ME012450318 and Hatch award #ME021905.

BACKGROUND

http://bio.pisceswebdesign.com/species/ixodes-scapularis

Ixodes scapularis



https://www.microbiologyinpictures.com/illustrations/borrelia.php

Borrelia burgdorferi

BACKGROUND

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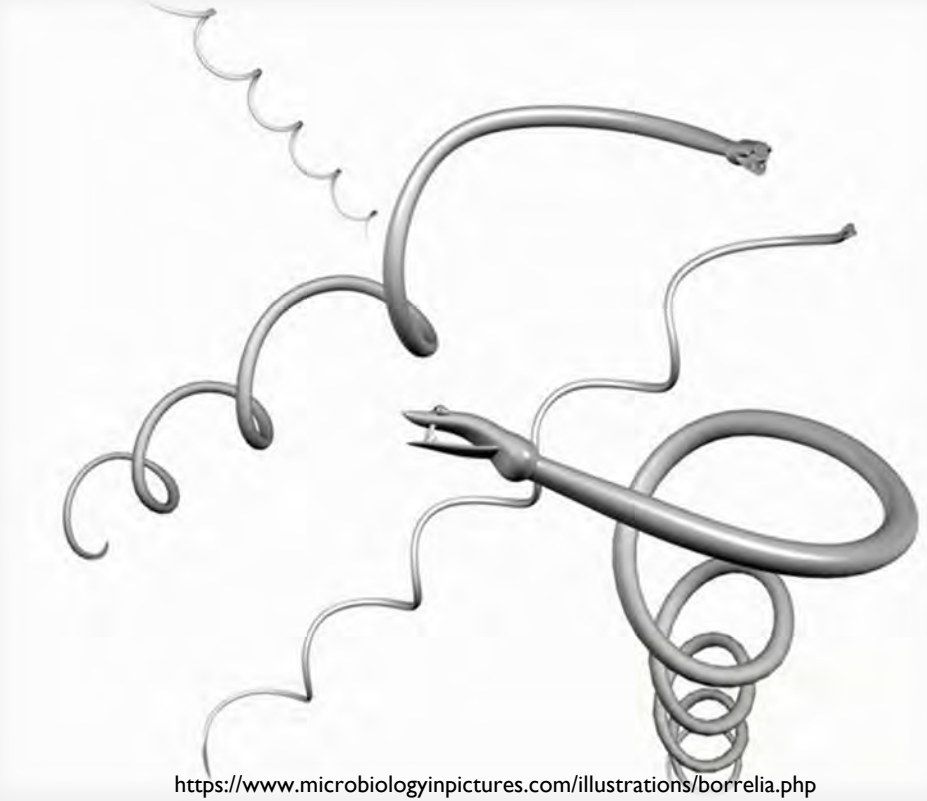
Ixodes scapularis

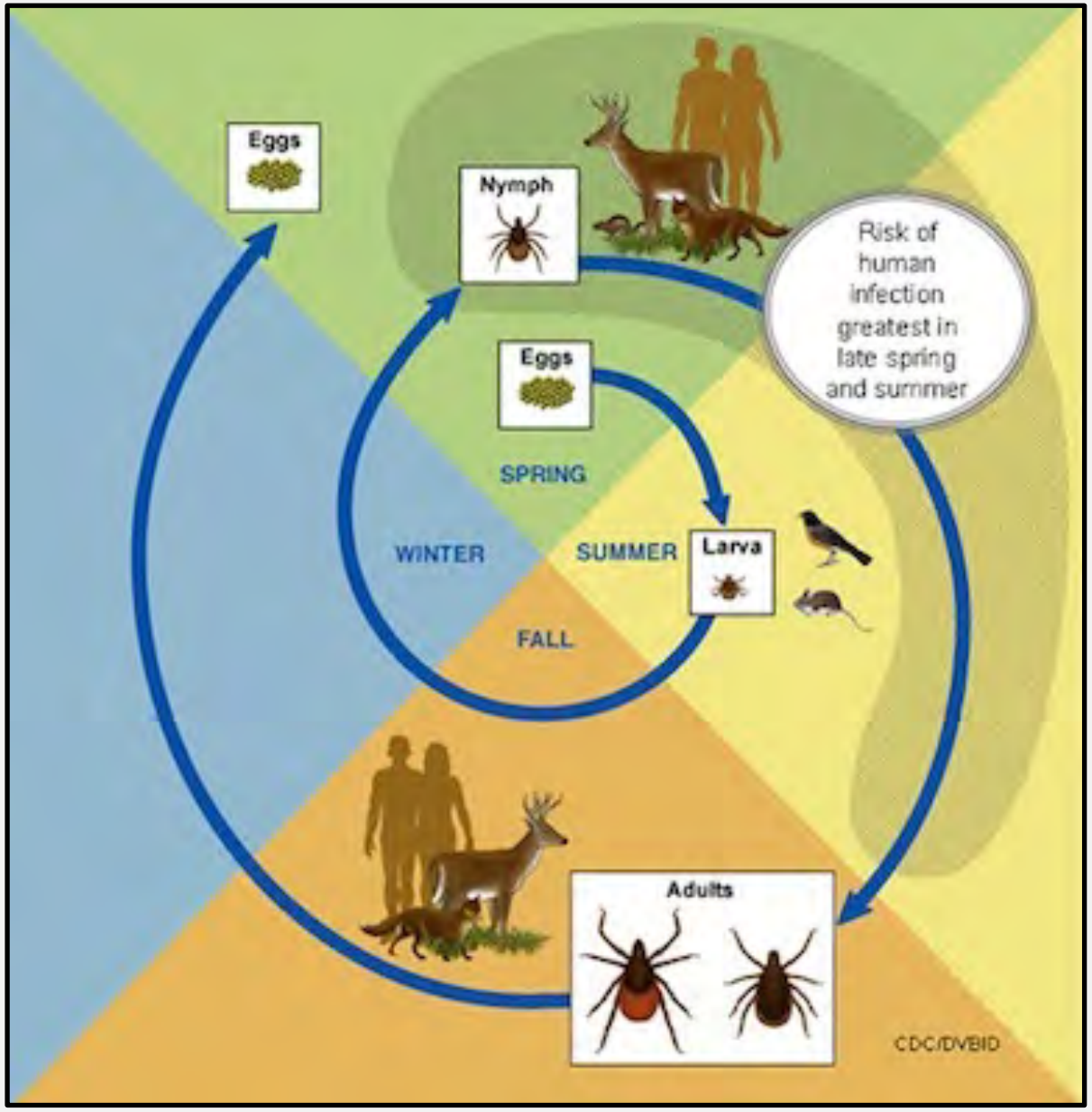


https://www.microbiologyinpictures.com/illustrations/borrelia.php

Borrelia burgdorferi

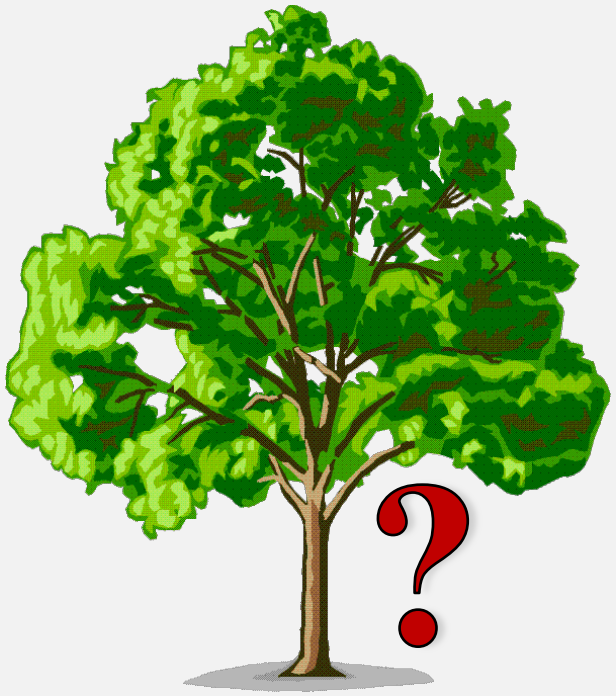
Most commonly occurring vector-borne disease: 30,000 cases/year[1]

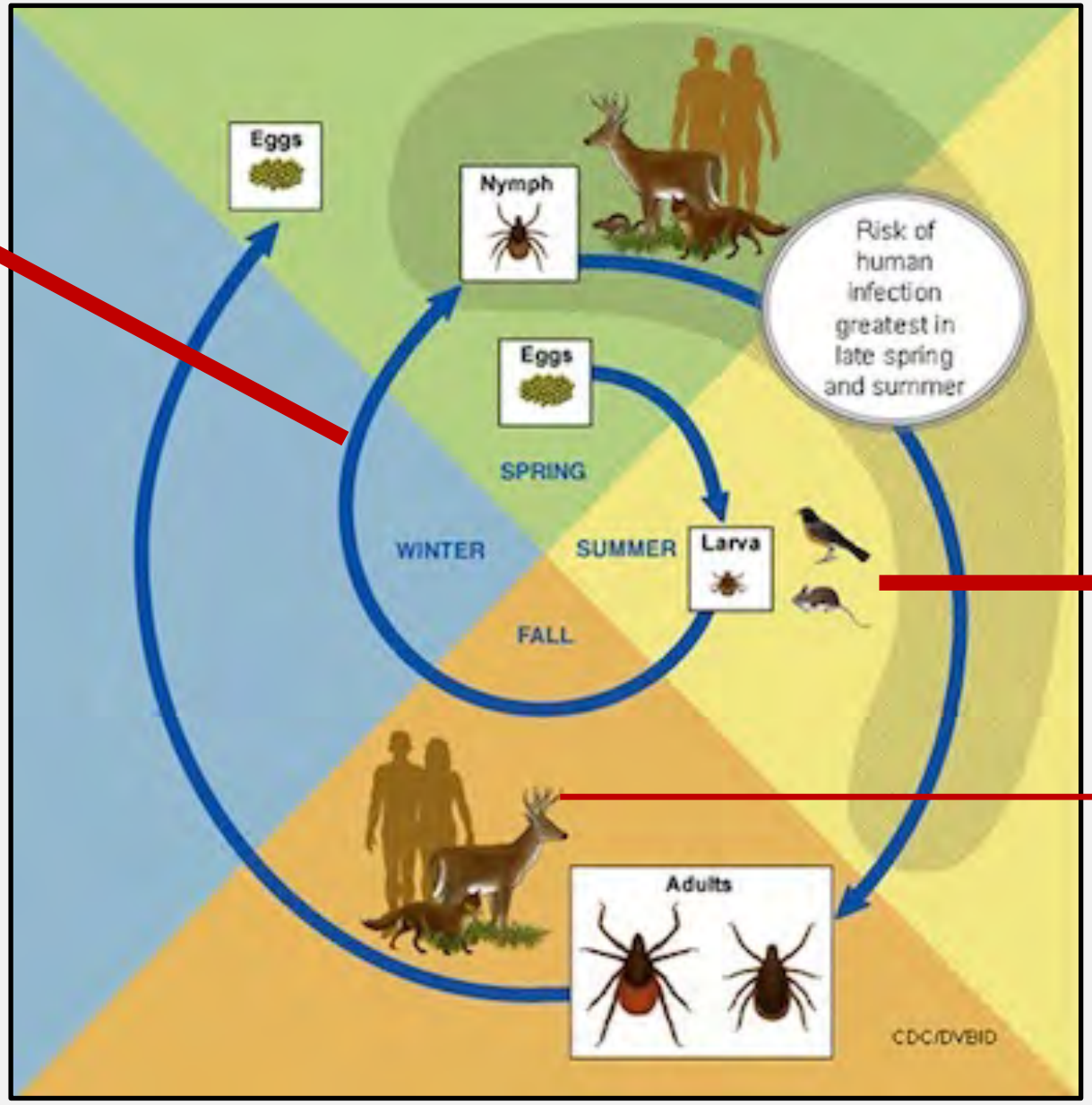
[1]"Data and Surveillance | Lyme Disease | CDC." *Centers for Disease Control and Prevention,* 2022


Eggs
Nymph
Risk of human infection greatest in late spring and summer
Eggs
SPRING
WINTER
SUMMER
Larva
FALL
Adults
CDC/DVBID

Survival in leaf litter

- Temperature
- Moisture



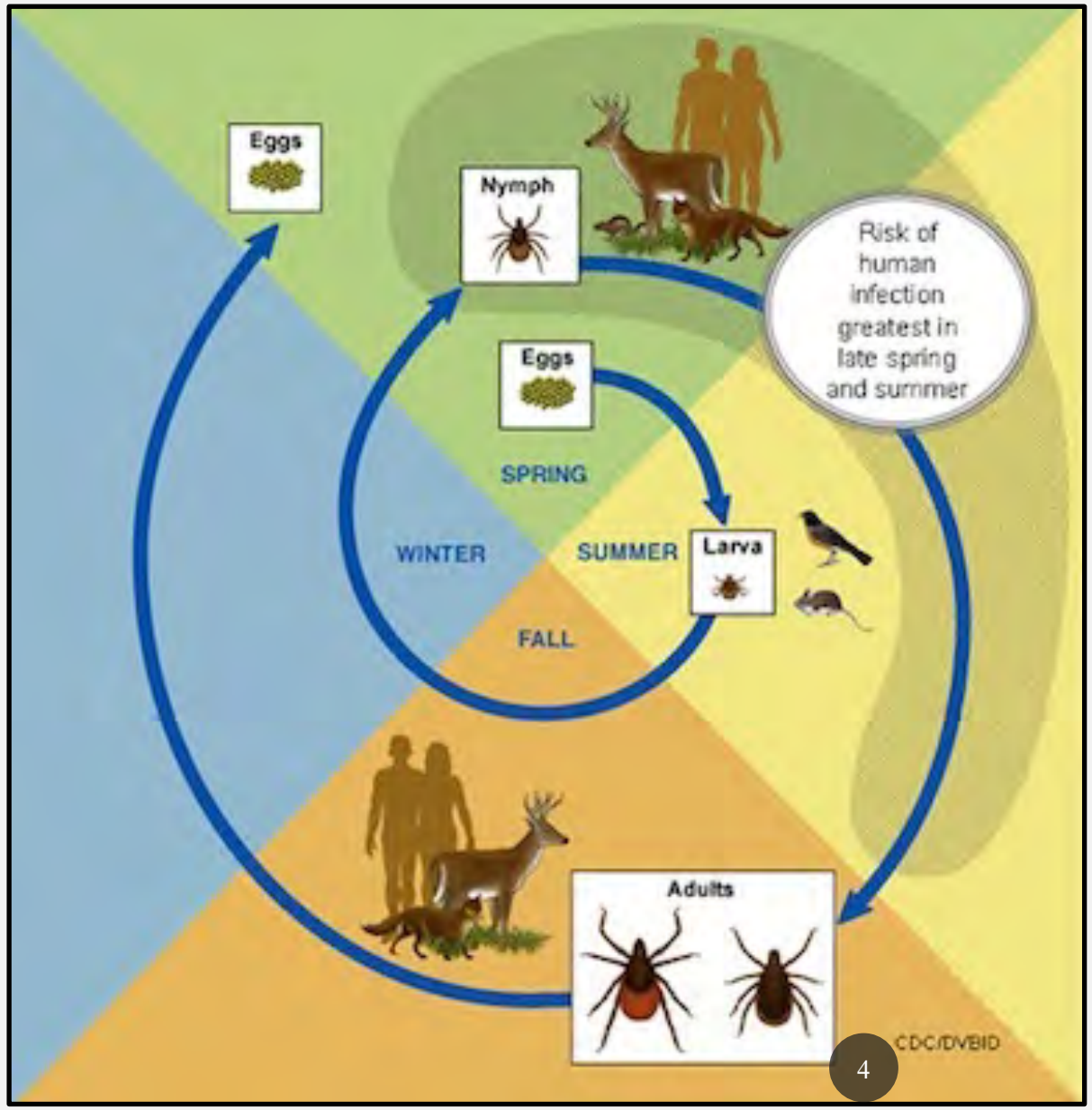


Host activity

Prescribed burns

Removal of invasive plants

Active Forest Management



Prescribed burns

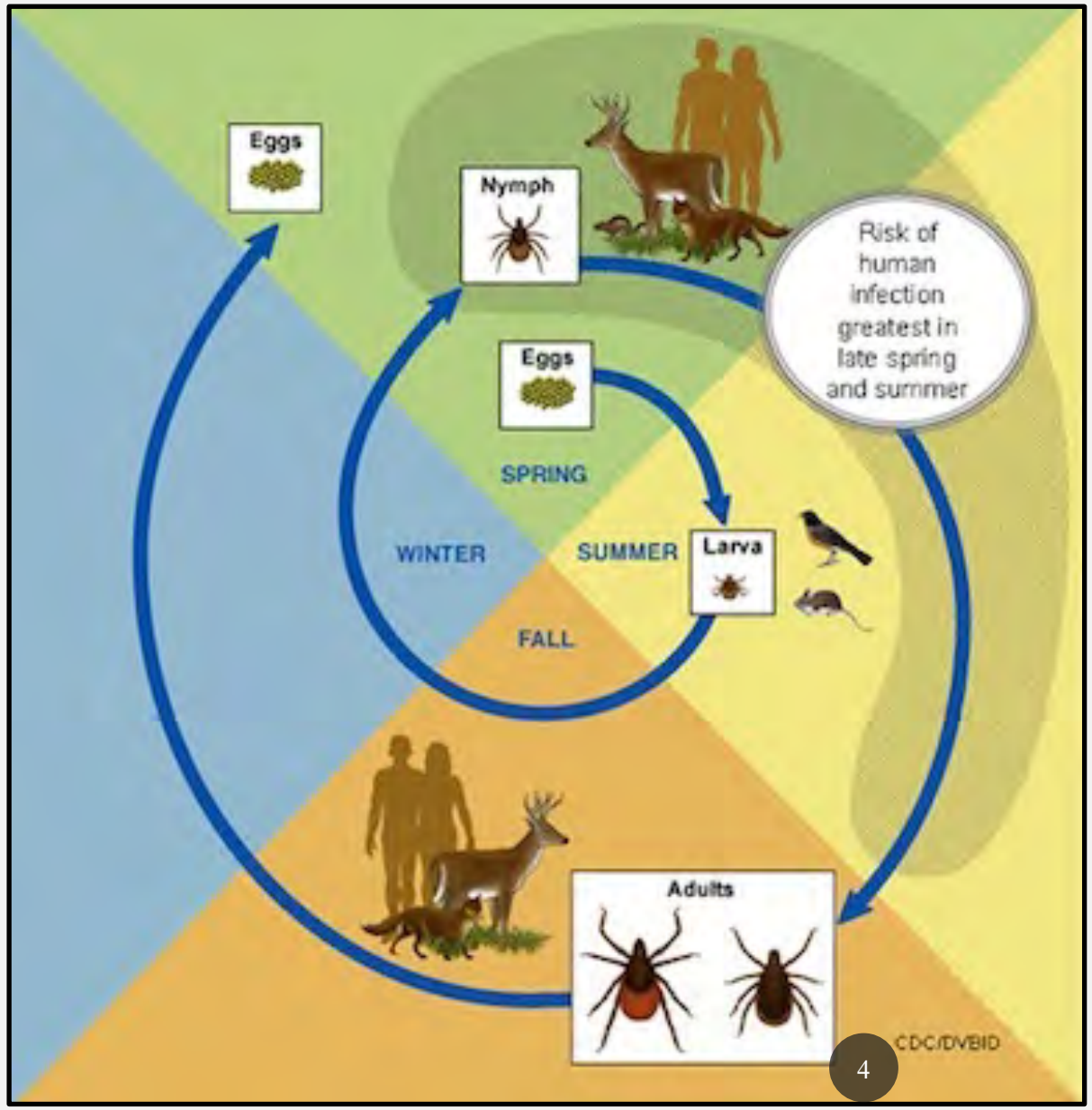
Removal of invasive plants

Active Forest Management

?

Timber Harvesting

Forest Structure



GOAL: How does forest structure affect *I. scapularis* densities?

OBJECTIVES

Determine how forest structure affects:


Tick abundance


Overstory & understory


Leaf litter


Microhabitat temperature & humidity


Daily deer activity

GOAL: How does forest structure affect *I. scapularis* densities?

OBJECTIVES

Determine how forest structure affects:

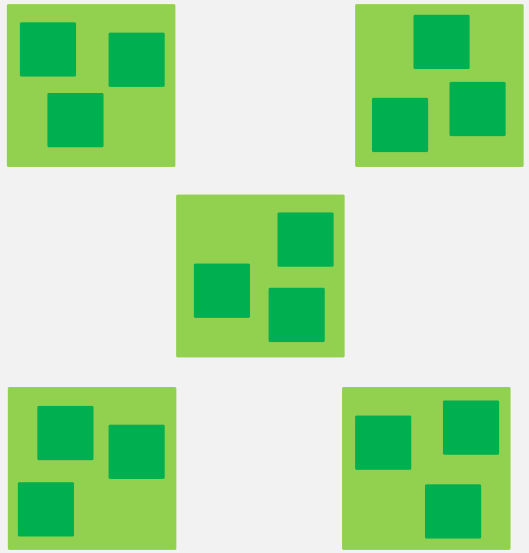
PATTERN →  Tick abundance

MECHANISMS

-  Overstory & understory
-  Leaf litter
-  Microhabitat temperature & humidity
-  Daily deer activity

EXPERIMENTAL DESIGN

15 properties total



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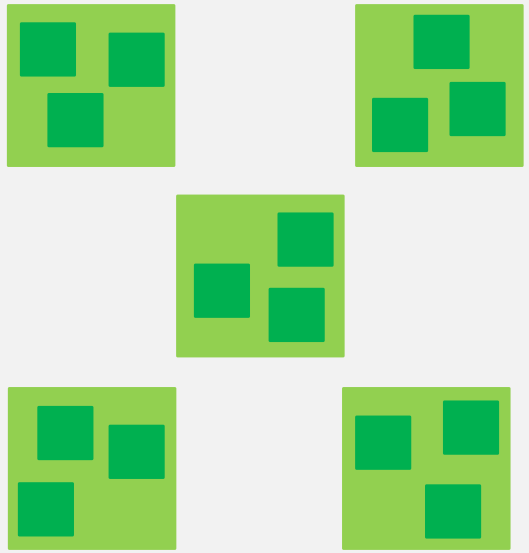
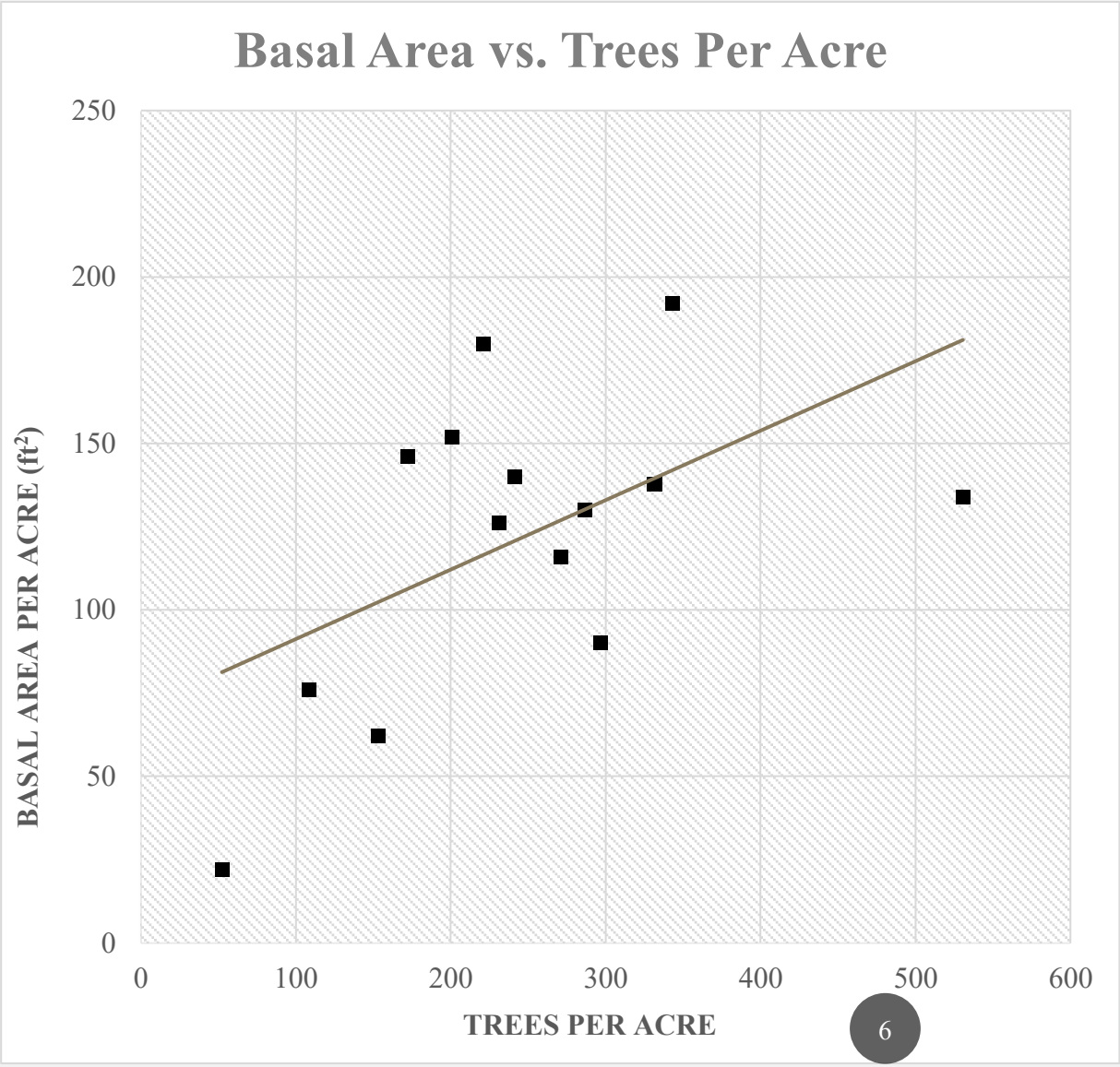


Stand structure



DATA COLLECTION

Drag sampling – tick density, 70m X 70m grid

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Microclimate – iButton (leaf litter)

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Microclimate – iButton (leaf litter)

Wildlife Community – Large mammals: trail cameras

DATA COLLECTION

Drag sampling – tick density, 70m X 70m grid

Microclimate – iButton (leaf litter)

Wildlife Community – Large mammals: trail cameras

Forestry

- Canopy closure
- Leaf litter depth & cover
- Sapling sampling

RESULTS
Tick Collection

Blacklegged Tick
(*Ixodes scapularis*)

American Dog Tick
(Dermacentor variabilis)

Rabbit Tick
(*Haemaphysalis leporispalustris*)

RESULTS
Tick Collection

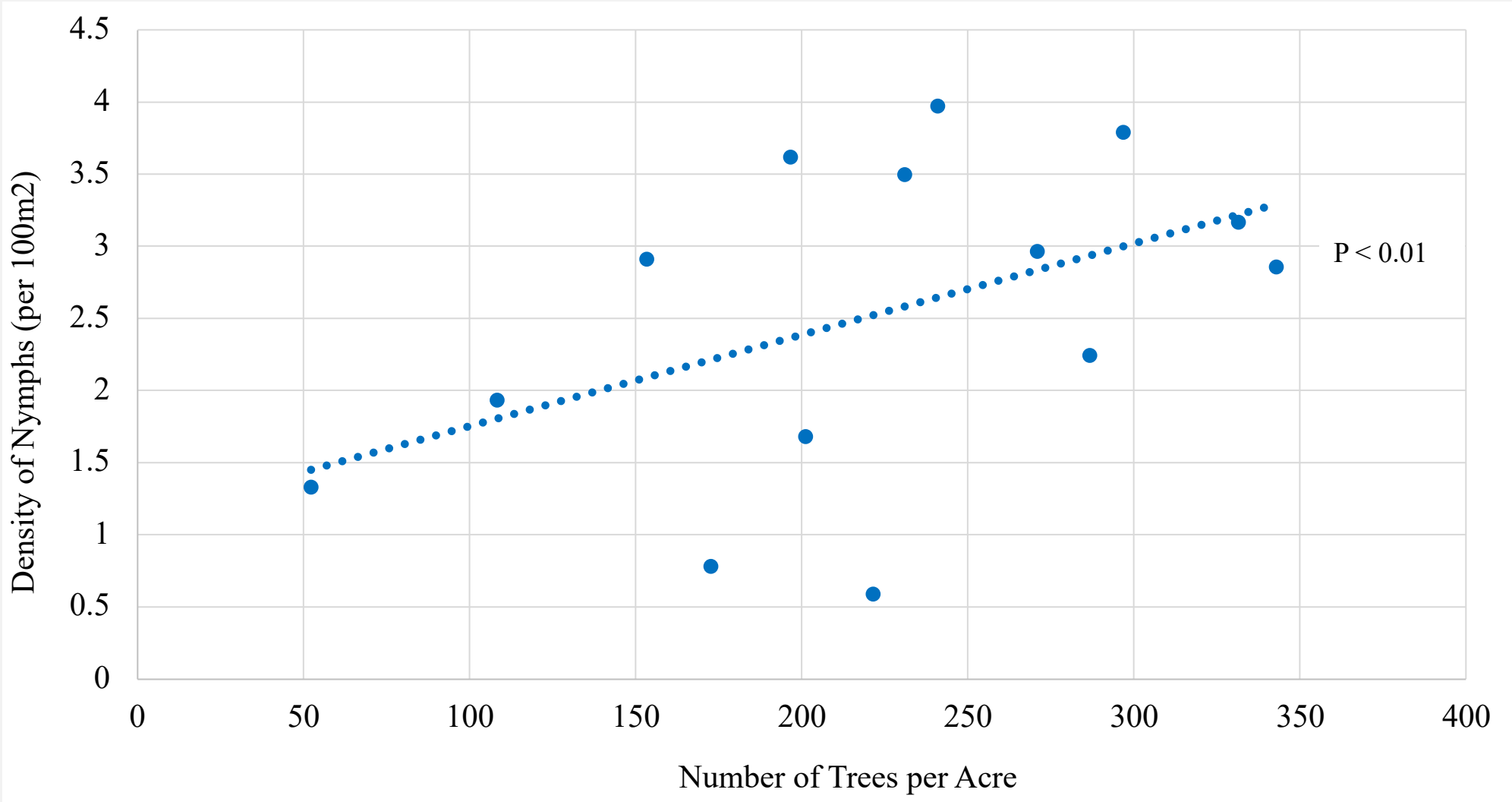
Blacklegged Tick
(*Ixodes scapularis*)

2,266 total

American Dog Tick
(Dermacentor variabilis)

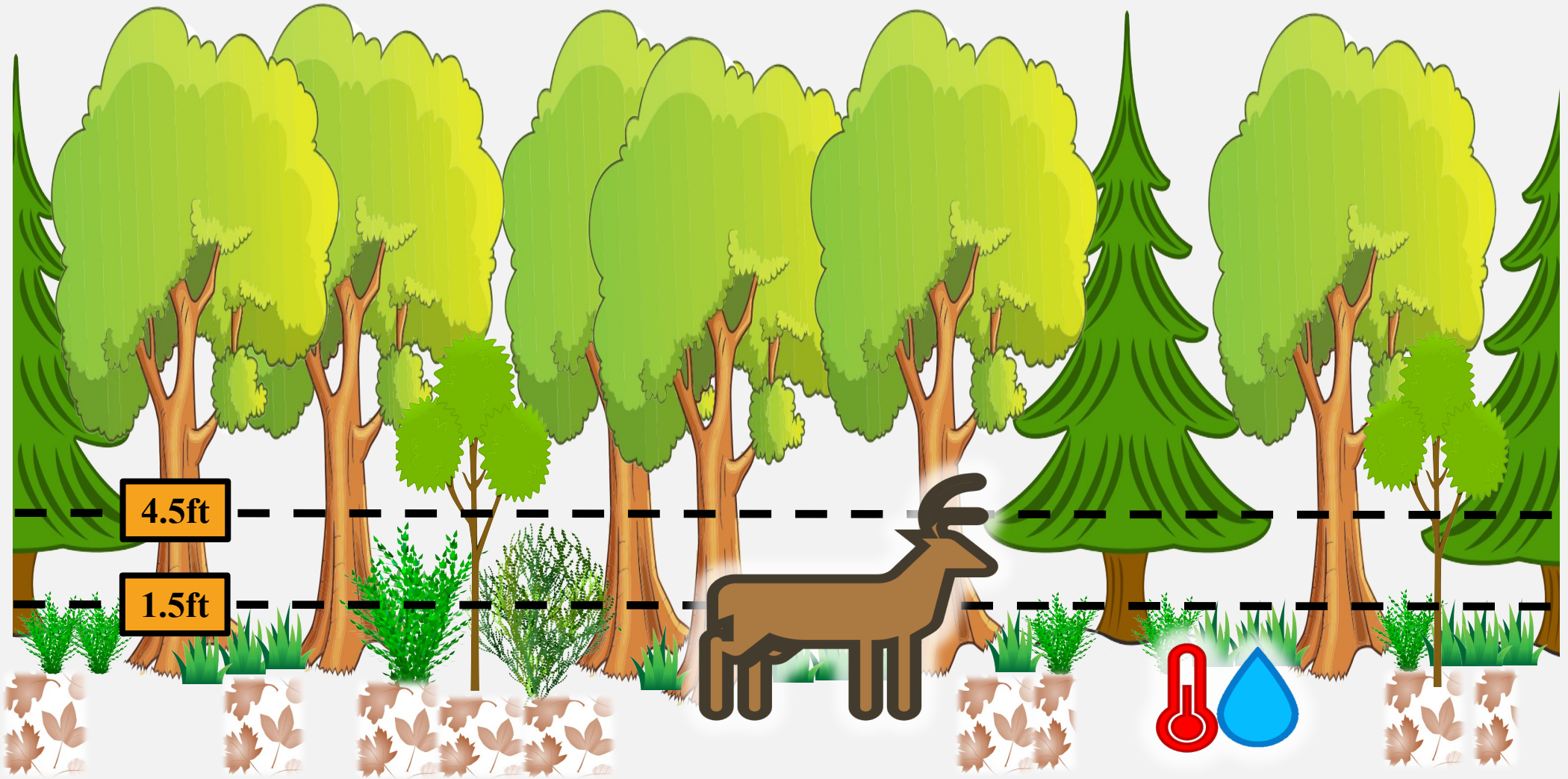
Rabbit Tick
(*Haemaphysalis leporispalustris*)

ANALYSES
Tick Collection



(OBJECTIVE **1**: Determine how forest stand structural attributes affect tick abundance)

MECHANISMS



(OBJECTIVES **2-5**: Determine how forest stand structural attributes affect overstory & understory, leaf litter, microhabitat, and deer)

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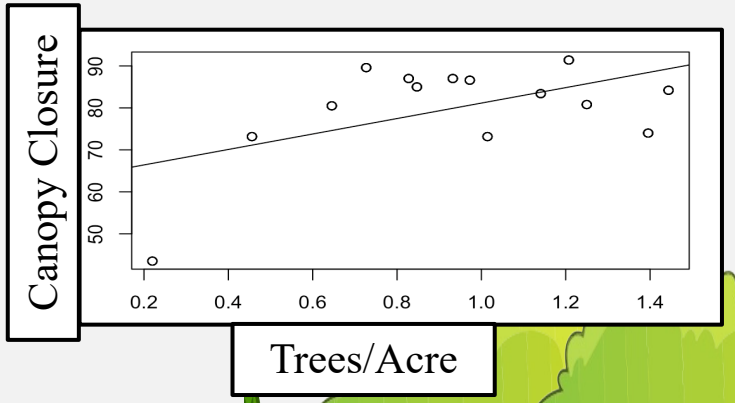

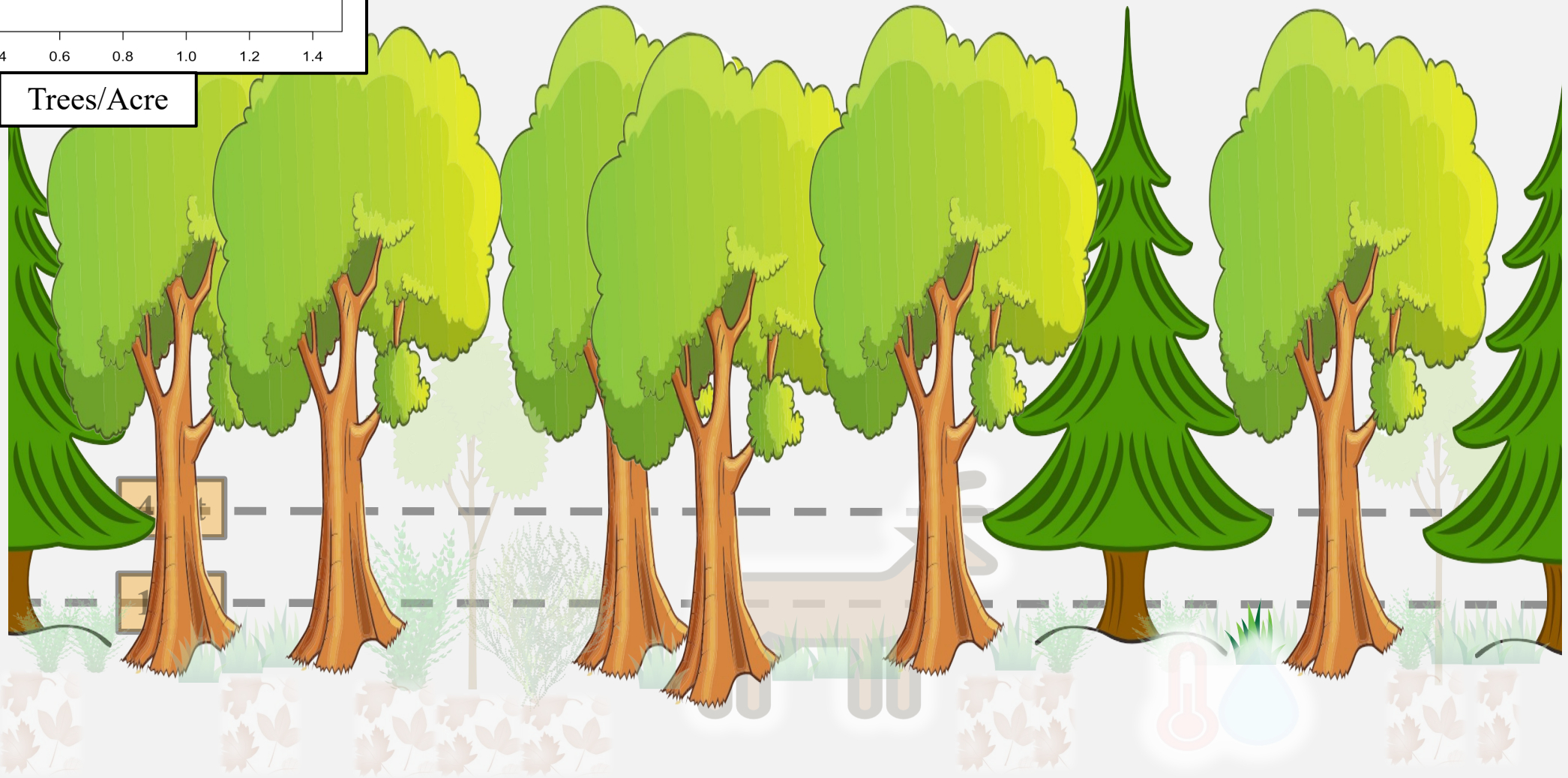

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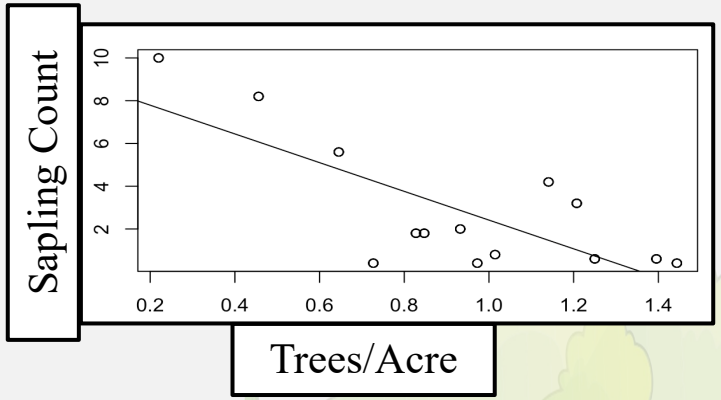

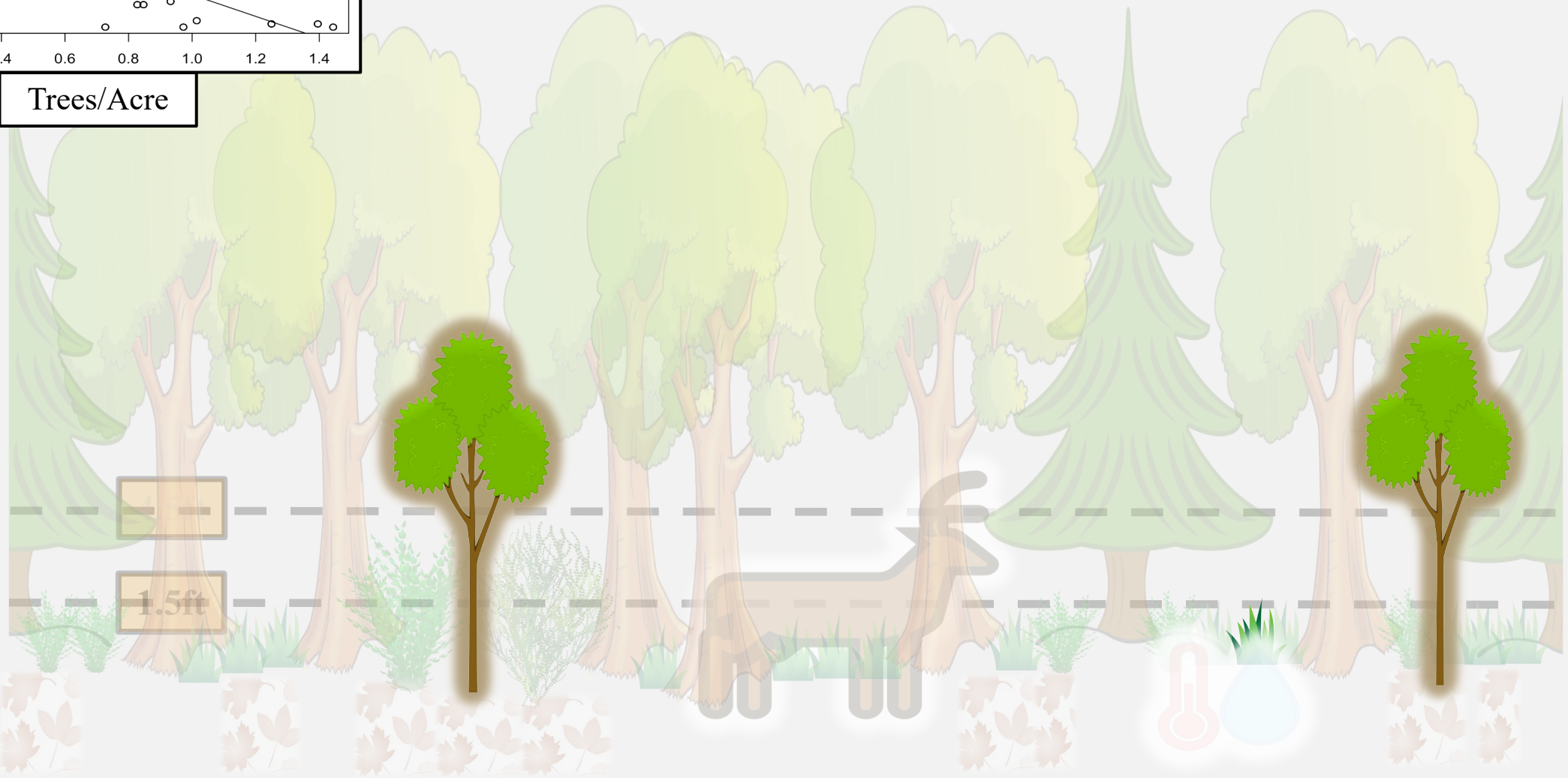

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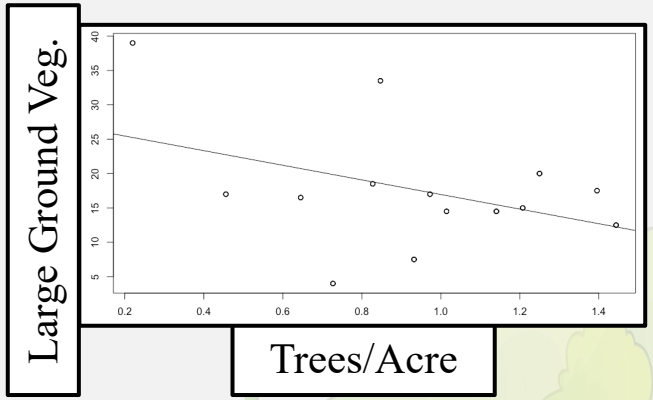

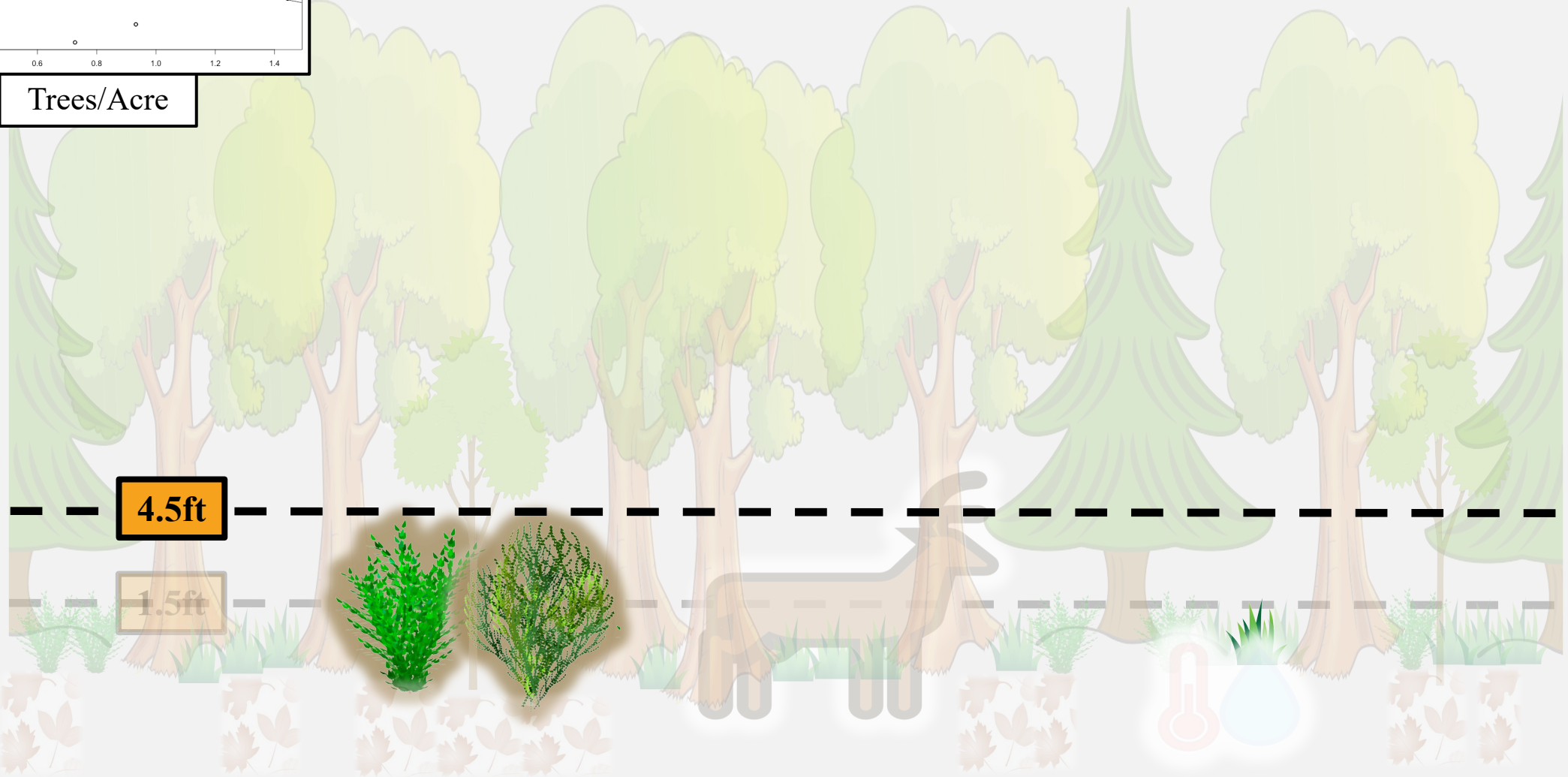

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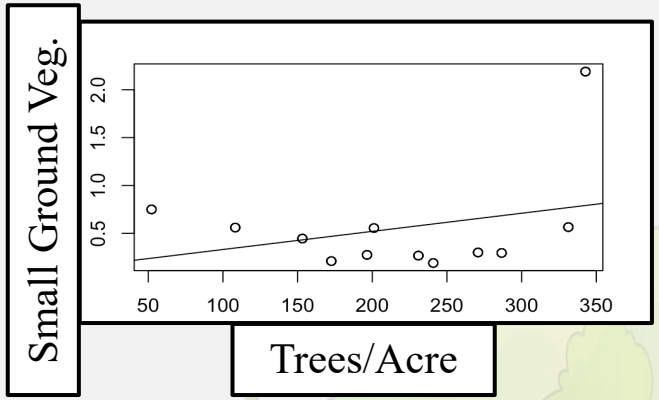

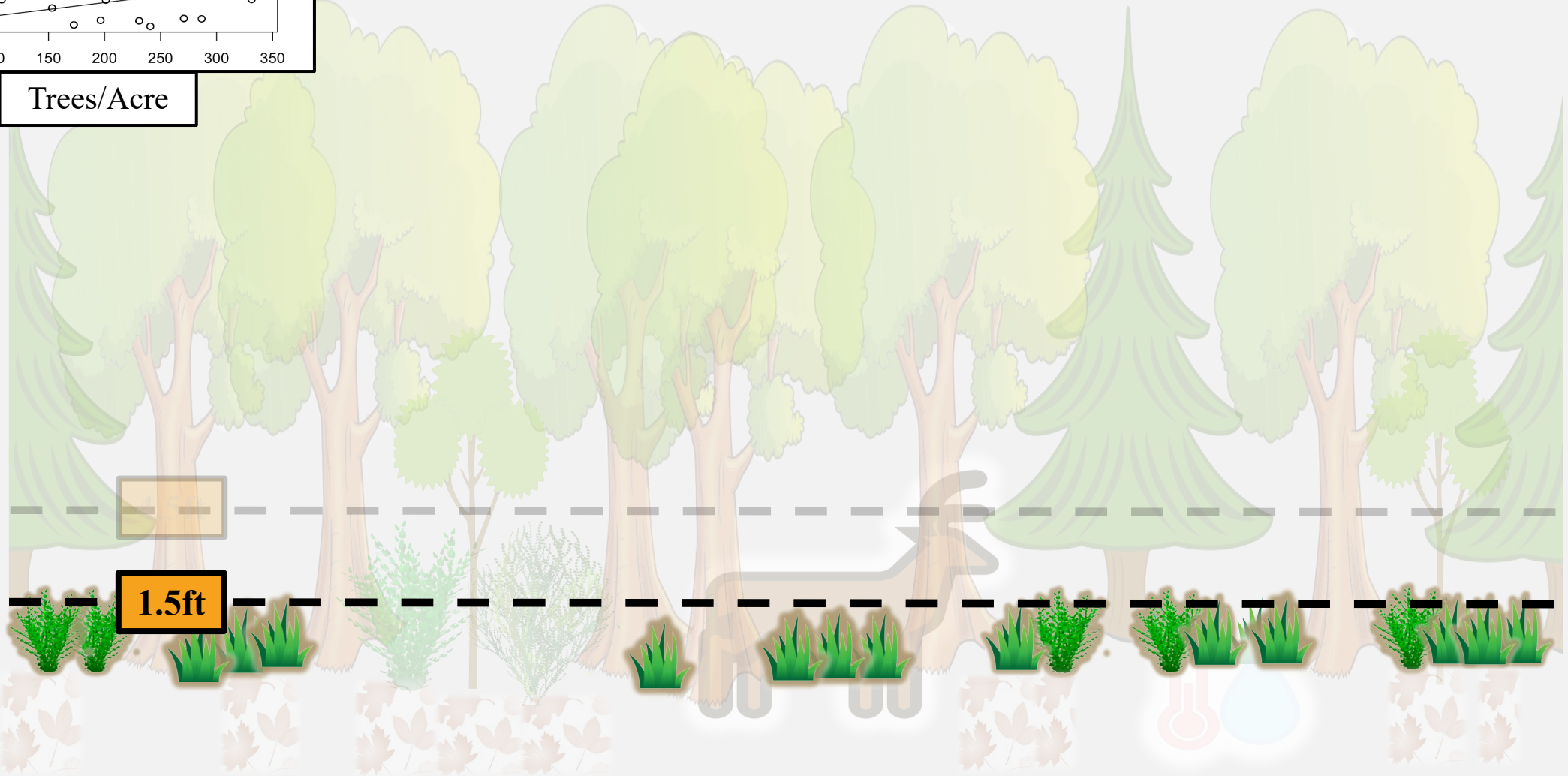

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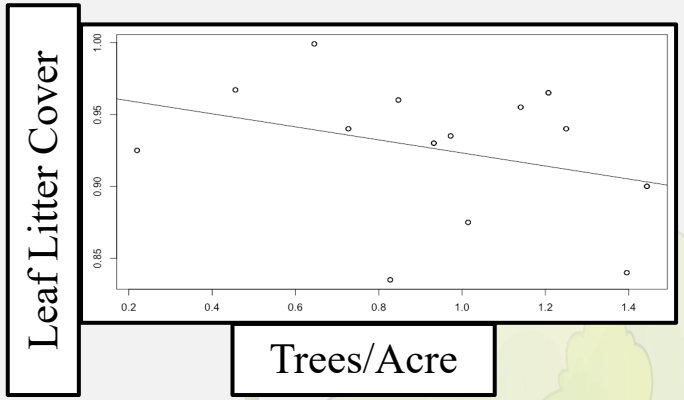

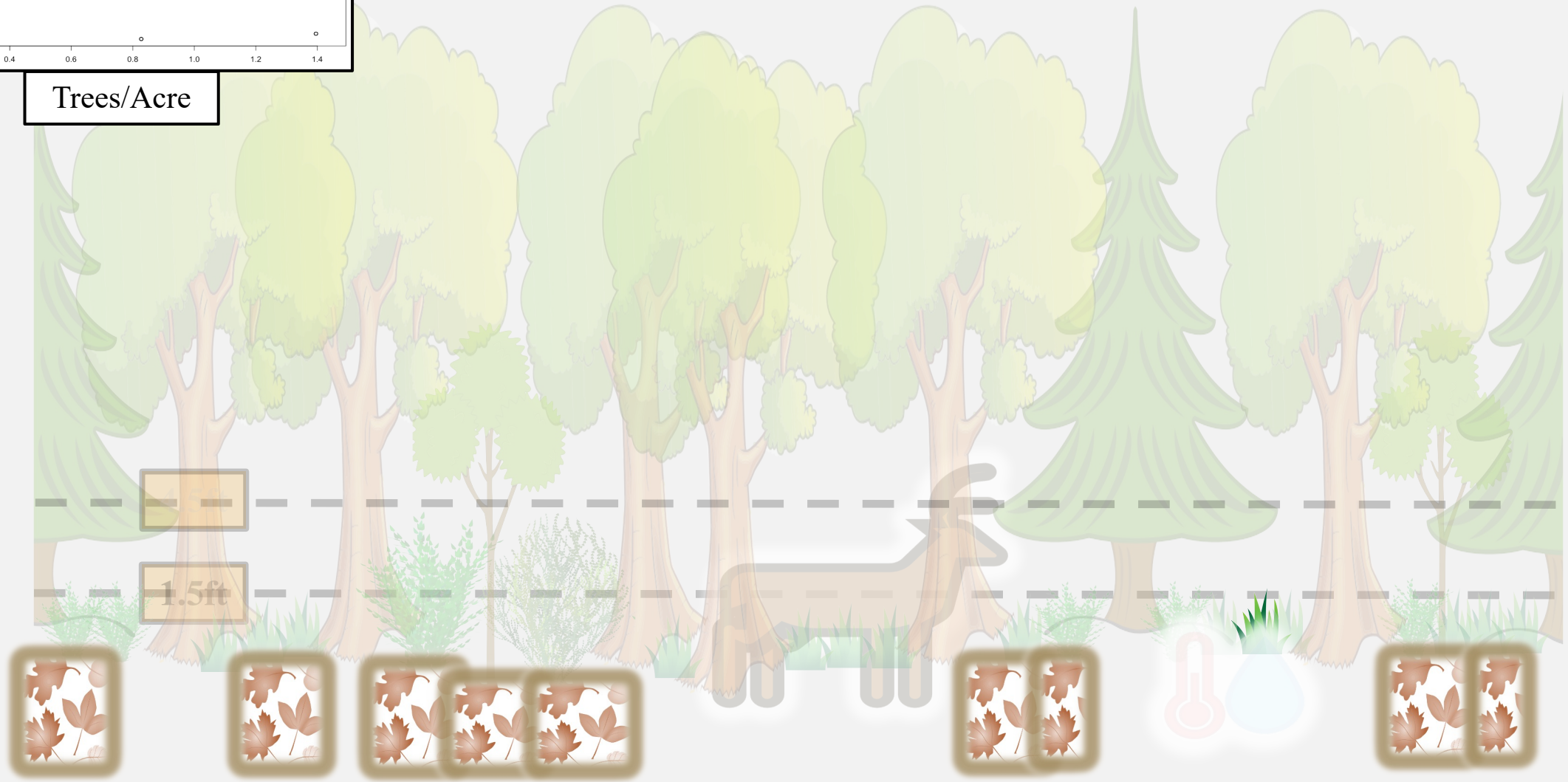

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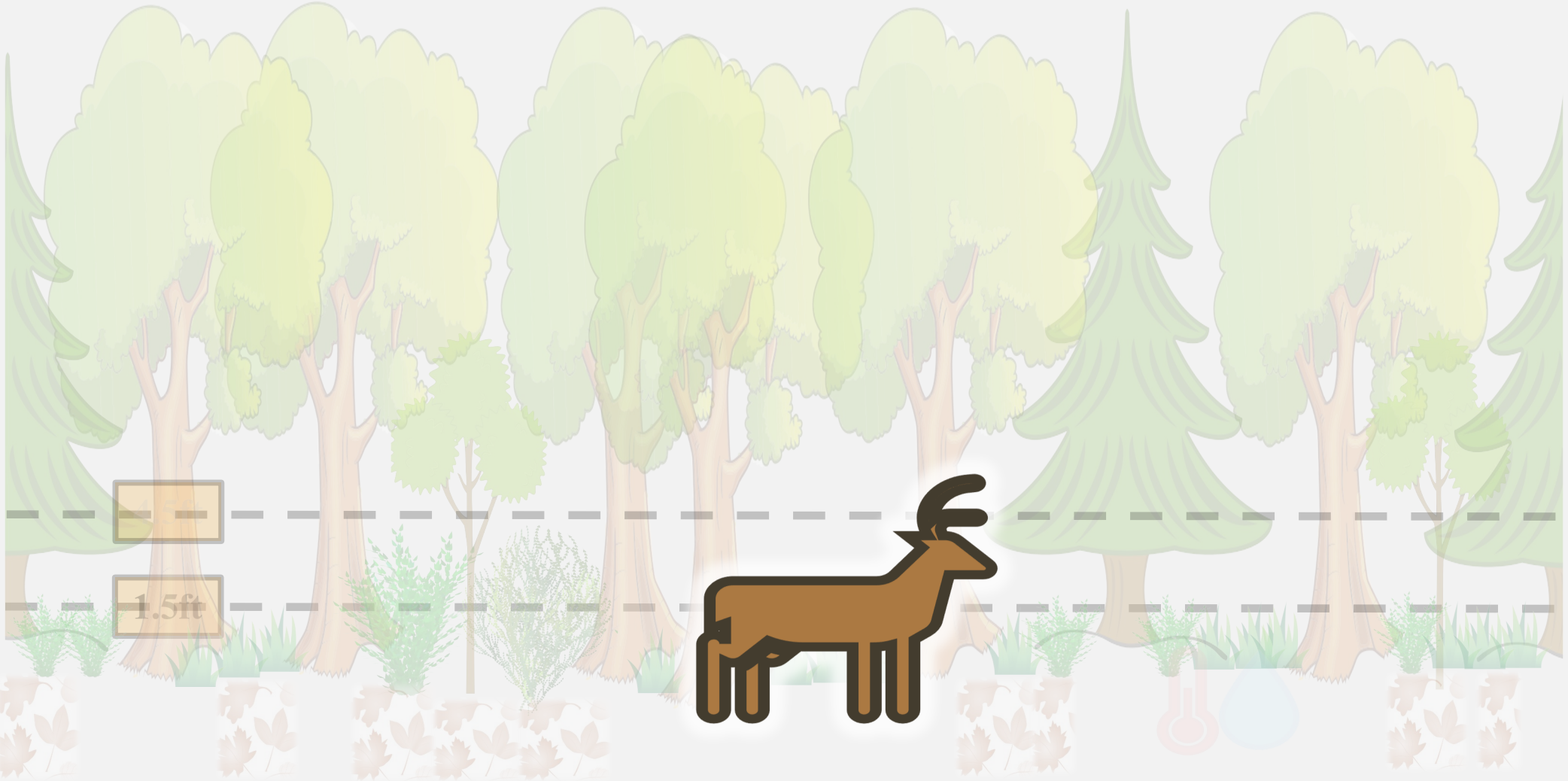

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↑ trees/acre = stabilized humidity

MECHANISMS

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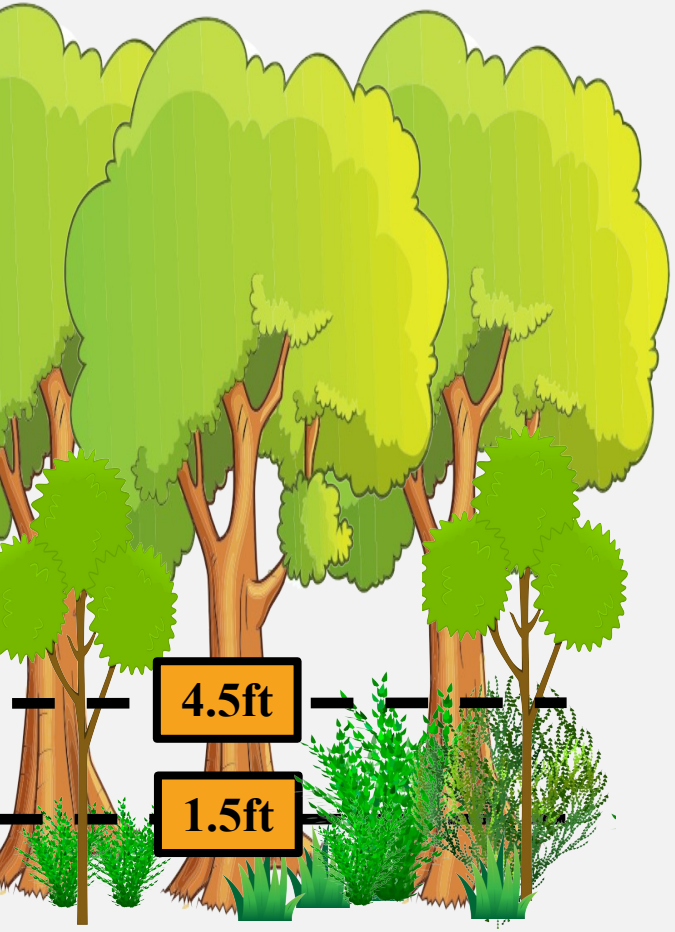
MECHANISMS



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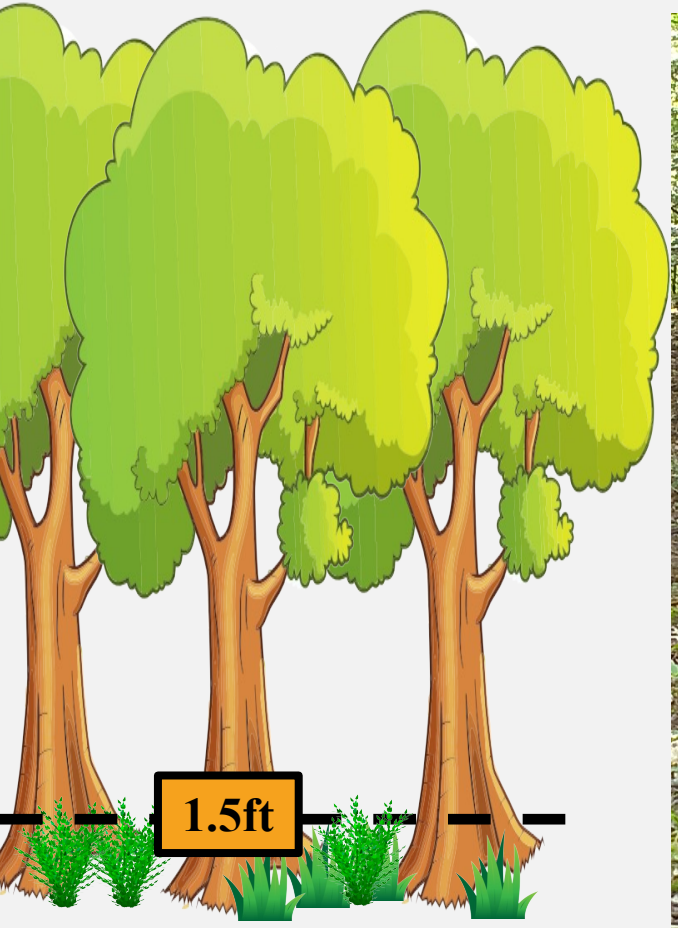

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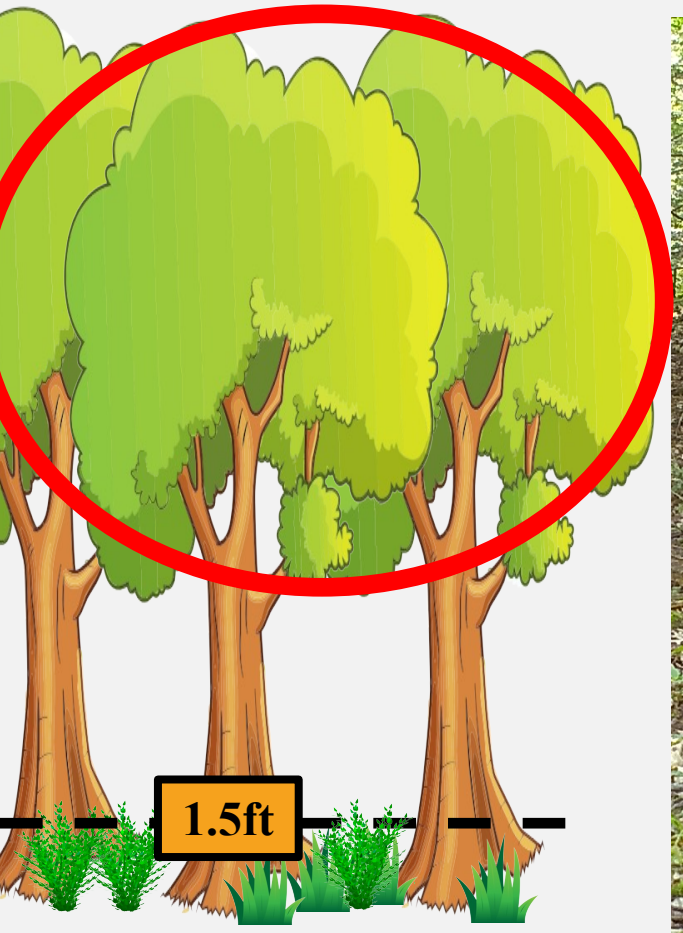

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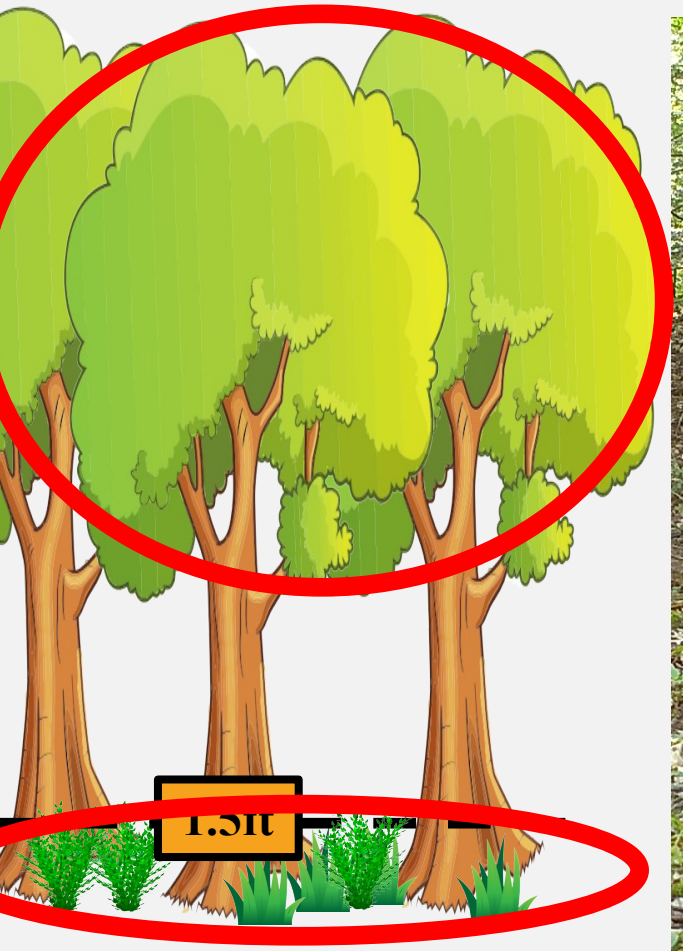

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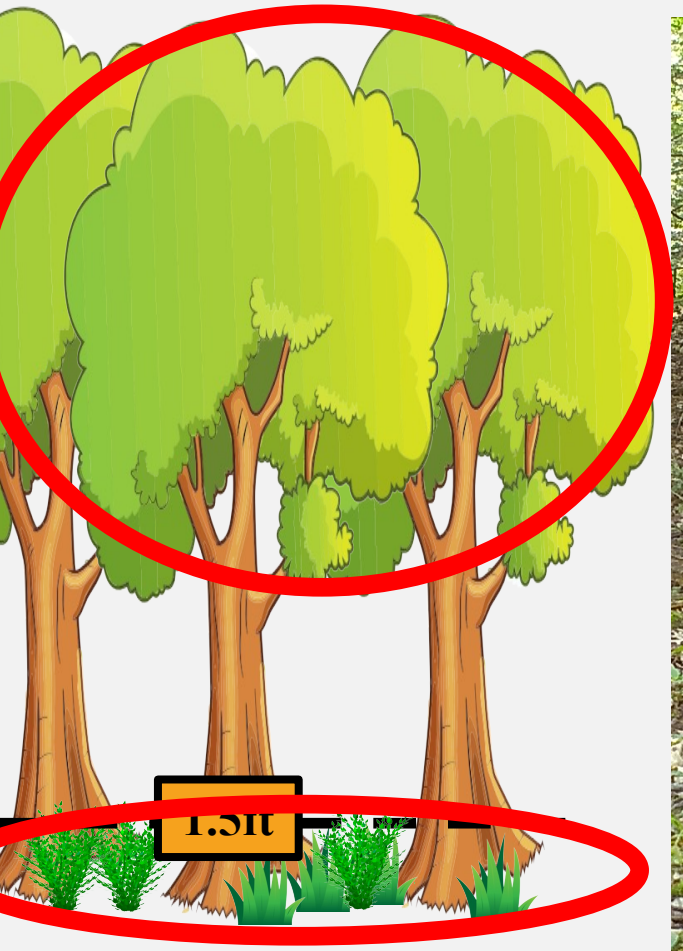

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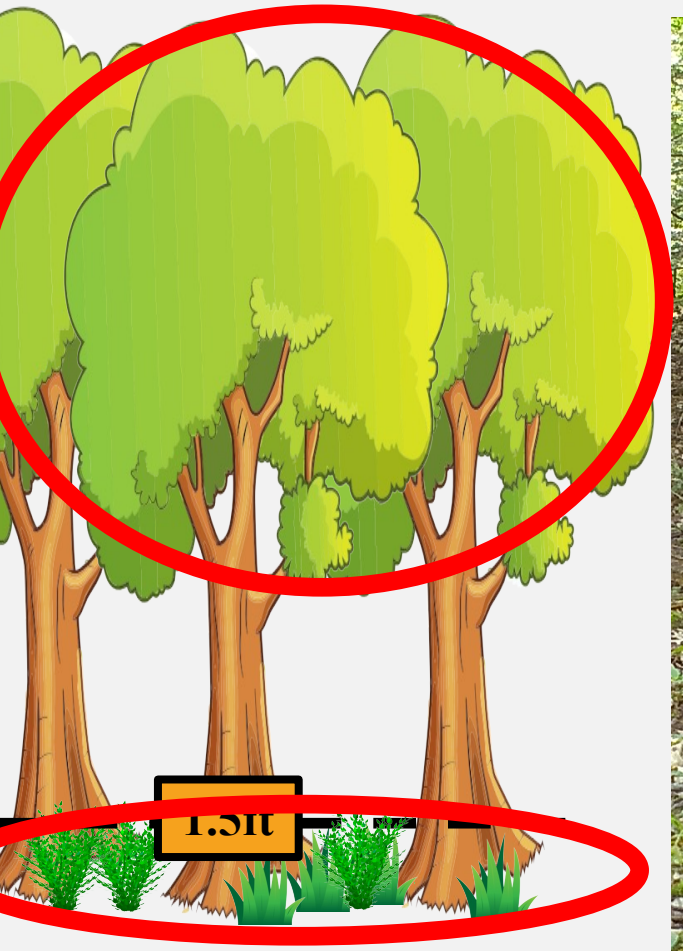

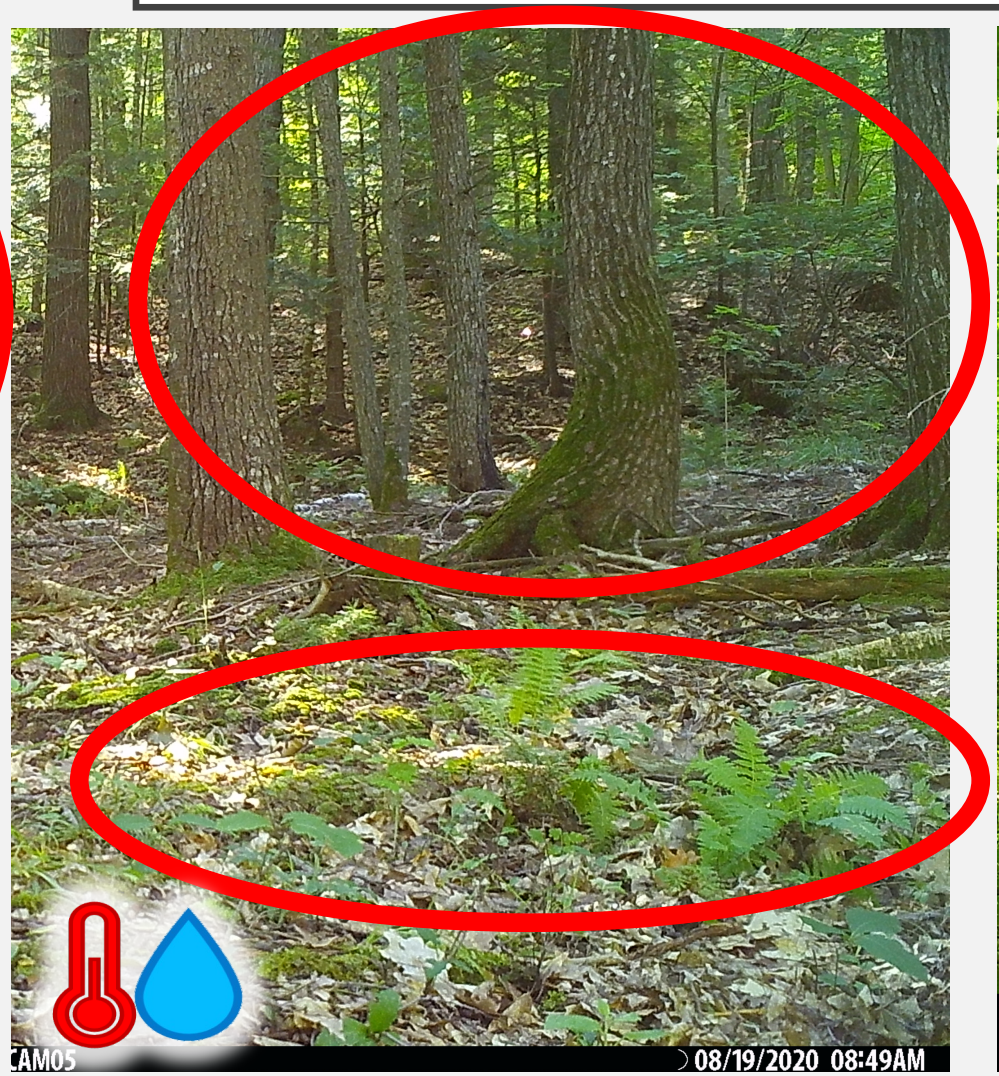

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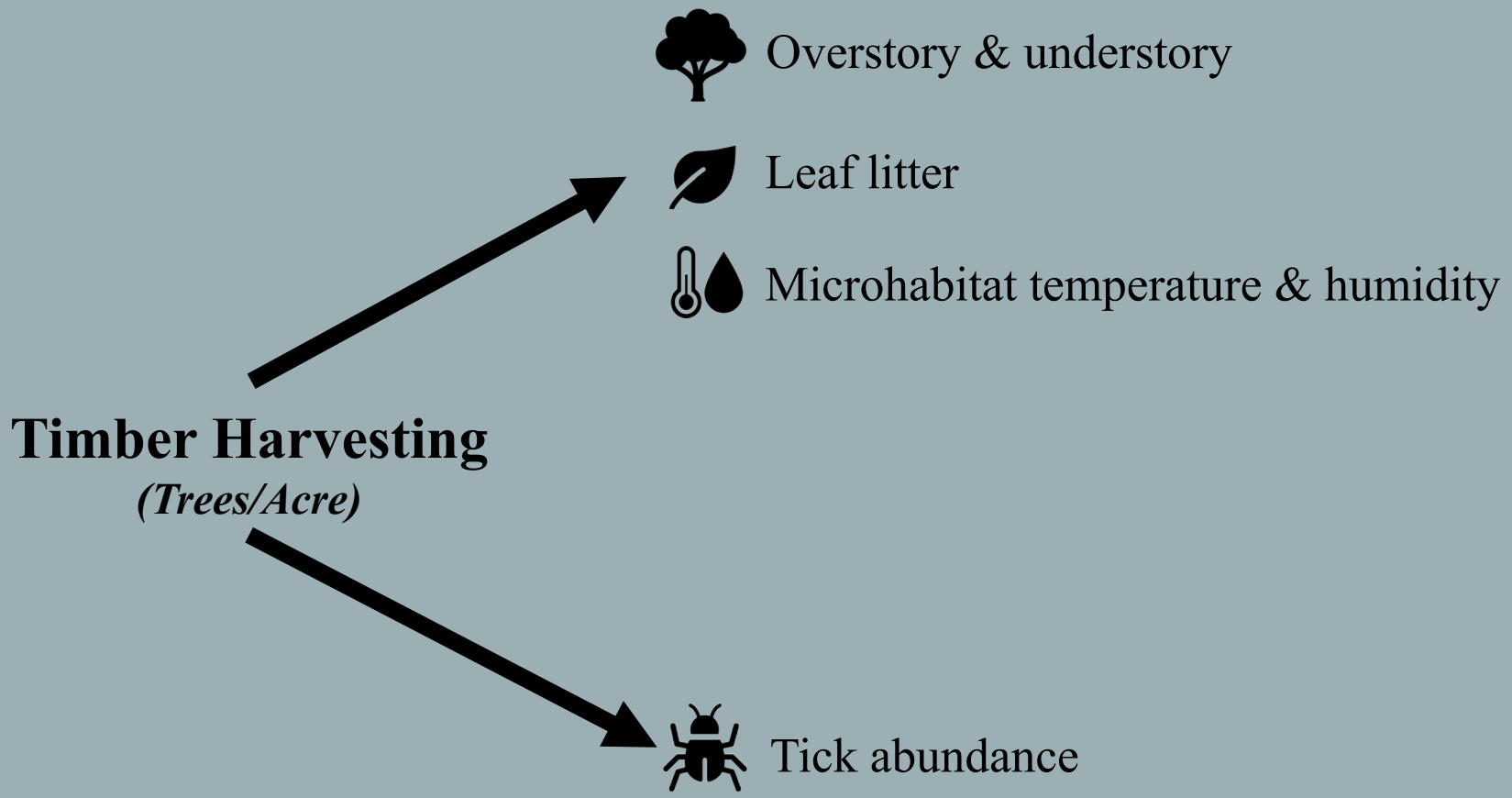
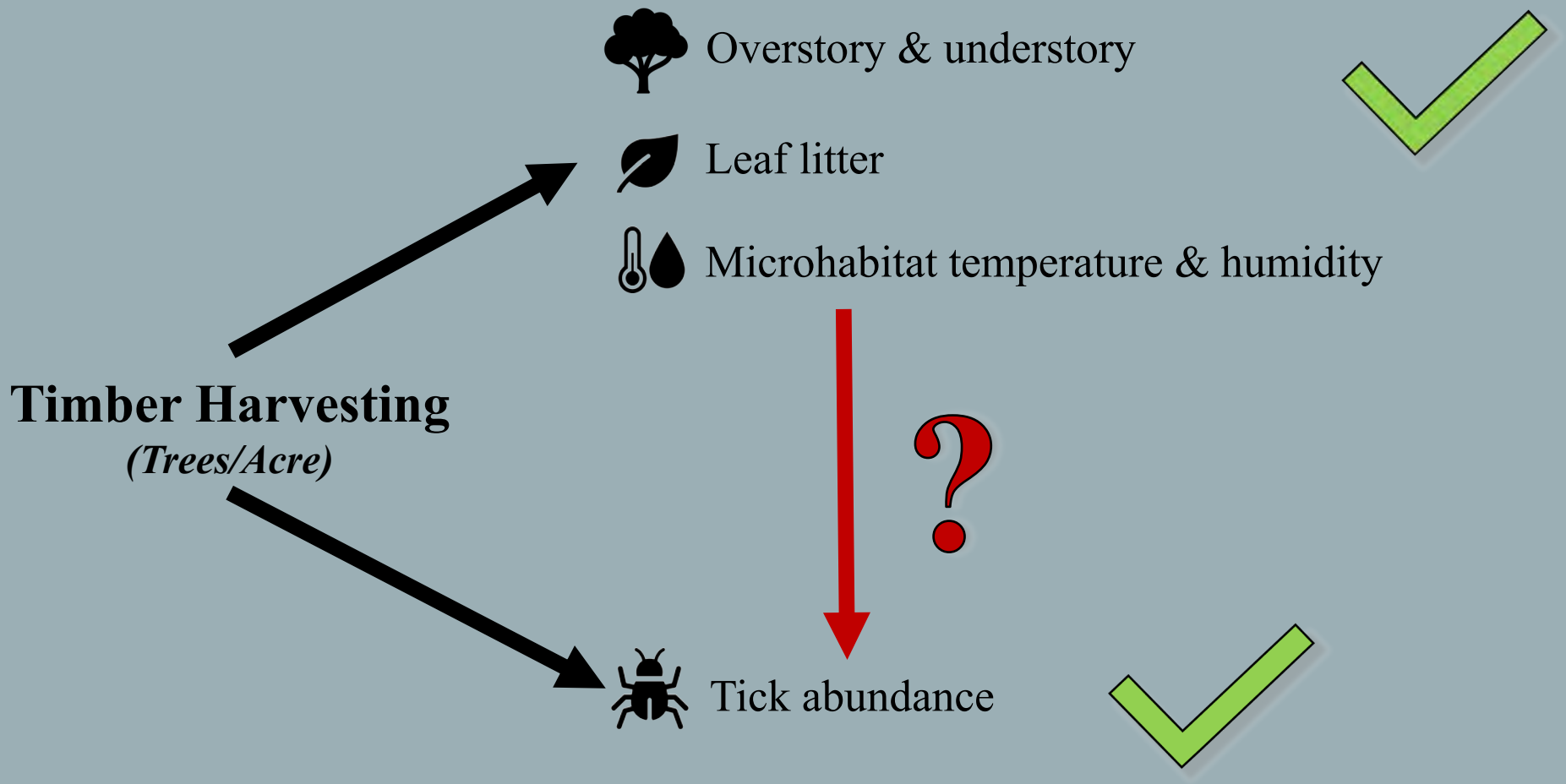

Overstory & understory
Leaf litter
Microhabitat temperature & humidity
Timber Harvesting
(Trees/Acre)
Tick abundance


Overstory & understory
Leaf litter
Microhabitat temperature & humidity
Timber Harvesting
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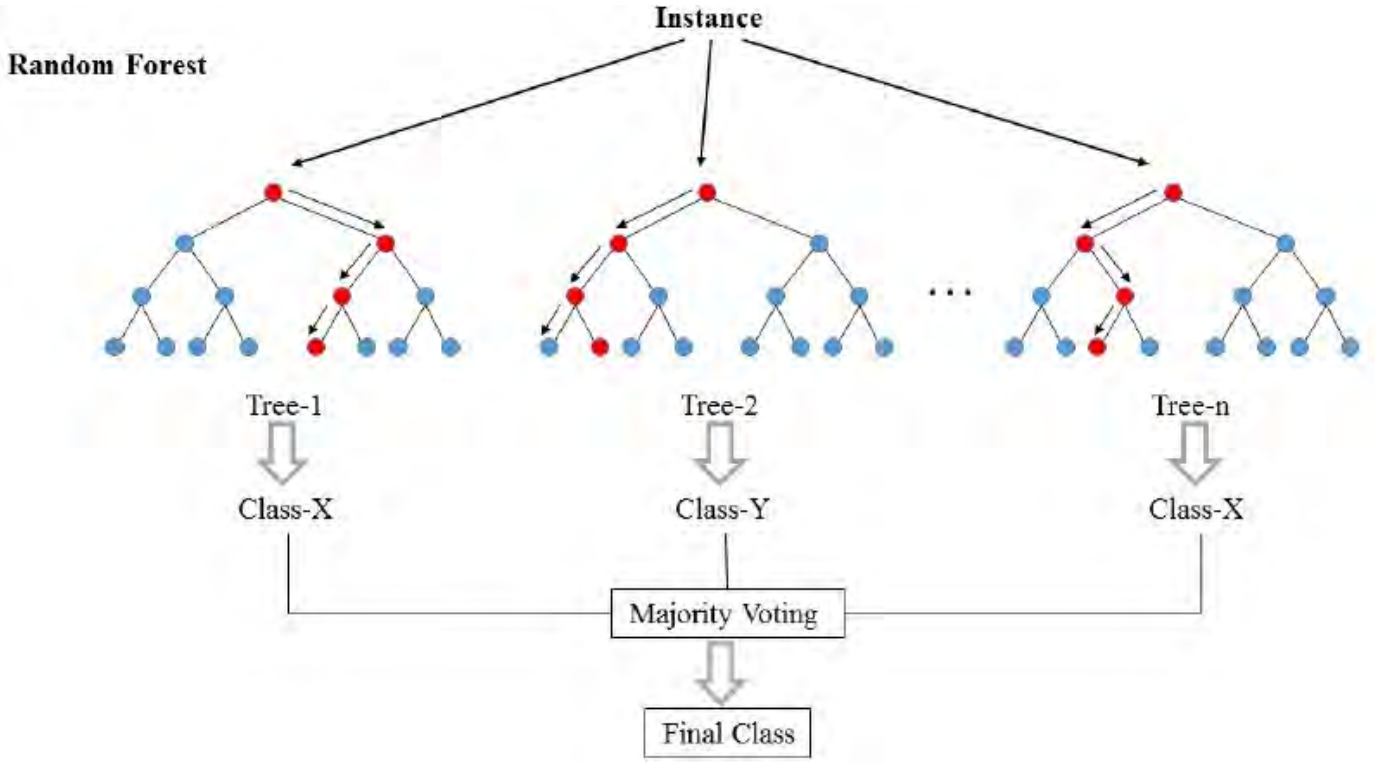
?
Tick abundance

What drives tick densities?

RANDOM FOREST MODEL



M.O. Rabin, Randomized byzantine generals, in 24th Annual Symposium on Foundations of Computer Science (IEEE, 1983), pp. 403–409

What drives tick densities?

RANDOM FOREST MODEL

Variable Name	Variable Importance
Small ground vegetation cover	1
Minimum humidity (in leaf litter)	2
Minimum temperature (in leaf litter)	3
Average humidity (in leaf litter)	4
Maximum temperature (in leaf litter)	5
Average temperature (in leaf litter)	6
Amount of ground covered by leaf litter	7
Dominant sapling species	8
Depth of leaf litter	9
Large ground vegetation cover	10
Number of trees per acre	11
Average basal area per acre	12
Number of class 1 saplings	13
Dominant small ground vegetation species	14
Dominant tree species	15
Number of class 2 saplings	16
Dominant leaf litter composition	17
Number of class 3 saplings	18
Dominant large ground vegetation species	19
Maximum humidity (in leaf litter)	20

What drives tick densities?

RANDOM FOREST MODEL

Variable Name	Variable Importance
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Maximum humidity (in leaf litter)	20

What drives tick densities?

RANDOM FOREST MODEL

Variable Name	Variable Importance
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Minimum humidity (in leaf litter)	2
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What drives tick densities?

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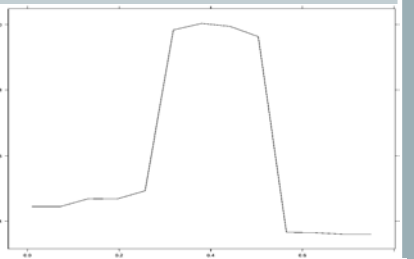
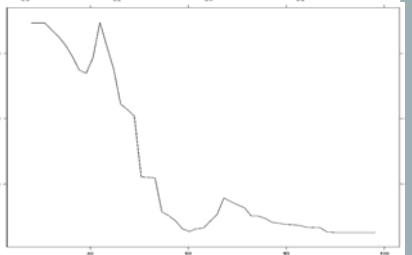
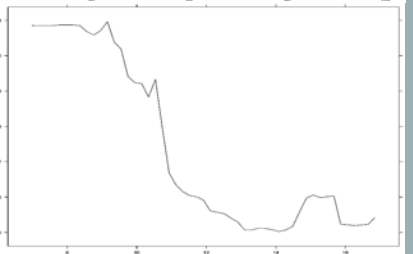
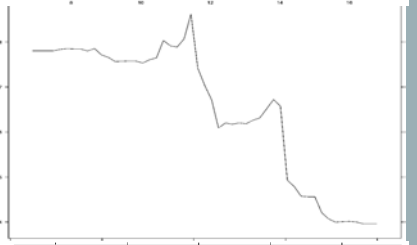
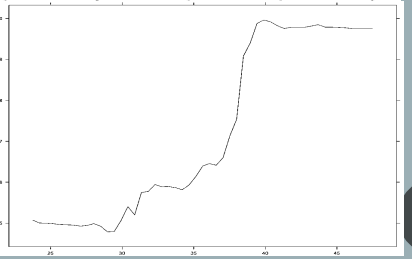
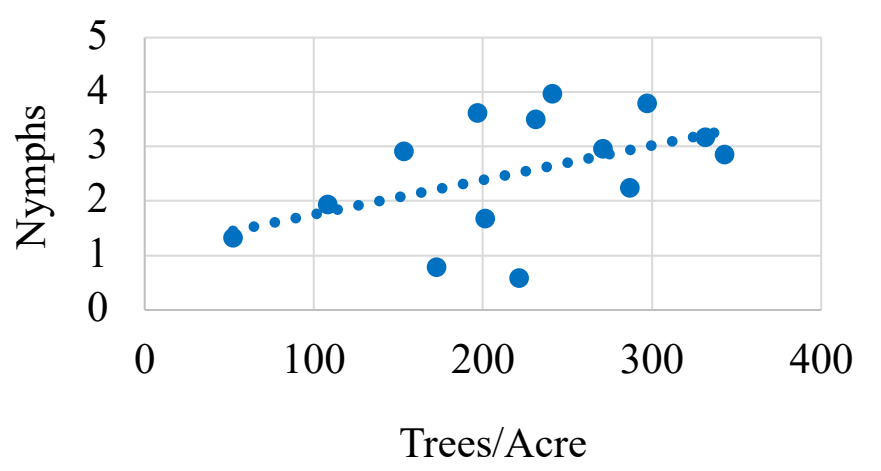
What drives tick densities?

RANDOM FOREST MODEL

Variable Name	Variable Importance	Response Curves
Small ground vegetation cover	1	
Minimum humidity (in leaf litter)	2	
Minimum temperature (in leaf litter)	3	
Average humidity (in leaf litter)	4	
Maximum temperature (in leaf litter)	5	

CONCLUSIONS

- Significant, positive relationship



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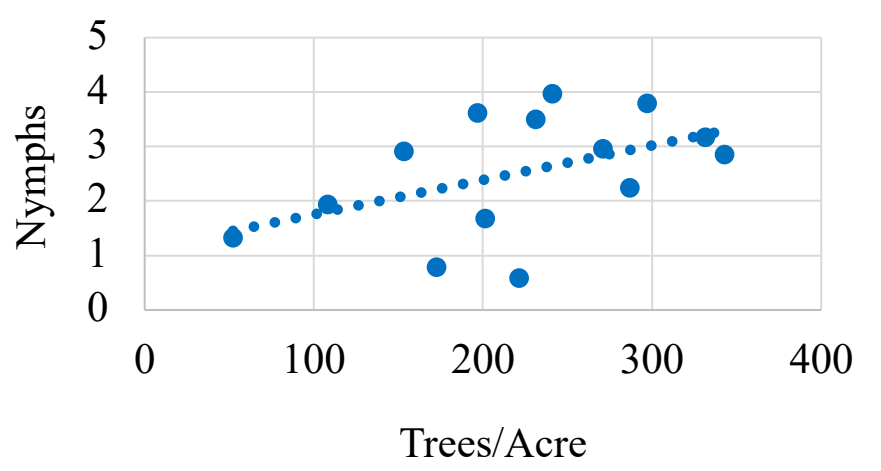

- Cascading effects

timber harvesting → forest structure → microclimate → nymph densities

CONCLUSIONS

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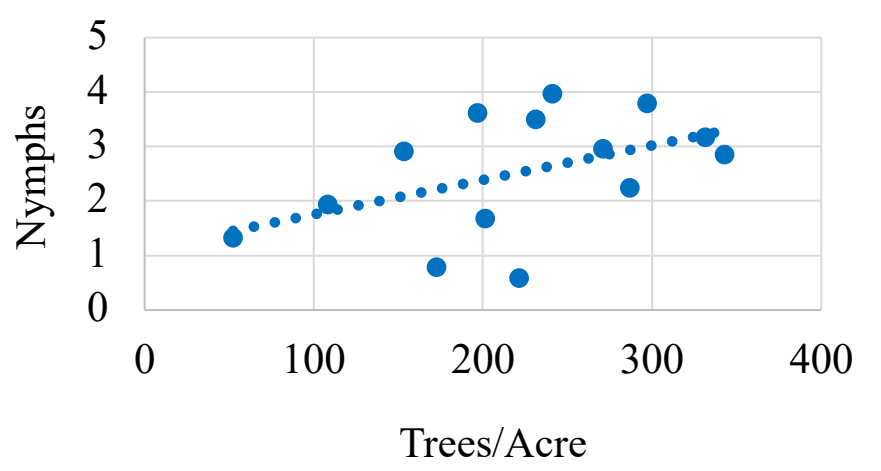

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- Management implications

CONCLUSIONS

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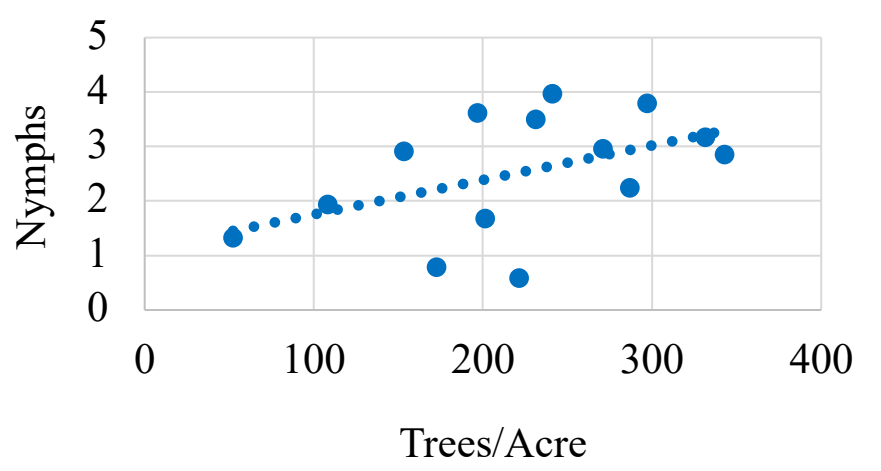

- Cascading effects

timber harvesting → forest structure → microclimate → nymph densities

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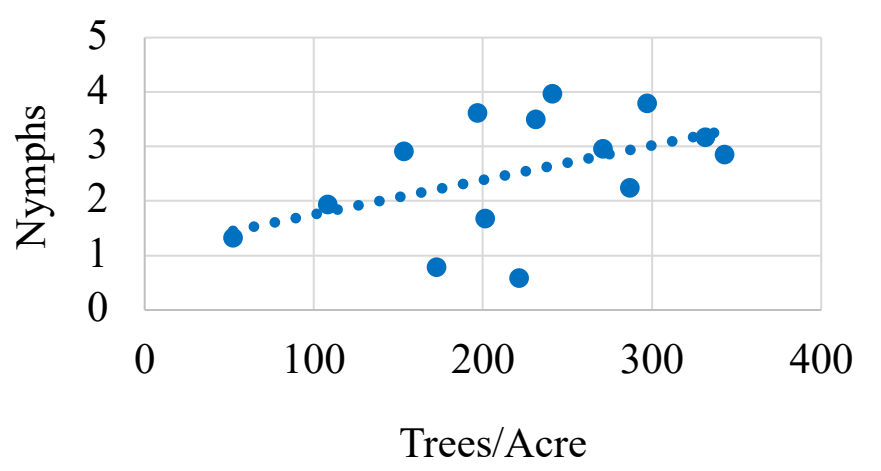
MECHANISMS

1. **Abiotic mechanism**

   Microclimate may be driving the identified pattern (see RF model)

CONCLUSIONS

- Significant, positive relationship



- Cascading effects

timber harvesting → forest structure → microclimate → nymph densities

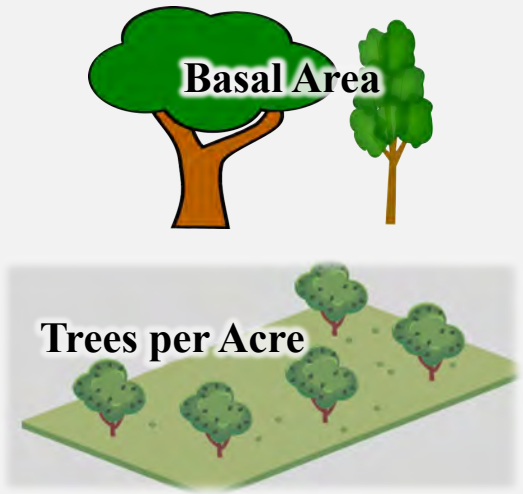
- Management implications

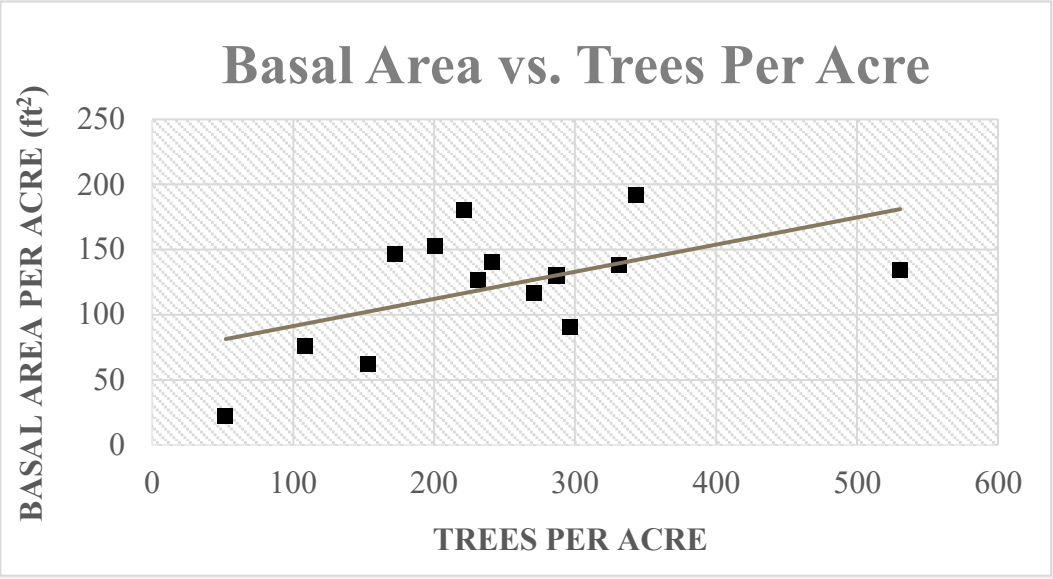
MECHANISMS

1. **Abiotic mechanism**
   Microclimate may be driving the identified pattern (see RF model)

2. **Biotic mechanism**
   What about the small mammals?

TIMBER HARVESTING





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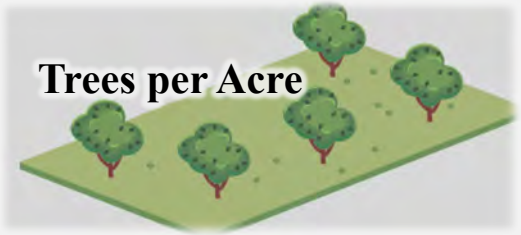
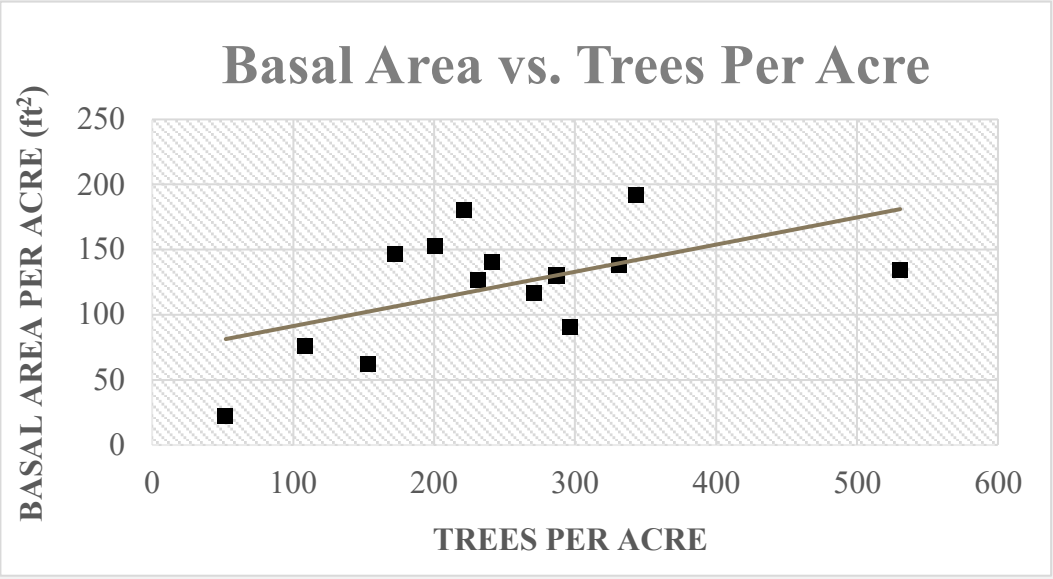
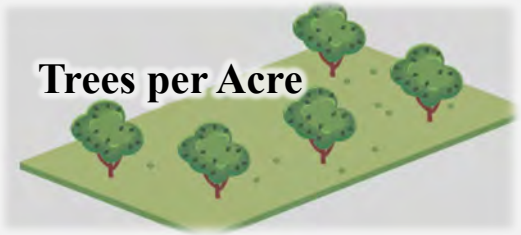
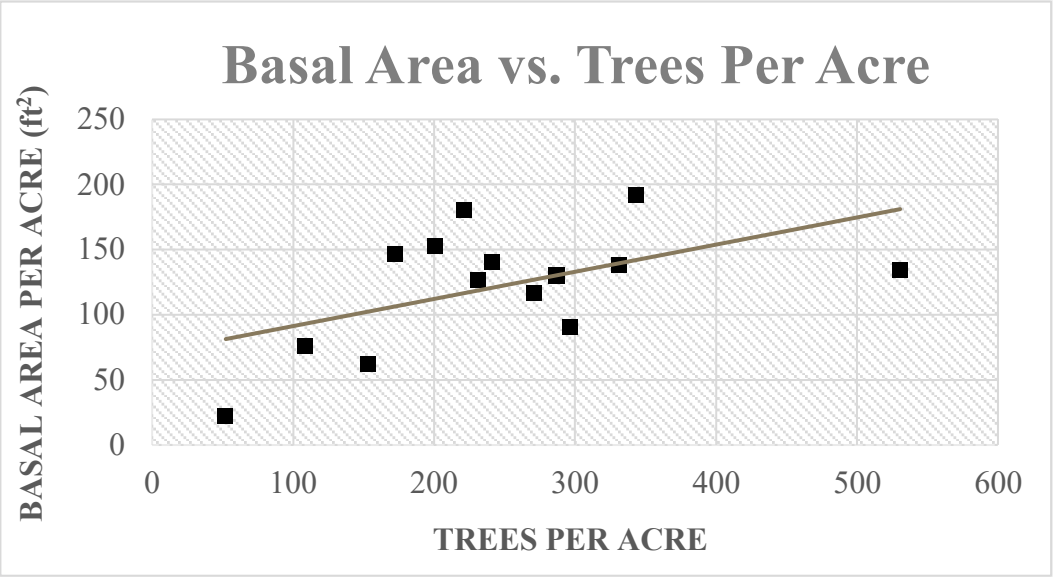




SMALL MAMMALS

TIMBER HARVESTING





SMALL MAMMALS

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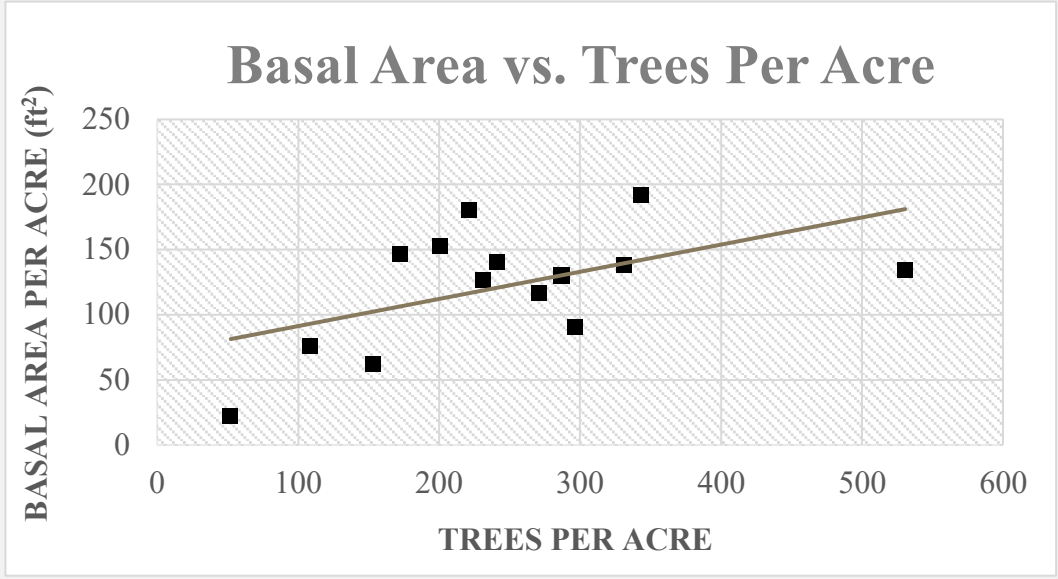

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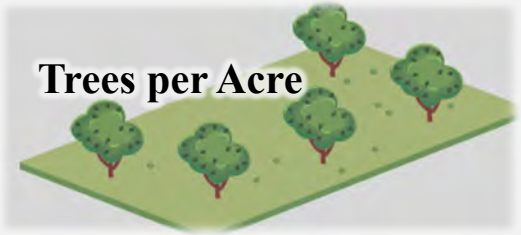

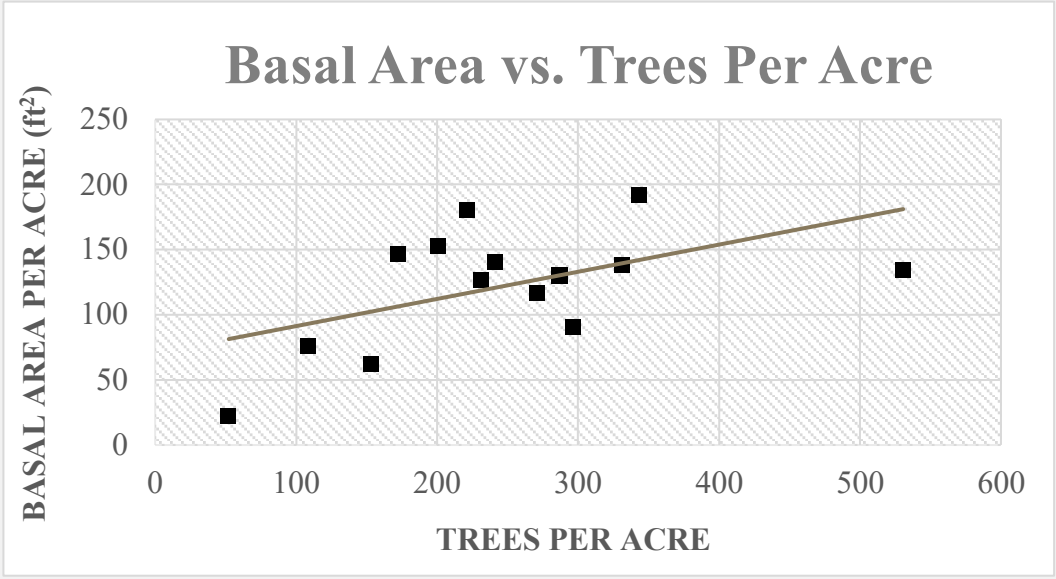

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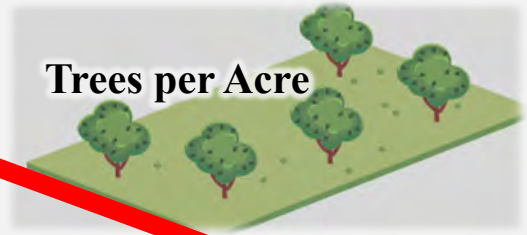

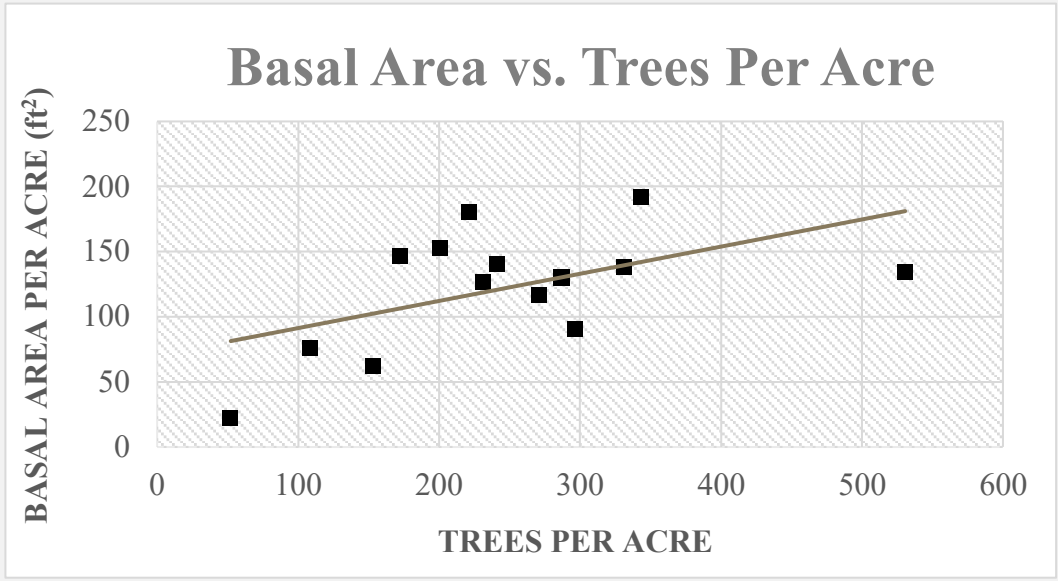

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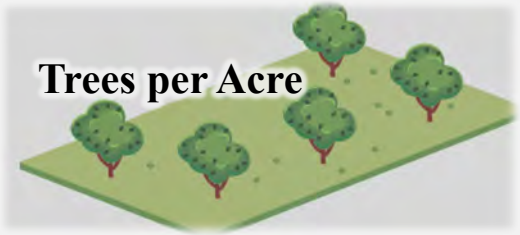

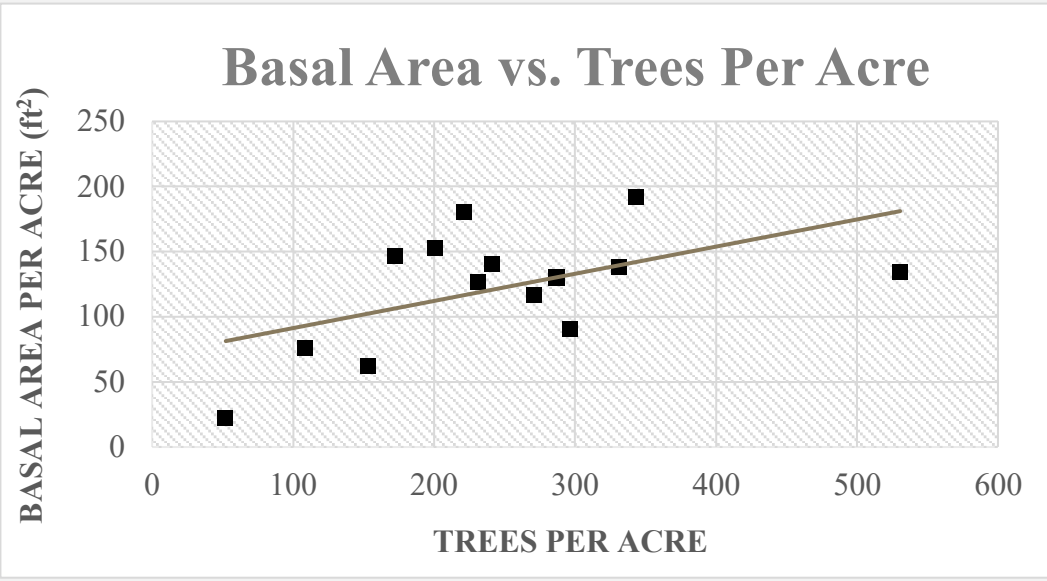

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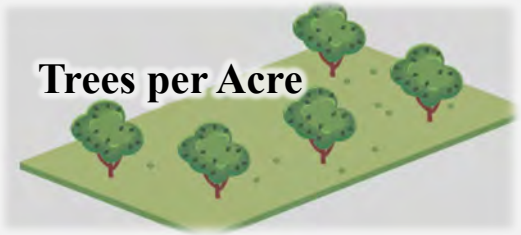

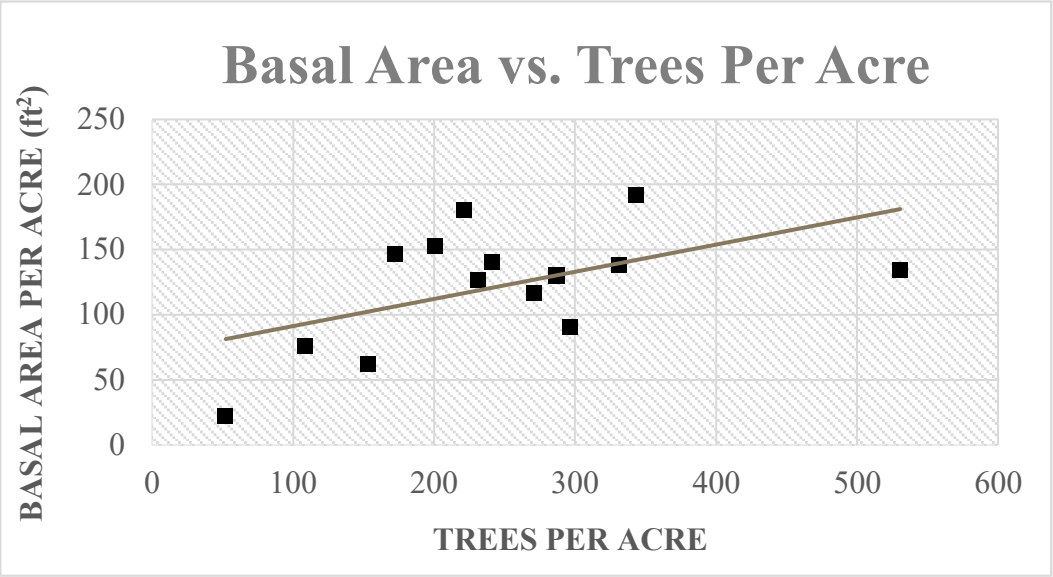

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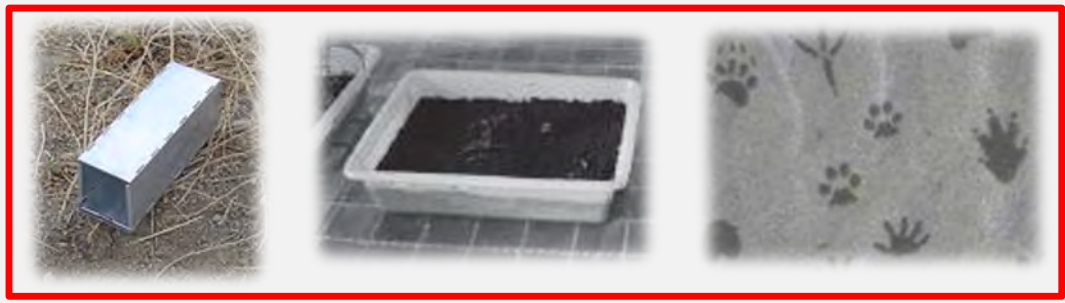

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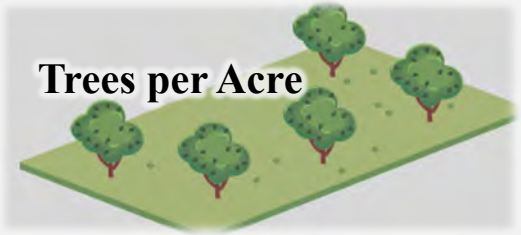

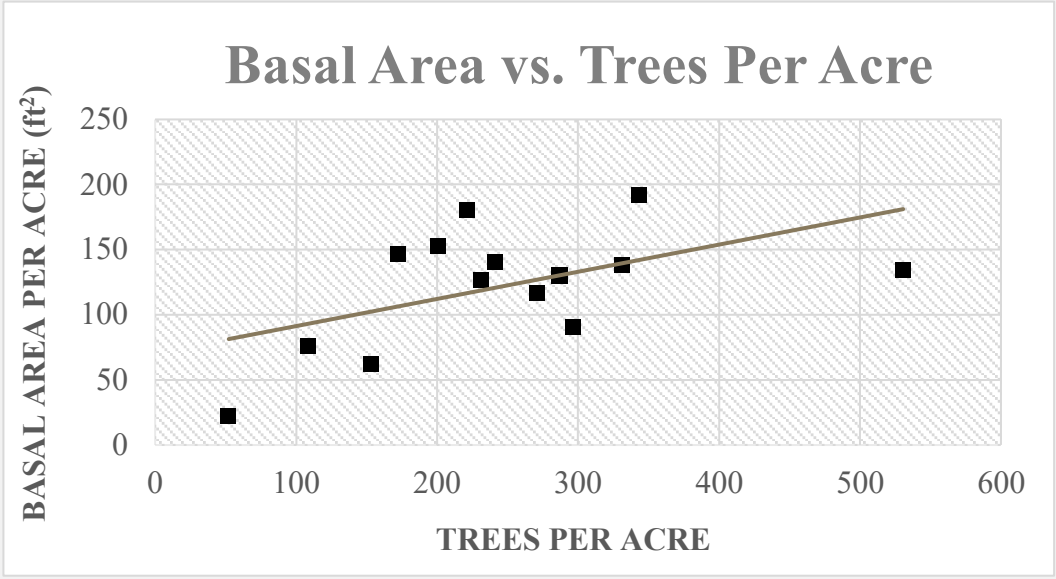

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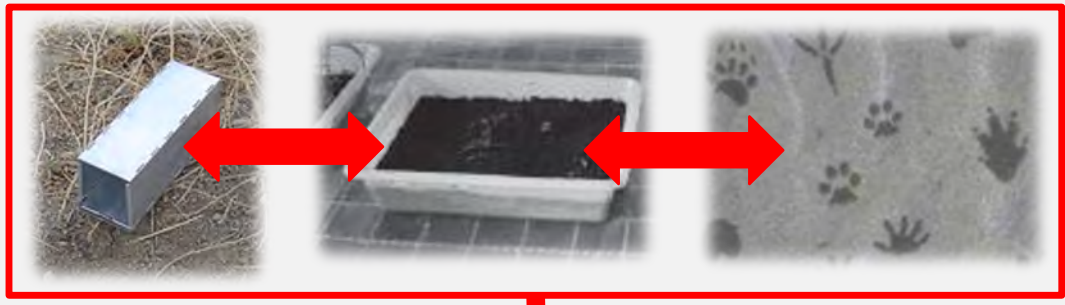

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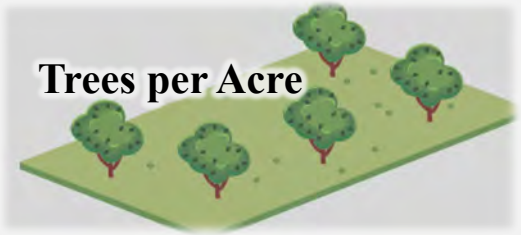
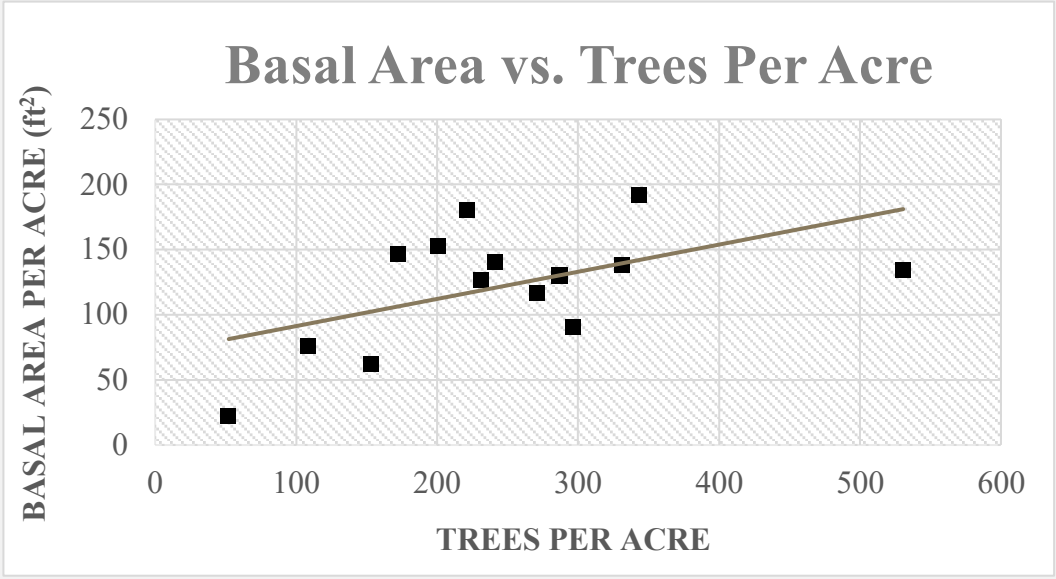


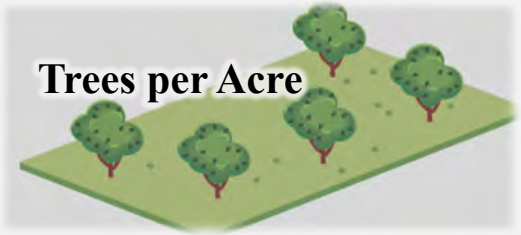


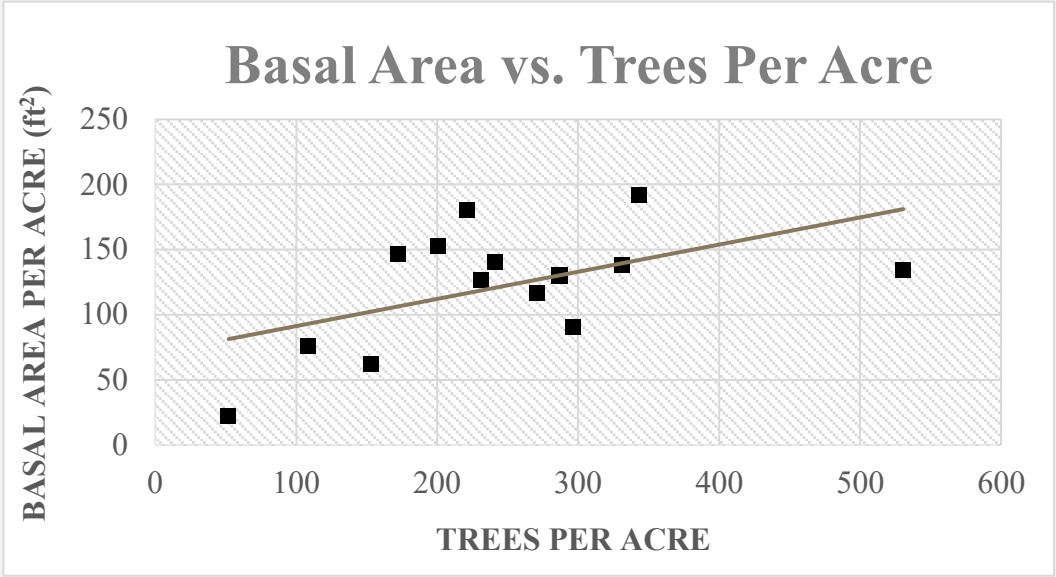
SMALL MAMMALS

OBJECTIVES

1. Determine how timber harvesting affects small mammal population sizes and activity, and the consequences for tick burdens and infection prevalence.
2. Compare three methods of small mammal sampling (live trapping, track plates, and foraging trays) to determine their ability to predict tick burdens and infection prevalence.

TIMBER HARVESTING





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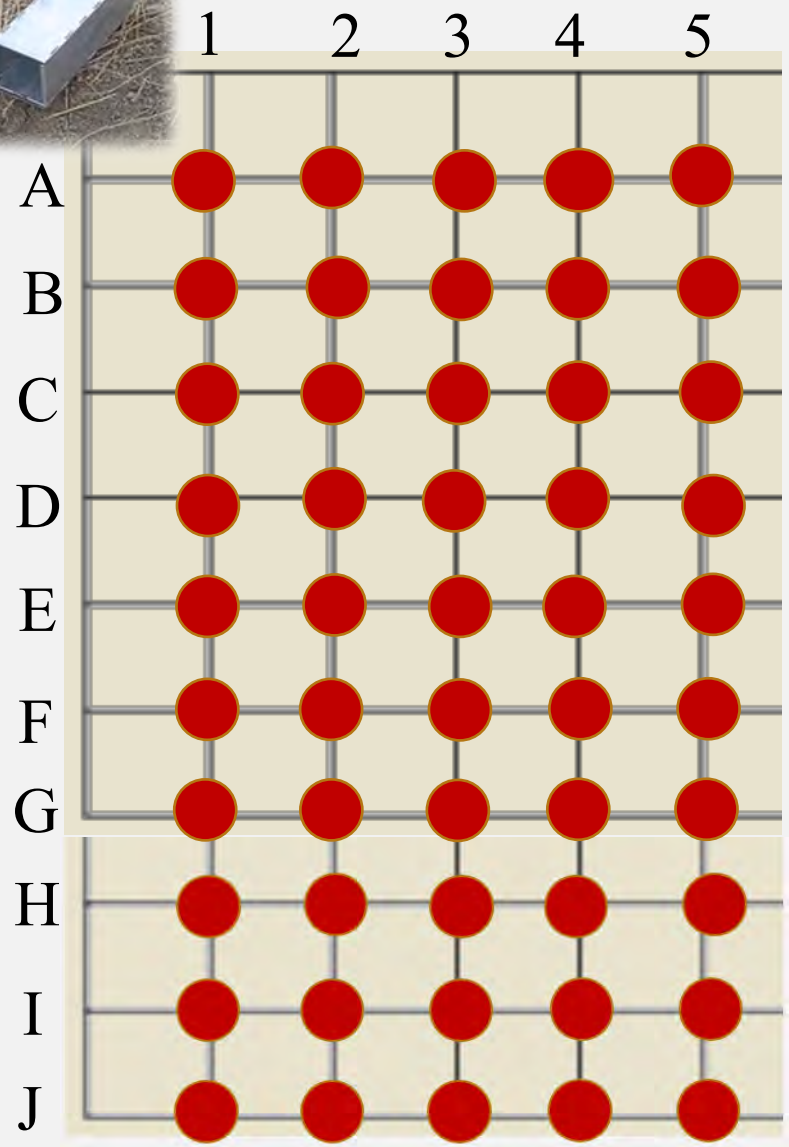

50 Sherman traps per property, 3 consecutive trap nights

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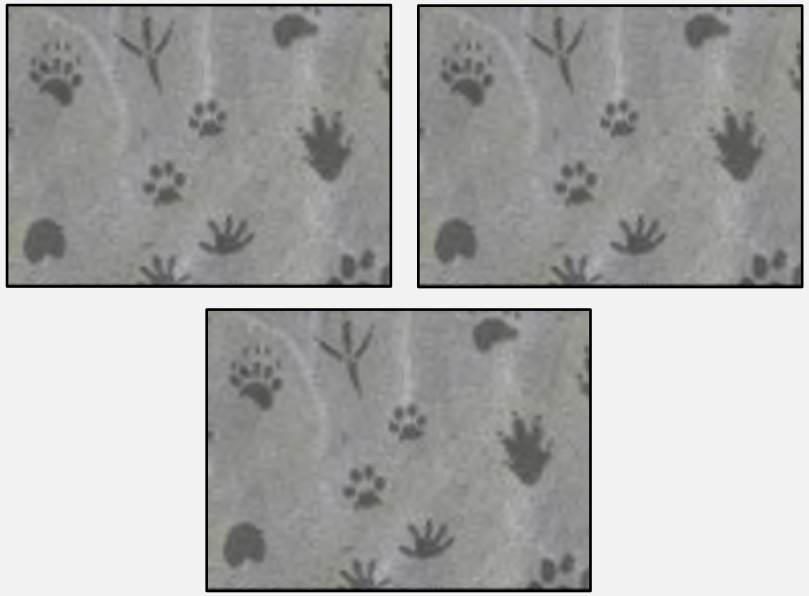
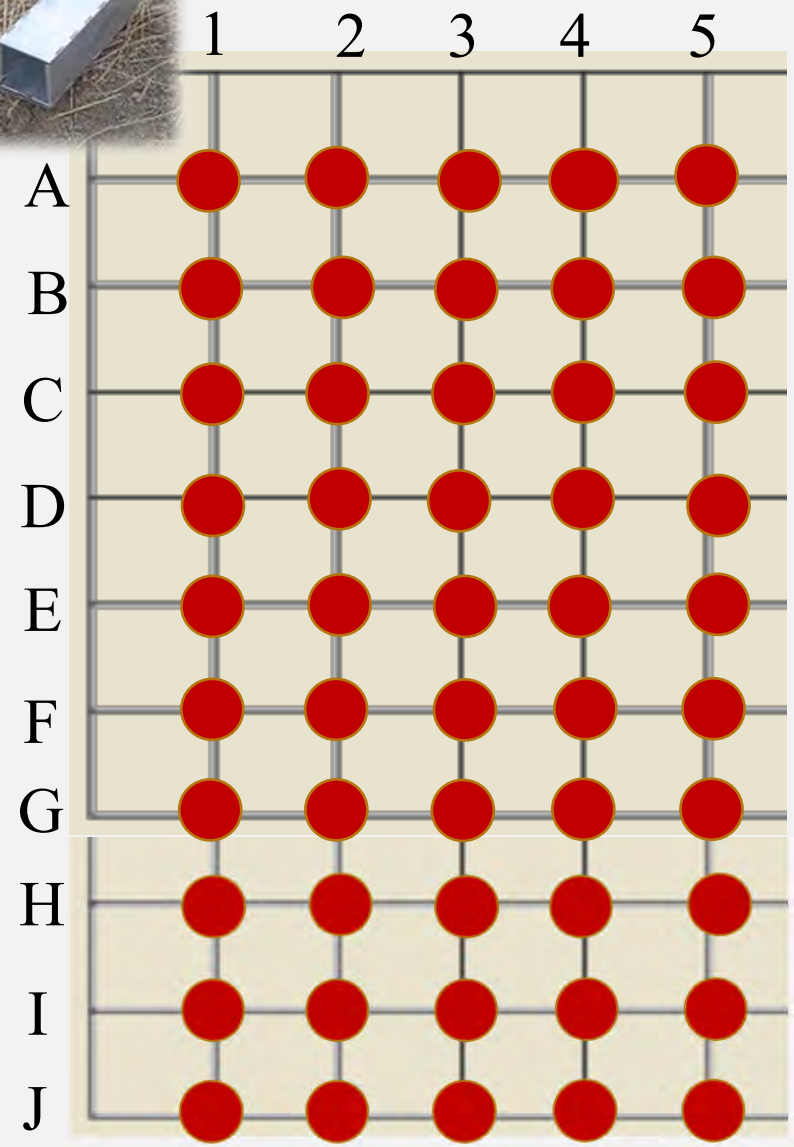


16 track plates per property

DATA COLLECTION



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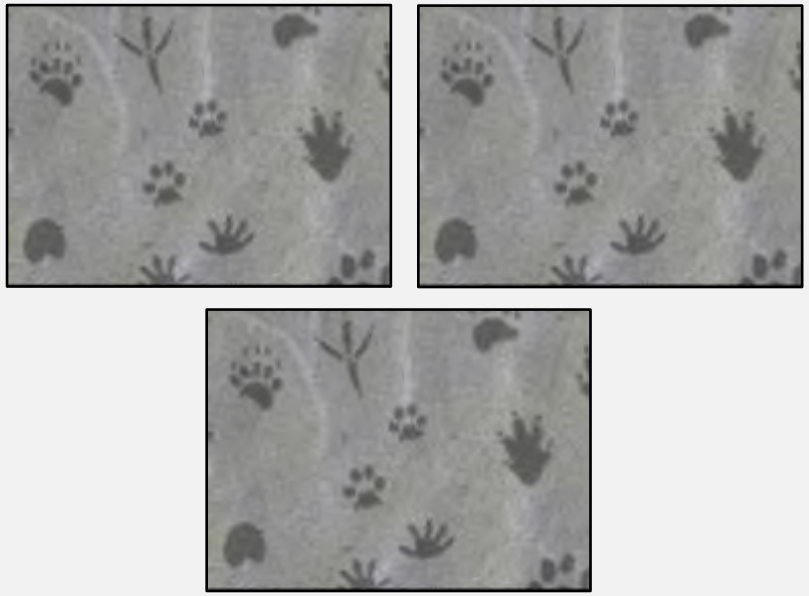

16 track plates per property

12 foraging trays per property

PRELIMINARY RESULTS/RAW NUMBERS

	More Trees/Acre	**Less Trees/Acre**
Larval tick burden *(larval ticks/animal)*	1.93	3.12
Foraging trays (*consumed seed)*	55%	49%
Population size estimate *(animals/hectare)*	50.6	22.9

FUTURE STEPS

SMALL MAMMALS





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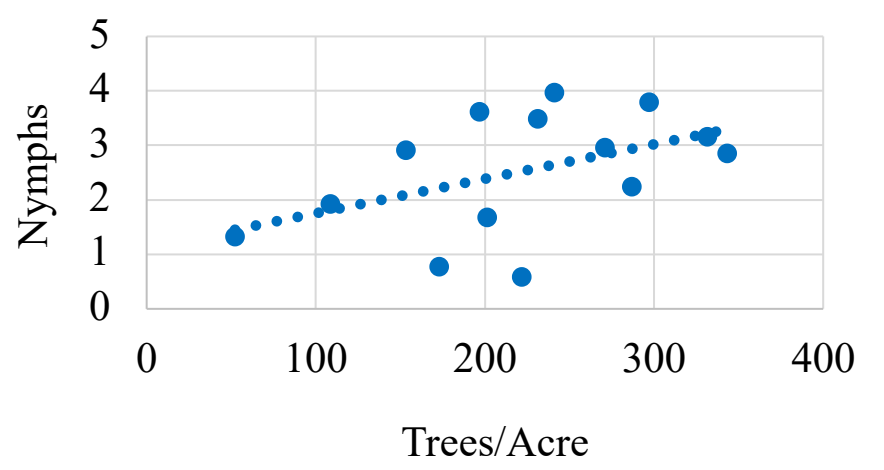
TAKEAWAYS

Relationship between forest structure and tick densities



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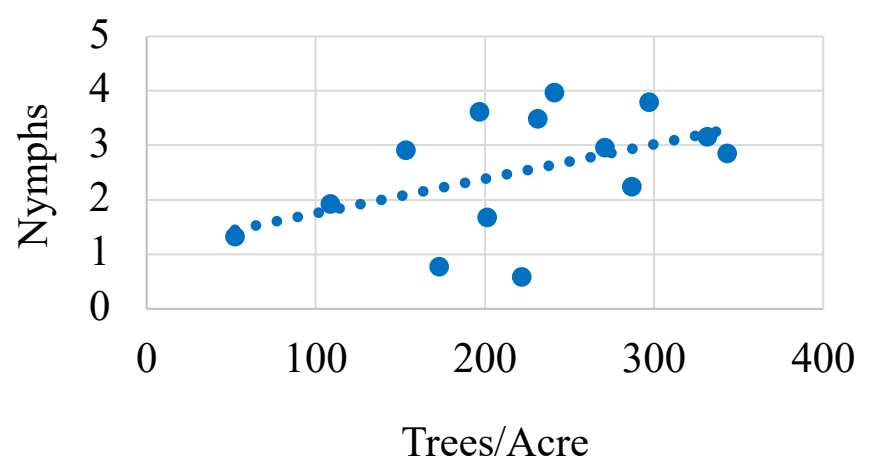

Abiotic mechanism:
Cascading effects on understory structure & microclimate

Biotic mechanism:
Small mammals
(population size, tick burden, foraging behavior)