Dead tree removal after drought-induced tree mortality: implications for mixed conifer forest recovery, fuels, and carbon

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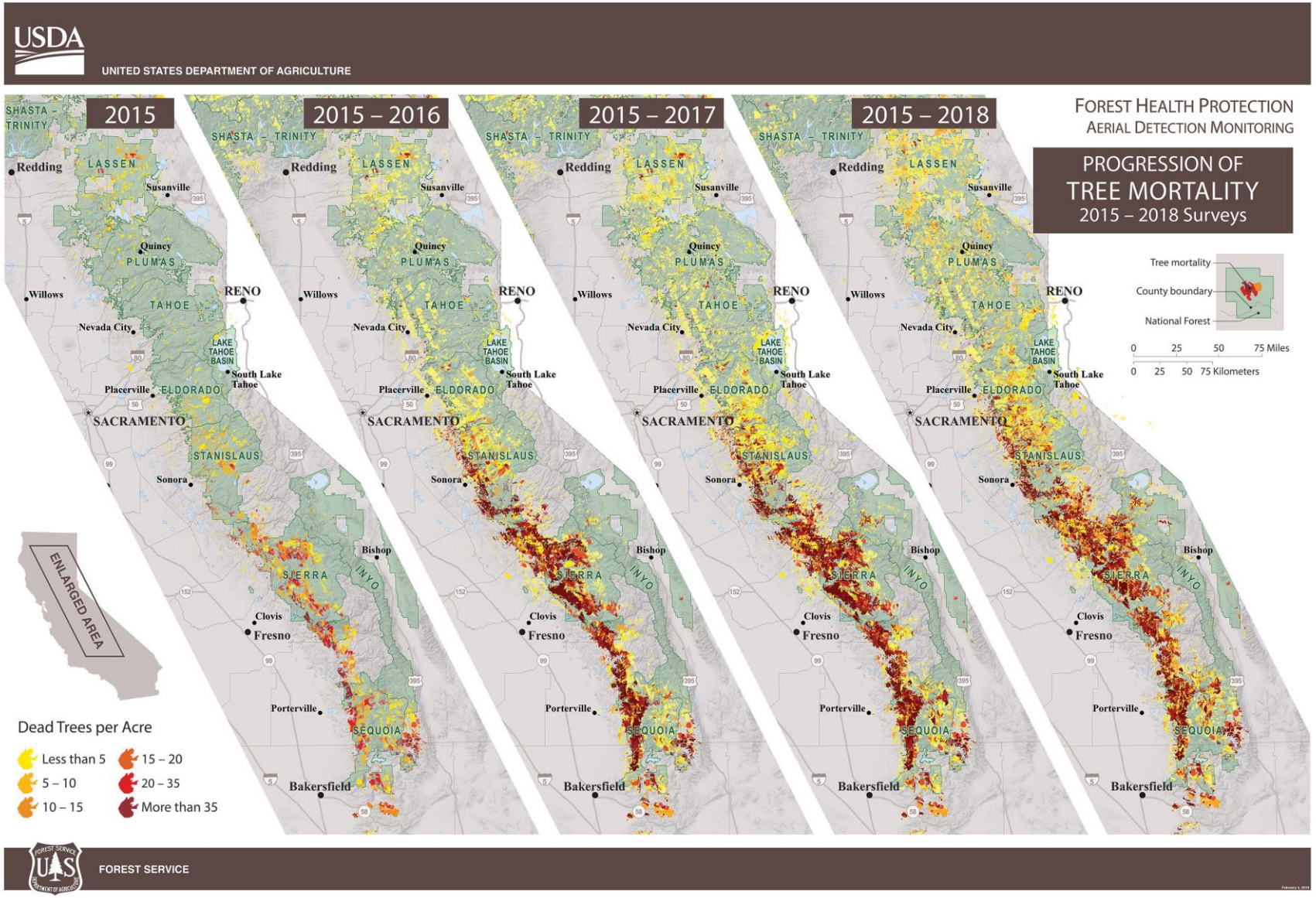
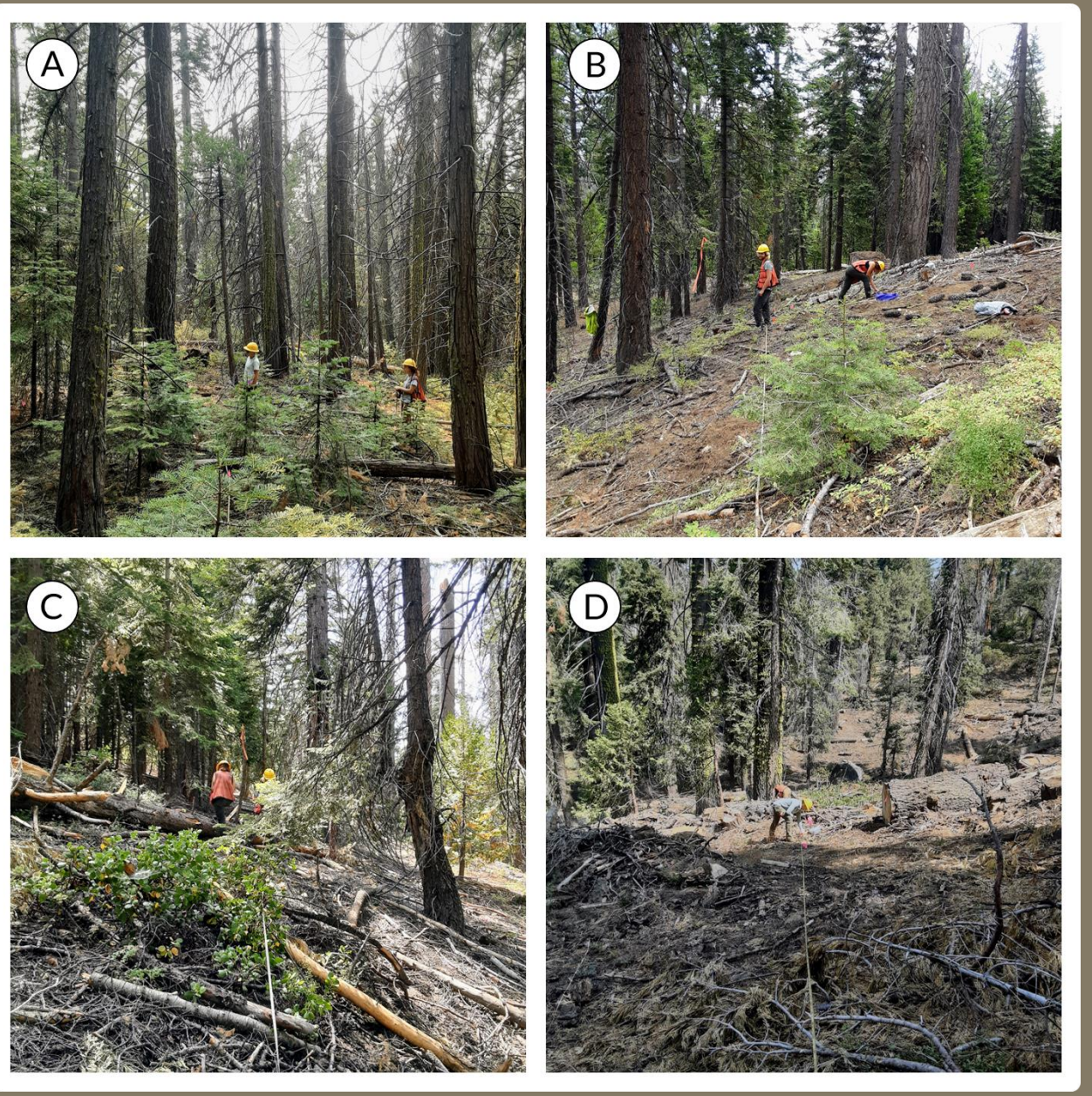
Extreme drought
+
Fire exclusion
=
Native bark beetle epidemic



What are the effects of dead tree removal on key ecological outcomes?

- Fuels
- Modeled future fire severity
- Tree regeneration
- Understory plant diversity
- Carbon

No removal

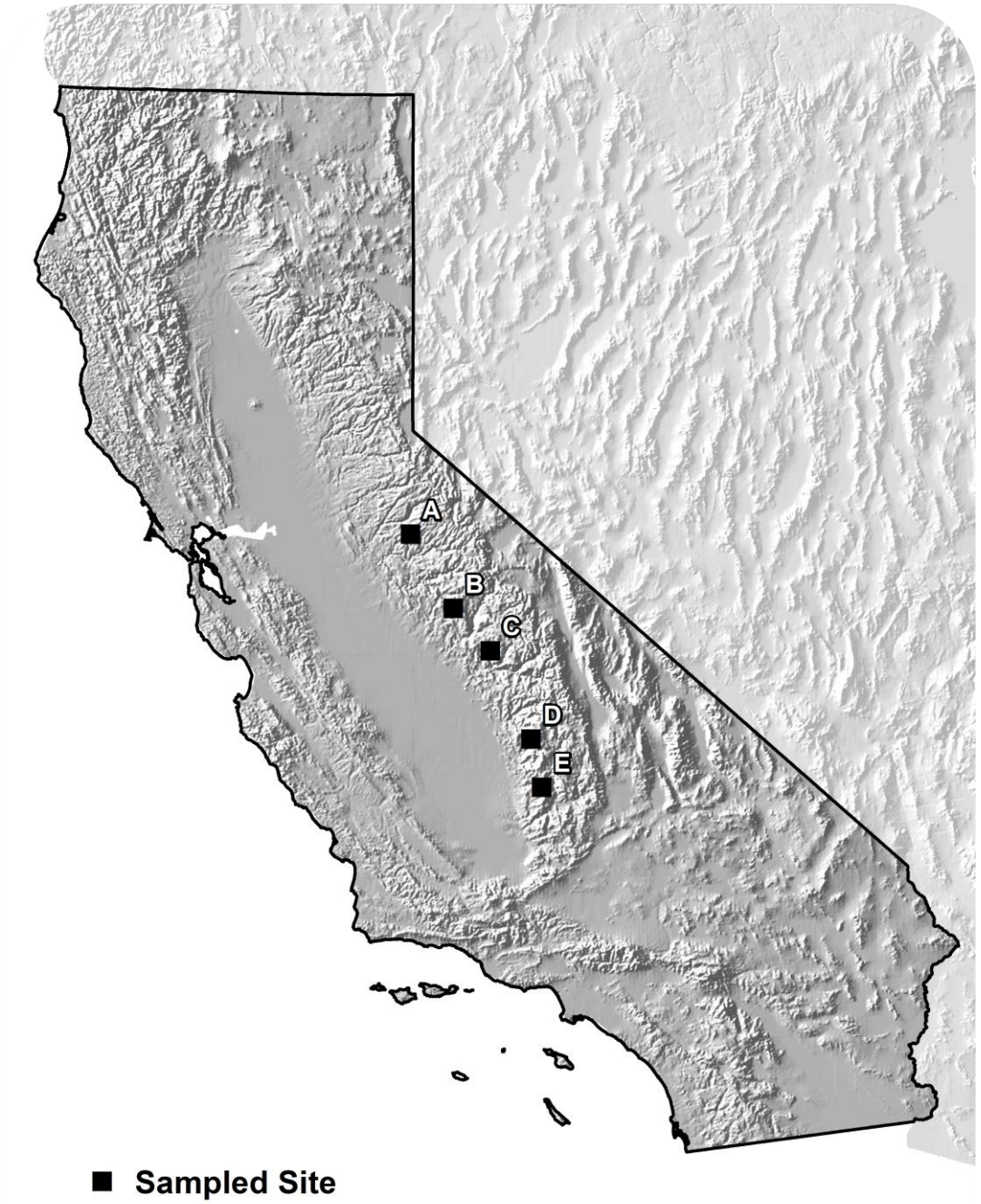


Dead tree removal

Sampling Design:

- 6 Sites (federal, state, private)
- 122 paired 0.04 ha (0.1 ac) plots
- Sierra Nevada mixed conifer
- Elevations 1200-2200 meters

A. Longbarn, Stanislaus NF (n = 30)
B. Bass Lake, Sierra NF (n = 28)
C. Dinkey Creek, Sierra NF (n = 24) and Southern California Edison (n = 8)
D. Mountain Home State Forest (n = 12)
E. Spear, Sequoia NF (n = 20)



Data Collected:

- Tree regeneration
- Cover of all plant species
- Forest structure & composition
- Ground covers
- Downed woody debris
- Site physical characteristics

Drought mortality differs from frequent fire

Surface fuels consumed

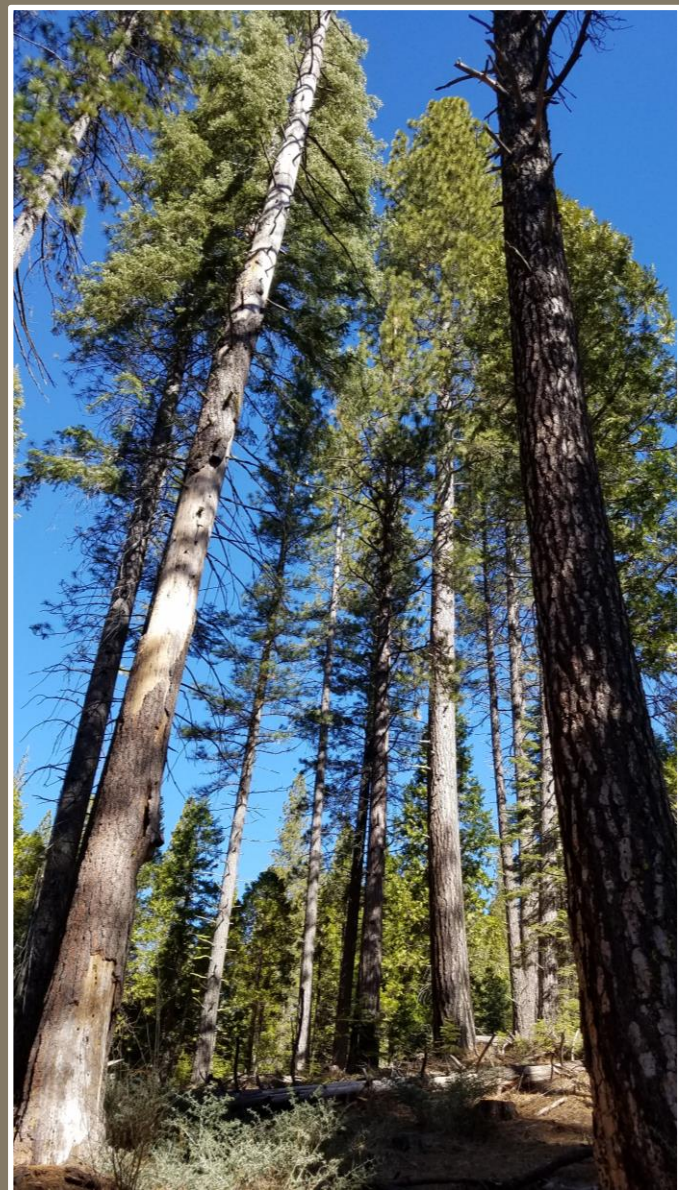
Smaller and less fire-tolerant trees killed

Rapid surface soil chemistry changes

Surface fuels increase

Large diameter, often fire-adapted trees killed

Lack of fire-induced soil changes



Overview of Treatment Effects

	Removal
Bare ground	↑
Litter depth	↓
Fine fuels	=
Sound CWD	↑
Rotten CWD	↓
Small tree density	↓
Canopy cover	↓
Dead tree density	↓

Tree regeneration

Study Questions:

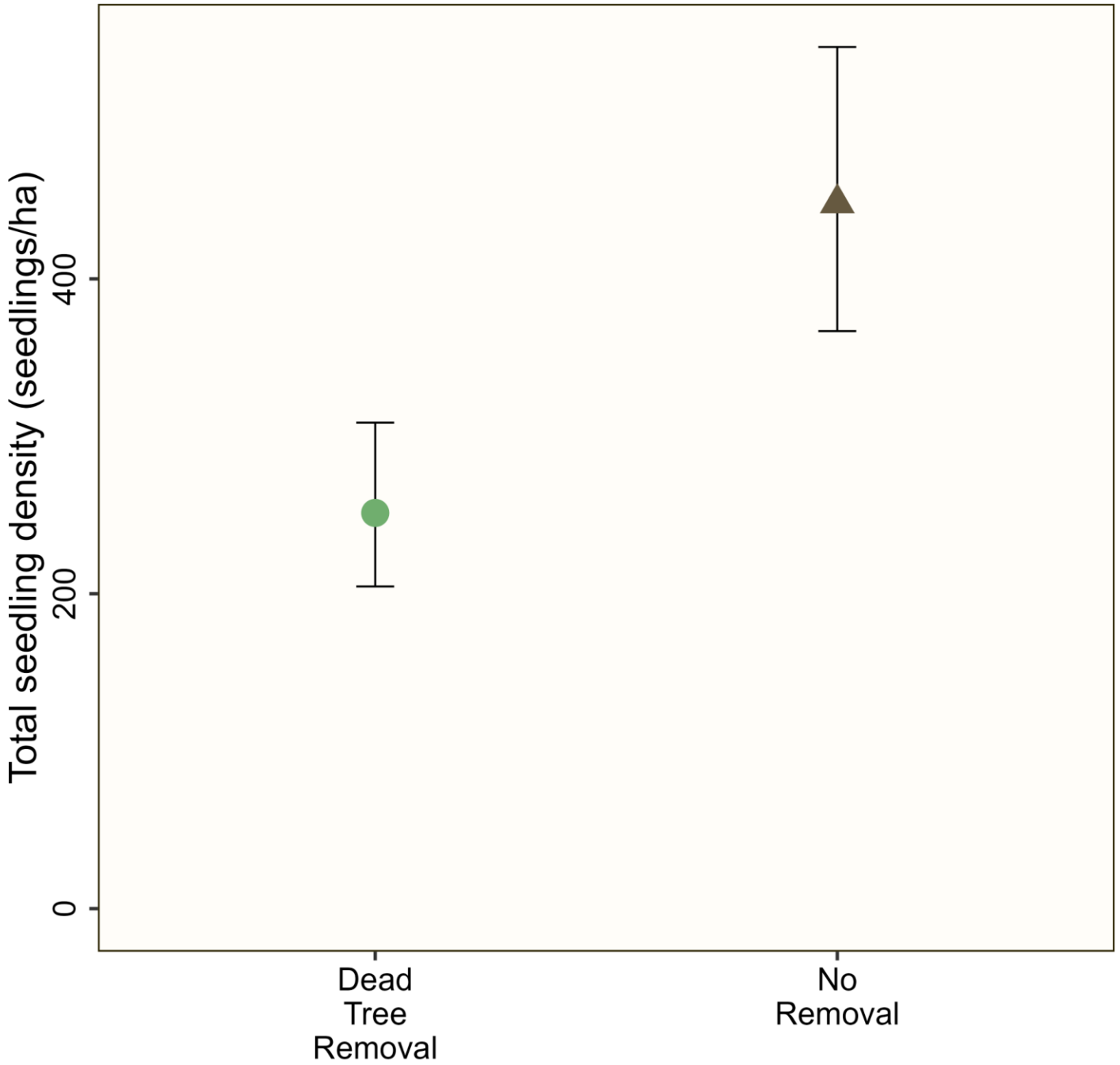
1) Does dead tree removal alter regeneration density? (seedlings and saplings)

2) Are species affected differently?

3) Do seedlings respond differently by age?

Seedling density reduced

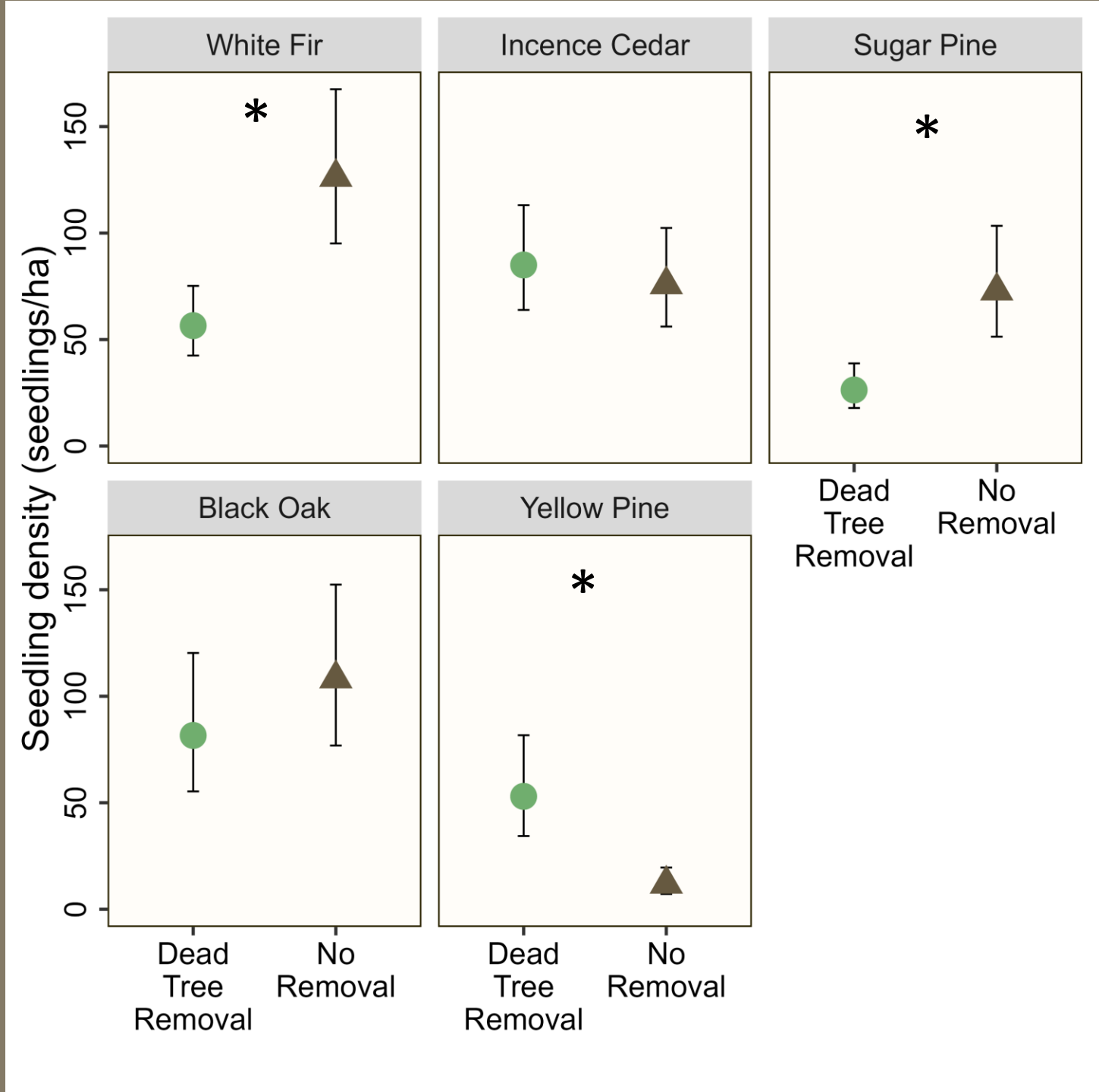
1) Treatment reduced total seedling density by 60%

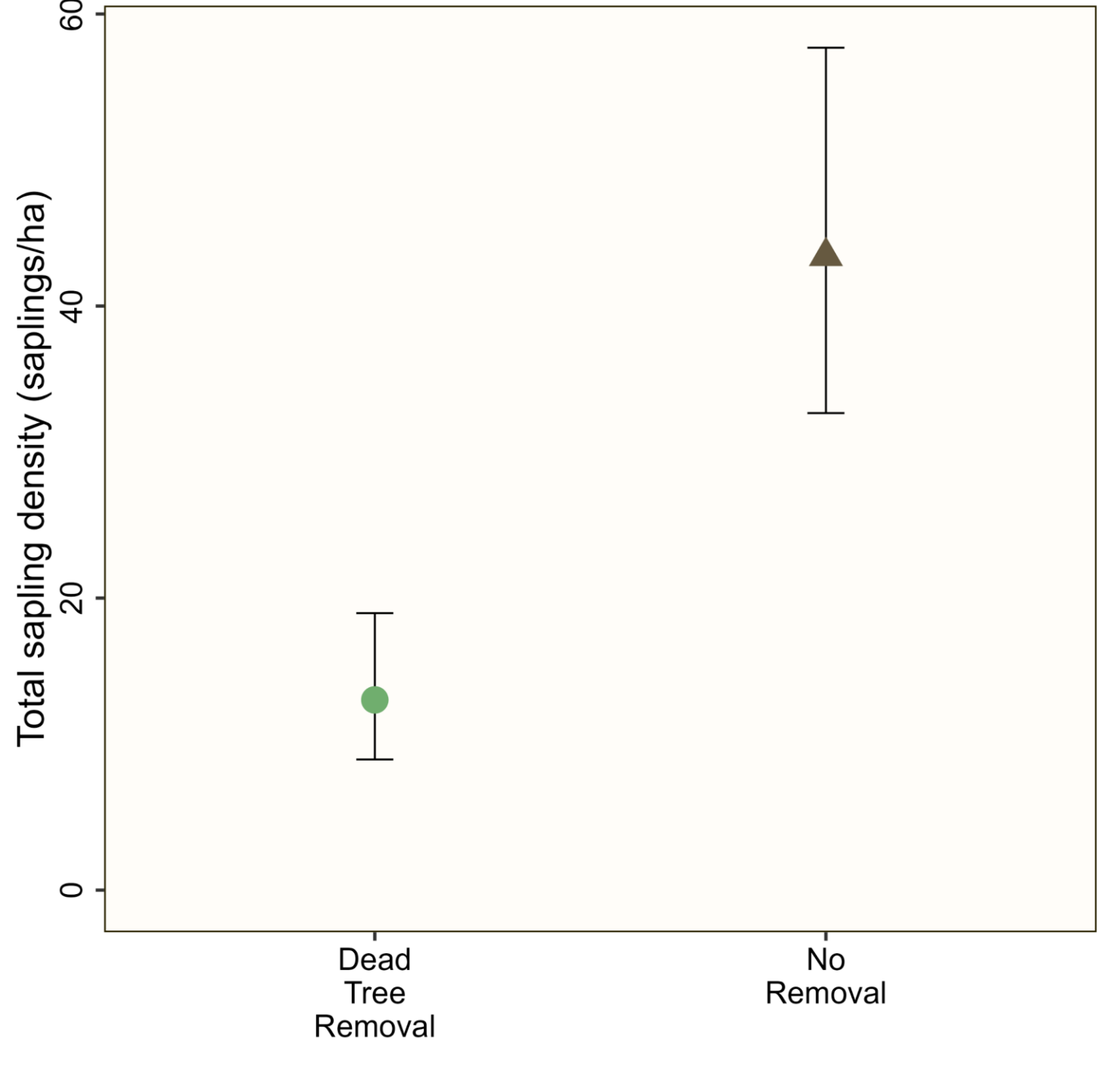


Seedling density reduced

1) Treatment reduced total seedling density by 60%

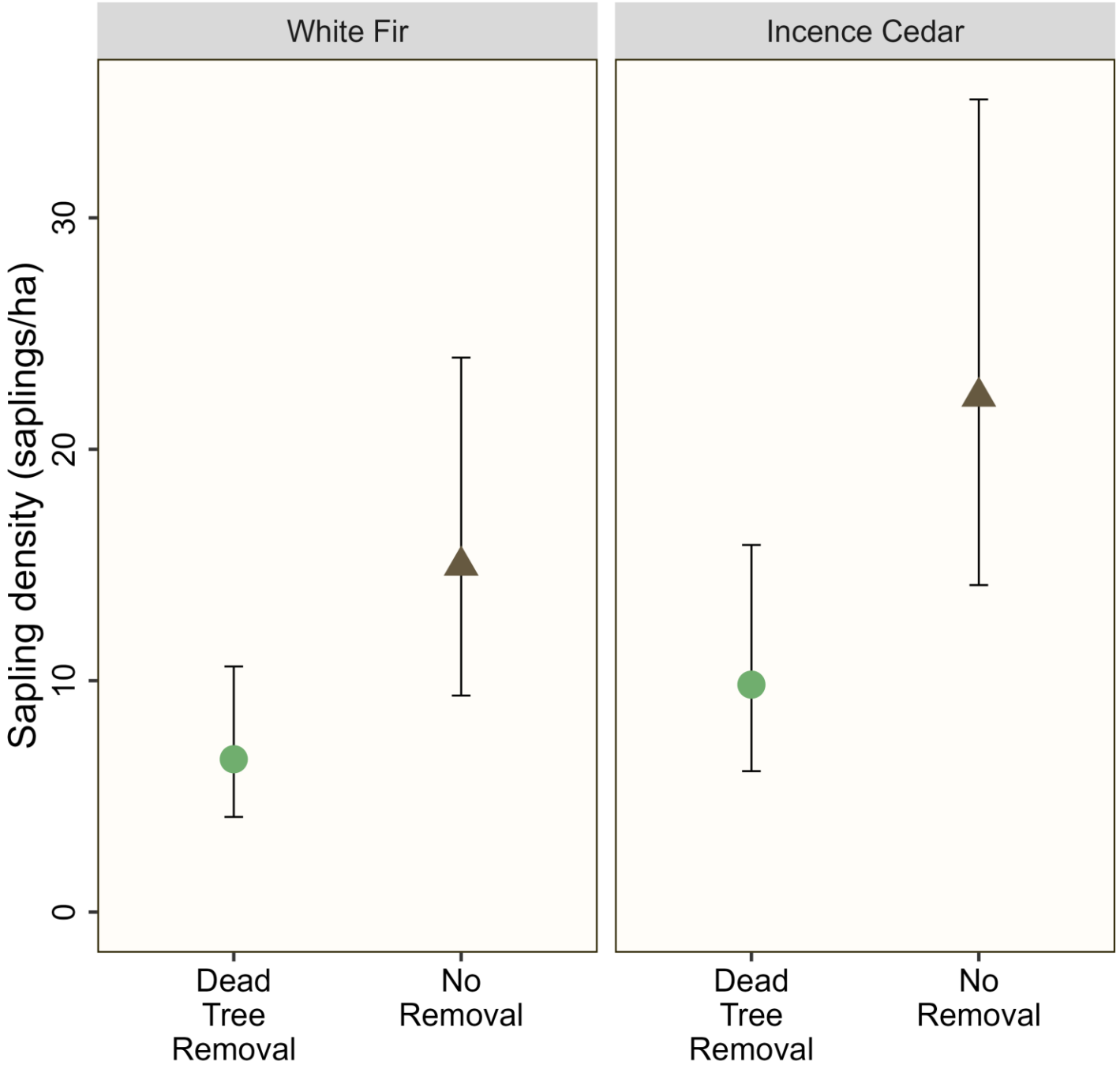
2) Species responded differently





Sapling density decreased by 65%

1) Treatment reduced total sapling density by 65%



Sapling density decreased by 65%

1) Treatment reduced total sapling density by 65%
2) Both species similar

Conclusions

1) Removal may reduce stand density into the future

2) Species composition may be influenced by removal

3) Yellow pine recruitment may benefit over time from removal

4) Removal may result in more favorable establishment, and reduced competition.

Fuels, carbon, and modeled fire severity

Study Questions:

1) Do fuels profiles differ over time between treatments?

2) Does modeled future fire behavior and severity change with treatment?

3) How will forest carbon be affected by treatment?

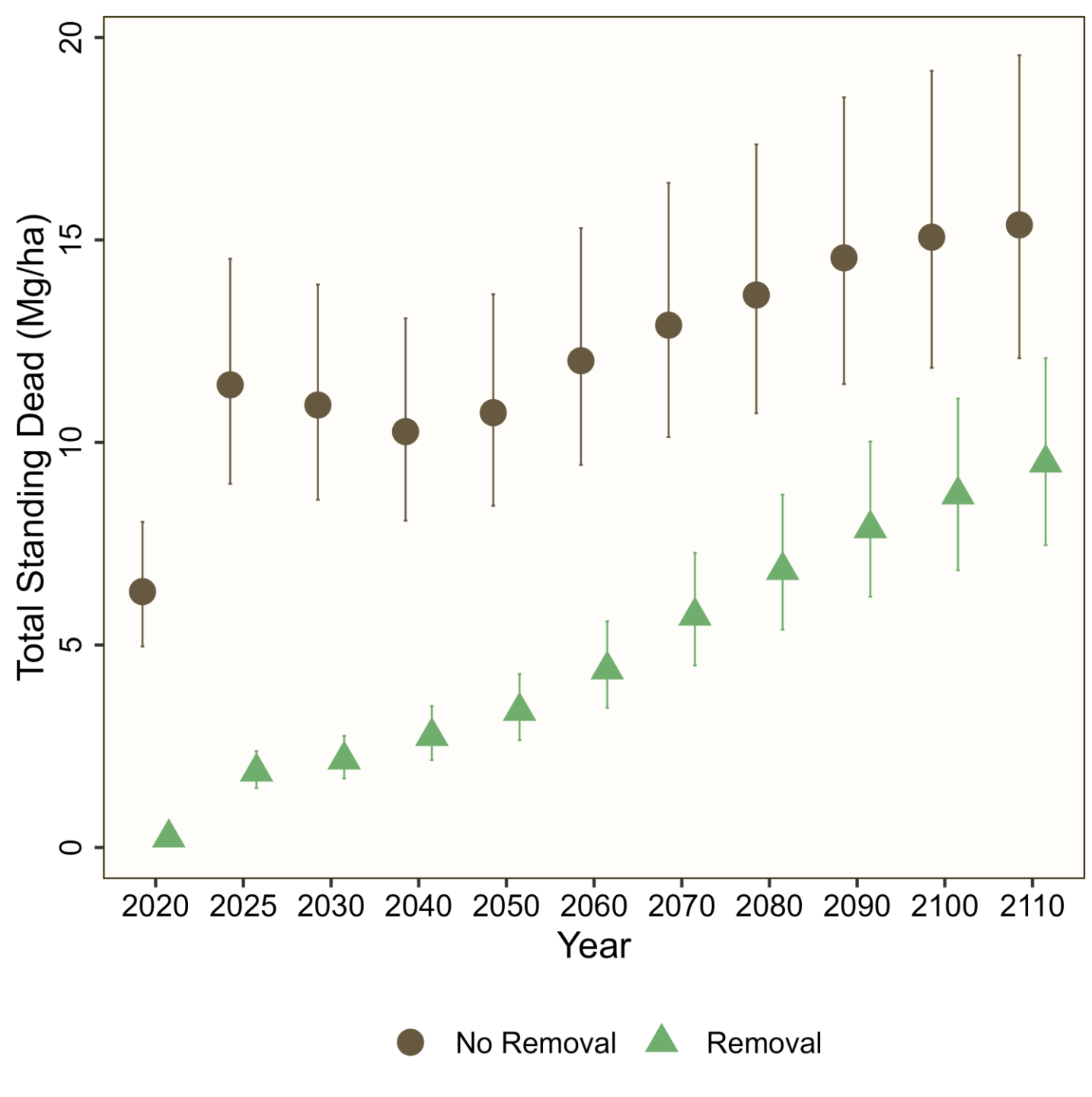
Forest vegetation simulator

1) Used measures of forest structure and fuels within plots

2) Simulated one hundred years

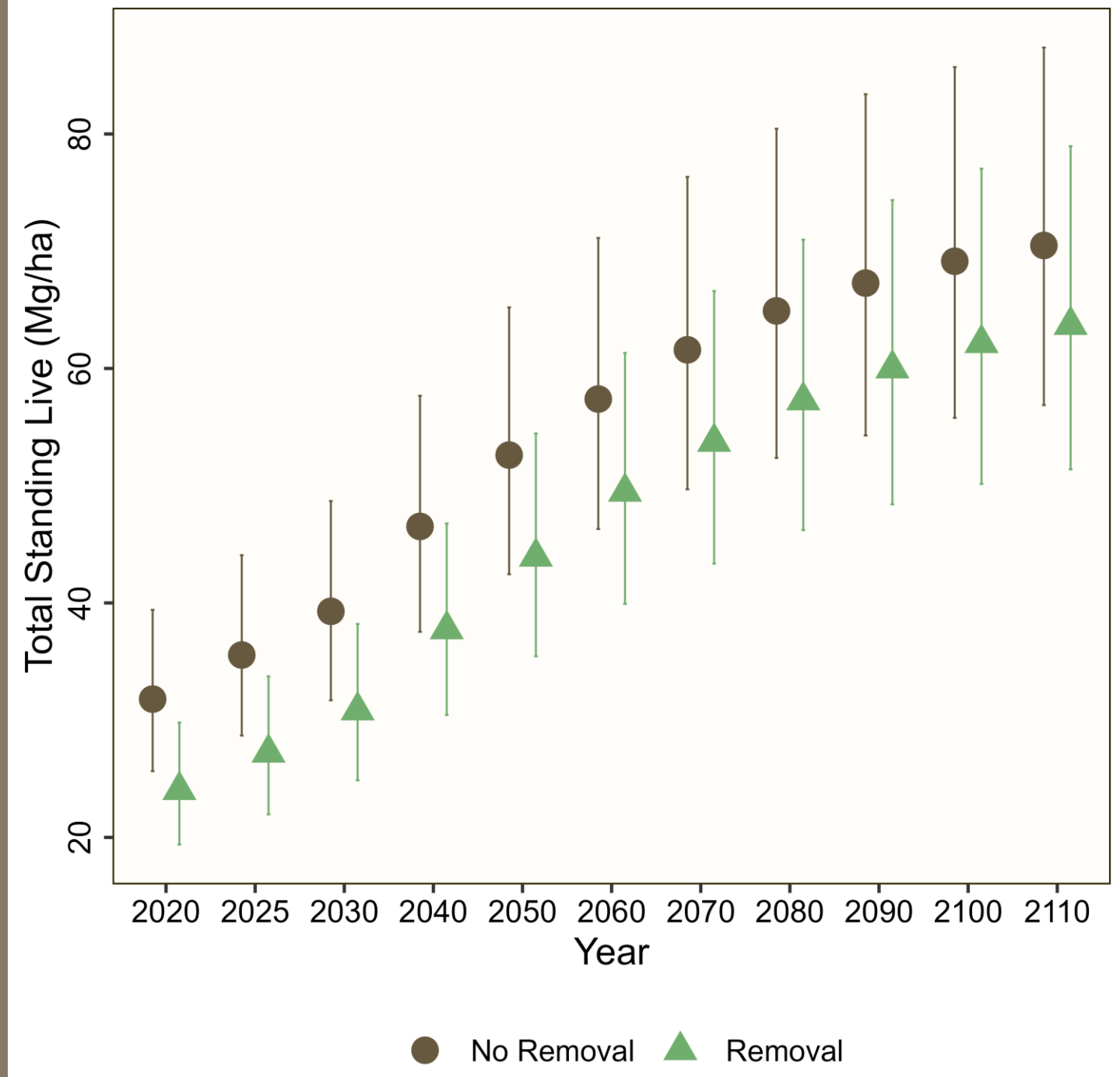
3) Fuels, wildfire, carbon stocks

4) Fuels and carbon projections assume no wildfire, and recruitment into the canopy only arises from seedlings and saplings

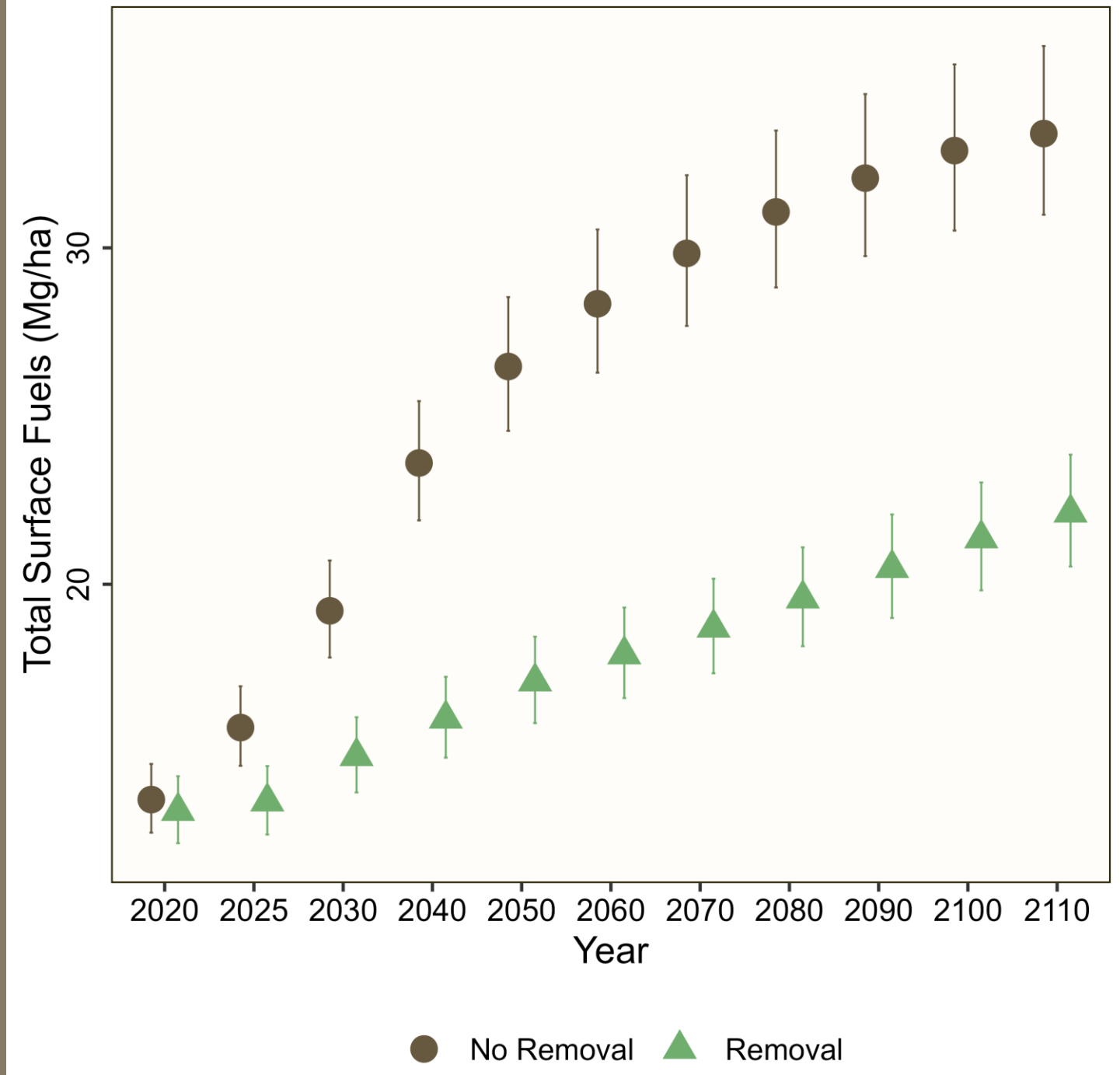


Standing dead fuel remains lower over time with treatment

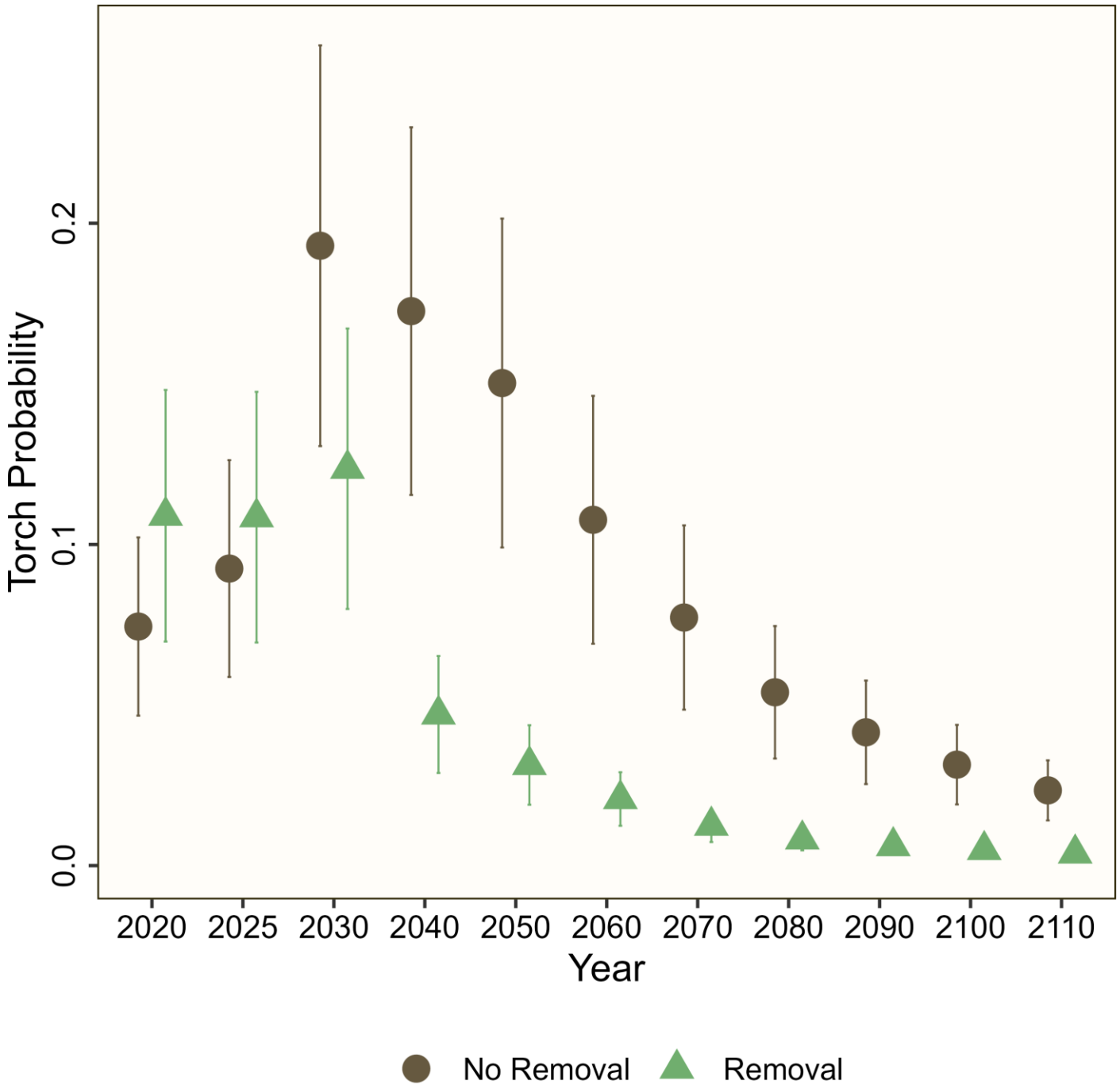
Differences in standing live fuels are less pronounced



Surface Fuels increase more slowly over time with treatment

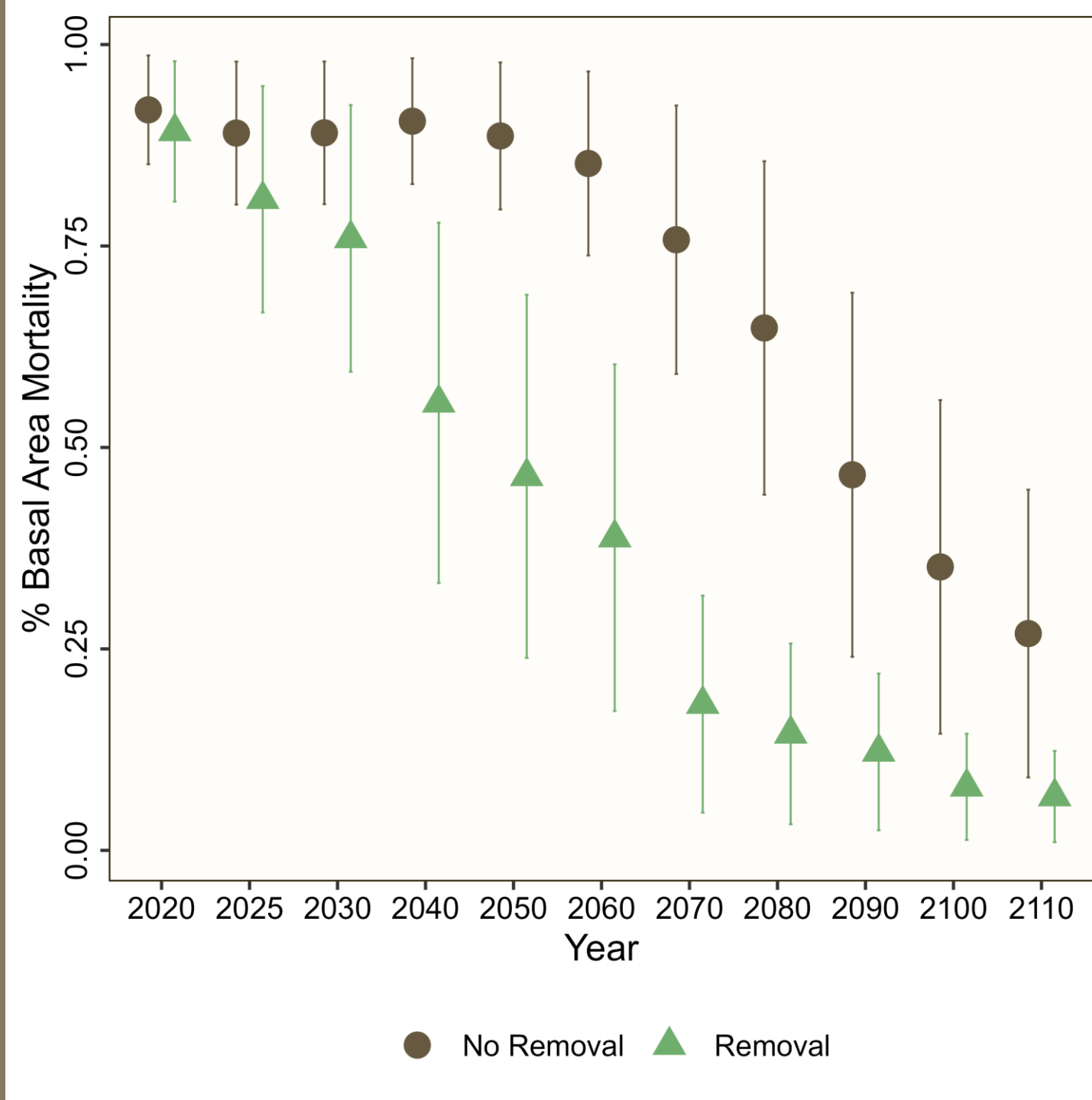


So, what happens if a fire comes through?

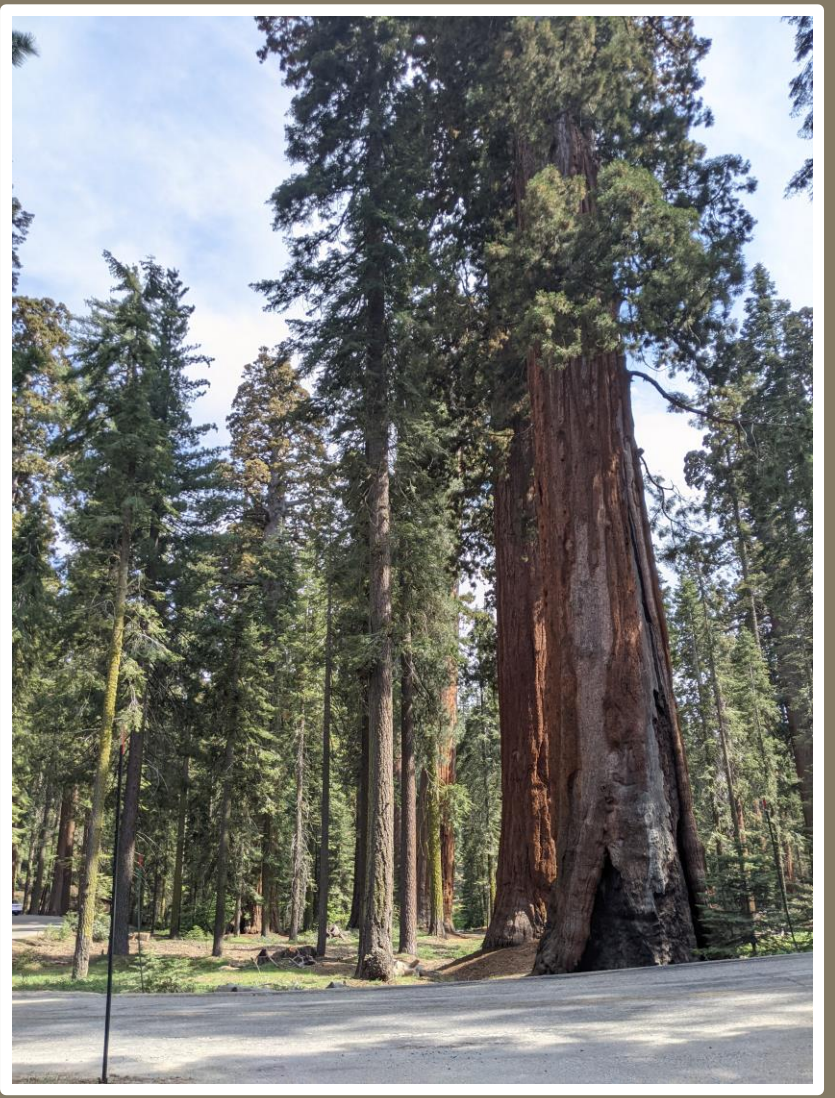


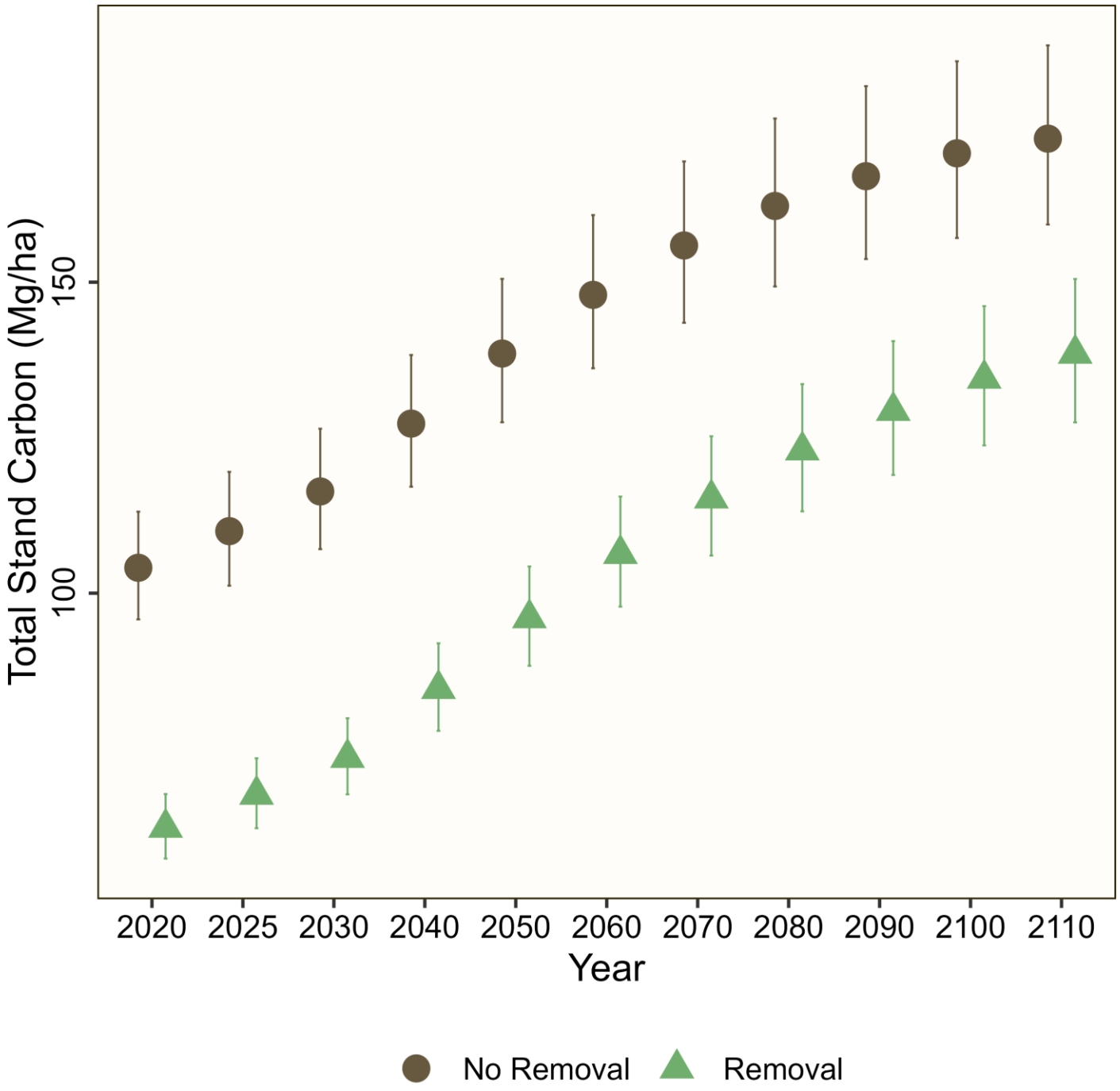
Torch probability higher initially with treatment, then decreases substantially

Mortality after wildfire substantially reduced by treatment after 10-15 years



What about the forest’s ability to hold carbon long term?





Total forest carbon is reduced with treatment

Conclusions

1) Pulse of surface fuels after dead tree removal increases likelihood of crown fire in near term, but likelihood is lower in treatment over longer term

2) Removal may be effective at reducing severe fire over time

3) Carbon stock may remain lower after removal long term, but if dead trees are salvaged, timber used for construction will decrease and delay carbon flux to the atmosphere, which we can't account for here.

Understory plants

What are the impacts of recent dead tree removal on understory plant species:

- Richness & Diversity
- Cover
- Community composition

Study Questions:

1) Does dead tree removal affect understory plant species diversity, and if so, what are the associated environmental factors?

2) How does dead tree removal affect understory vegetation cover?

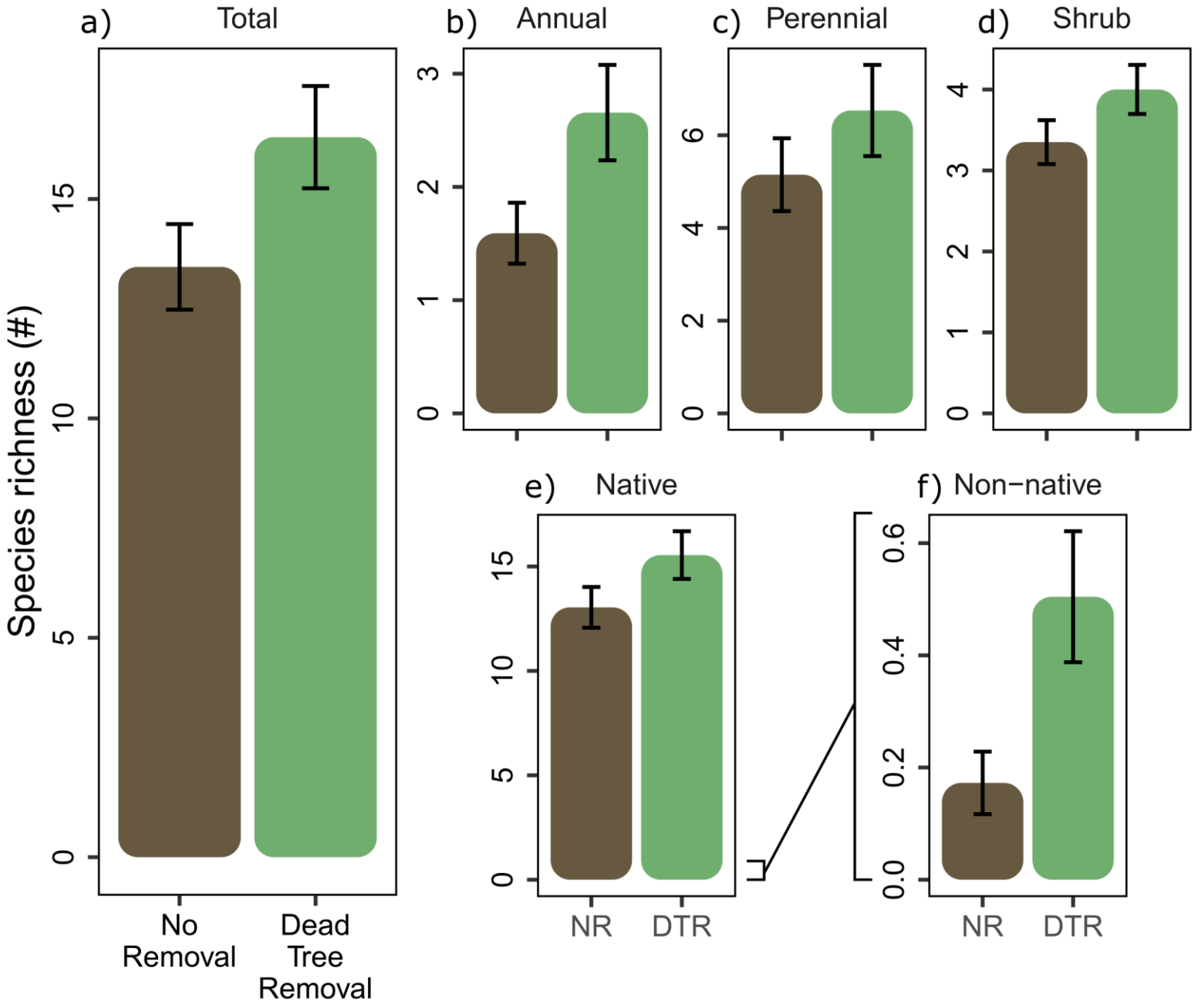
3) Does dead tree removal alter understory plant community composition, and if so, which environmental characteristics and plant functional groups are associated with the changes?

Question 1:

Does dead tree removal affect understory plant species diversity, and if so, what are the associated environmental factors?

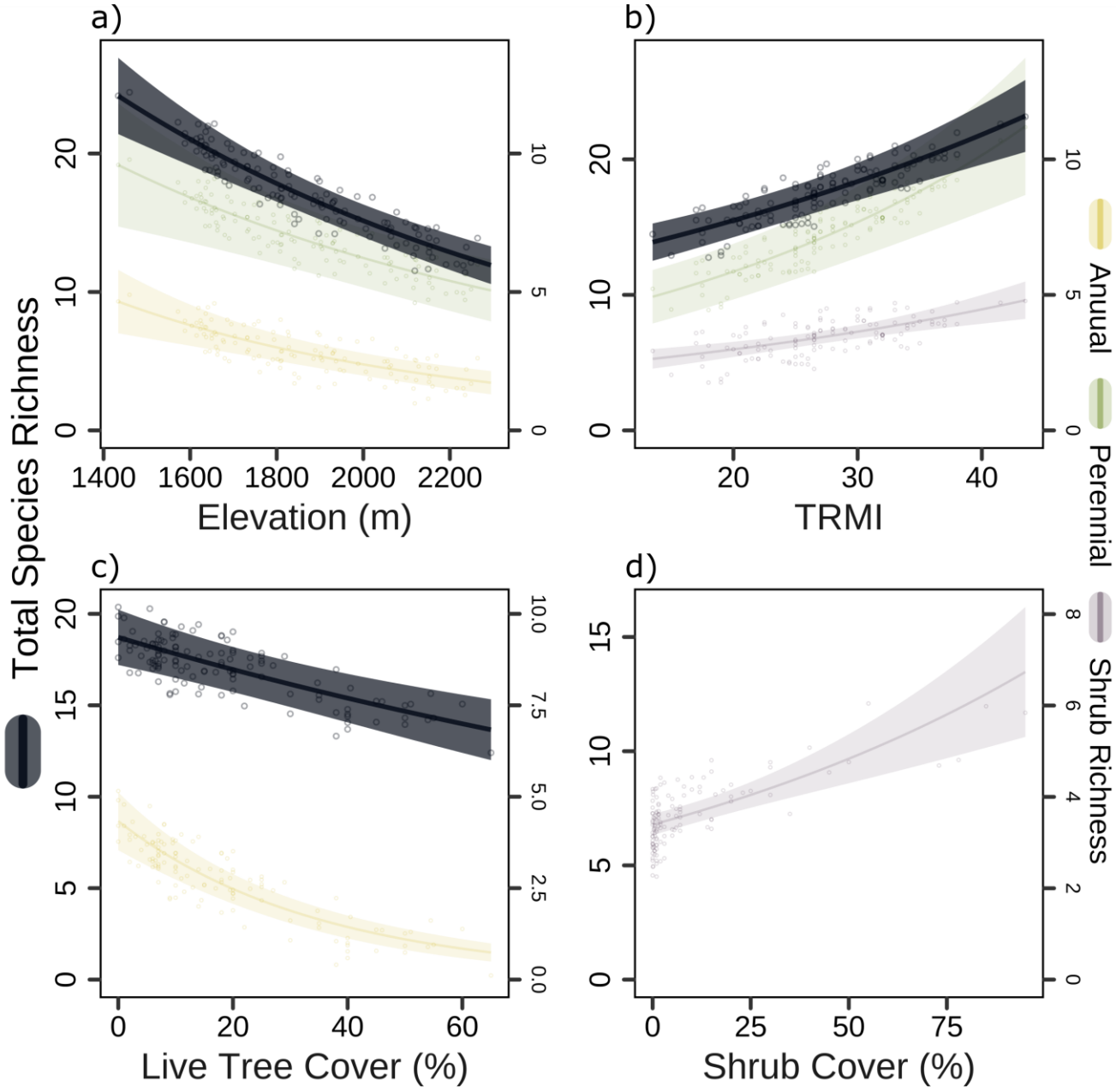
Species Richness:

- Higher in treated plots
- Driven by annuals



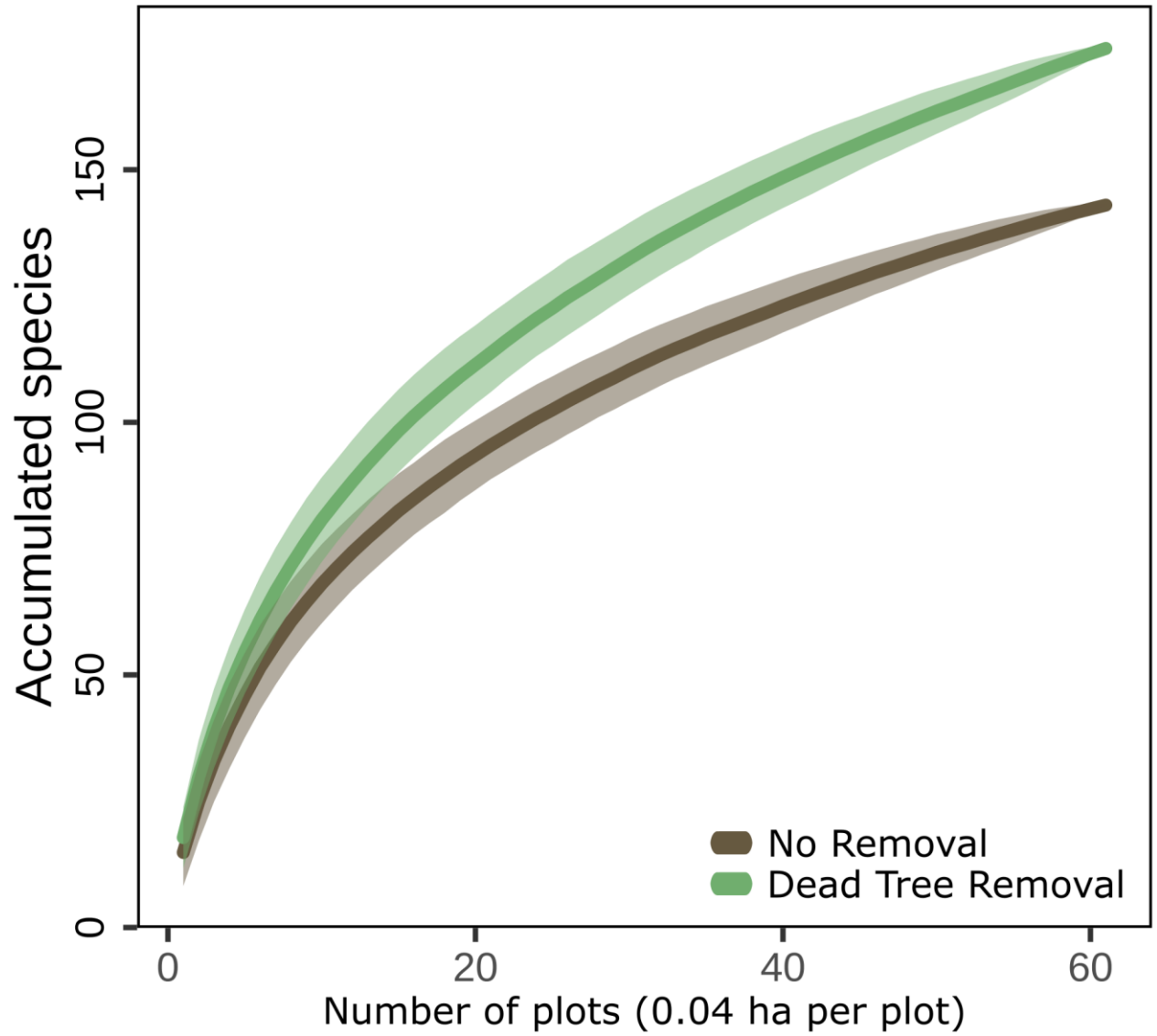
Environmental Drivers of Species Richness:

- Annual and total richness decrease with increasing tree cover



Species Accumulation:

- Faster in treated plots

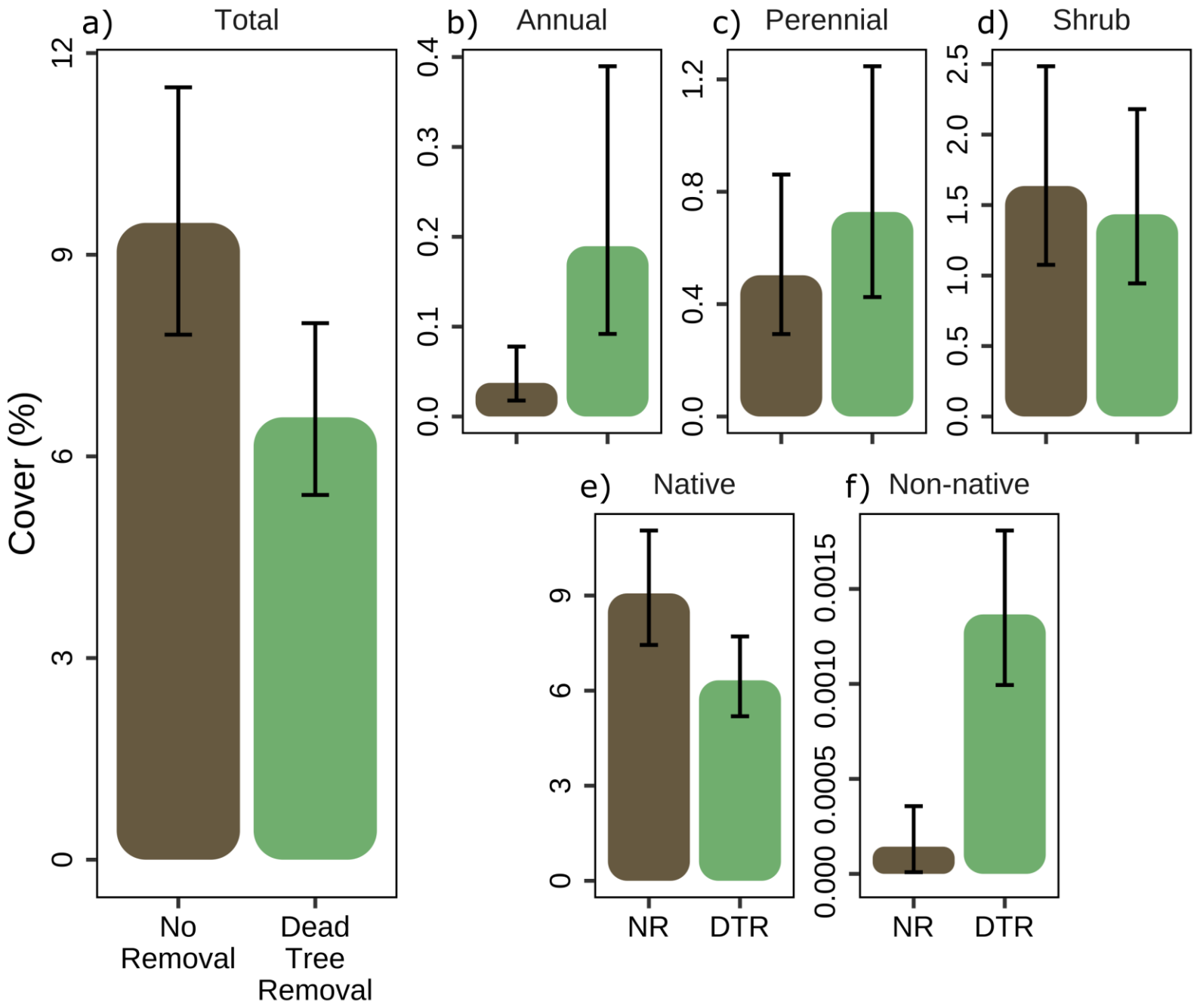


Question 2:

How does dead tree removal affect understory vegetation cover?

Plant Cover:

- 30% lower in treatments
- Differed by functional group

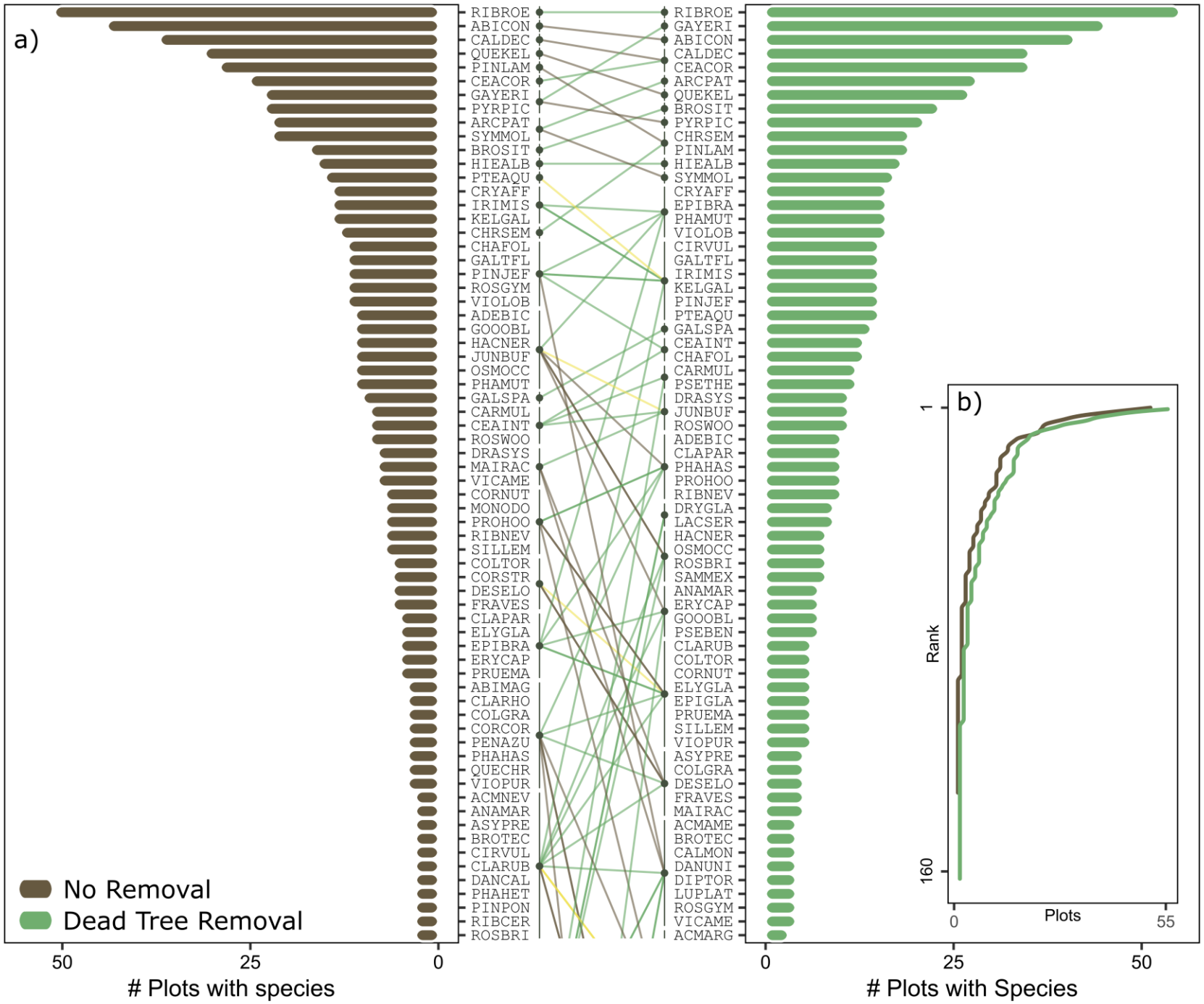


Question 3:

Does dead tree removal alter understory plant community composition, and if so, which environmental characteristics and plant functional groups are associated with the changes?

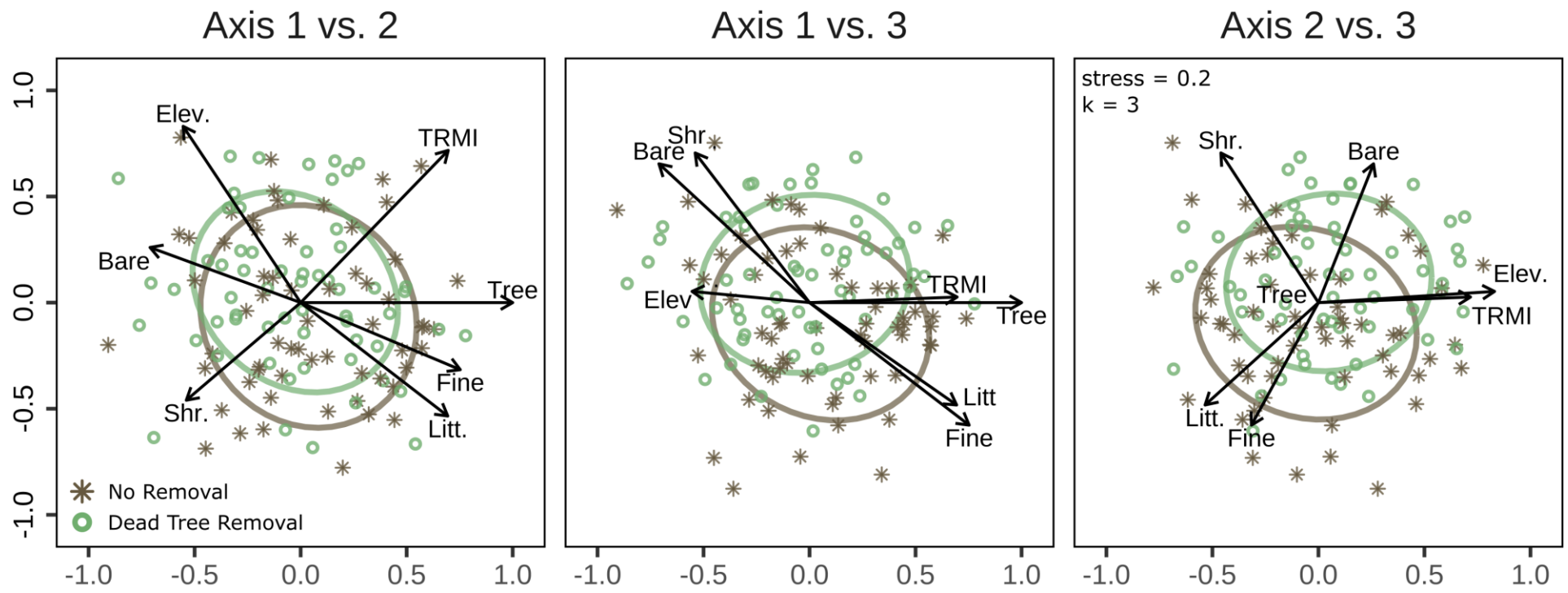
Species Rank Abundance:

- Similar for most common species
- Community differences driven by less common species



NMDS ordination →

PERMANOVA: p = 0.006



Indicator Species Analysis

Control (3 species):

- 0 annuals
- 2 shrubs
- 1 parasitic plant
- 0 non-natives

Treatment (9 species):

- 4 annuals
- 1 shrub
- 0 parasitic plants
- 2 non-natives

Recent dead tree removal was associated with:

- Increased alpha and gamma richness
- Higher proportion of annual plants
- Increased cover of annuals, non-natives
- Subtle changes to community composition

Thank you

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