Regeneration following fire in the Blue Mountains

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A quick note on images…

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A road map: Where we are headed together this morning

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1. Post-fire regeneration following high-severity fire in dry mixed-conifer forests

A road map:
Where we are headed together this morning?

1. Post-fire regeneration following high-severity fire in dry mixed-conifer forests

2. Post-fire Alaska yellow-cedar mortality and regeneration in the Cedar Grove Botanical Area

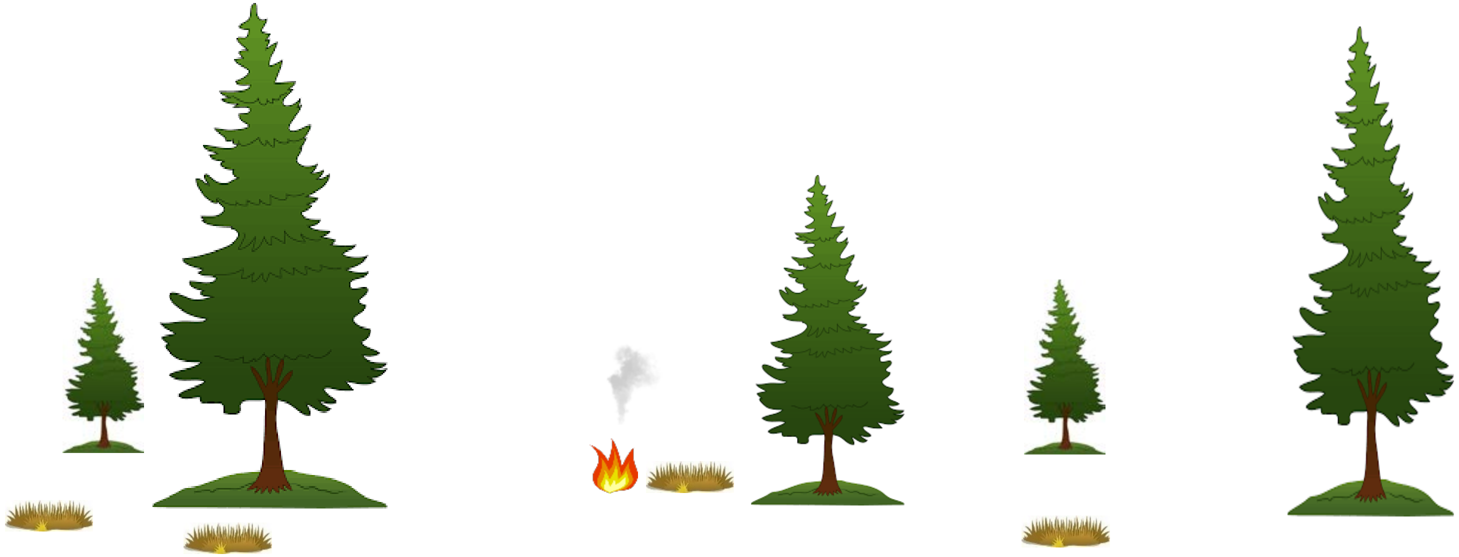

747 Fire, 2002
Southern Blue Mountains

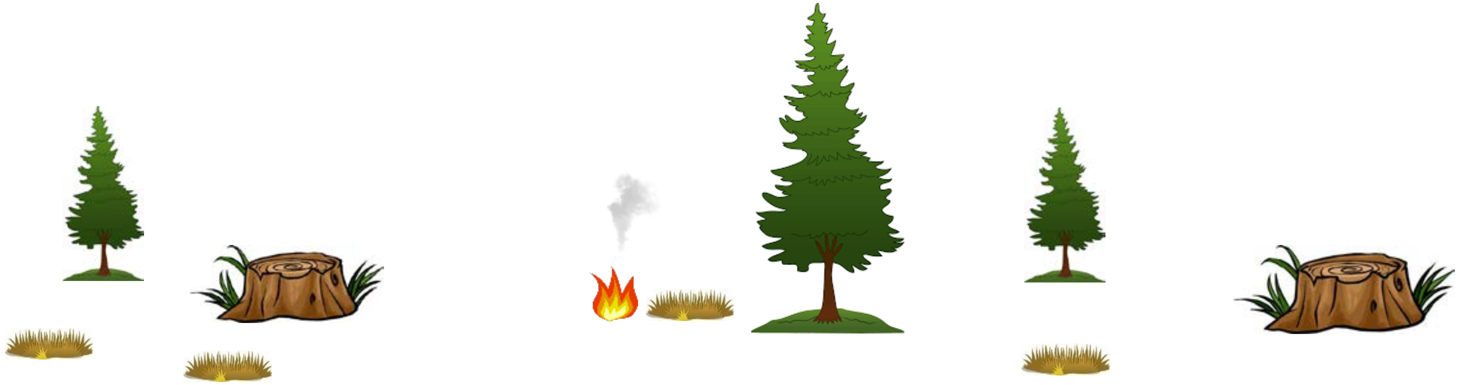

Roberts Creek Fire, 2002
Malheur National Forest


Hash Rock Fire, 2000
Ochoco National Forest

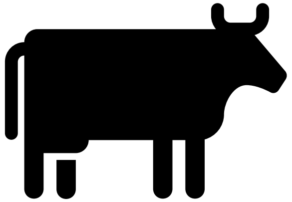
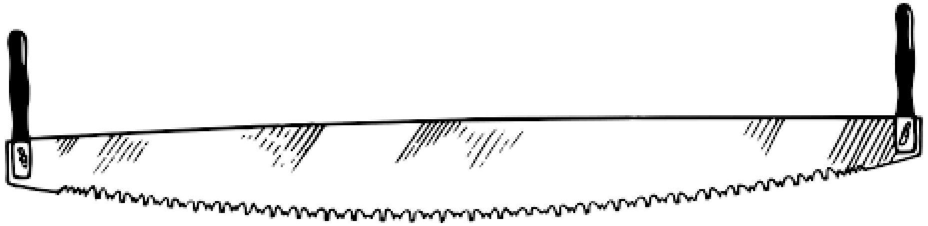
Pre-settlement dry mixed-conifer forests in the Blue Mountains

Frequent historical fire

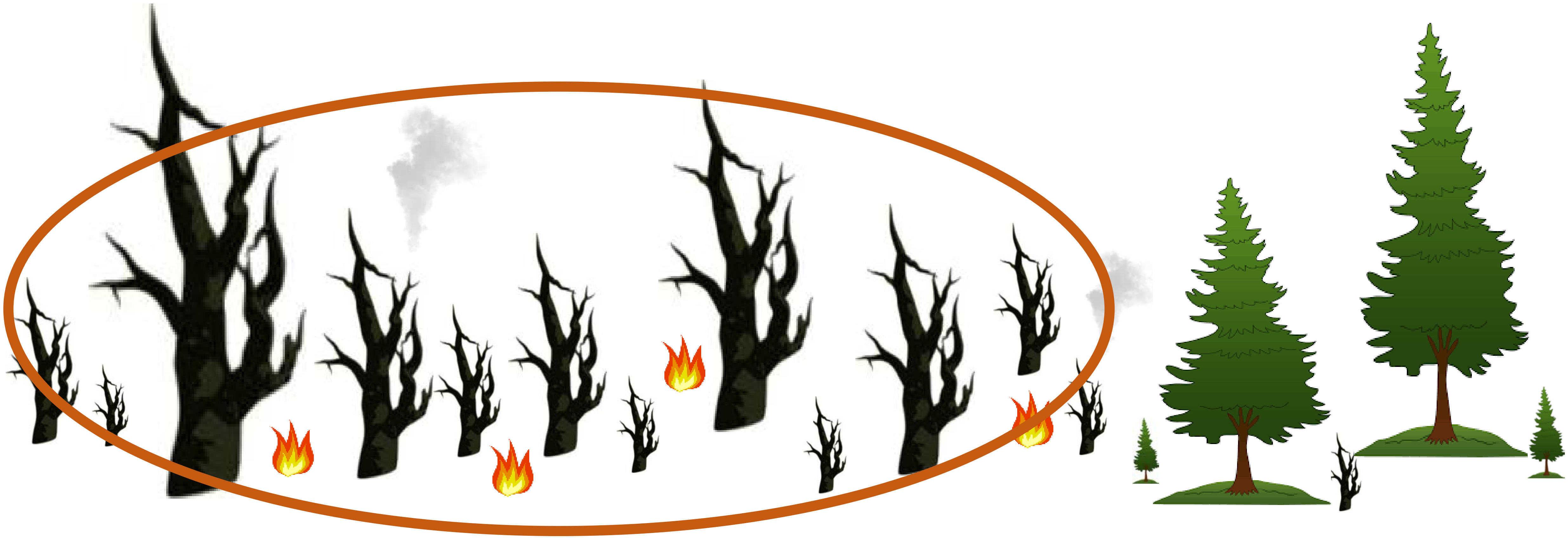




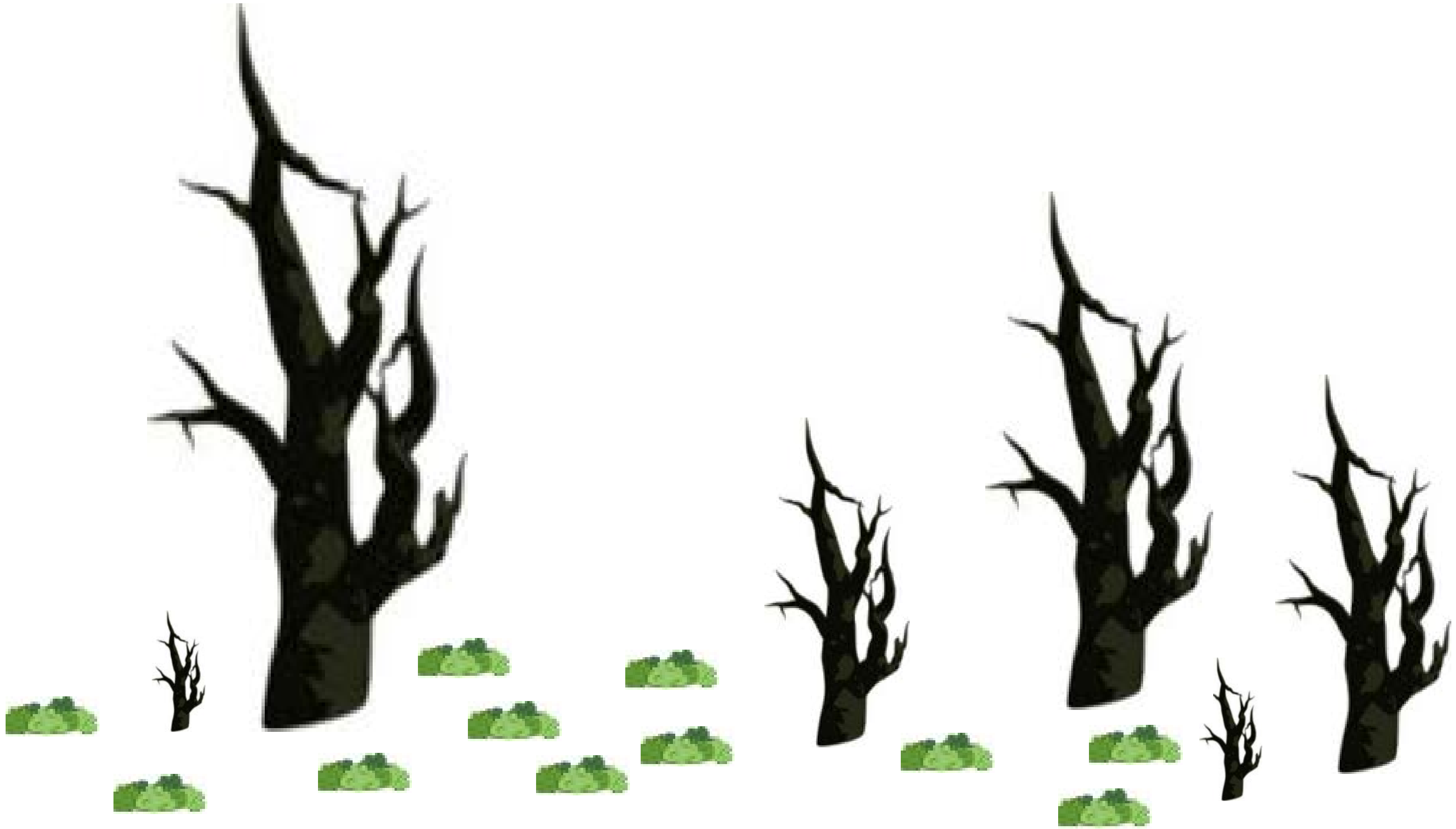
Significant changes in forest structure and the periodicity of fire

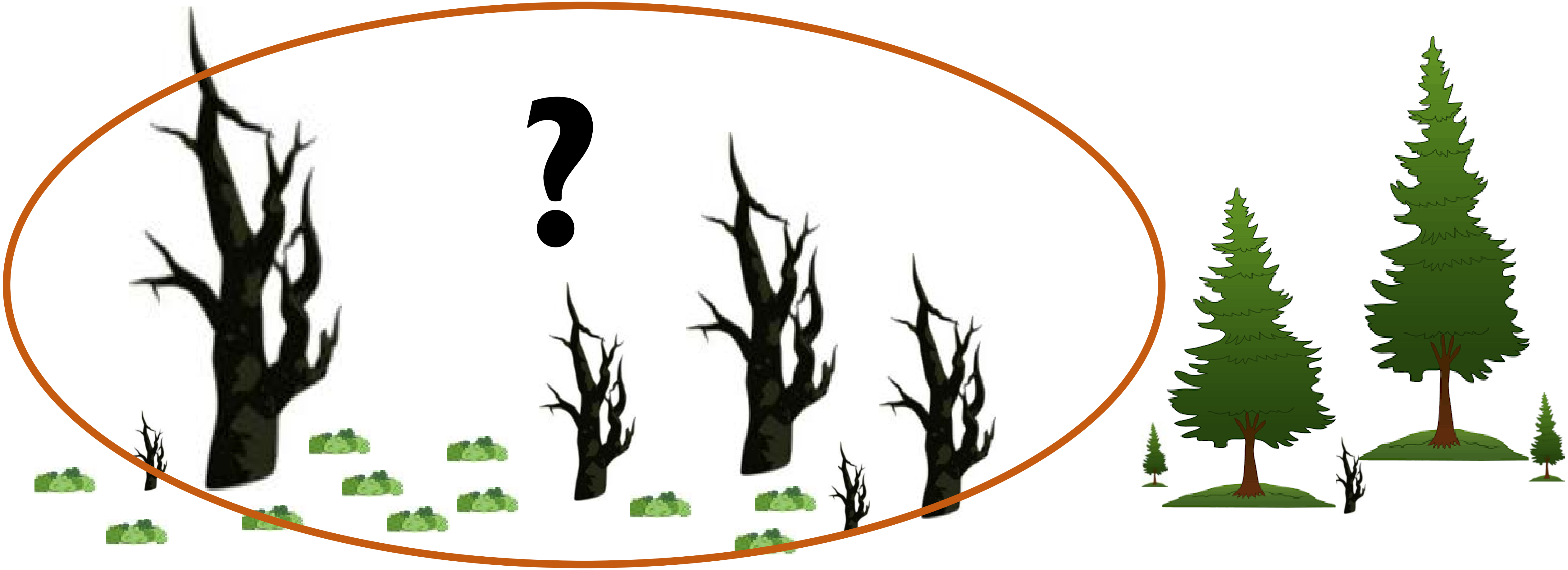
Contemporary fire effects raising concerns about forest resilience



High-severity burned areas may be at risk of converting to non-forest, alternative stable states



Can high-severity burned areas regenerate forest?



Can high-severity burned areas regenerate forest?

1. Quantify conifer seedling regeneration following stand-replacement fire in Oregon's Blue Mountains.

Can high-severity burned areas regenerate forest?

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Can high-severity burned areas regenerate forest?

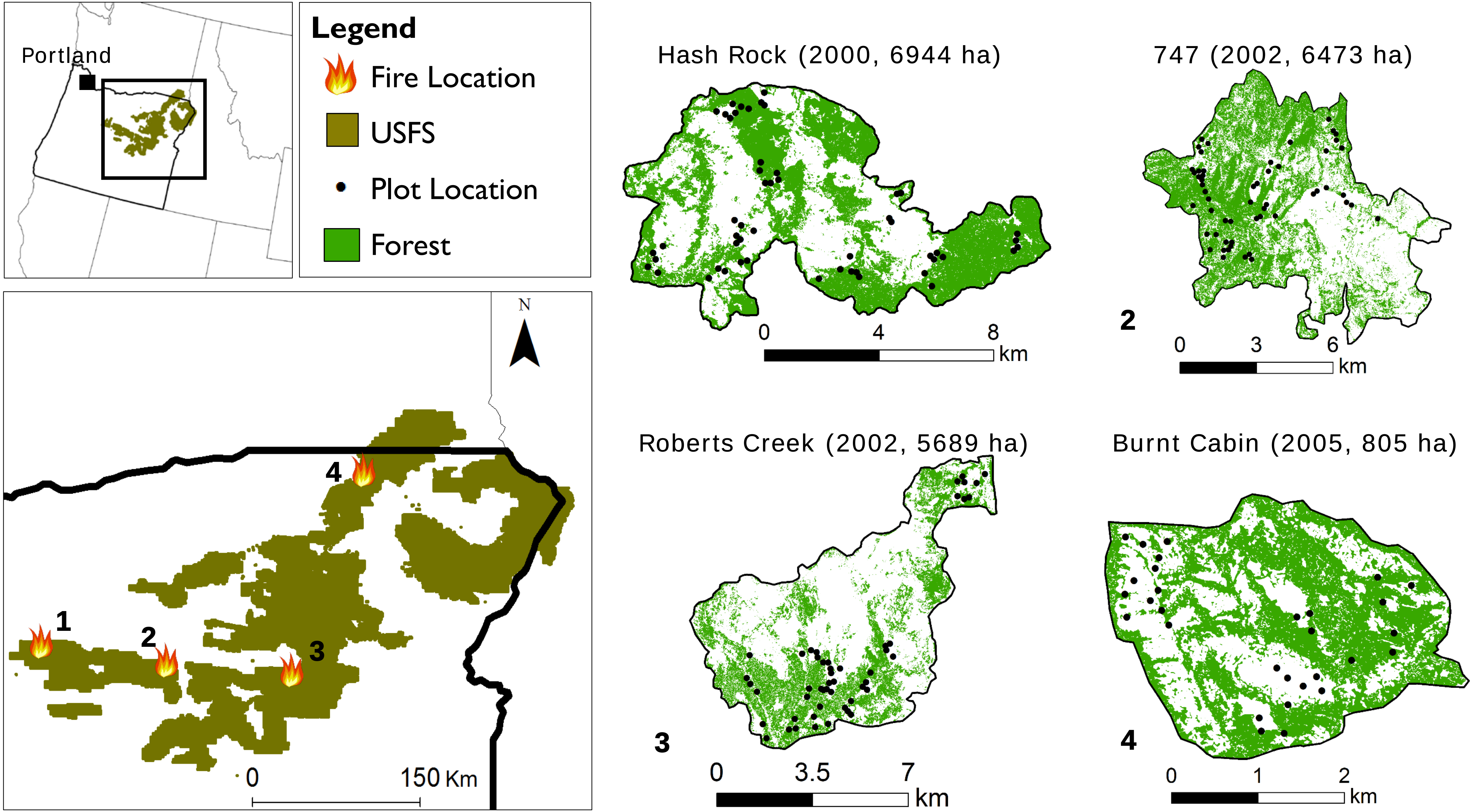
1. Quantify conifer seedling regeneration following stand-replacement fire in Oregon's Blue Mountains. Are forests regenerating?

2. Identify the drivers of post-fire conifer seedling regeneration.

Can high-severity burned areas regenerate forest?

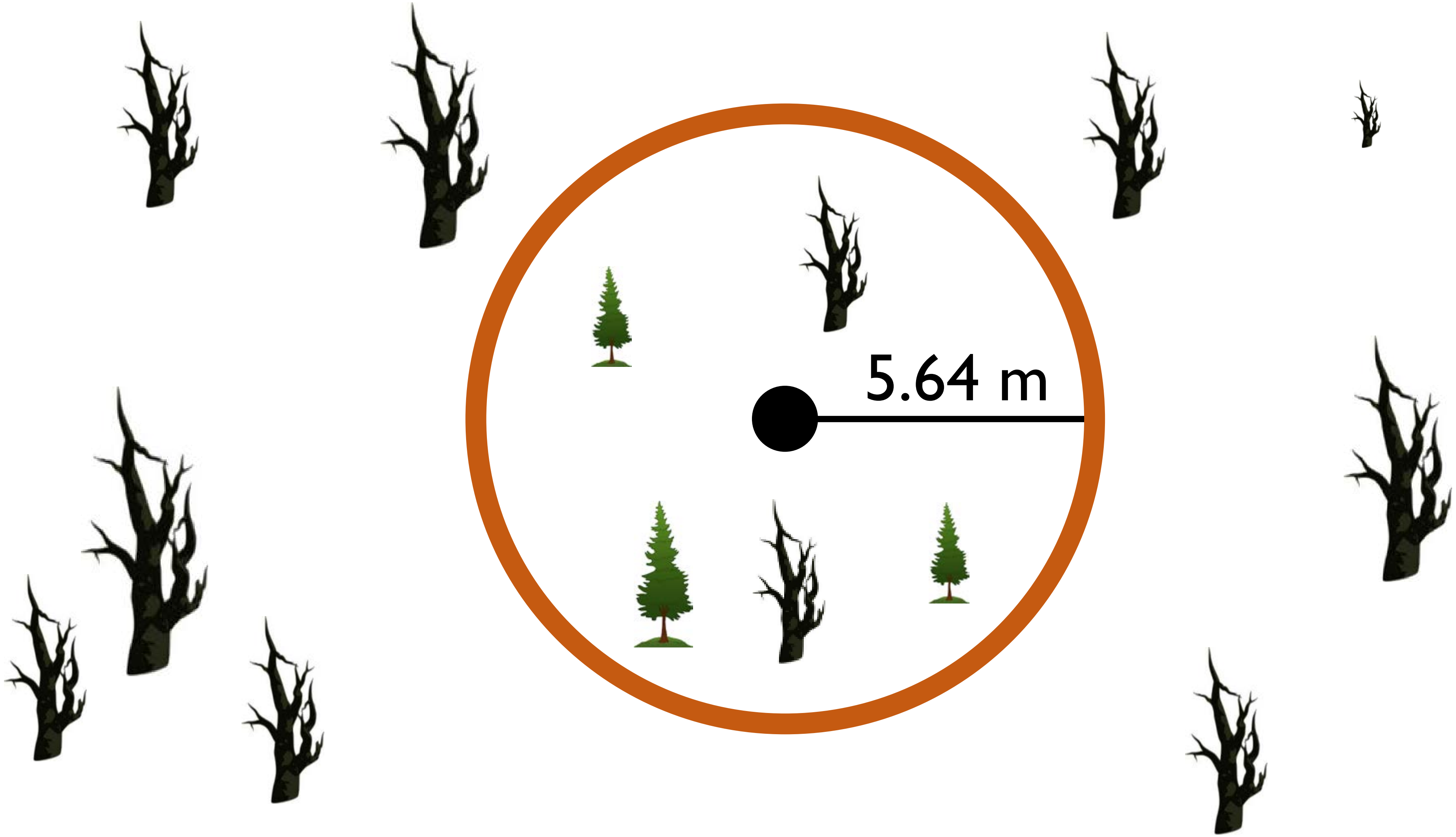
1. Quantify conifer seedling regeneration following stand-replacement fire in Oregon's Blue Mountains. Are forests regenerating?

2. Identify the drivers of post-fire conifer seedling regeneration. What is the influence of surviving seed source pattern on conifer regeneration in stand-replacement patches?



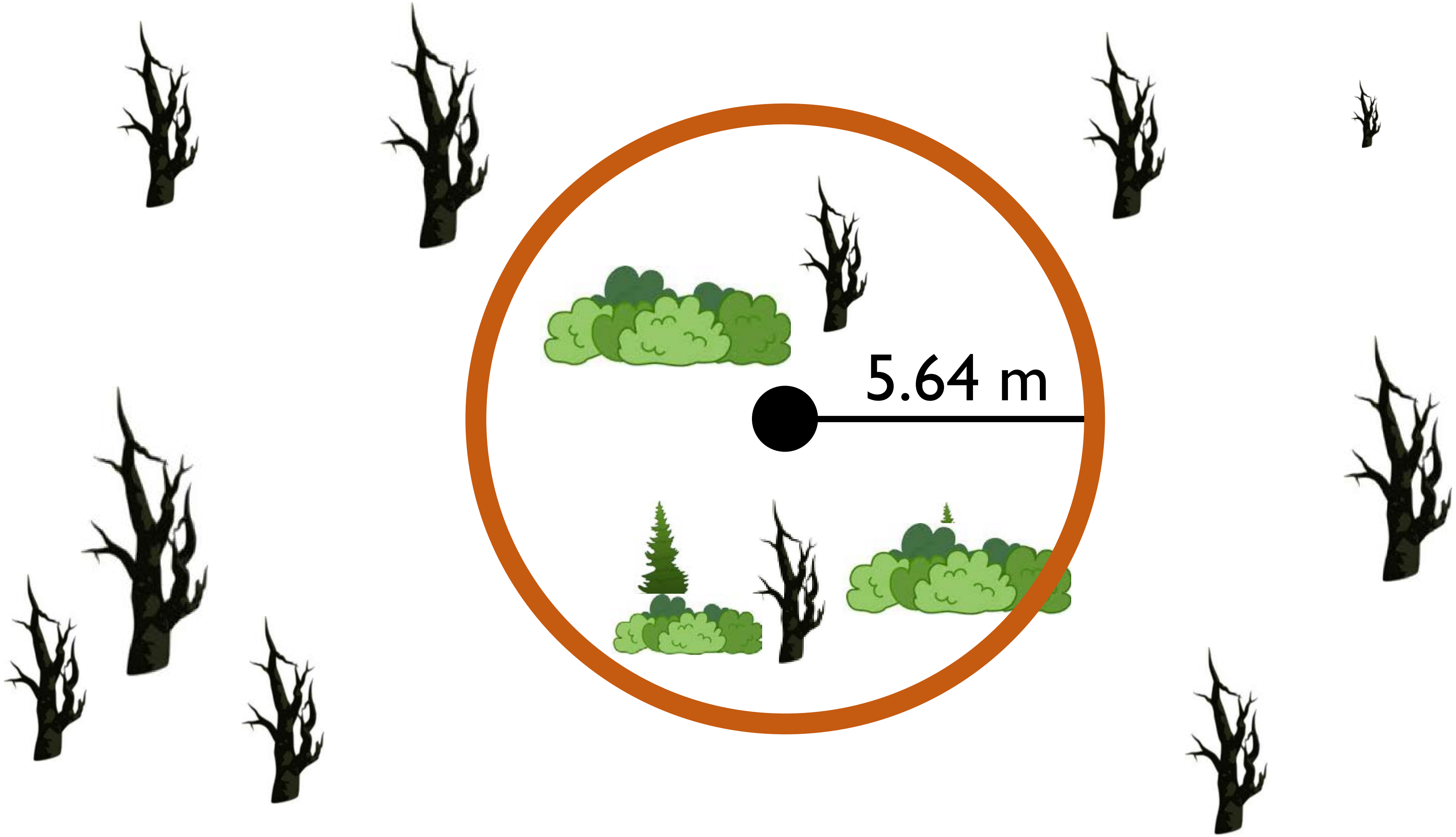
Portland
Legend
Fire Location
USFS
Plot Location
Forest
N
4
1
2
3
0
150 Km
Hash Rock (2000, 6944 ha)
0
4
8
km
747 (2002, 6473 ha)
2
0
3
6
km
Roberts Creek (2002, 5689 ha)
3
0
3.5
7
km
Burnt Cabin (2005, 805 ha)
4
0
1
2
km

Study design
of seedlings



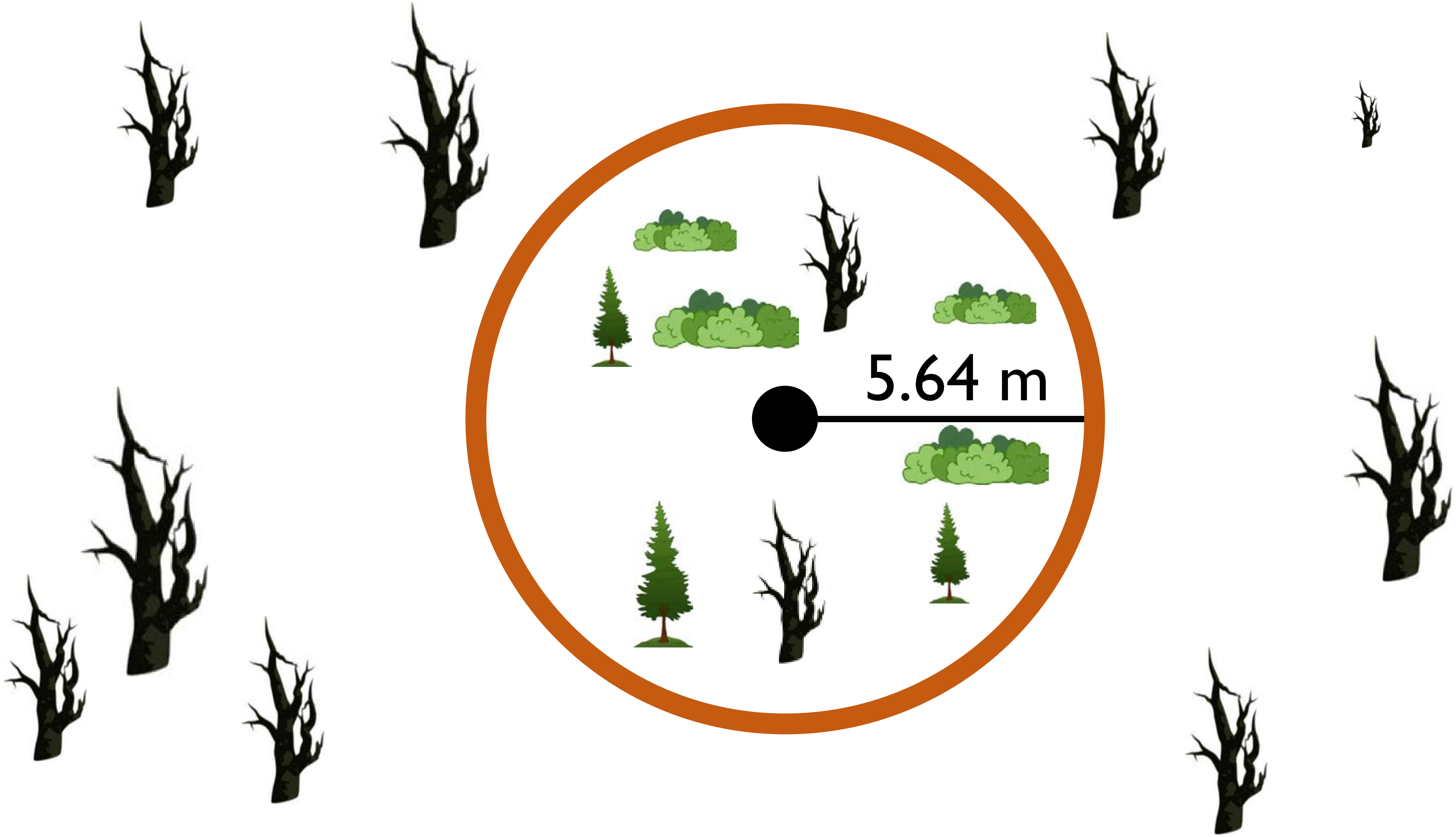
Study design

of seedlings, overtopped Y/N



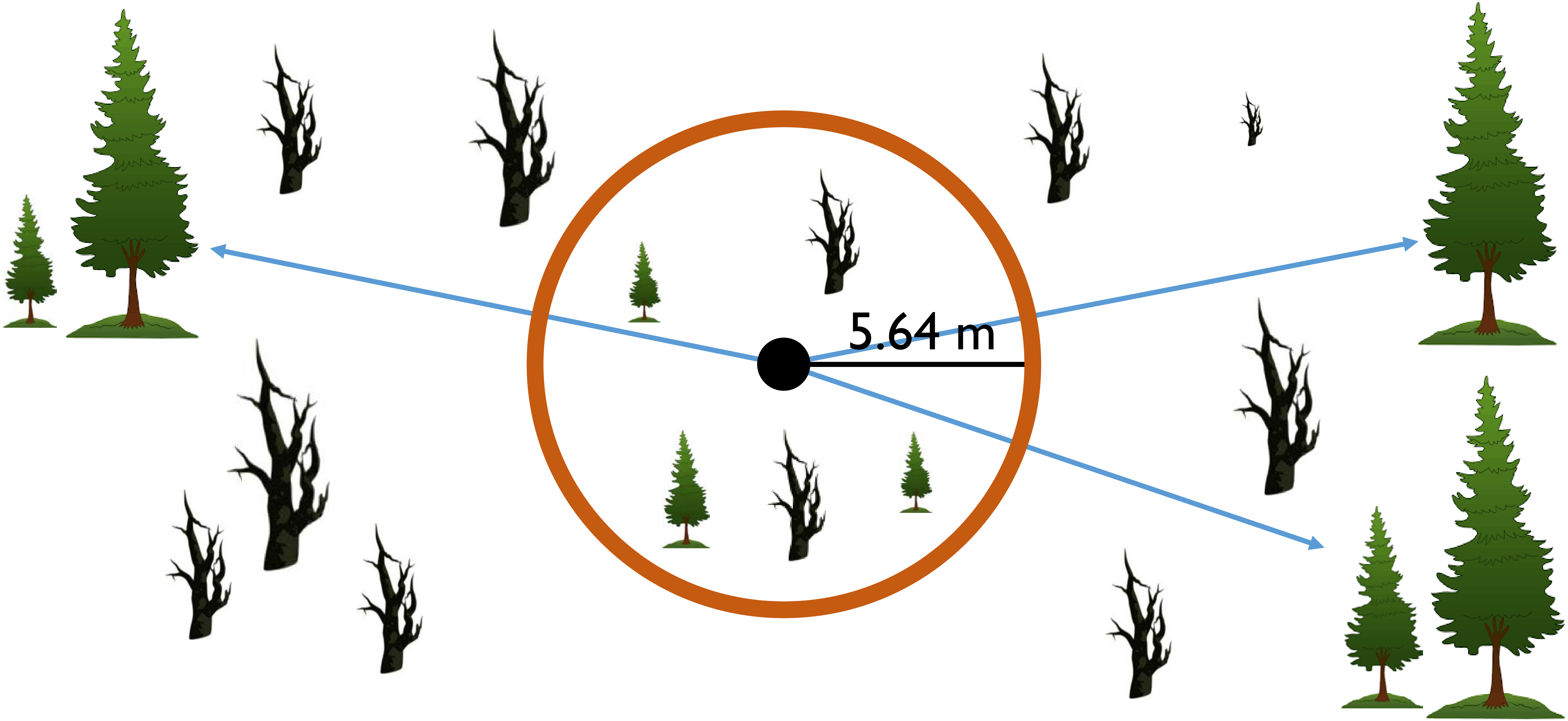
Study design

of seedlings, overtopped Y/N, shrub cover



Study design

of seedlings, overtopped Y/N, shrub cover, distance to seed source



Results:

Results: No evidence of large-scale regeneration failure

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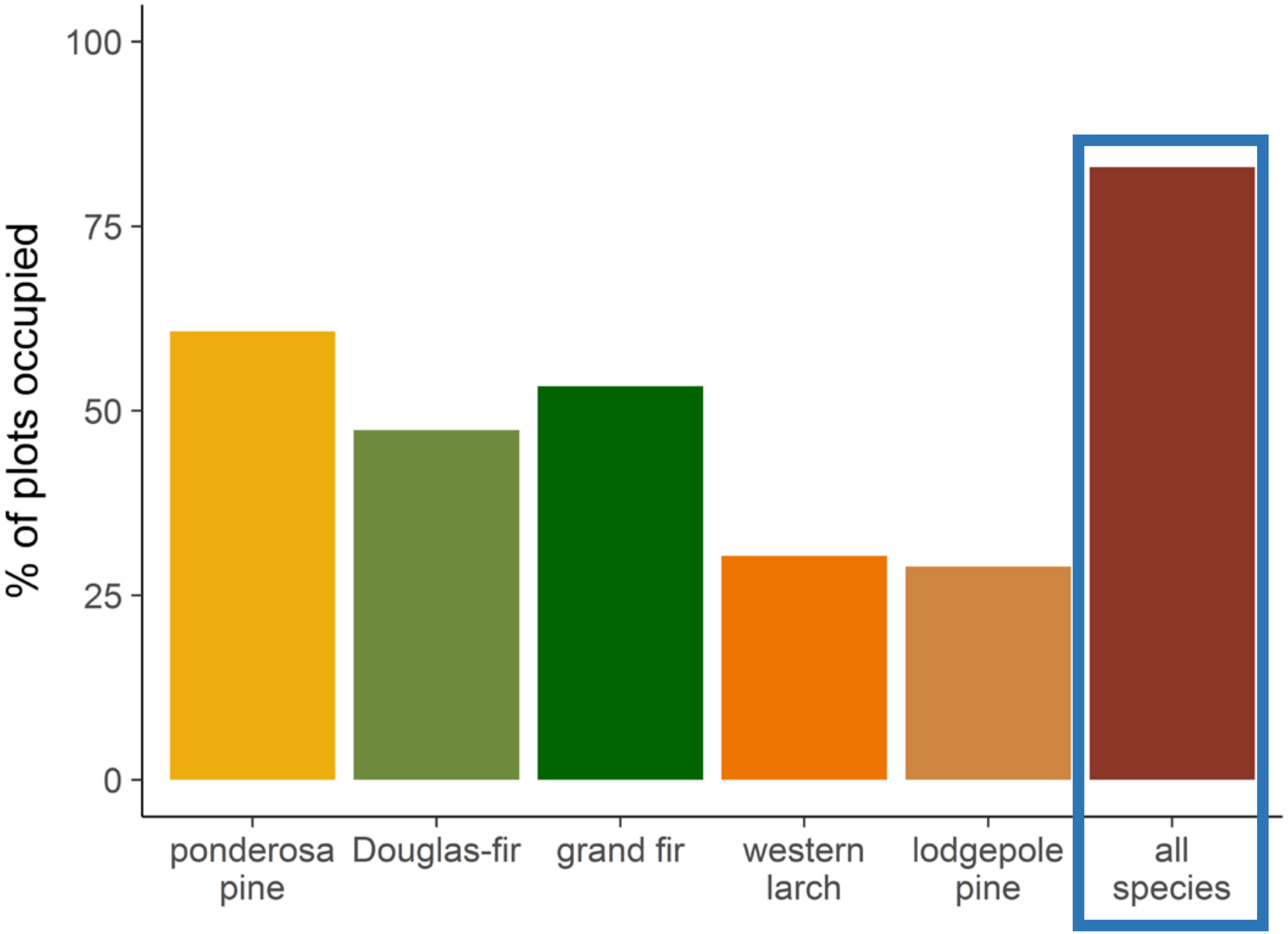
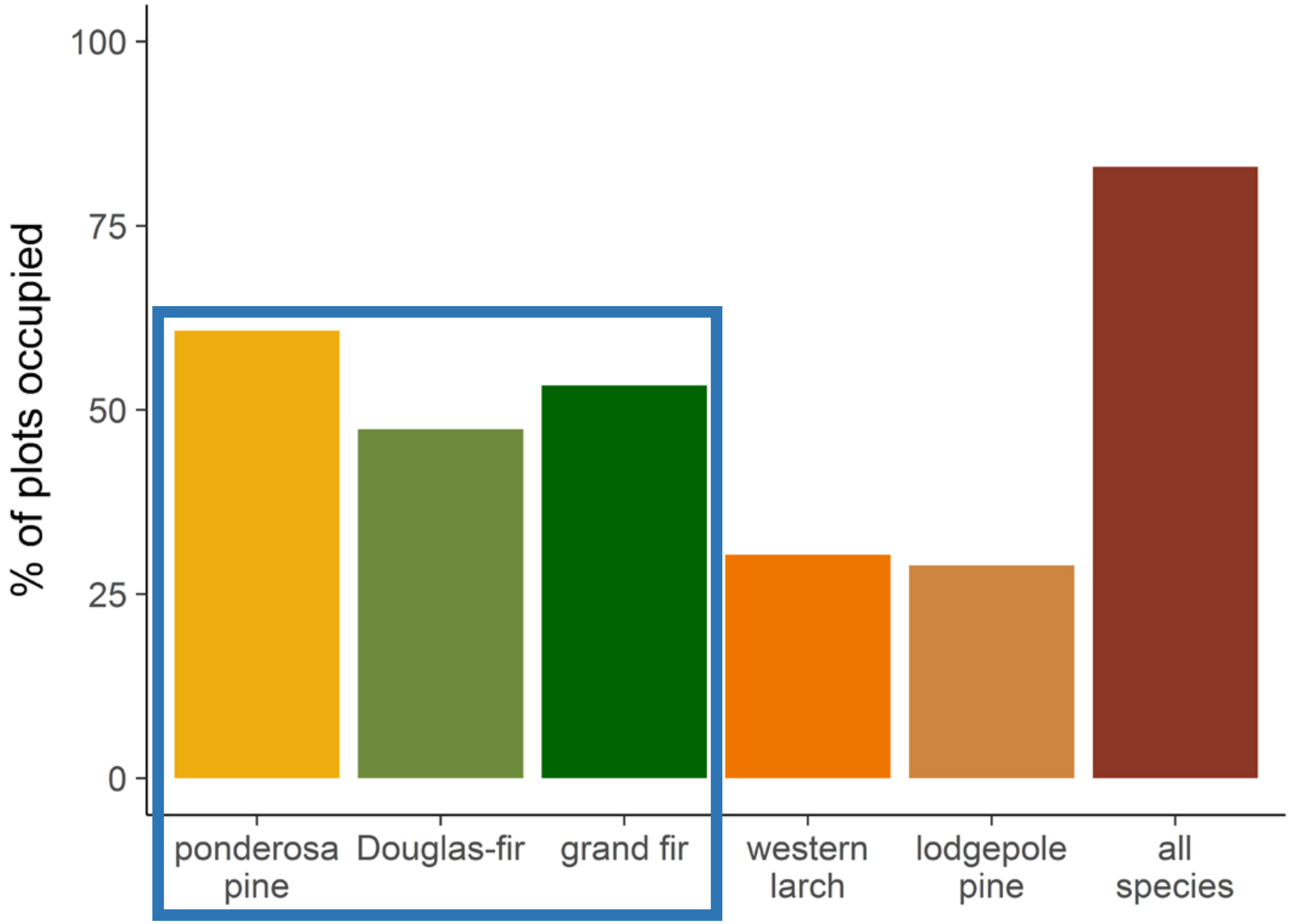
83% of plots contained conifer seedlings



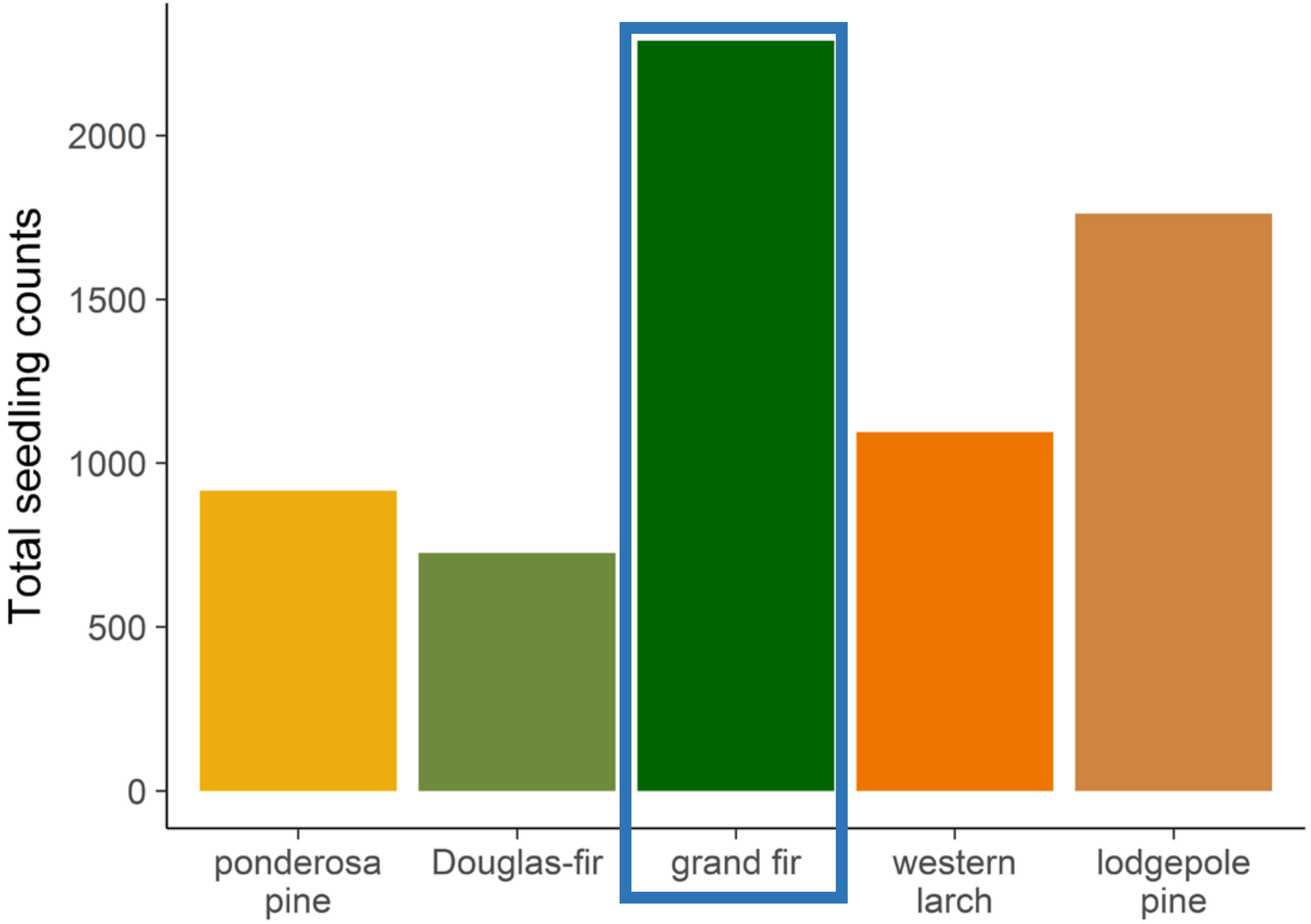
Results: No evidence of large-scale regeneration failure

Most widespread species were ponderosa pine, Douglas-fir, and grand fir



Results: No evidence of large-scale regeneration failure

Most abundant species was grand fir



Variability in post-fire seedling densities

Variability in post-fire seedling densities

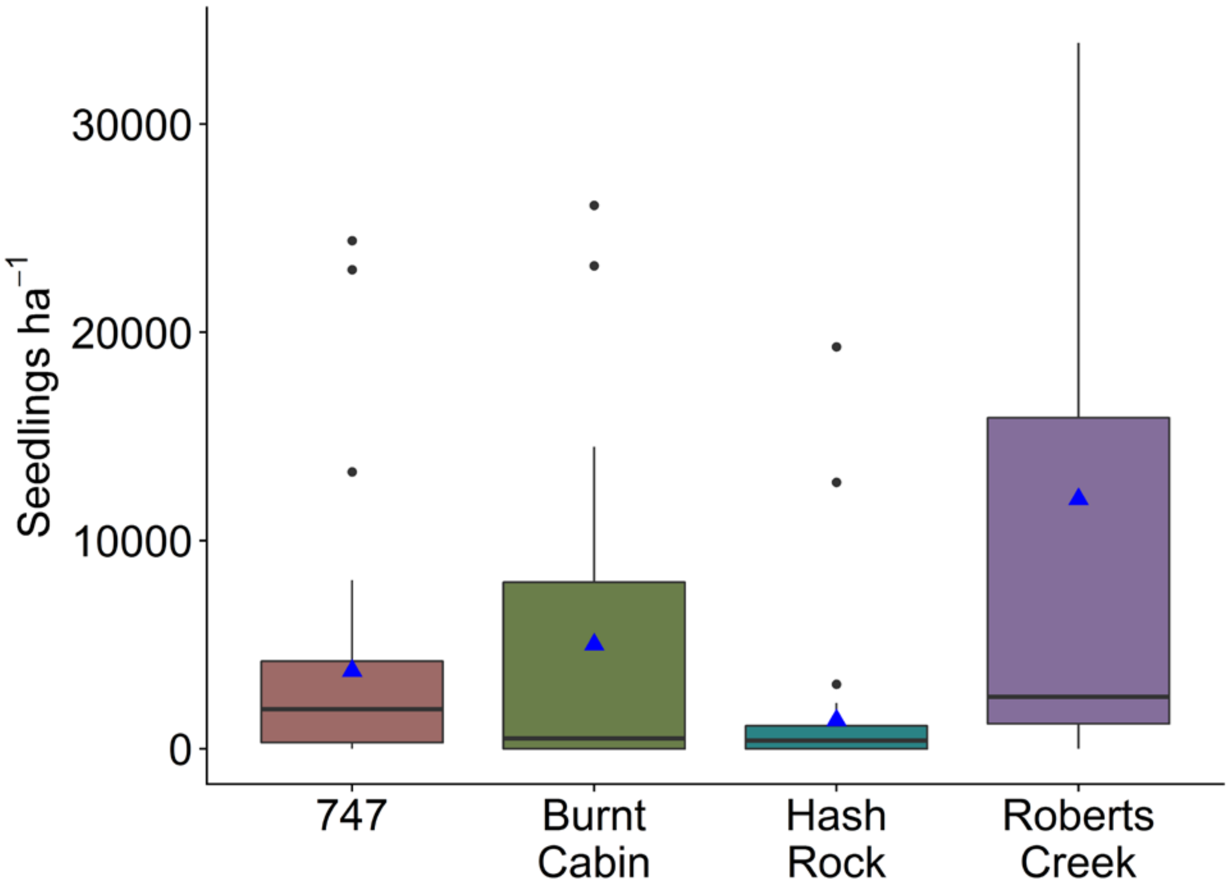
Dense regeneration:

Variability in post-fire seedling densities

Sparse, or absent regeneration:

Variability in post-fire seedling densities

Median seedling density across all plots was 1100 seedlings ha^{-1}



Results: Widespread post-fire regeneration

What are the key drivers of post-fire seedling density?

ponderosa pine

What are the key drivers of post-fire seedling density?

ponderosa pine Douglas-fir

What are the key drivers of post-fire seedling density?

ponderosa pine   Douglas-fir   grand fir

What are the key drivers of post-fire seedling density?

ponderosa pine Douglas-fir grand fir all species

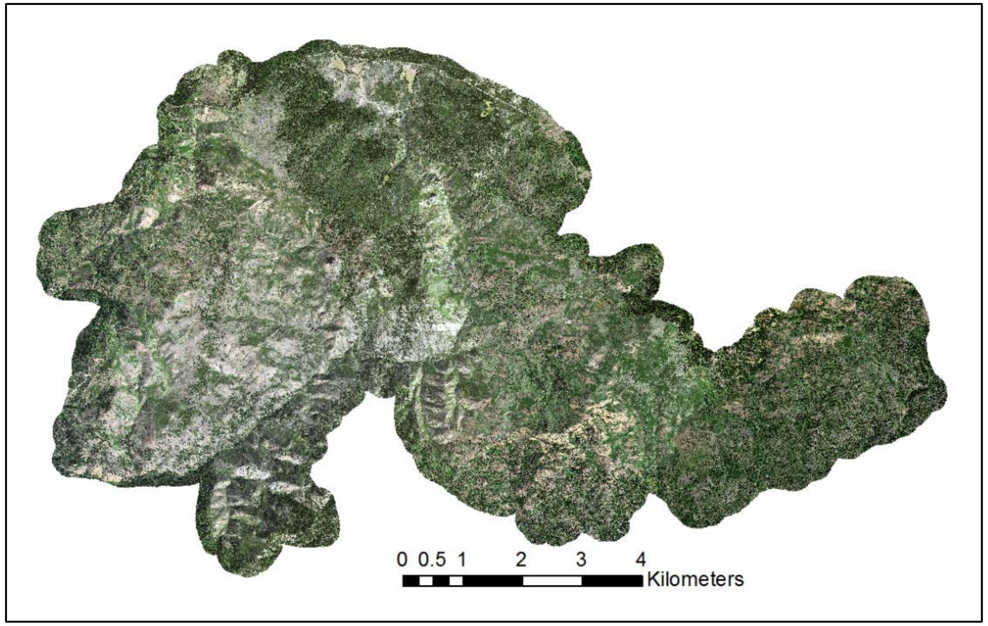
Post-fire regeneration as a function of seed sources

Post-fire regeneration as a function of seed sources

Abundance of seed source

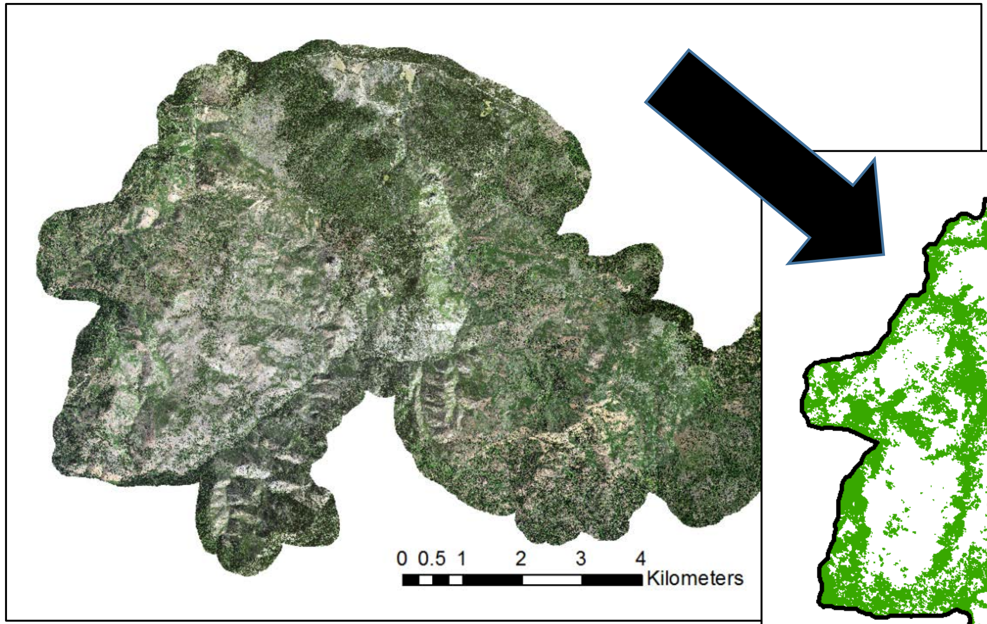
Seed source abundance

1 meter aerial imagery

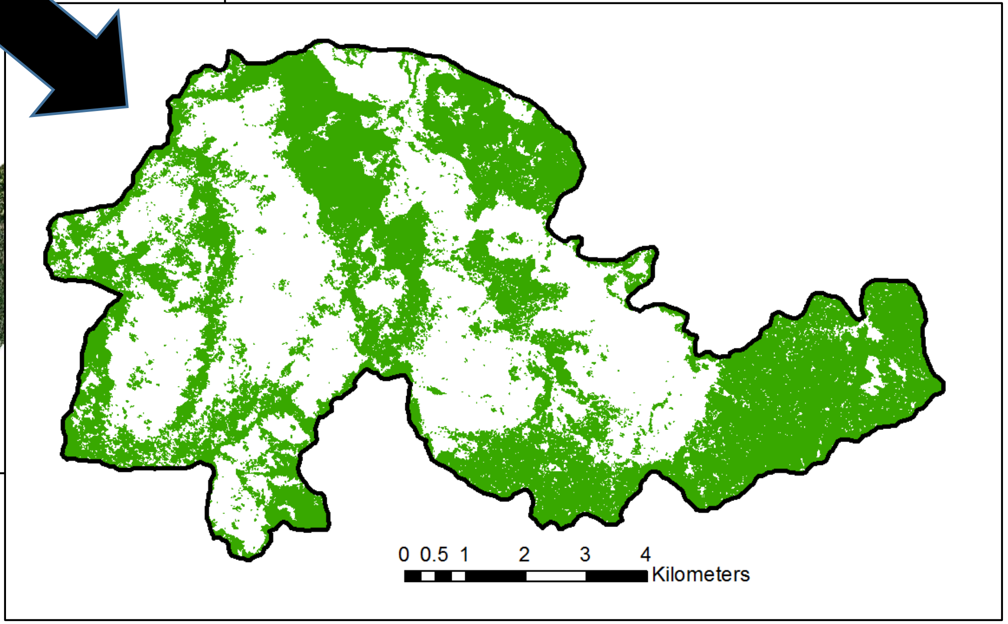


Seed source abundance

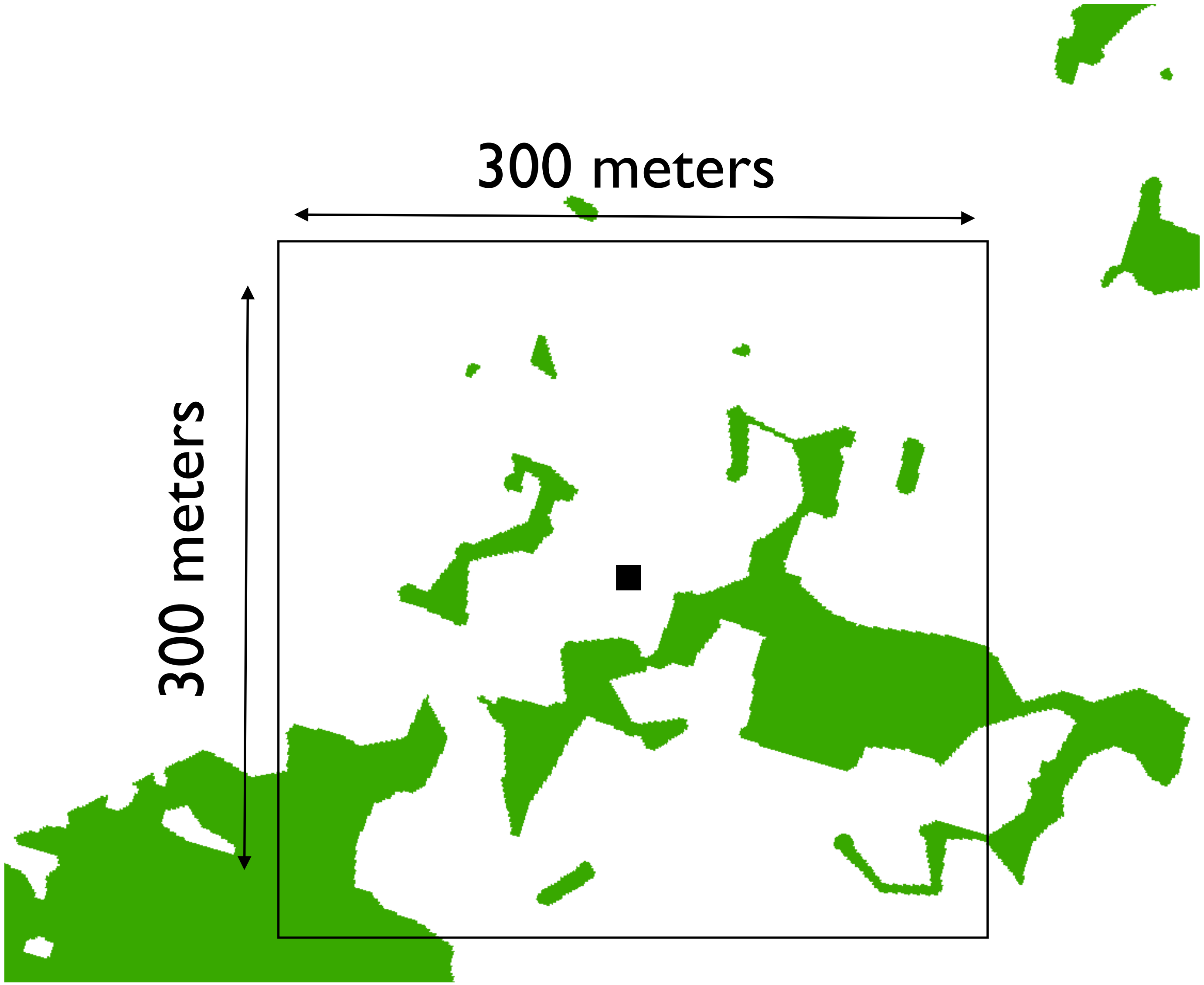
I meter aerial imagery



I meter maps of surviving seed source



Seed source abundance



Post-fire regeneration as a function of seed sources and site characteristics

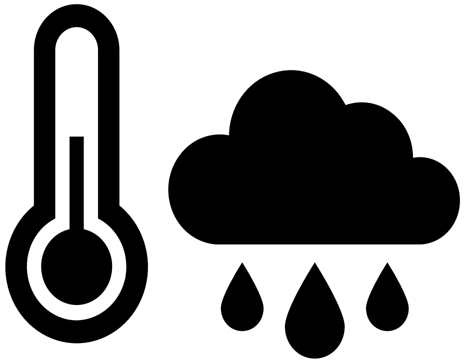
- Distance to seed source
- Abundance of seed source

Post-fire regeneration as a function of seed sources and site characteristics

- Distance to seed source
- Abundance of seed source
- Elevation

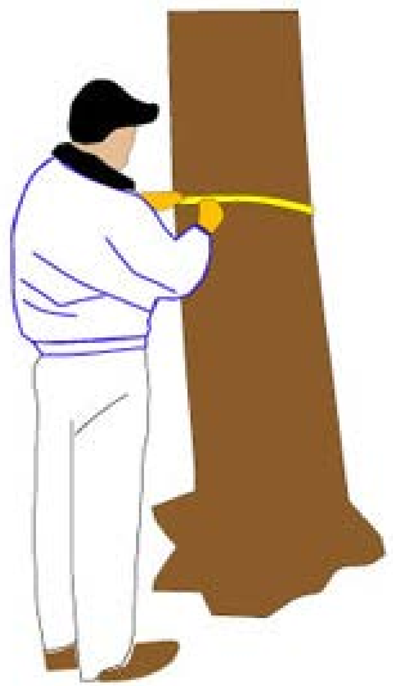
Post-fire regeneration as a function of seed sources and site characteristics

- Distance to seed source
- Abundance of seed source
- Elevation
- Climatic moisture deficit



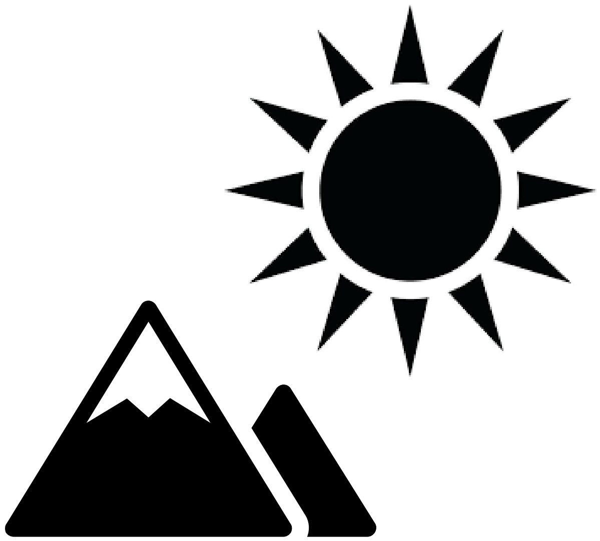
Post-fire regeneration as a function of seed sources and site characteristics

- Distance to seed source
- Abundance of seed source
- Elevation
- Climatic moisture deficit
- Pre-fire basal area



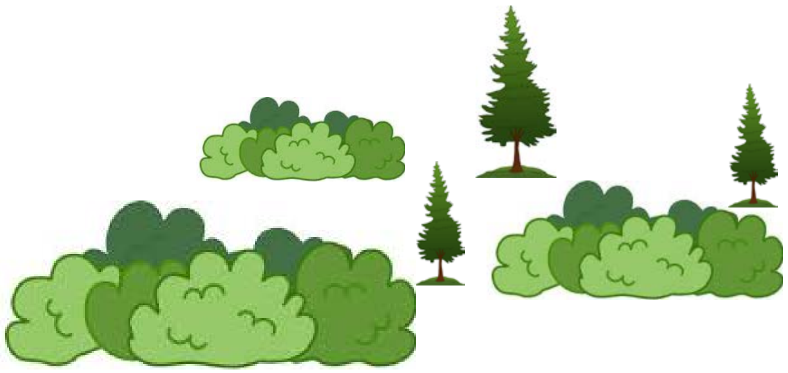
Post-fire regeneration as a function of seed sources and site characteristics

- Distance to seed source
- Abundance of seed source
- Elevation
- Climatic moisture deficit
- Pre-fire basal area
- Heat load



Post-fire regeneration as a function of seed sources and site characteristics

- Distance to seed source
- Abundance of seed source
- Elevation
- Climatic moisture deficit
- Pre-fire basal area
- Heat load
- Shrub cover



Post-fire regeneration as a function of seed sources and site characteristics

- Distance to seed source
- Abundance of seed source
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- Shrub cover
- Fire severity (dNBR)

Post-fire regeneration as a function of seed sources and site characteristics

- Distance to seed source
- Landscape fire refugia density
- Elevation
- Climatic moisture deficit
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- Fire severity (dNBR)

ponderosa pine

Post-fire regeneration as a function of seed sources and site characteristics

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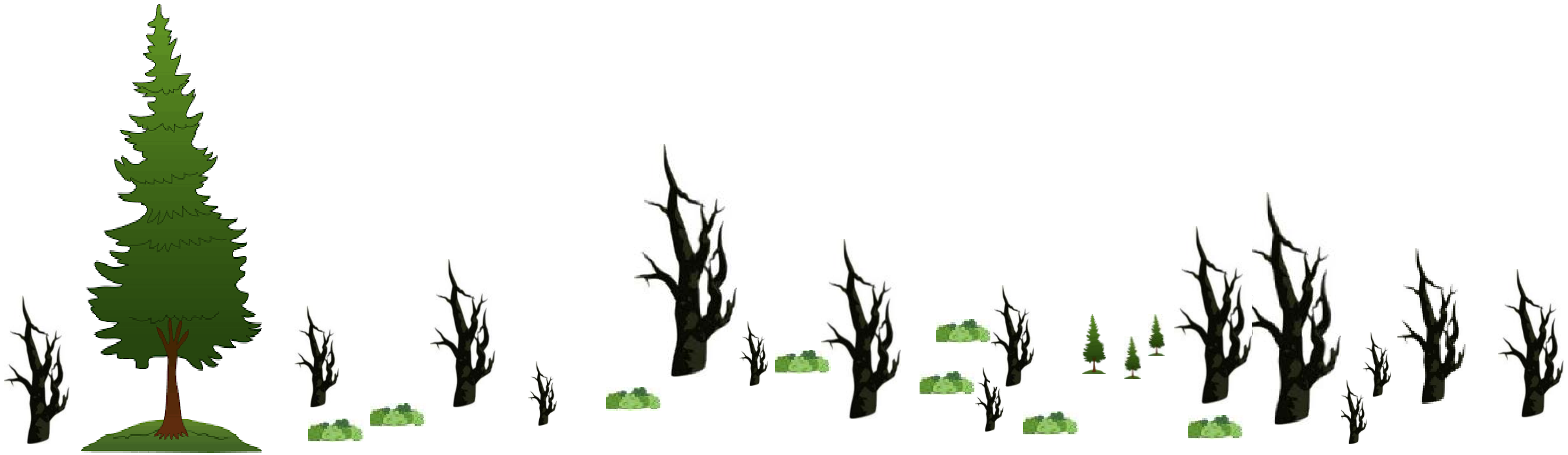
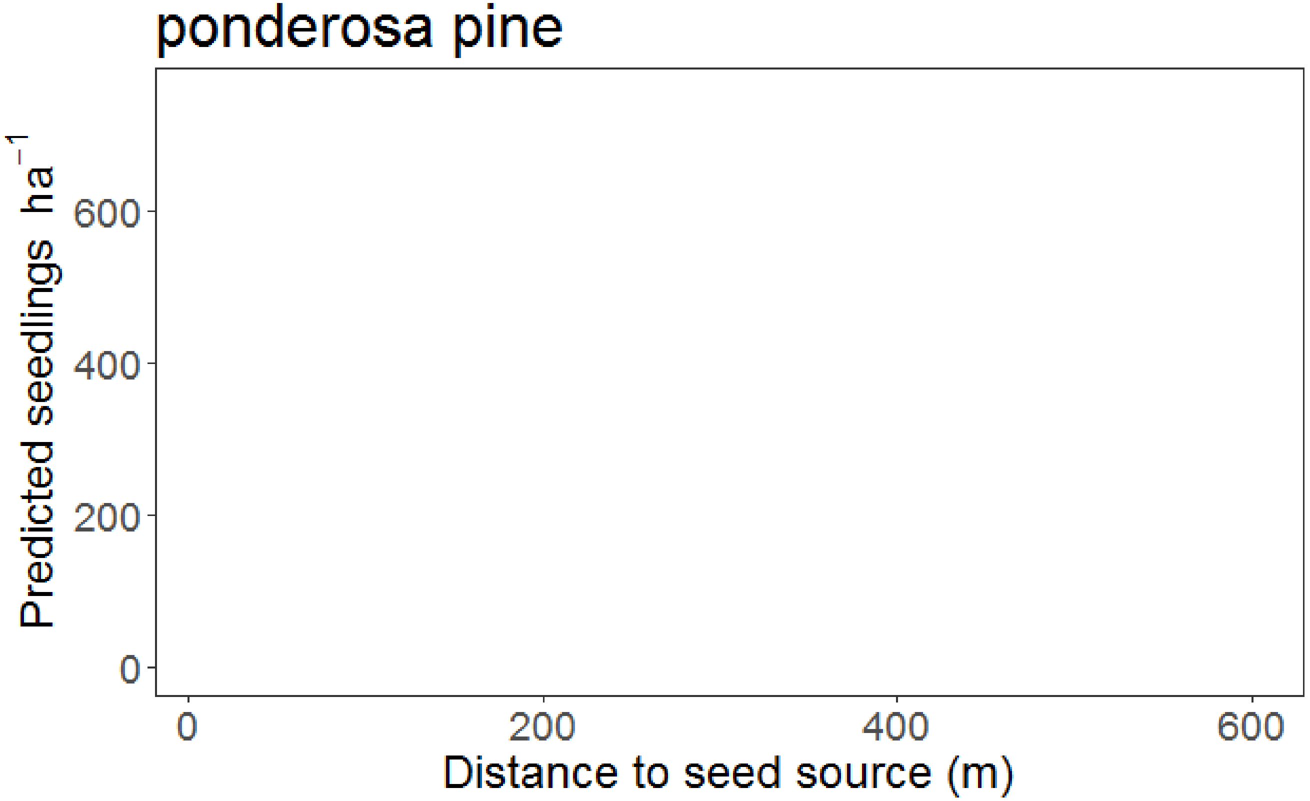
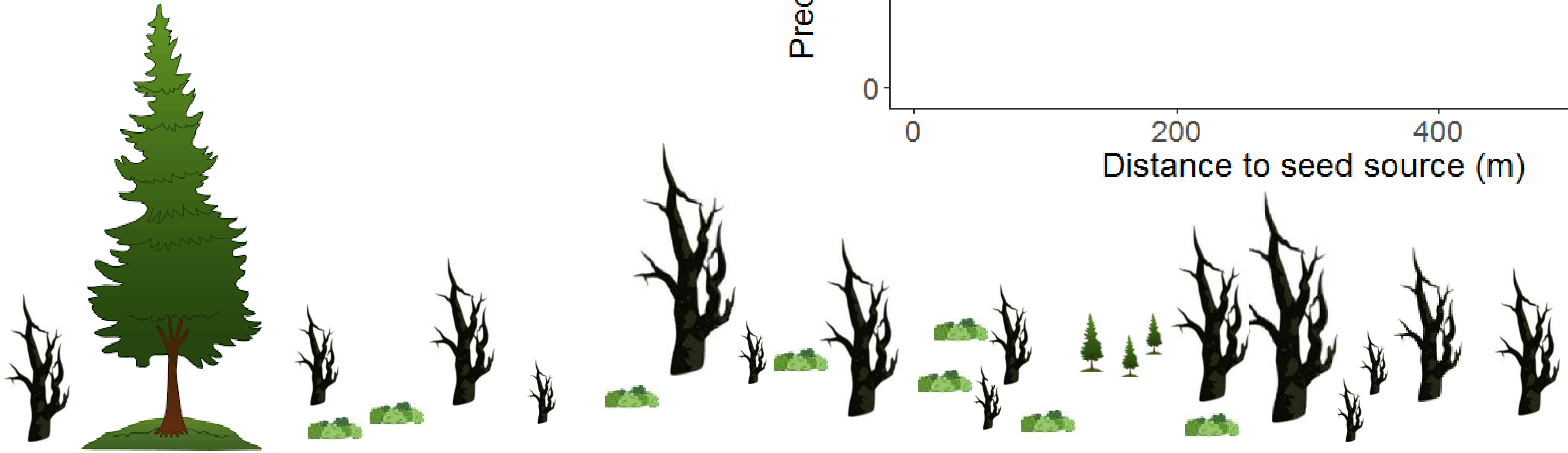
ponderosa pine

Distance to and **abundance of seed source** are key drivers of post-fire seedling abundance



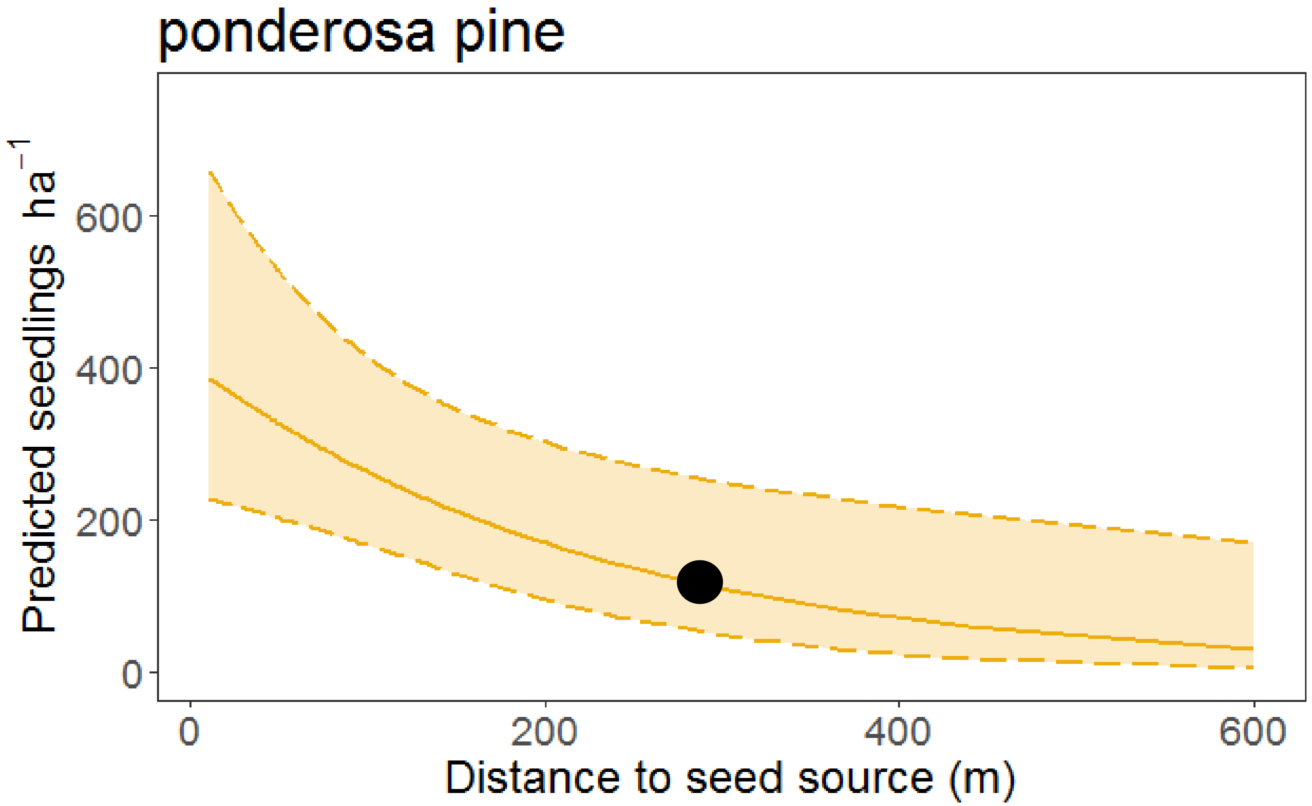
Distance to and abundance of seed source are key drivers of post-fire seedling abundance

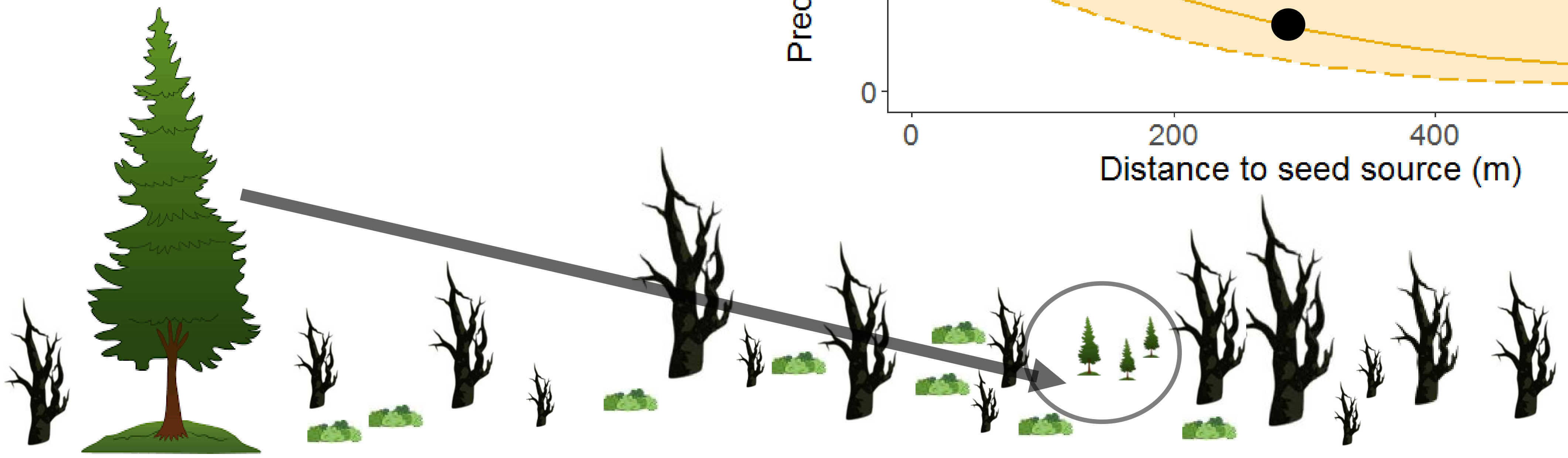




Distance to and abundance of seed source are key drivers of post-fire seedling abundance

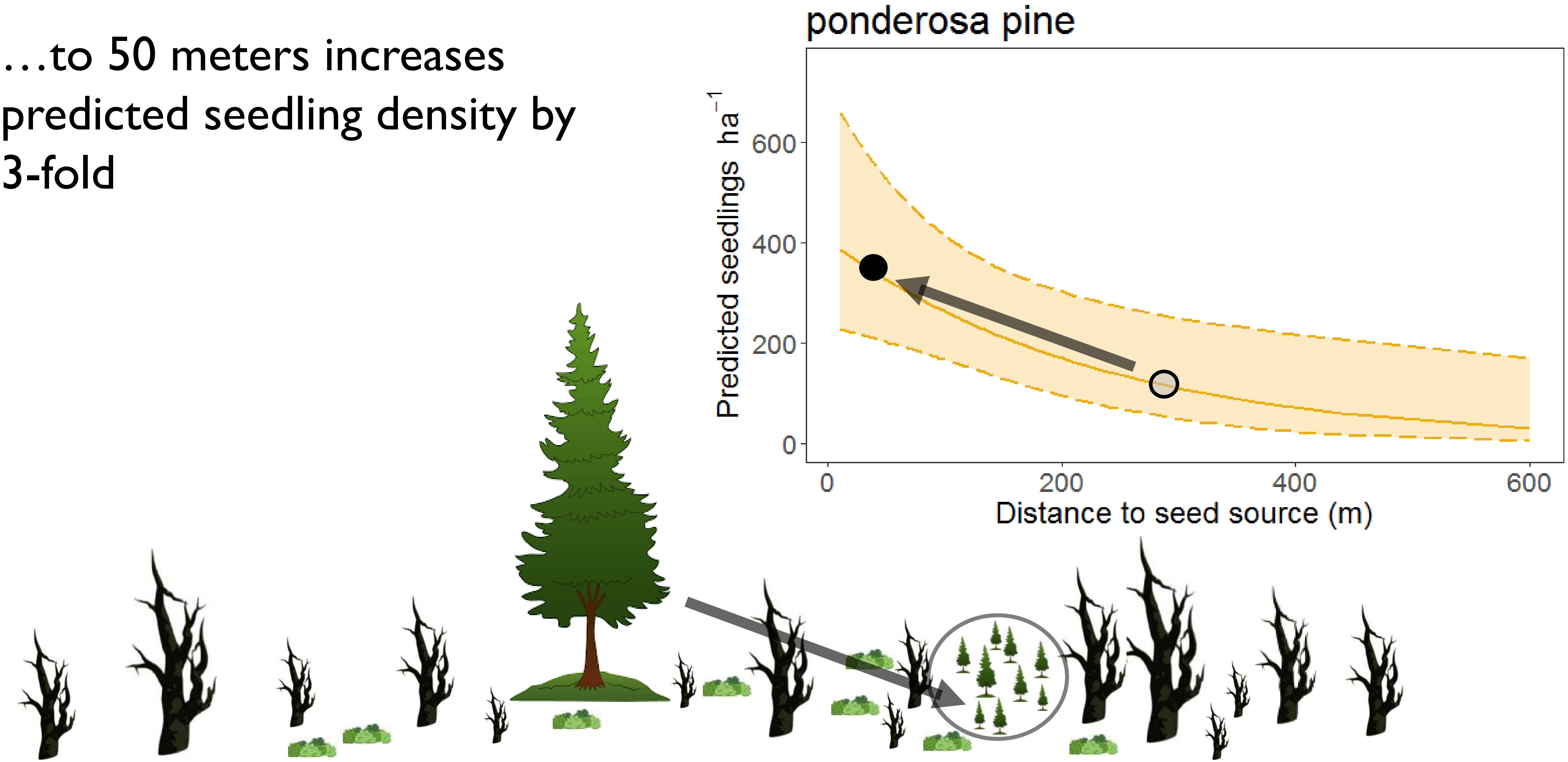
Decreasing distance to seed source from 300 meters…





Distance to and abundance of seed source are key drivers of post-fire seedling abundance

…to 50 meters increases predicted seedling density by 3-fold



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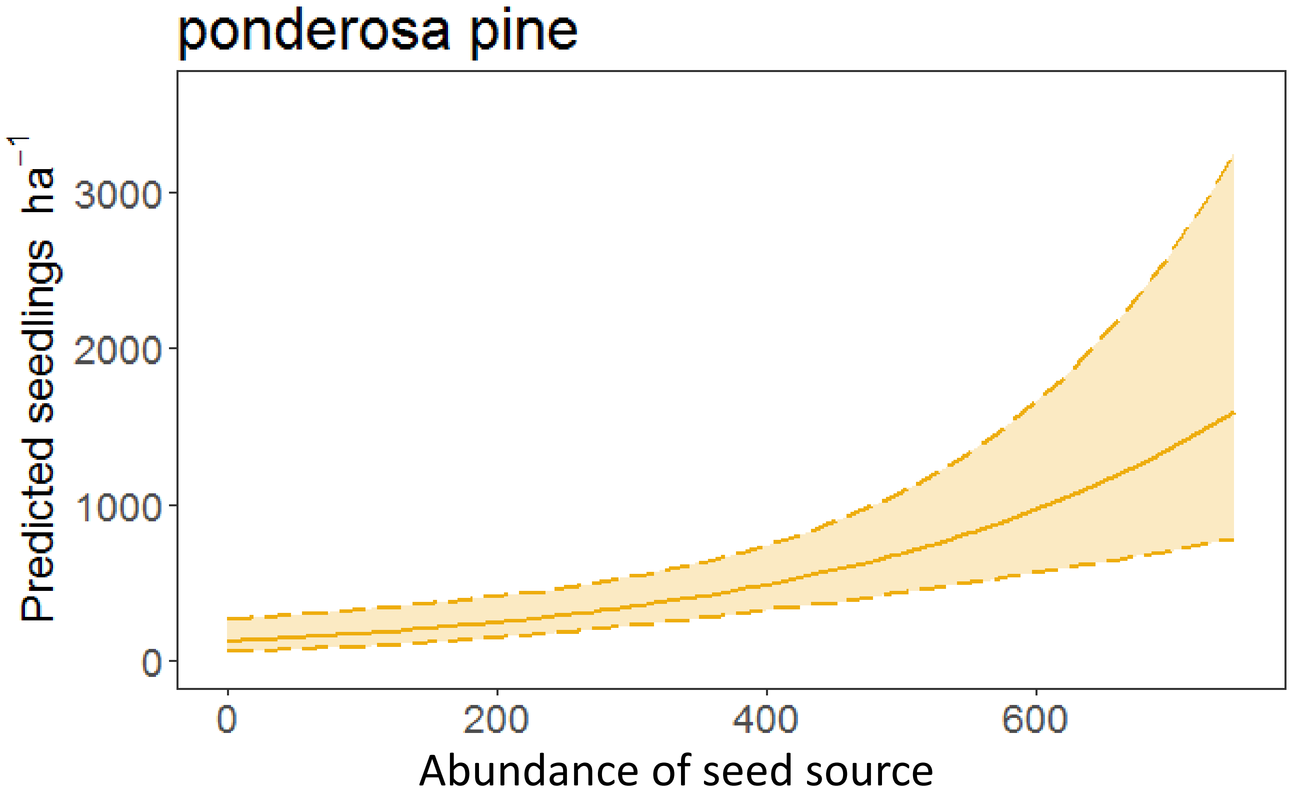
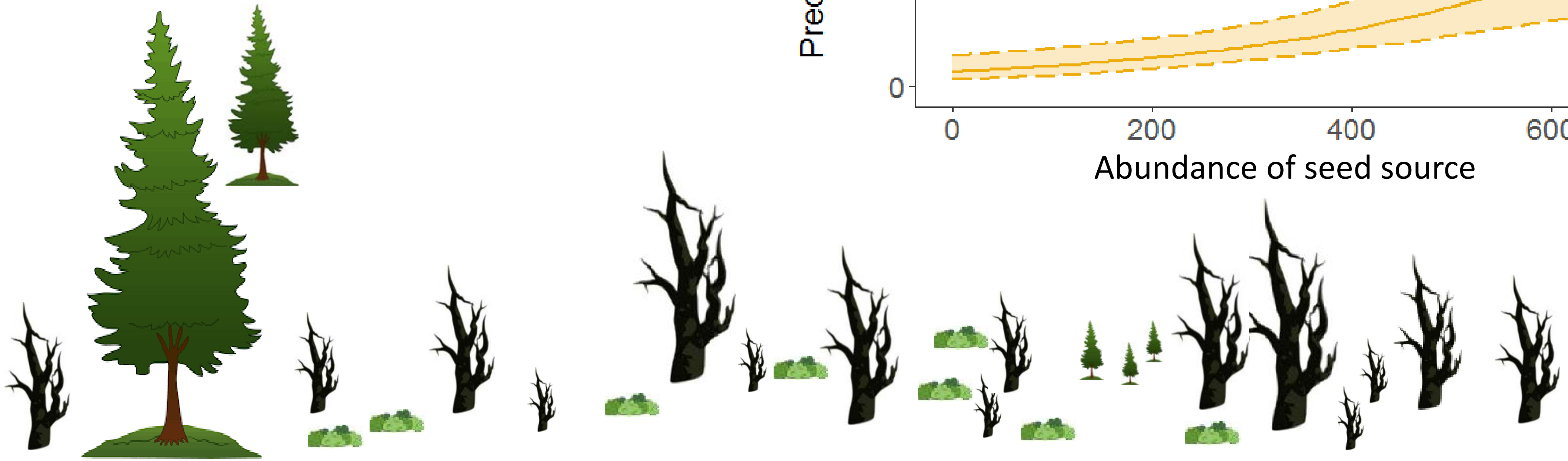
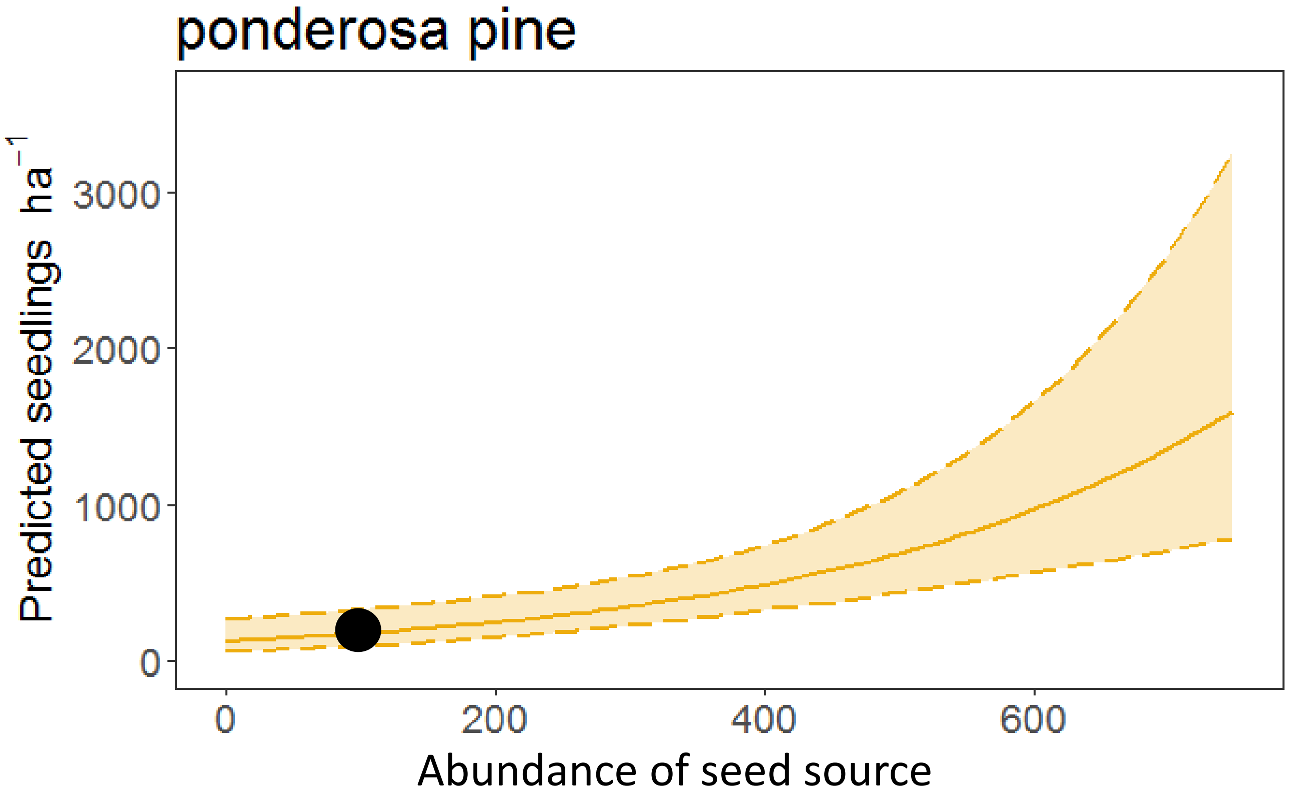
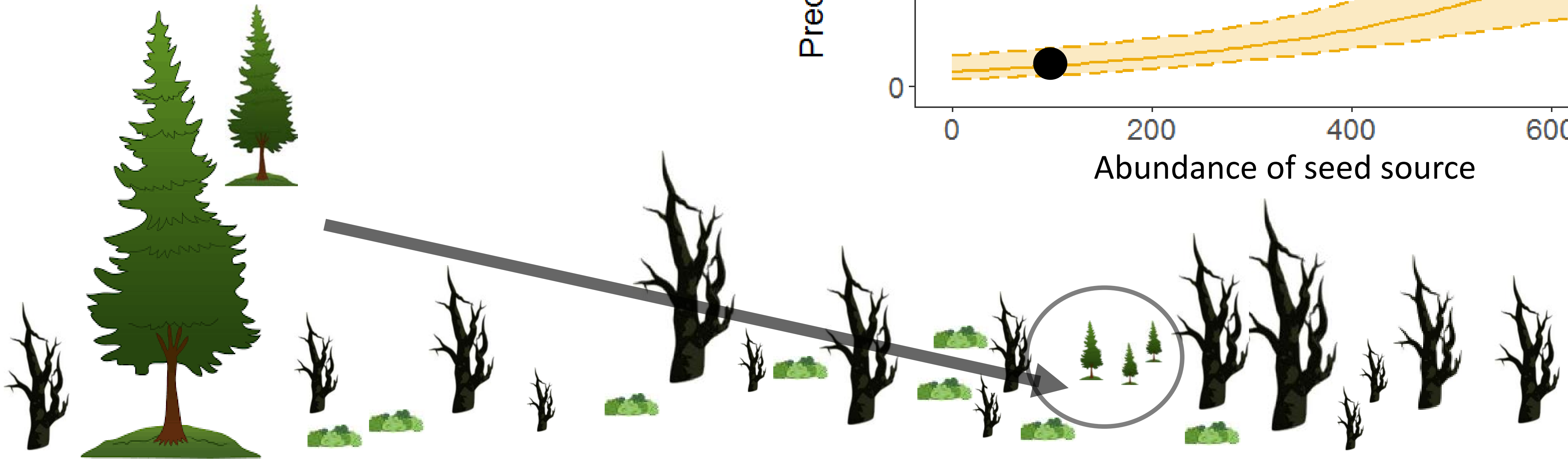




Distance to and **abundance of seed source** are key drivers of post-fire seedling abundance

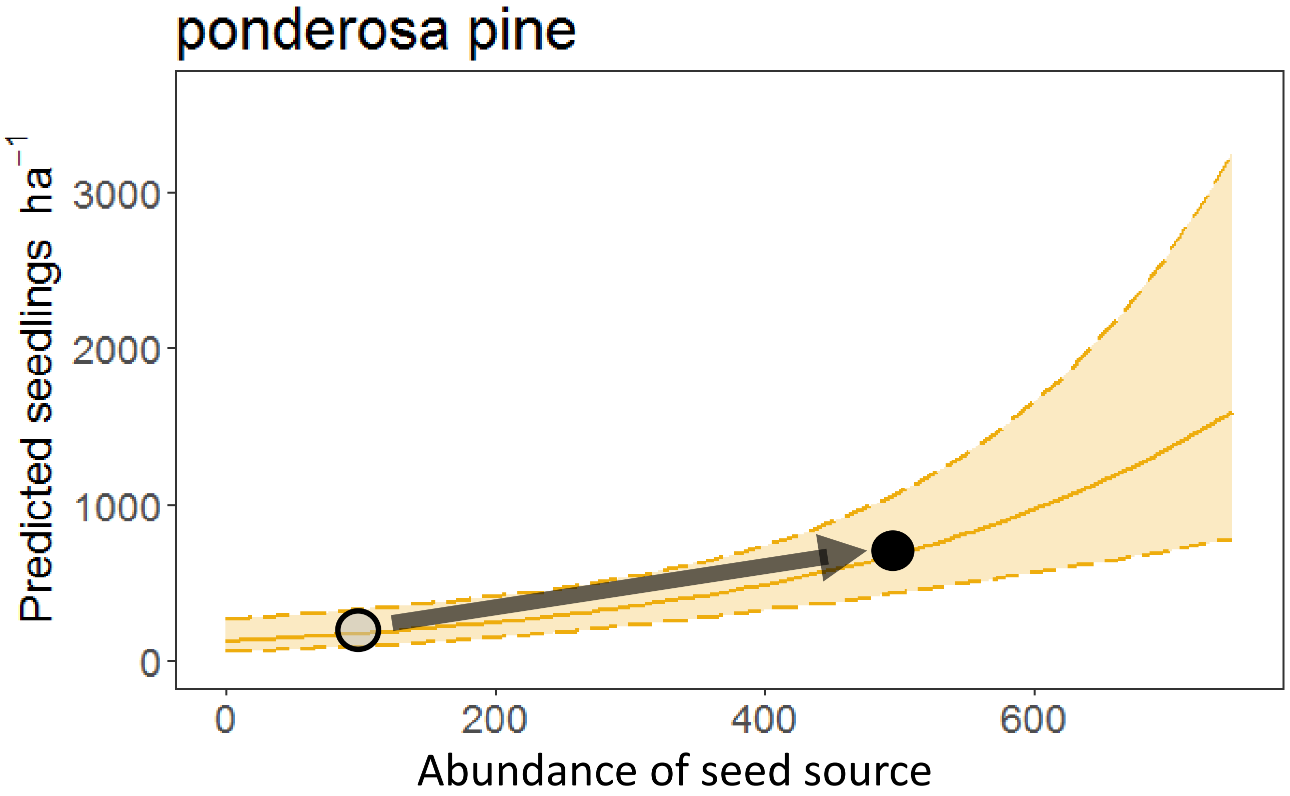
Increasing seed source abundance from 100…

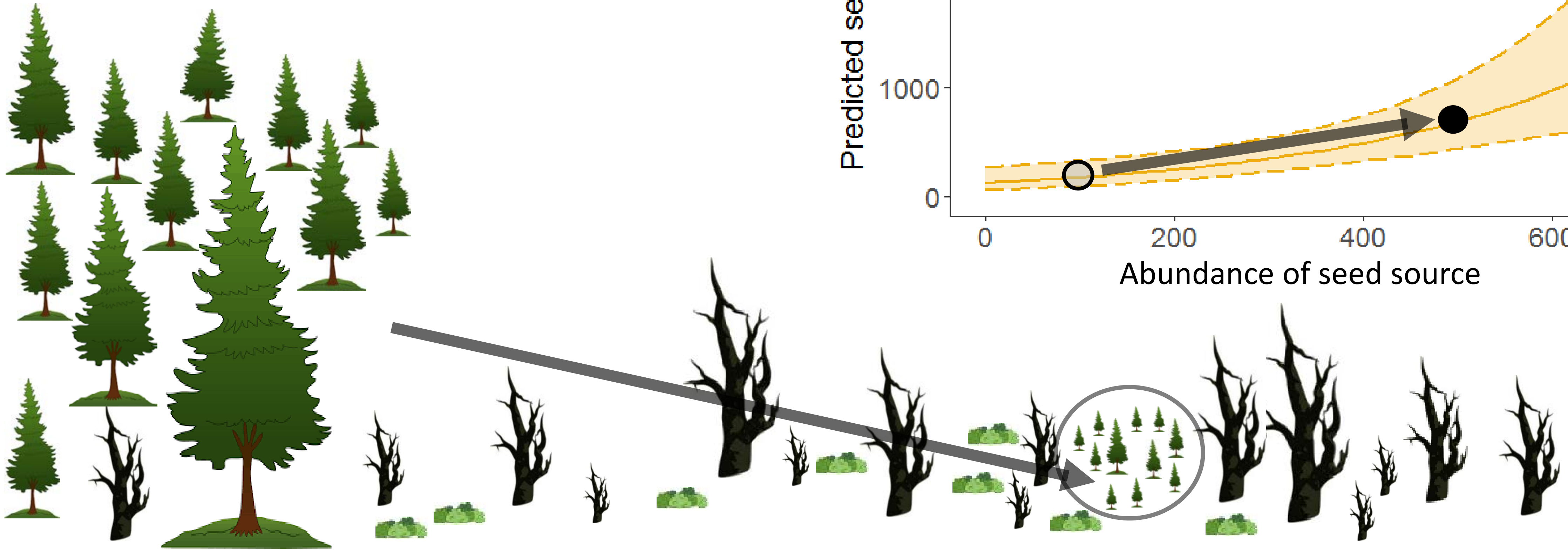




Distance to and **abundance of seed source** are key drivers of post-fire seedling abundance

… to 500, triples predicted seedling density





A shrub dominated post-fire landscape

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No evidence of a competitive relationship between shrubs and regenerating conifers

No evidence of a competitive relationship between shrubs and regenerating conifers

No evidence of a competitive relationship between shrubs and regenerating conifers

Can high-severity burned areas regenerate forest?

Key Points

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1. Forest is regenerating in high-severity burned patches of dry mixed-conifer forest in the Blue Mountains, providing evidence of resilience to contemporary fire effects.

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1. Forest is regenerating in high-severity burned patches of dry mixed-conifer forest in the Blue Mountains, providing evidence of resilience to contemporary fire effects.

2. The critical drivers of post-fire seedling abundance are distance to, and abundance of, surviving seed sources.

Can high-severity burned areas regenerate forest?

Key Points

1. Forest is regenerating in high-severity burned patches of dry mixed-conifer forest in the Blue Mountains, providing evidence of resilience to contemporary fire effects.

2. The critical drivers of post-fire seedling abundance are distance to, and abundance of, surviving seed sources.

3. Shrubs are abundant in the post-fire environment, but do not appear to constrain forest recovery.

Shifting gears…

Shifting gears…

Post-fire Alaska yellow-cedar mortality and regeneration in the Malheur NF's Cedar Grove Botanical Area

Alaska yellow-cedar (*Callitropsis nootkatensis*): An introduction

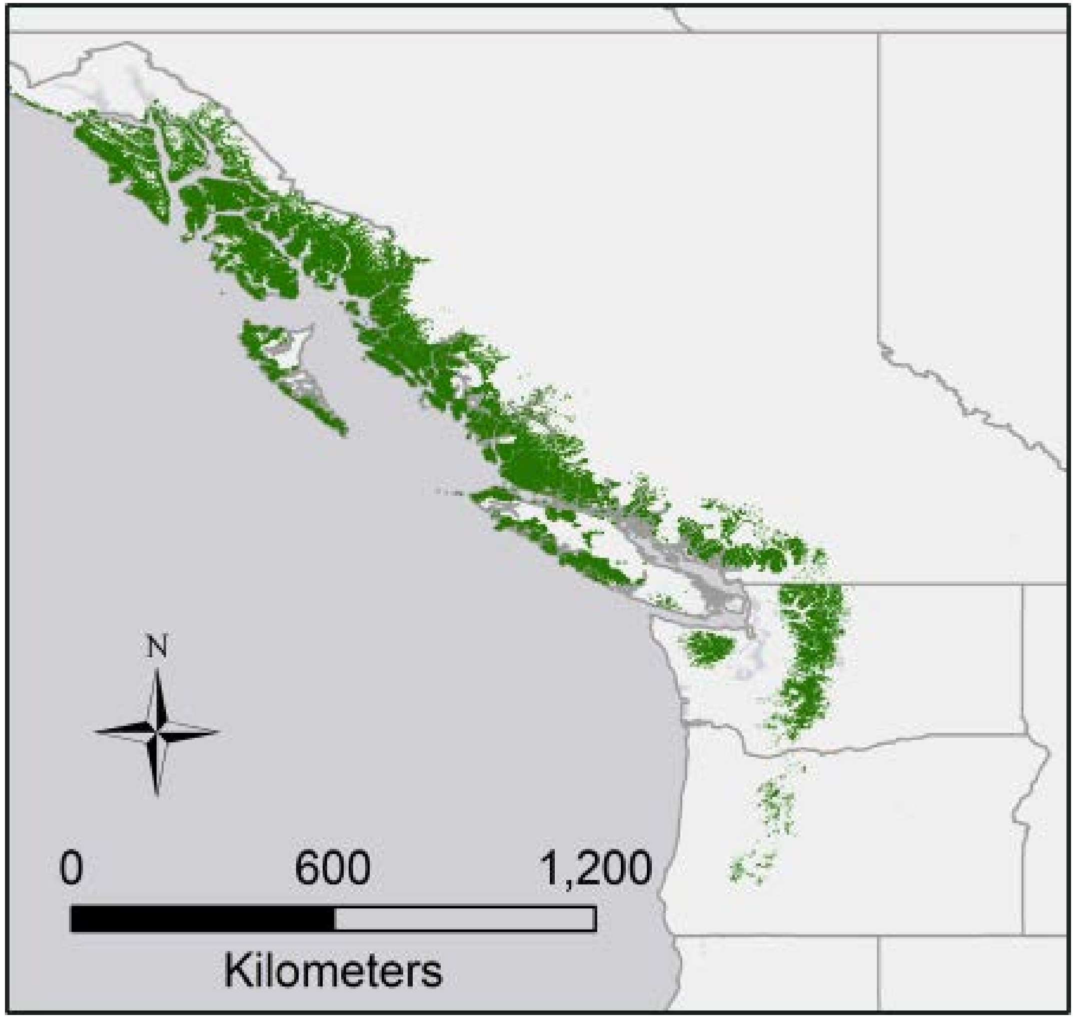
Alaska yellow-cedar (*Callitropsis nootkatensis*): An introduction

Culturally important

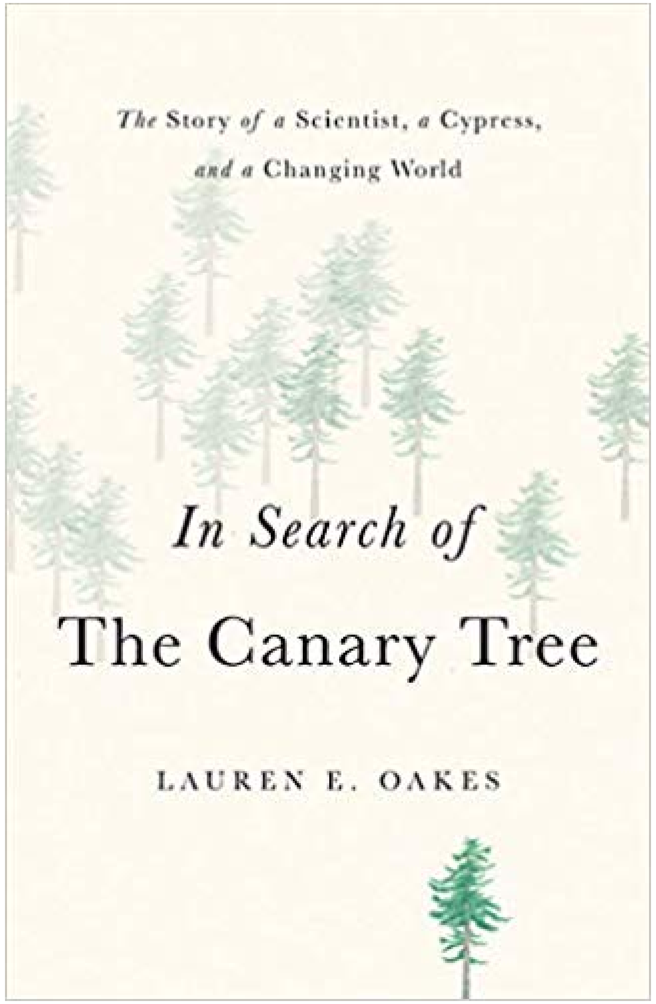
Alaska yellow-cedar (*Callitropsis nootkatensis*): An introduction

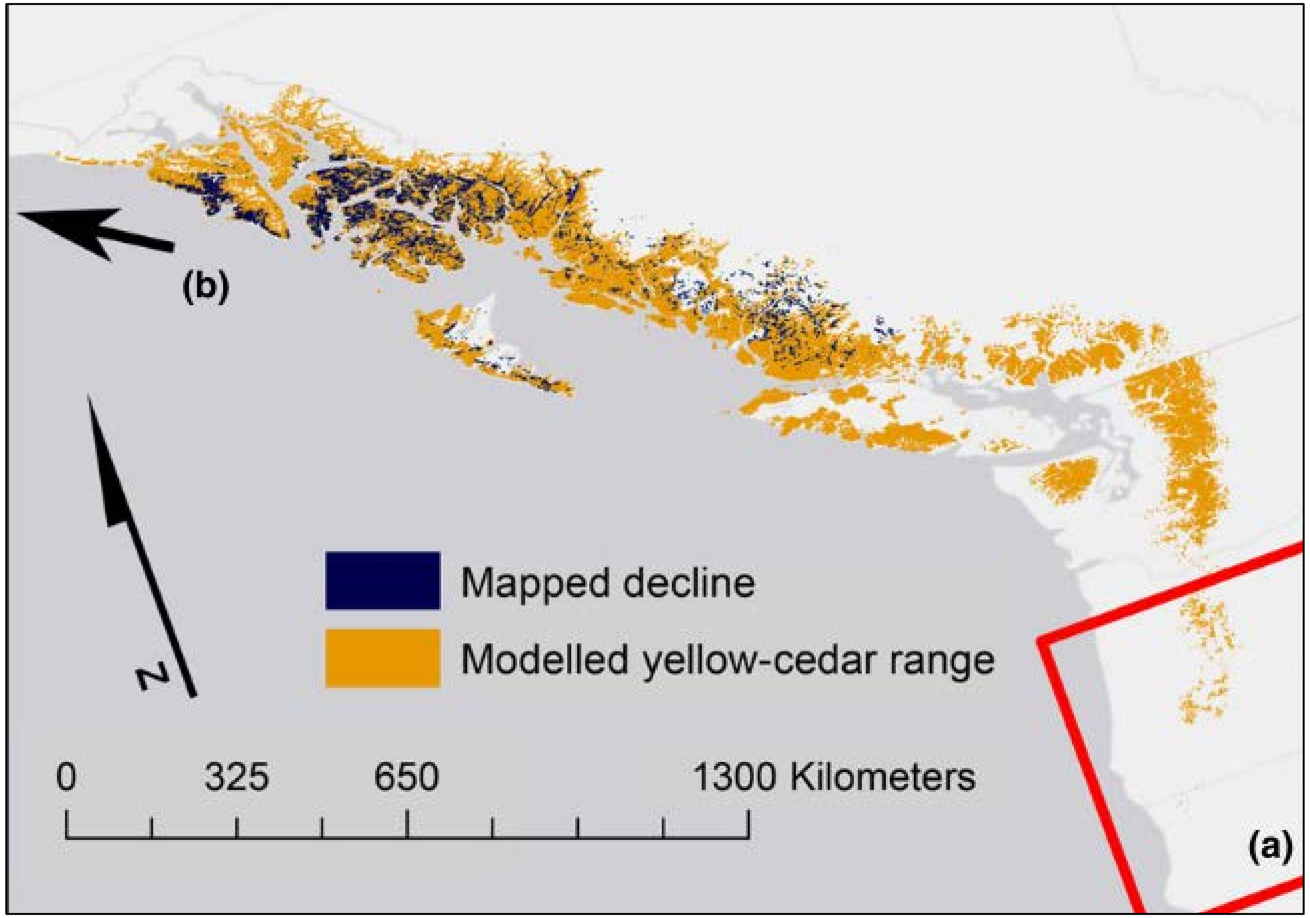
Commercially valuable

Alaska yellow-cedar's distribution is cool and wet



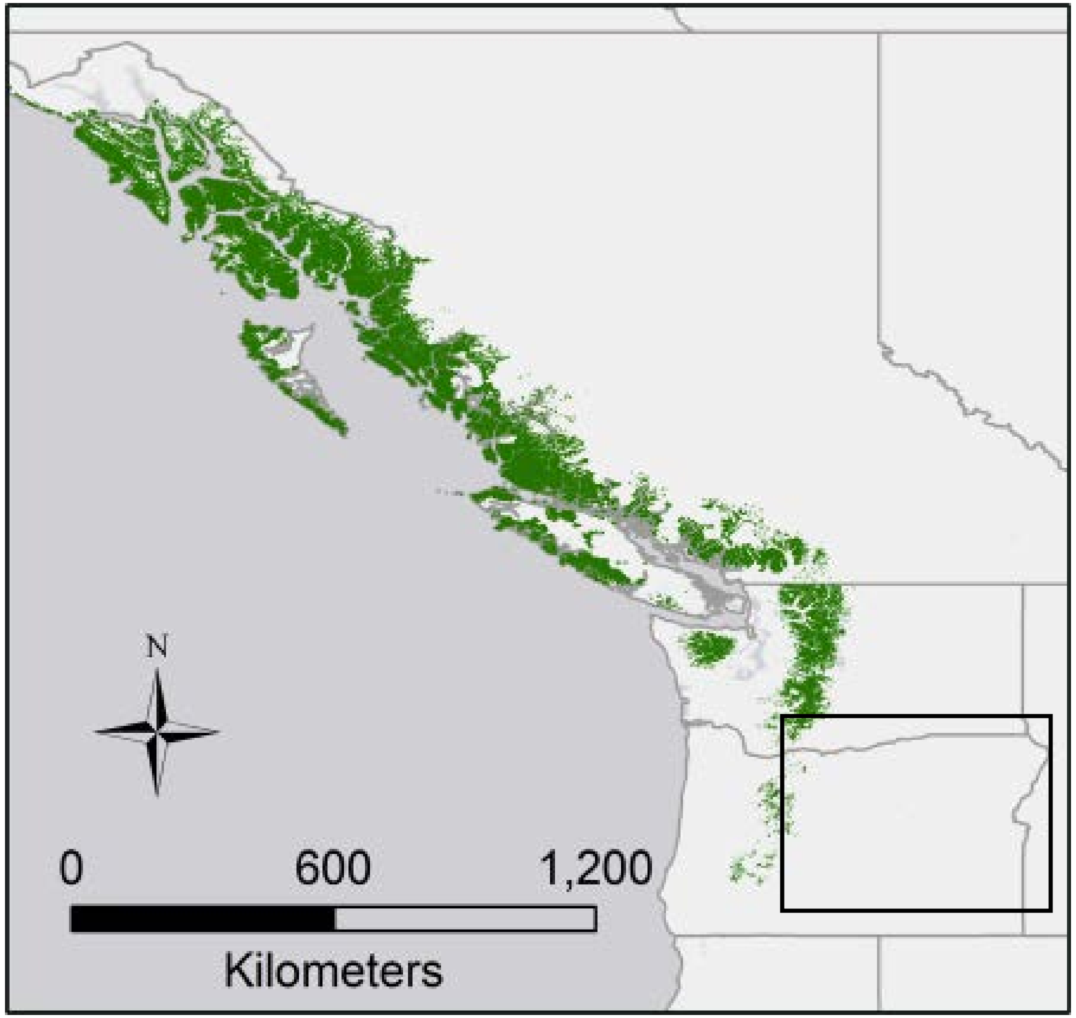
Alaska yellow-cedar is declining across much of its range due to warming temperatures





Buma et al. 2017

A cedar island in a dry mixed-conifer sea



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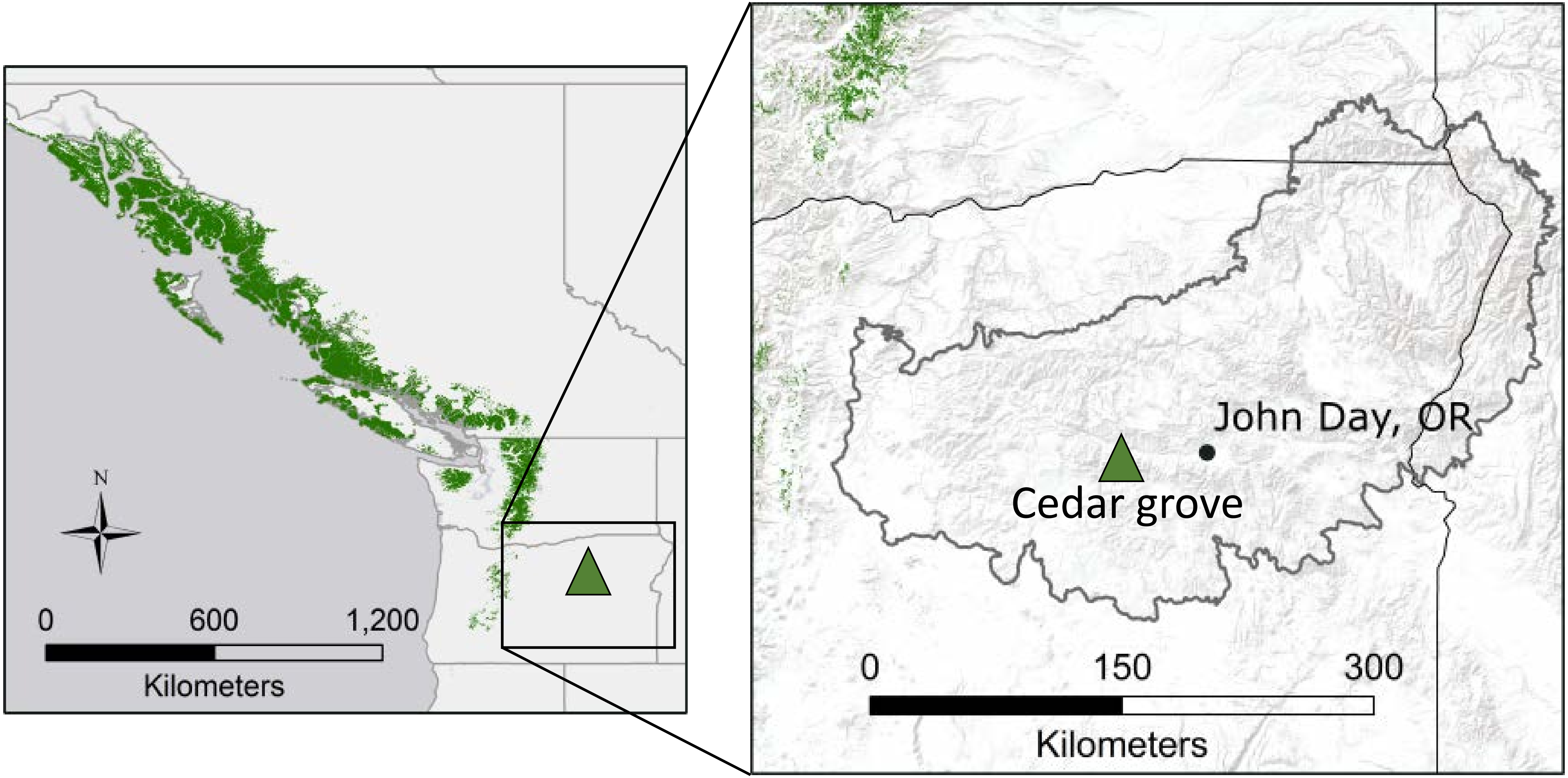

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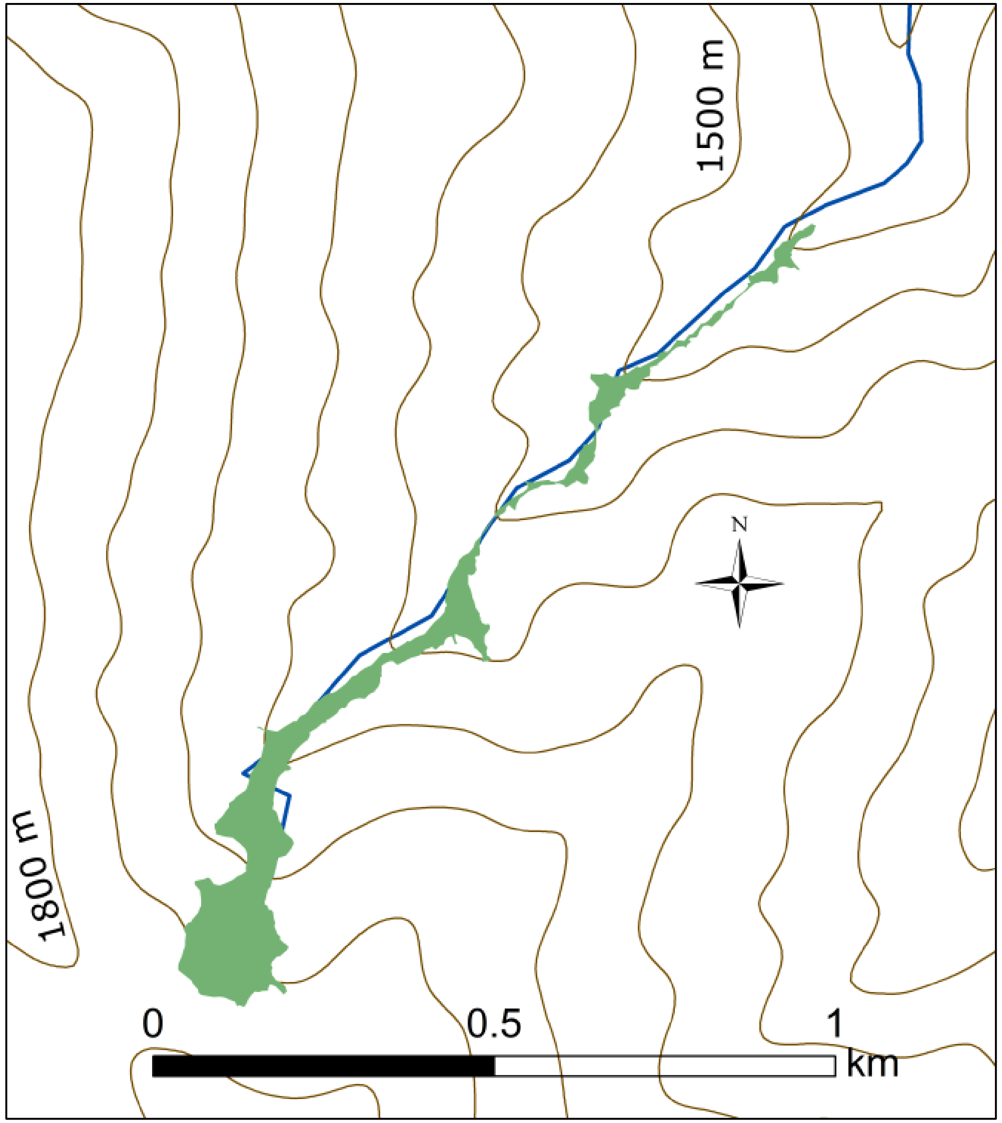

A cedar island in a dry mixed-conifer sea

A history of frequent fire followed by fire exclusion

In 2006, after over a century of fire exclusion, the grove burned

Despite low mortality in other species,

Despite low mortality in other species, initial assessments suggested that fire-induced cedar mortality was high

Study objectives

1. What percentage of Alaska yellow cedar has died since fire in 2006?

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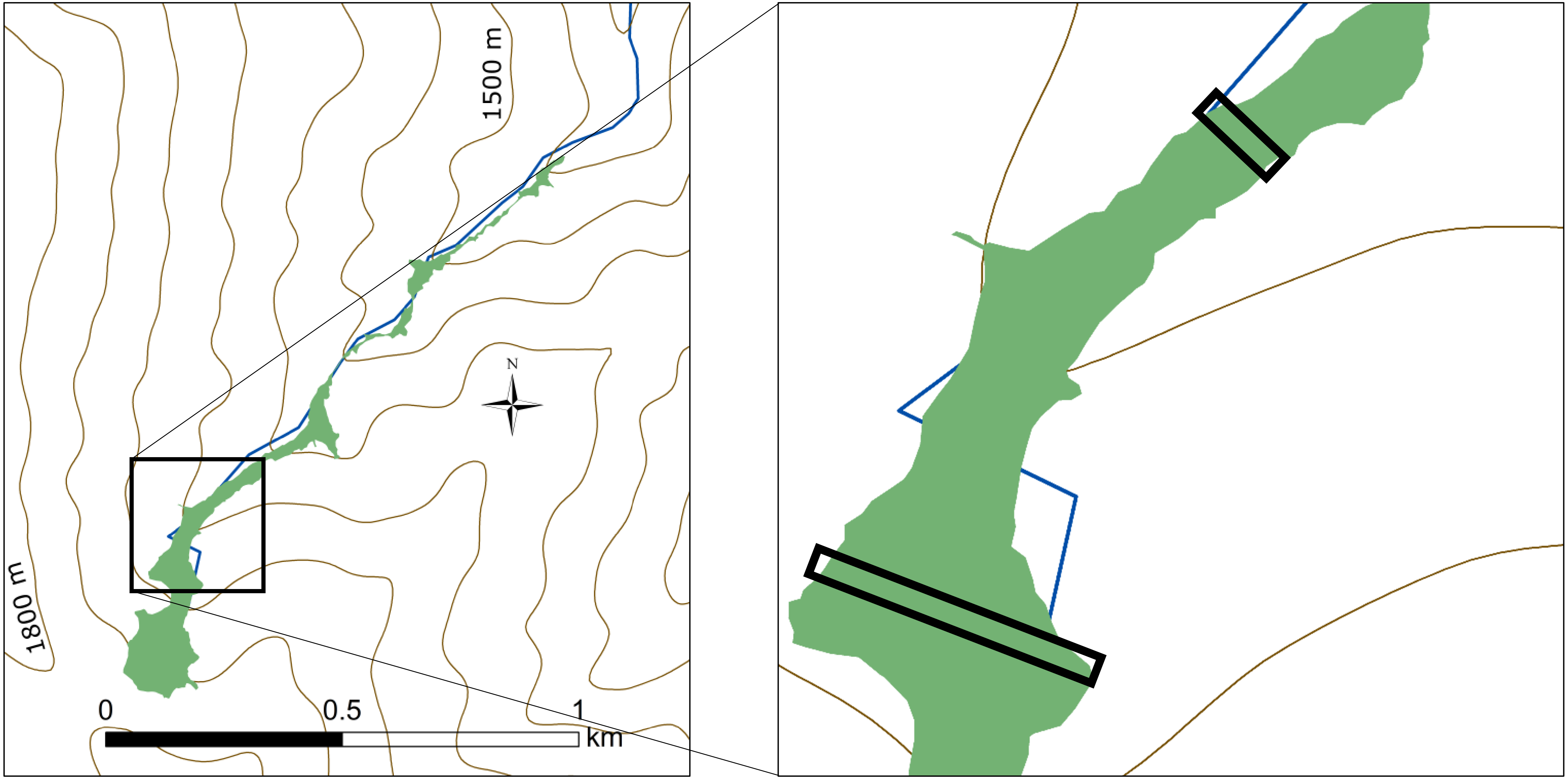
1. What percentage of Alaska yellow cedar has died since fire in 2006?

2. Is cedar regenerating following fire?

Study design

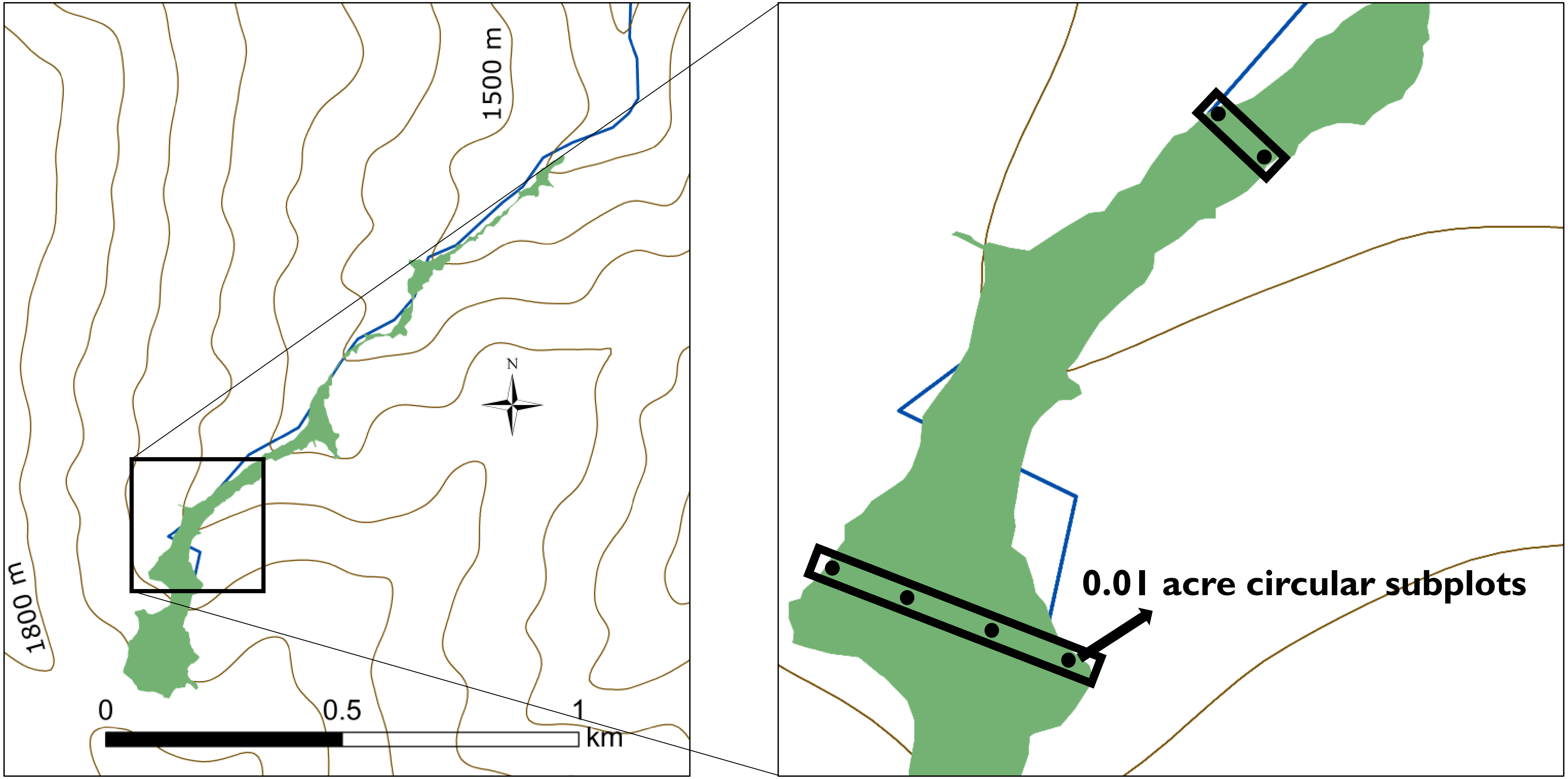
Study design

12 transects along the length of the grove



Study design

12 transects along the length of the grove

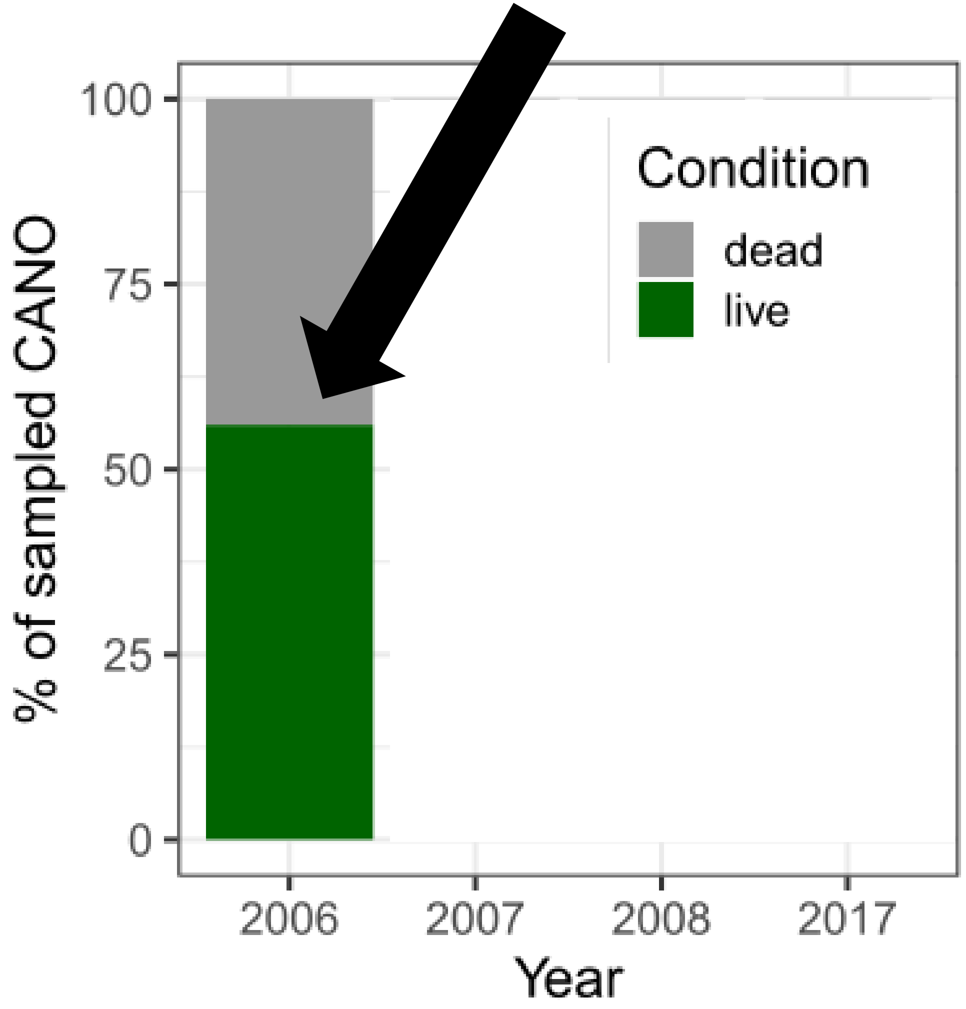


Results

Mortality

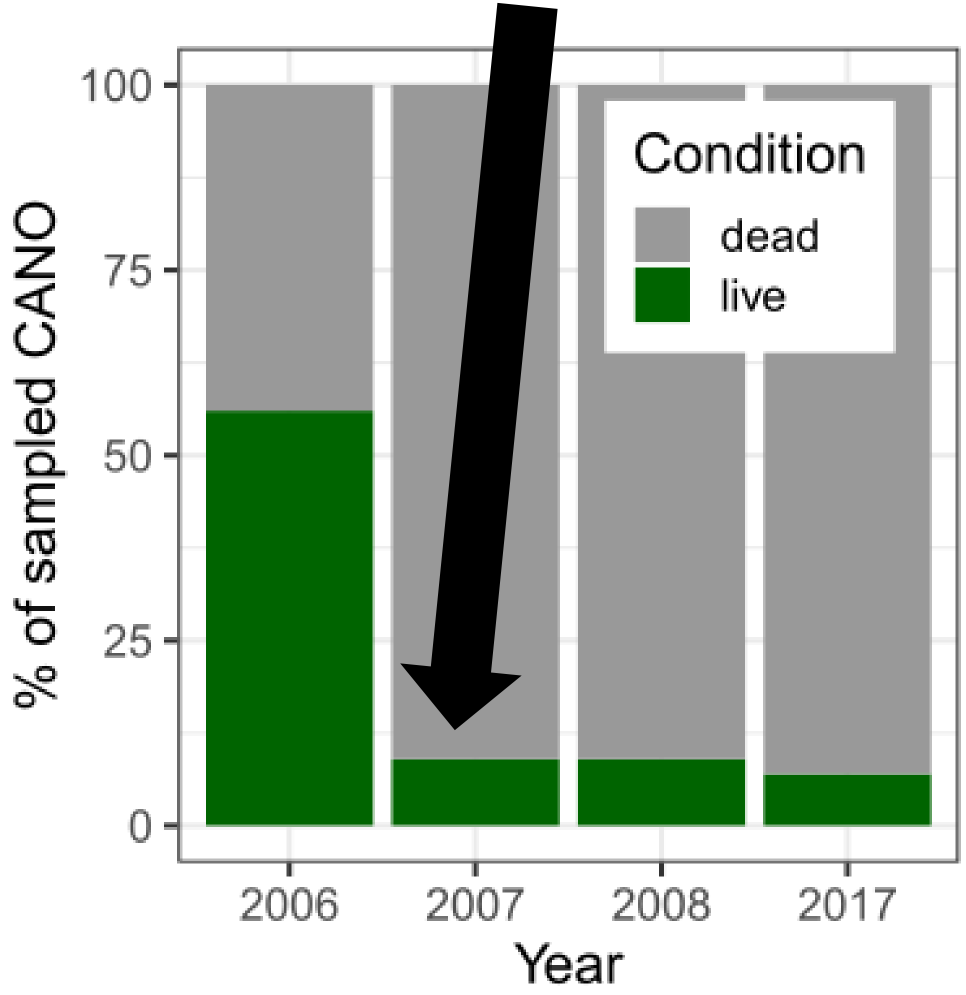
Results

Moderate cedar mortality in 2006…



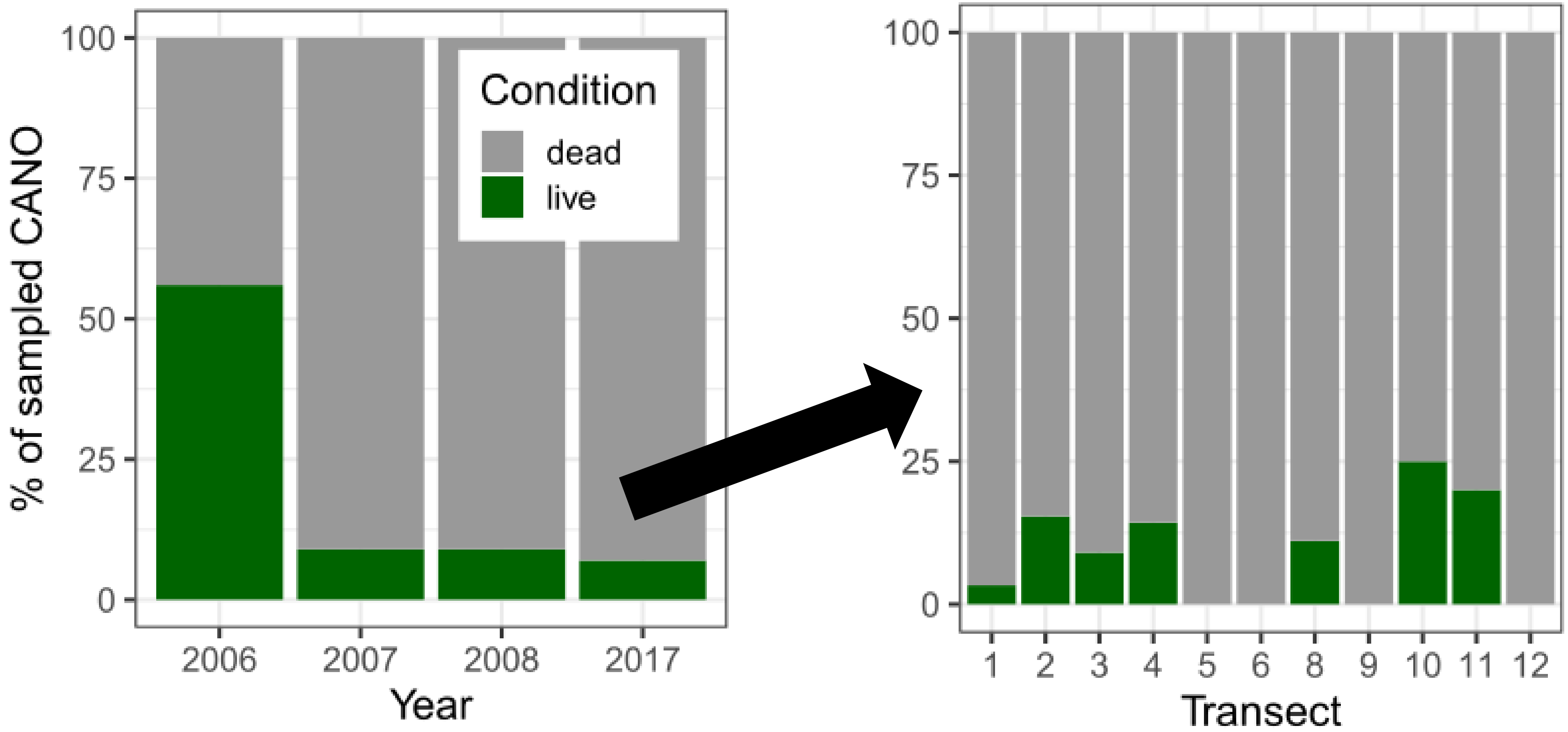
Results

A year later, over 90% were dead



Results

Surviving cedar are distributed across the grove



Results

	Seedlings ha^{-1}				
Species	2006	2007	2008	2017	% change (2008-2017)
yellow-cedar					
grand fir	--	--			
Douglas-fir	--	--			
western larch	--	--			
ponderosa pine	--	--			

Results

Cedar is regenerating

	Seedlings ha^{-1}				
Species	**2006**	**2007**	**2008**	**2017**	**% change (2008-2017)**
yellow-cedar	125 (0 – 35250)				
grand fir	--	--			
Douglas-fir	--	--			
western larch	--	--			
ponderosa pine	--	--			

Results

Cedar is regenerating vigorously!

	Seedlings ha^{-1}				
Species	**2006**	**2007**	**2008**	**2017**	**% change (2008-2017)**
yellow-cedar	125 (0 – 35250)	2750 (0 – 41000)	7375 (0 – 10100)	8125 (0 – 69250)	+10%
grand fir	--	--			
Douglas-fir	--	--			
western larch	--	--			
ponderosa pine	--	--			

Results

Other species regenerating at background levels

	Seedlings ha^{-1}				
Species	**2006**	**2007**	**2008**	**2017**	**% change (2008-2017)**
yellow-cedar	125 (0 – 35250)	2750 (0 – 41000)	7375 (0 – 10100)	8125 (0 – 69250)	+10%
grand fir	--	--			
Douglas-fir	--	--	1250 (0 – 16000)	1625 (0 – 13250)	+30%
western larch	--	--	0	250 (0 – 3500)	NA
ponderosa pine	--	--	0 (0 – 1750)	0 (0 – 2000)	0%

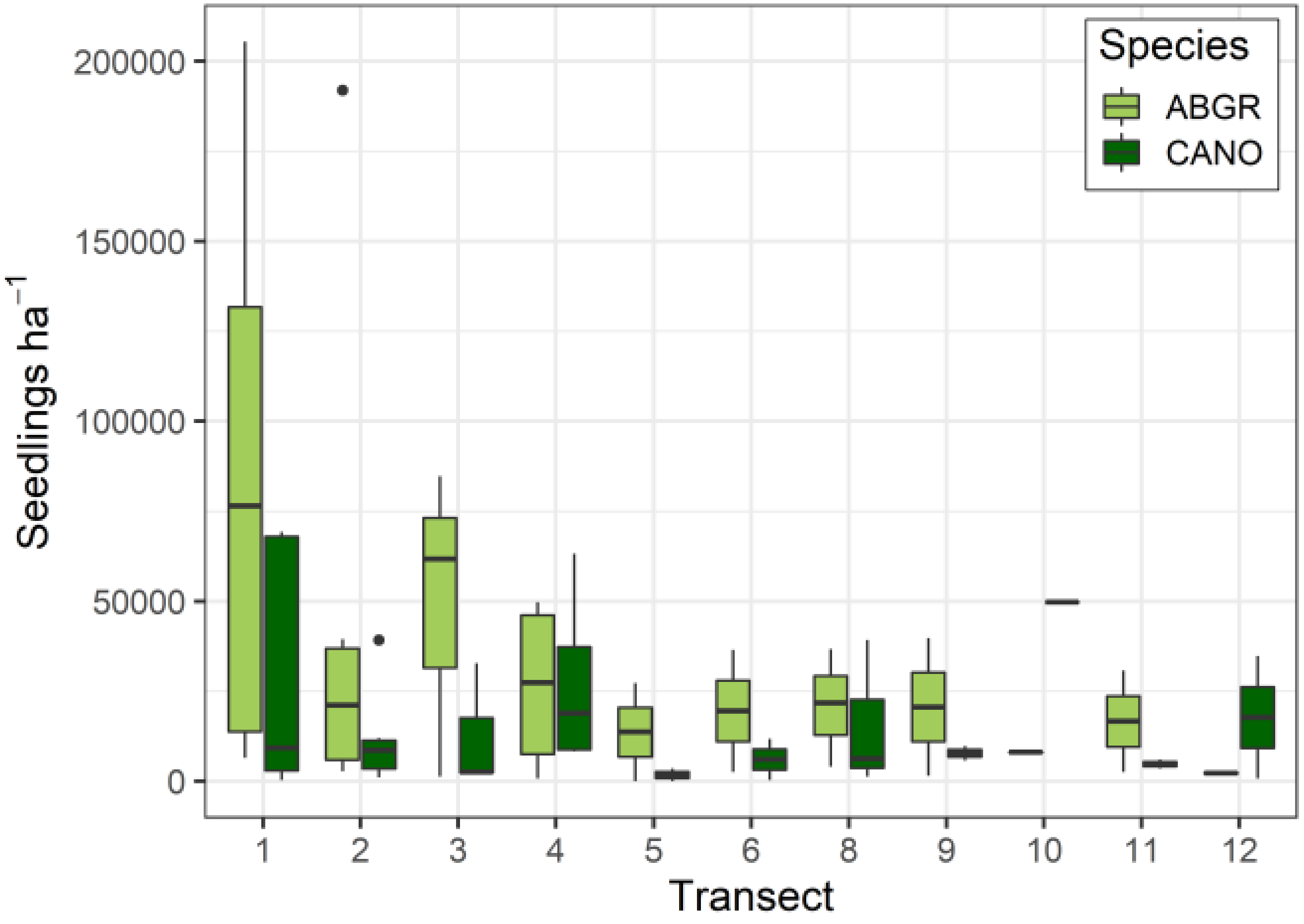
Results

Cedar is regenerating, but not as vigorously as grand fir

	Seedlings ha^{-1}				
Species	**2006**	**2007**	**2008**	**2017**	**% change (2008-2017)**
yellow-cedar	125 (0 – 35250)	2750 (0 – 41000)	7375 (0 – 10100)	8125 (0 – 69250)	+10%
grand fir	--	--	2750 (0 – 20250)	17750 (0 – 205500)	**+545%**
Douglas-fir	--	--	1250 (0 – 16000)	1625 (0 – 13250)	+30%
western larch	--	--	0	250 (0 – 3500)	NA
ponderosa pine	--	--	0 (0 – 1750)	0 (0 – 2000)	0%

Results

Cedar is regenerating, but not as vigorously as grand fir



Key Points

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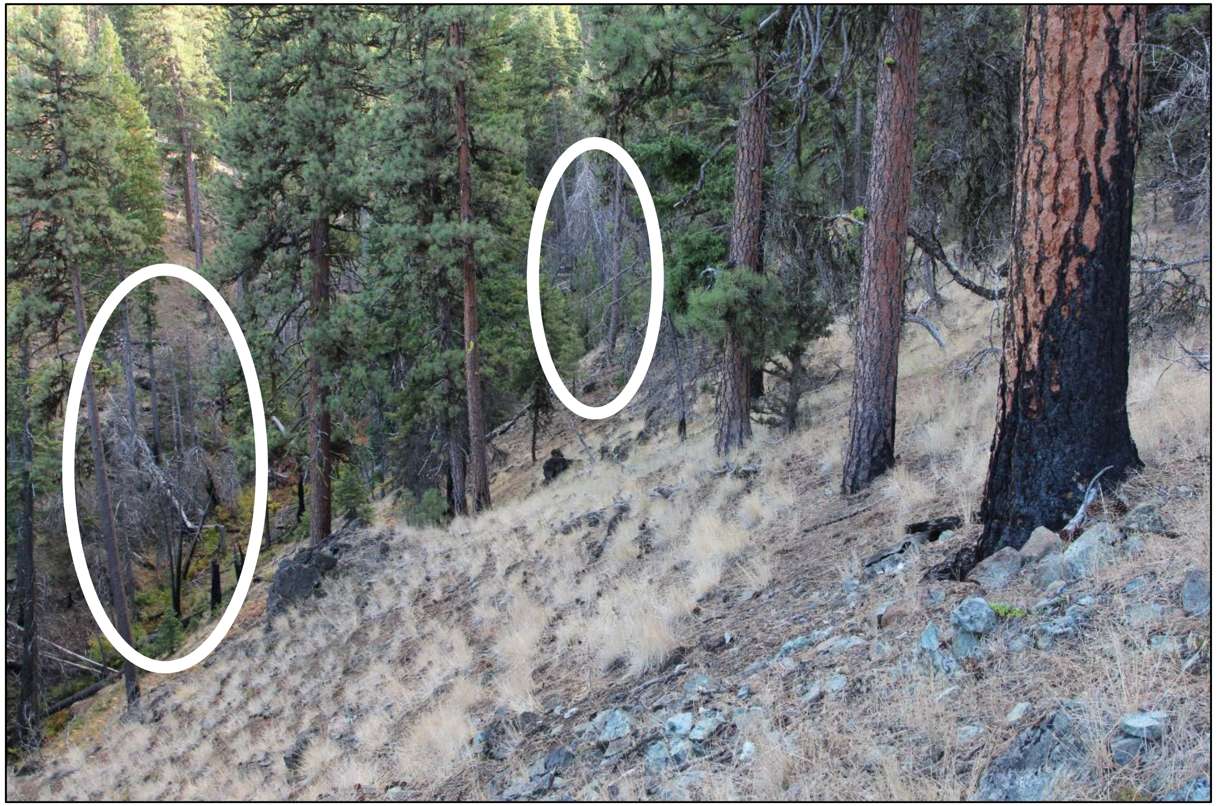
1. Contemporary (2006) low-intensity fire resulted in substantial (>90%) cedar mortality, and future fire could result in the local extirpation of the species.



Key Points

1. Contemporary low-intensity fire resulted in substantial (>90%) cedar mortality, and future fire could result in the local extirpation of the species.

2. Cedar is regenerating in the grove, but species with more surviving seed sources, like grand fir, may eventually outcompete reestablishing cedar seedlings.

Management implications

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1. Consider frequent (~every 15 yrs) prescribed fire treatments to limit the likelihood of future, severe fire in the grove.

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2. Consider mechanical removal of grand fir to reduce competition with yellow-cedar.

Take-home points

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1. Dry forests can regenerate following stand-replacement fire in the Blues, provided there is adequate seed source

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1. Dry forests can regenerate following stand-replacement fire in the Blues, provided there is adequate seed source

2. Despite high fire-induced mortality, yellow-cedar is regenerating, but the population might need out help to persist

Acknowledgements

Krawchuk LCSRG Lab

Garret Meigs
Anna Talucci
Claire Tortorelli
Nathan Blades
Andrew Merschel
Ana Barros

Field Crew

Claire Tortorelli
Jean McCalmont
Julie VanSant

Collaborators

James Johnston
Ellen Whitman
Ryan Walker
Marc Parisien
Sandra Haire
Joe Rausch
Carol Miller
Jonathan Coop
Geneva Chong

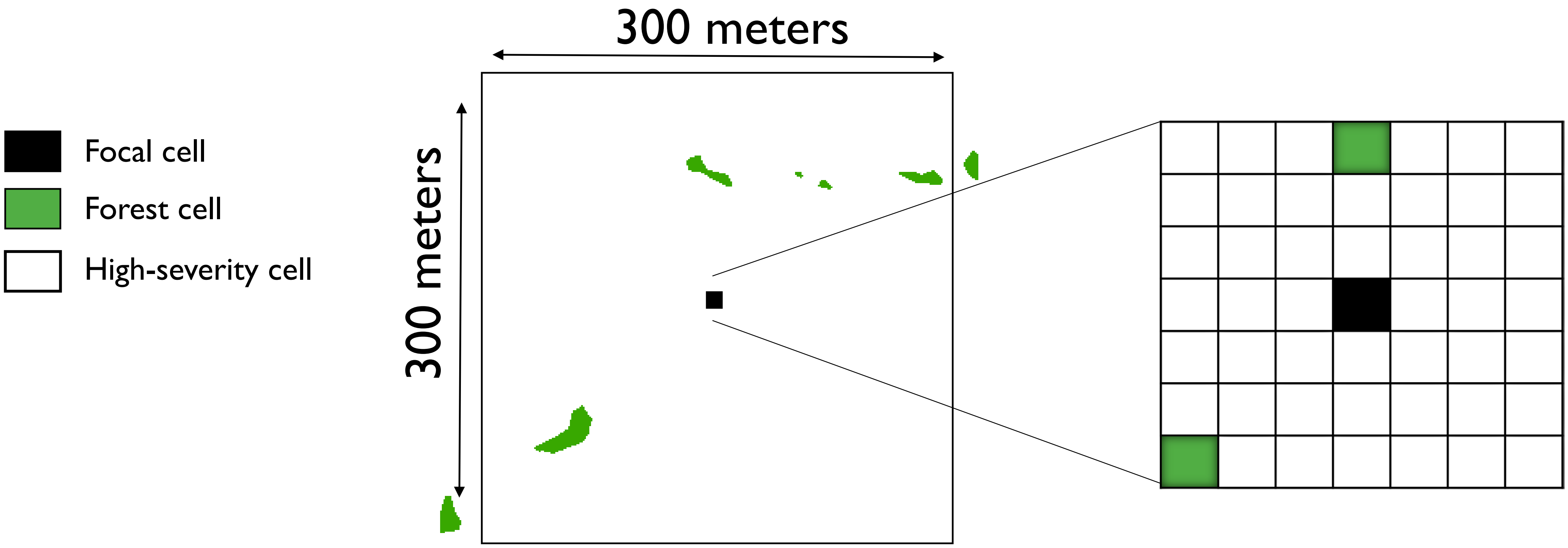
Thanks!
Any questions?

Will Downing, James Johnston, Meg Krawchuk, Joseph Rausch

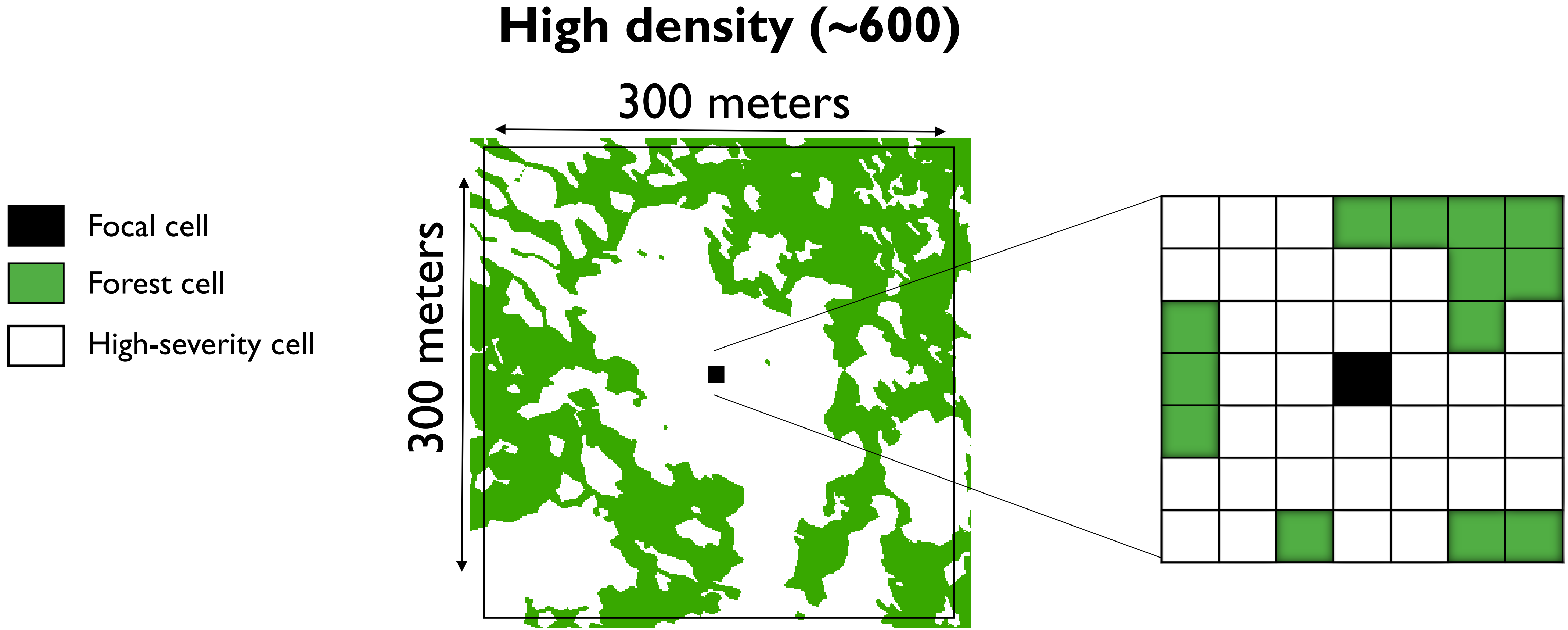
Oregon State University

Seed source abundance

Low density (~50)



Seed source abundance



Seed source abundance can vary when distance to seed source is held constant

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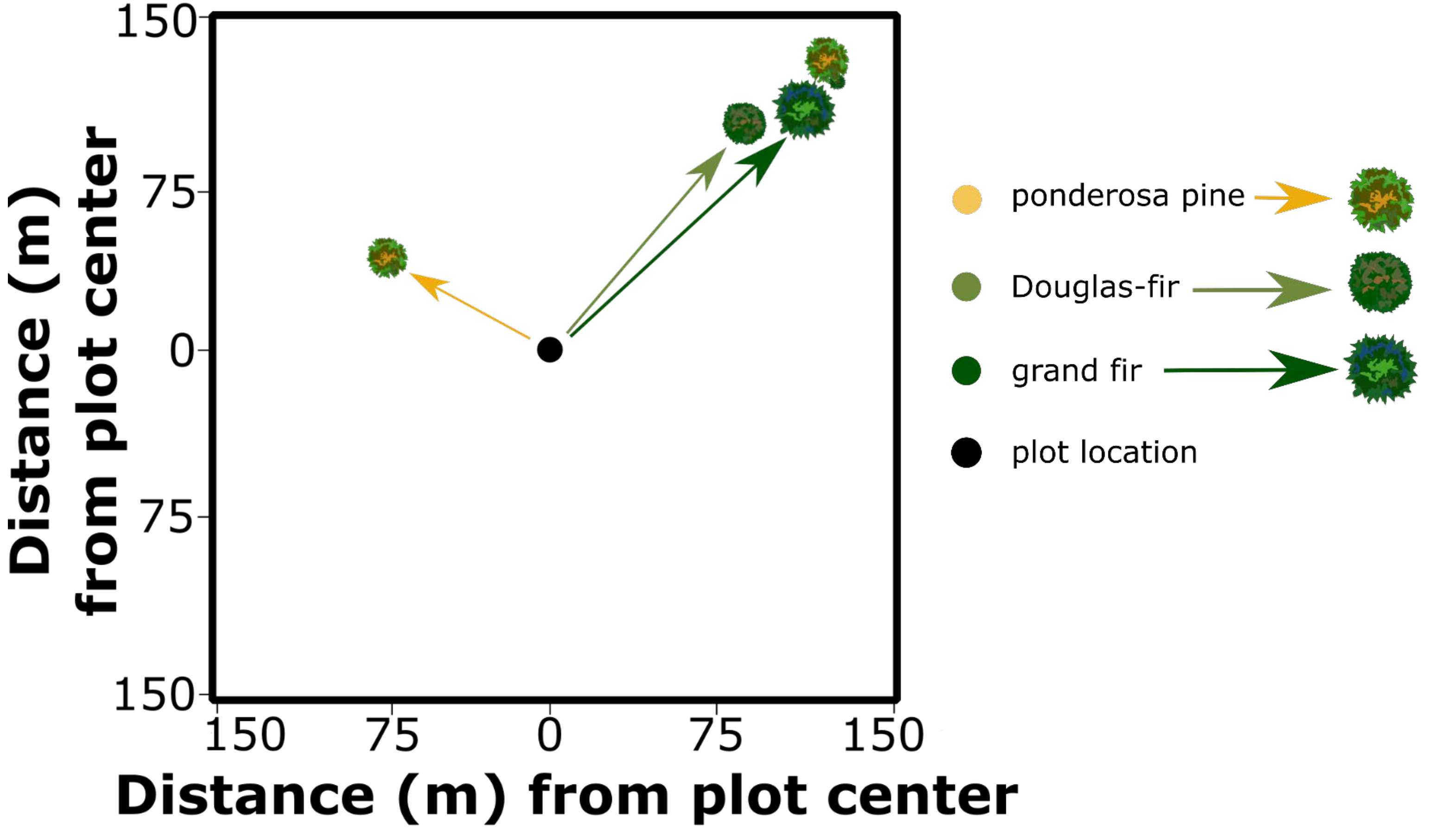
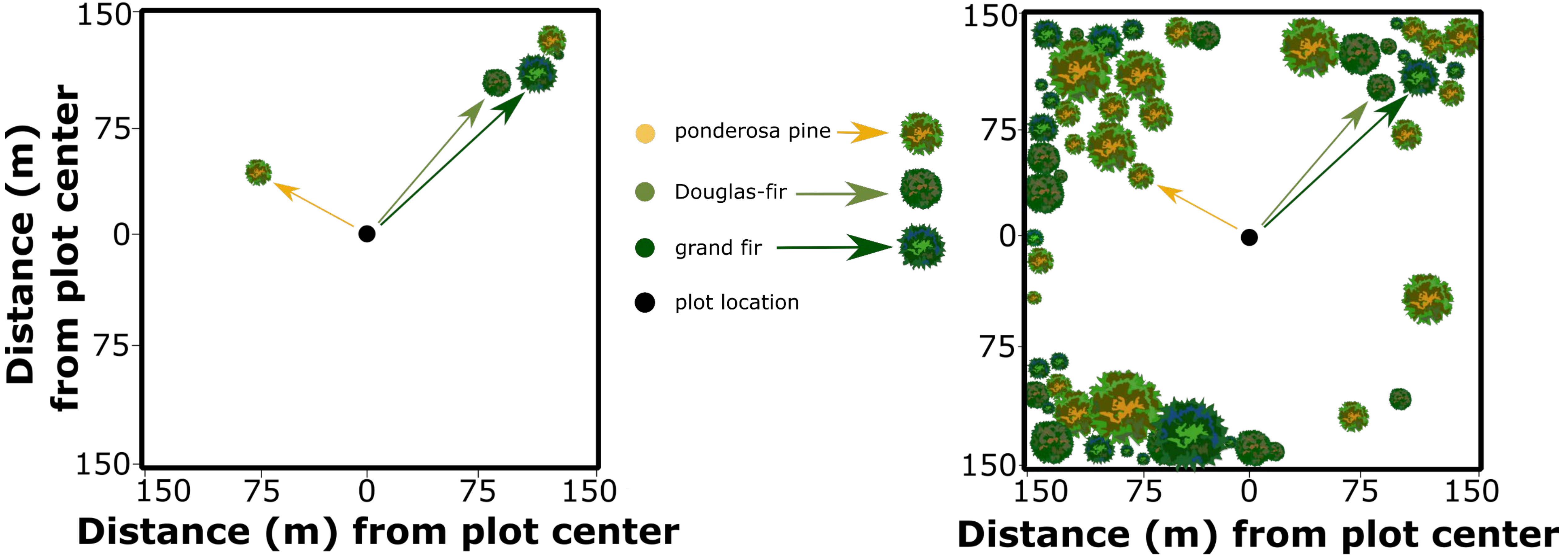


Seed source abundance can vary when distance to seed source is held constant



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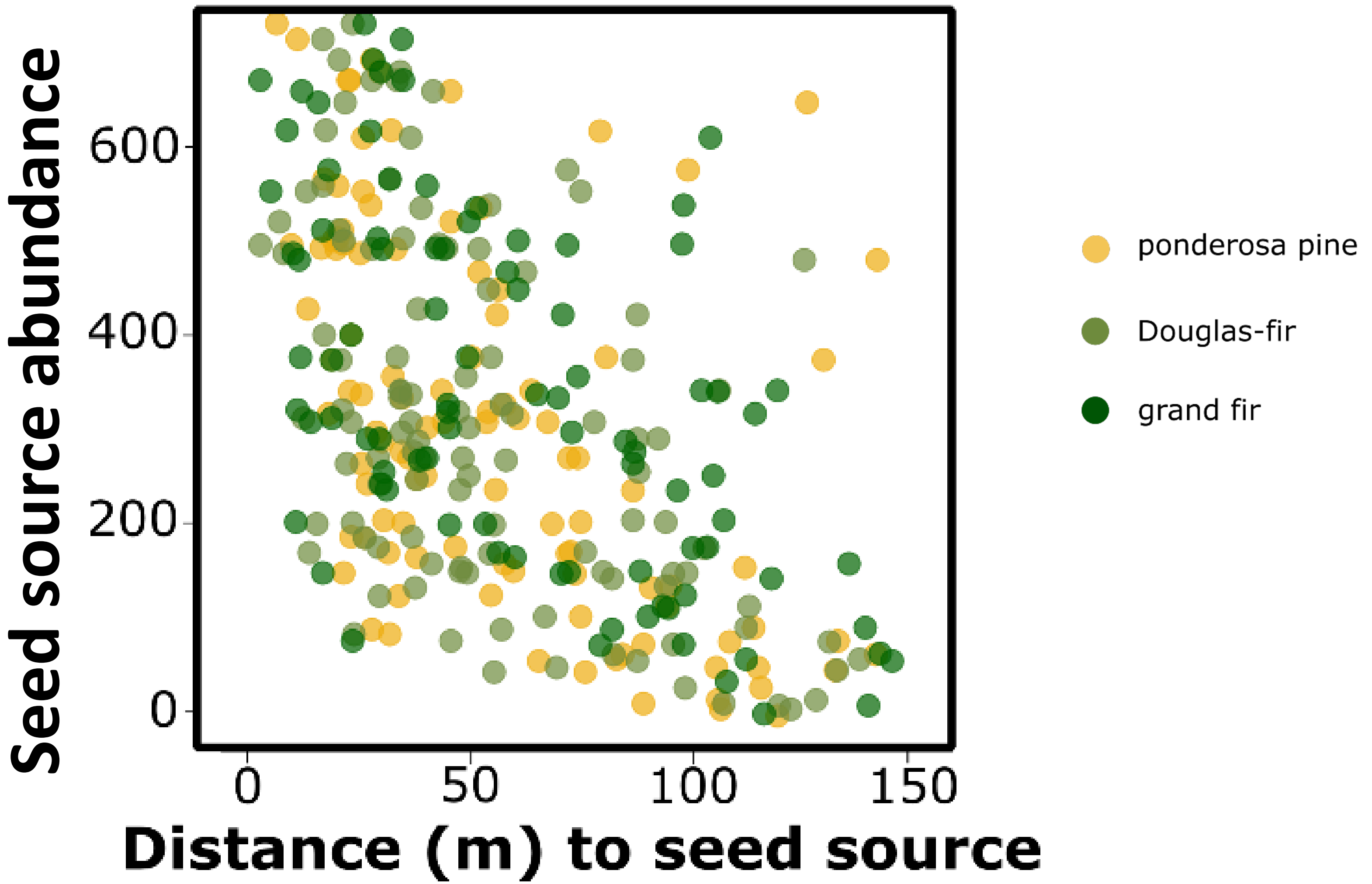
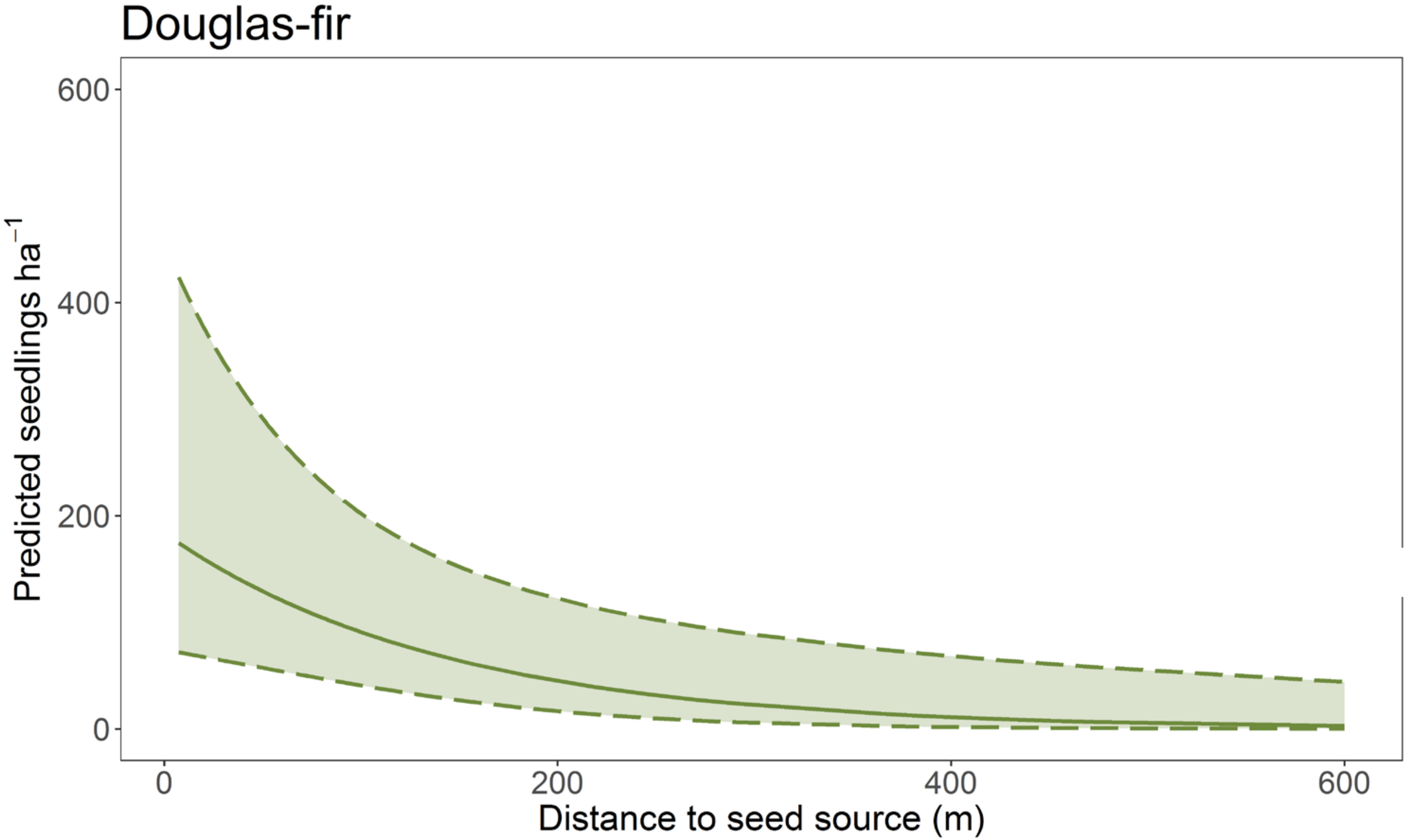
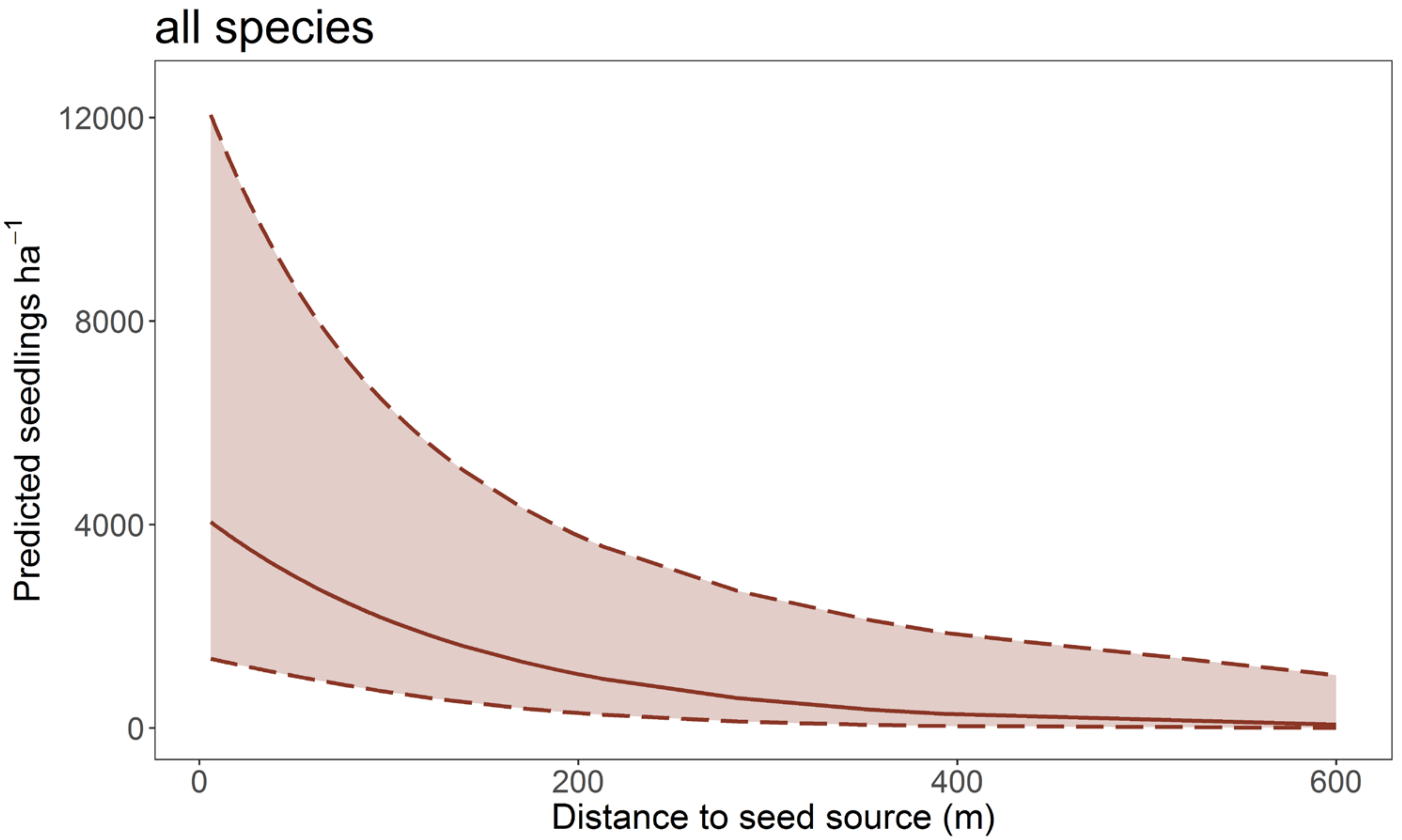


Distance to and **abundance of seed source** are key drivers of post-fire seedling abundance



Distance to and abundance of seed source are key drivers of post-fire seedling abundance



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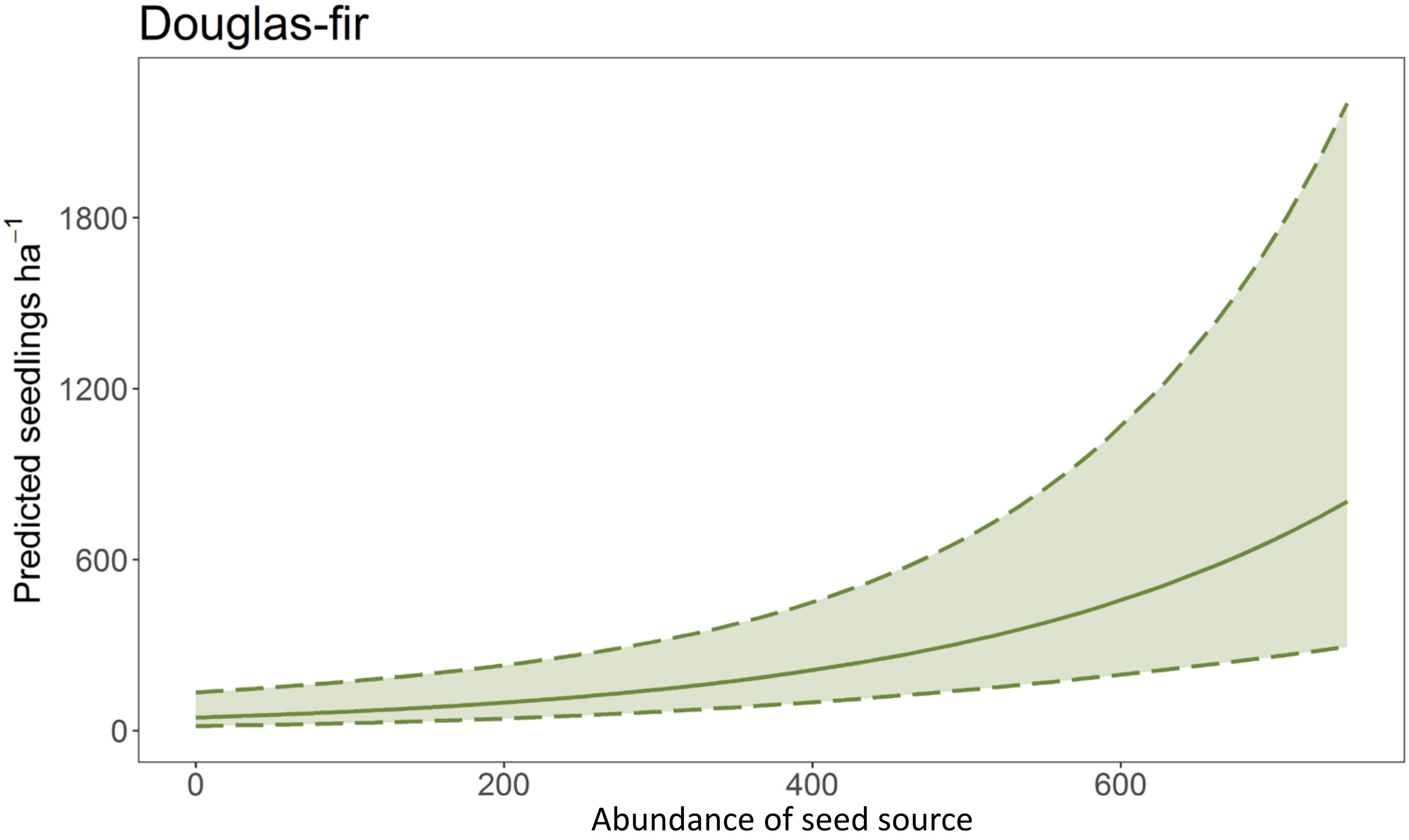

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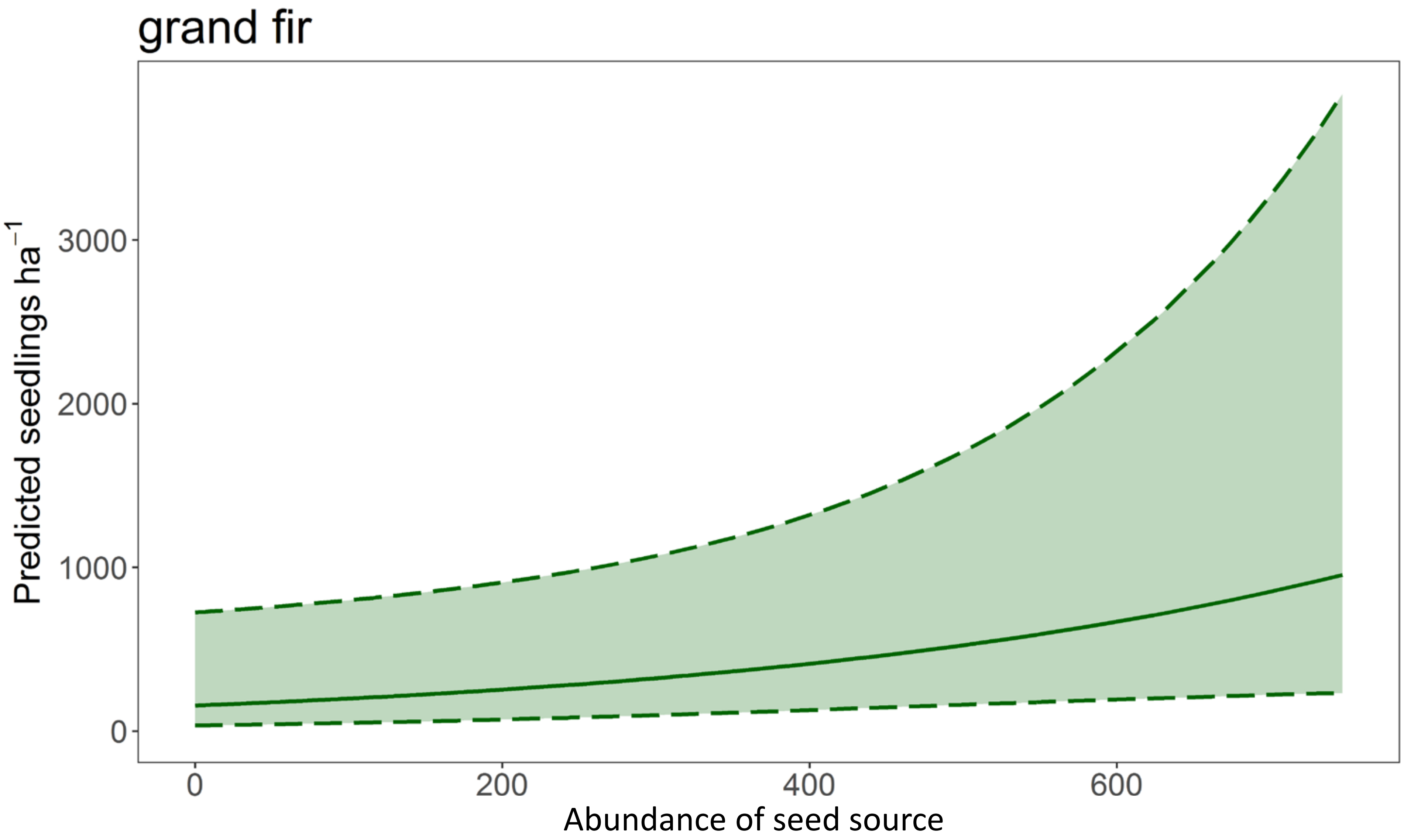

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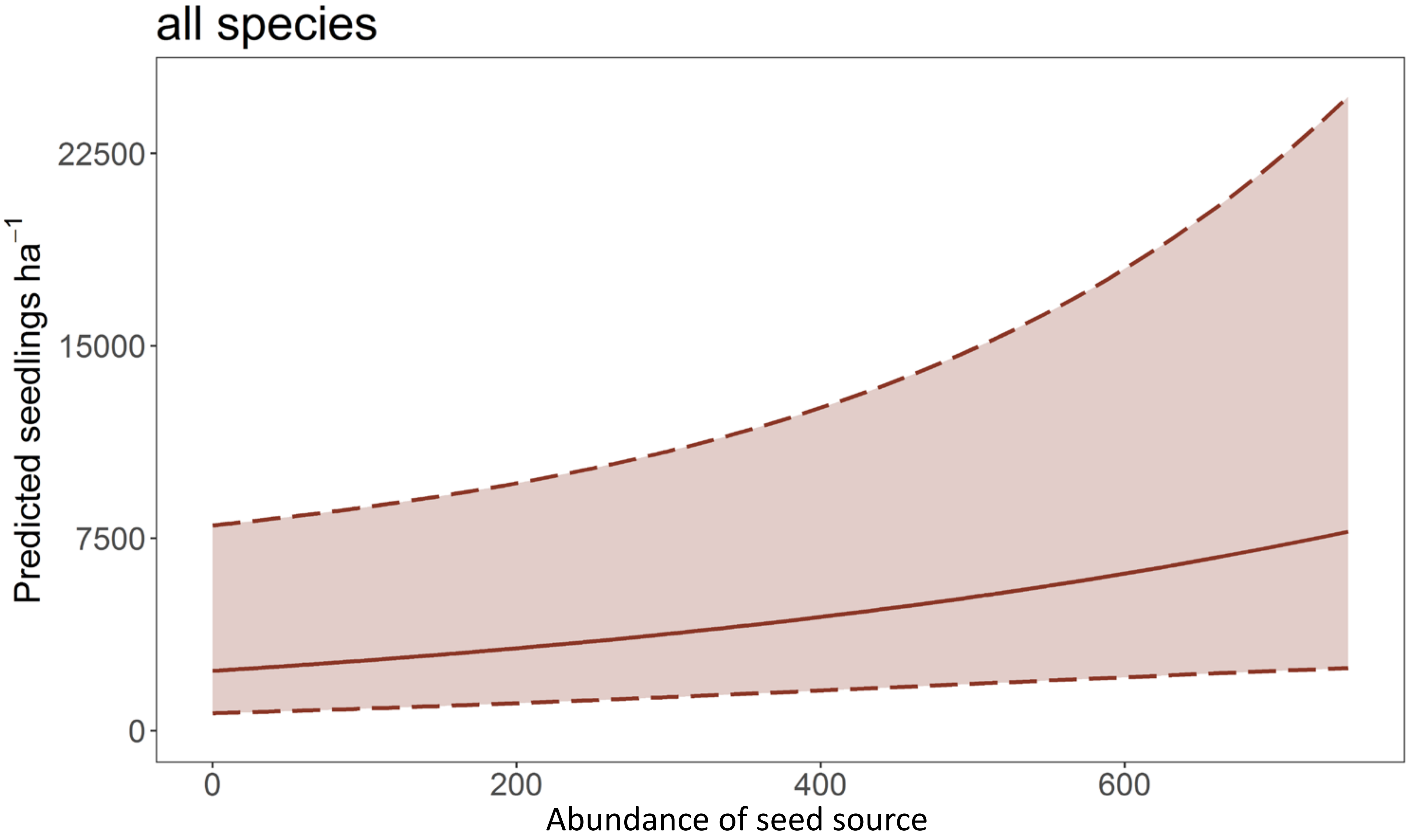
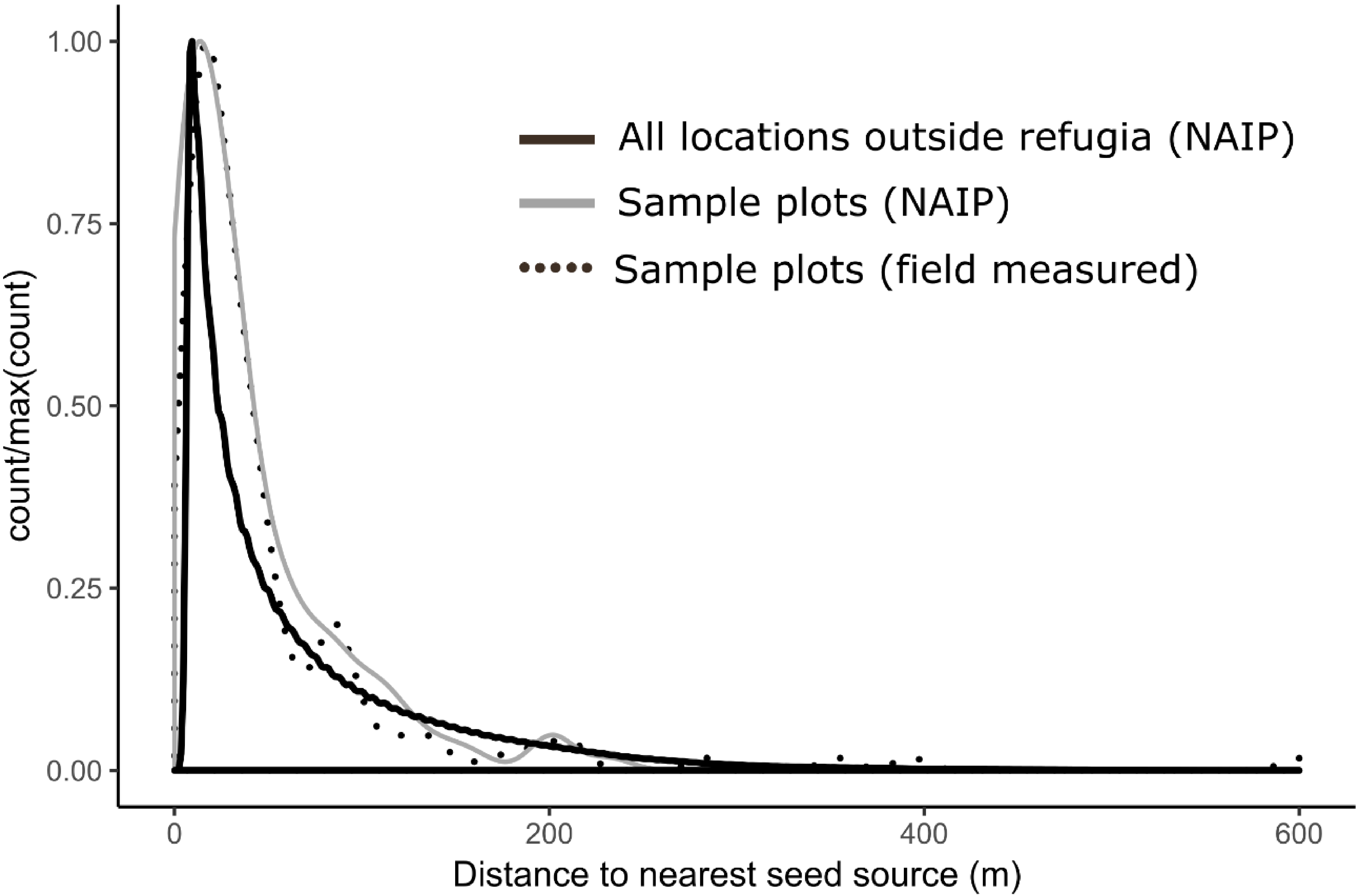
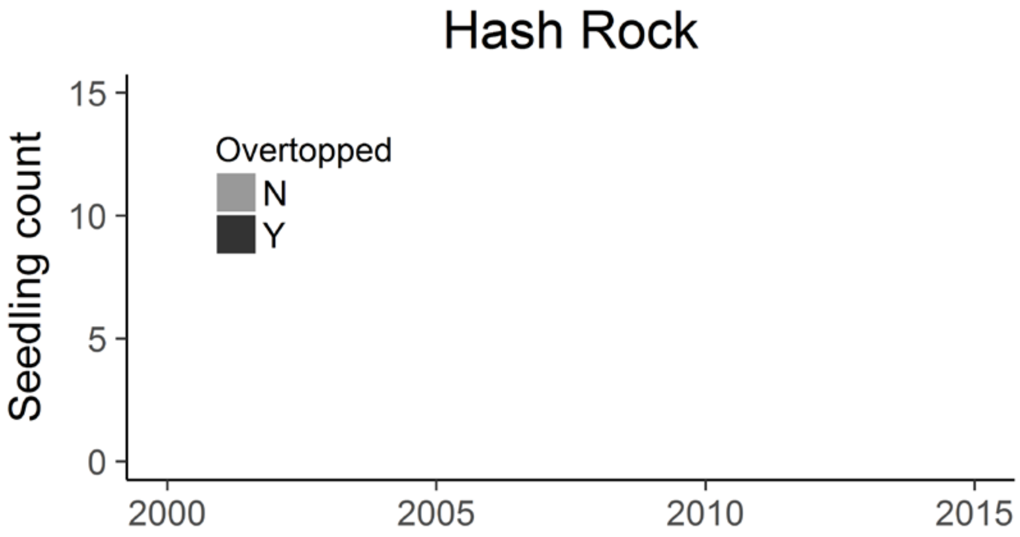




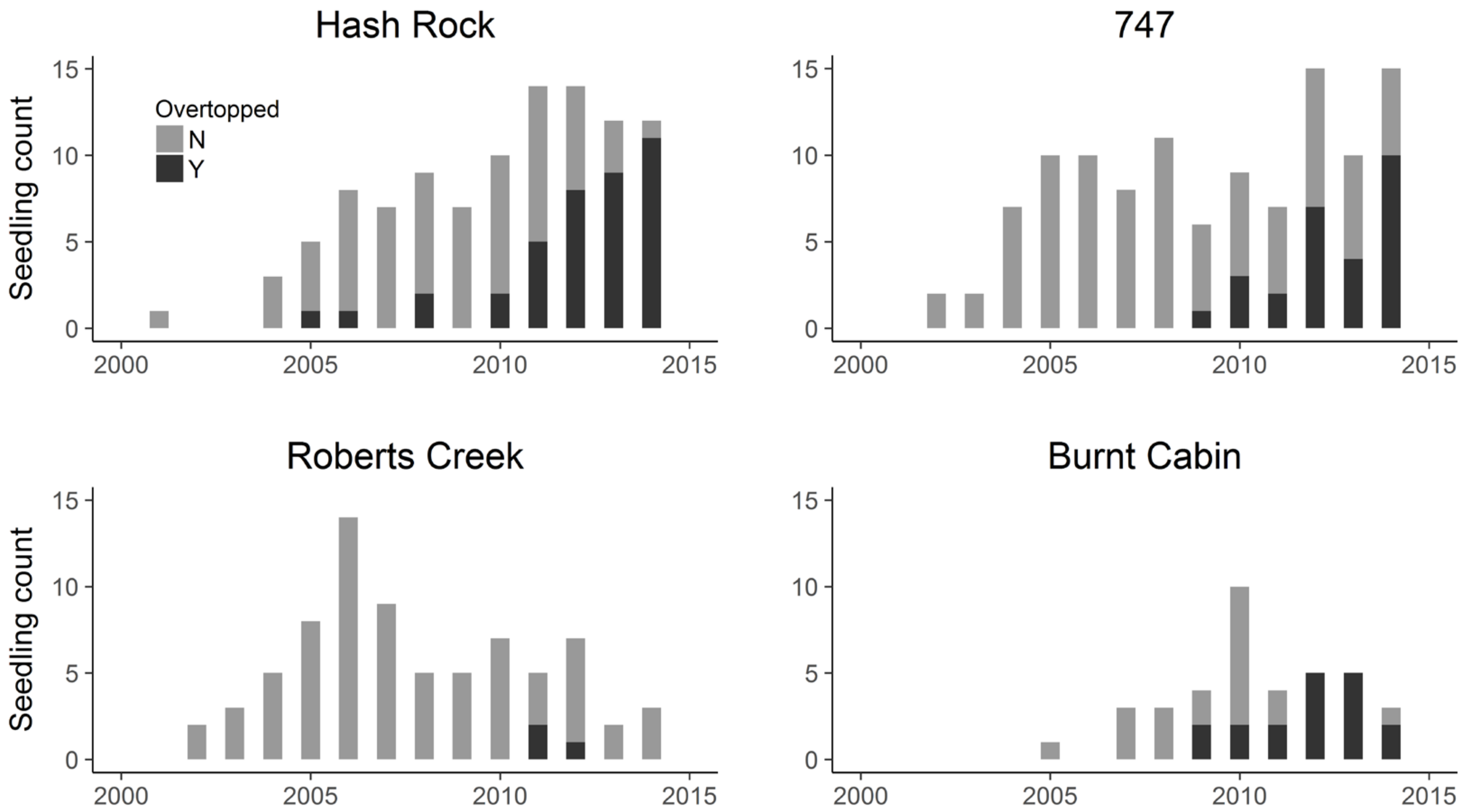
All locations outside refugia (NAIP)
Sample plots (NAIP)
Sample plots (field measured)
count/max(count)
1.00
0.75
0.50
0.25
0.00
0
200
400
600
Distance to nearest seed source (m)

Estimated PIPO establishment dates

Estimated PIPO establishment dates

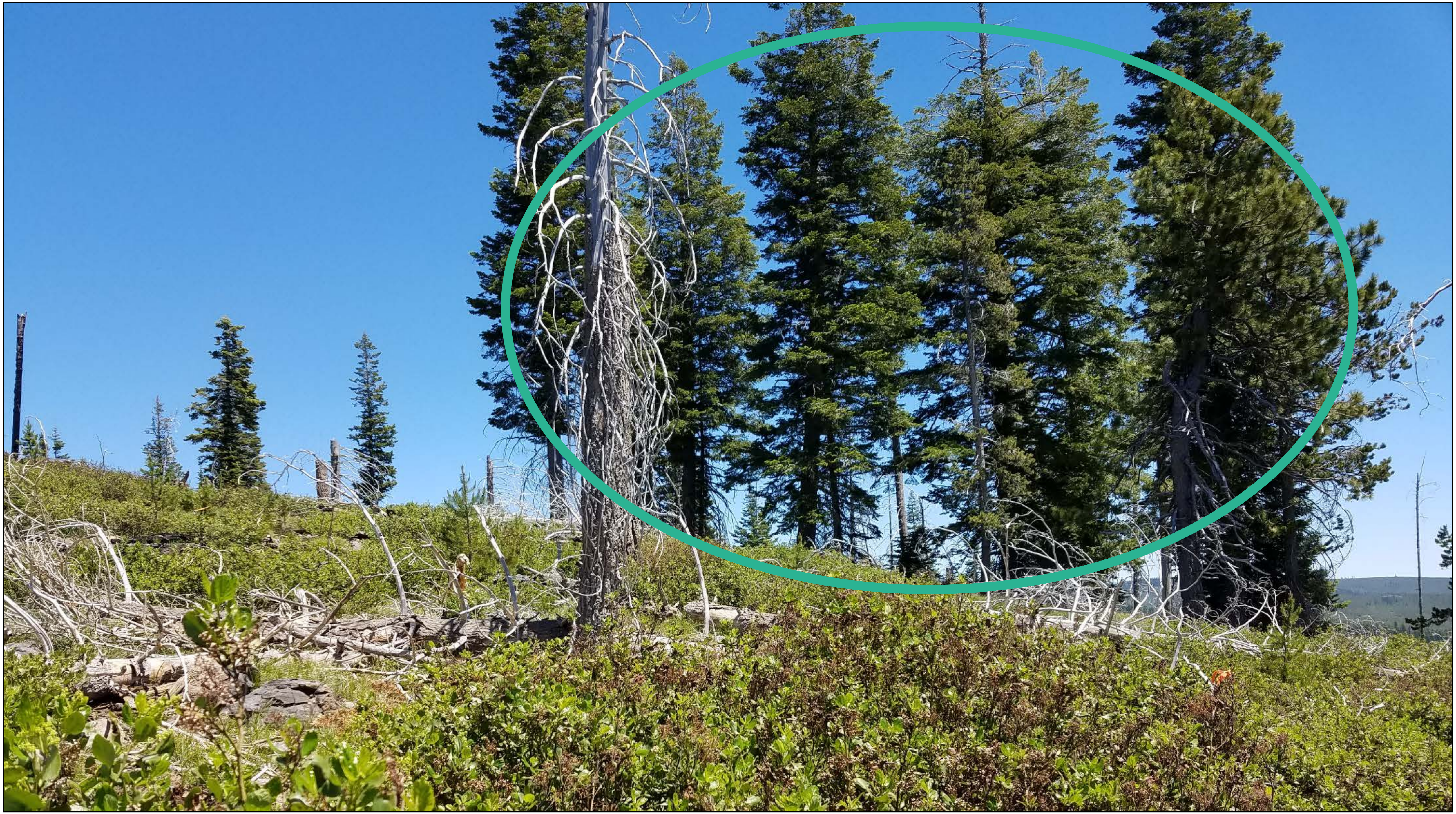


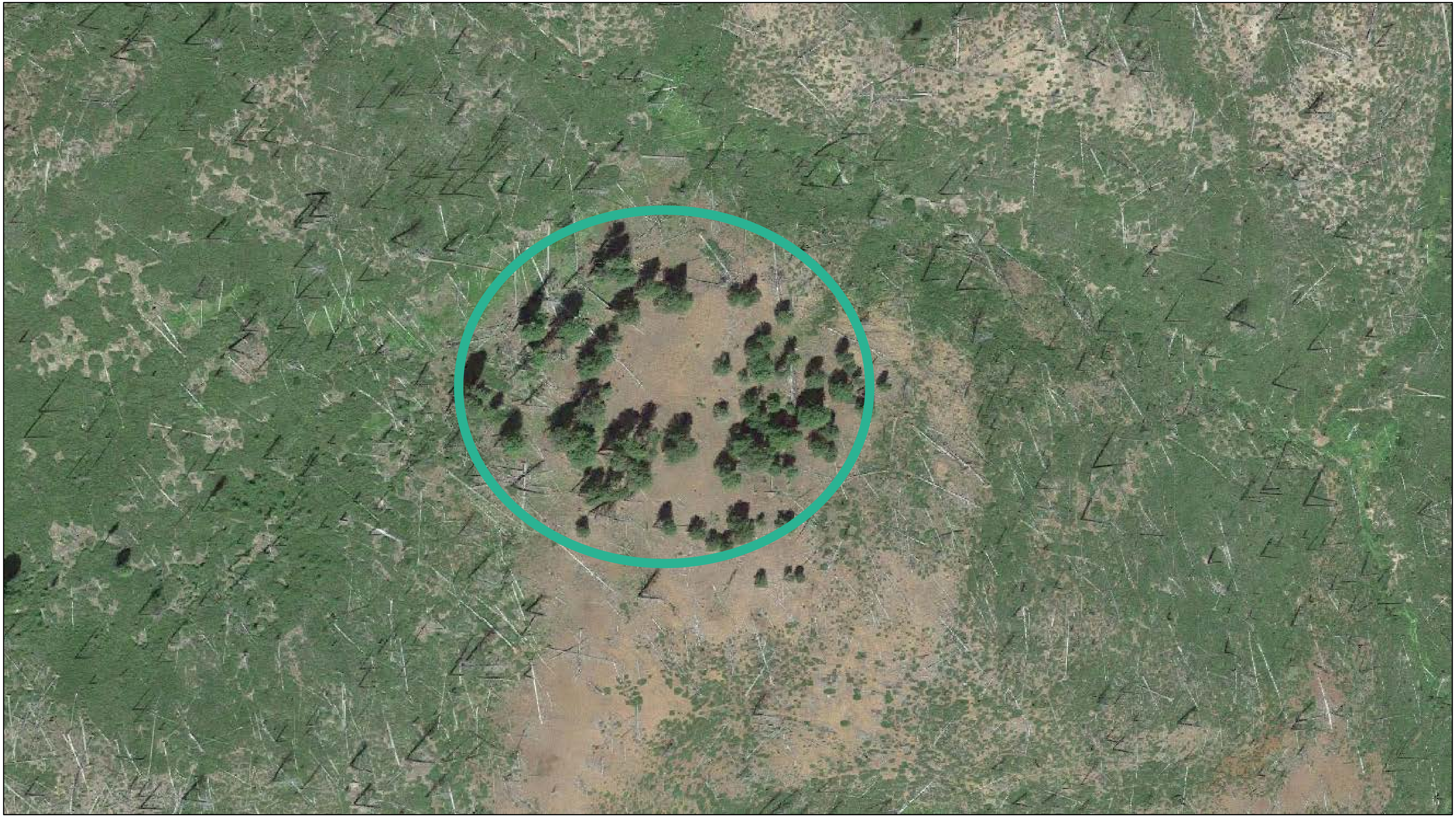
Estimated PIPO establishment dates
Regeneration takes time!

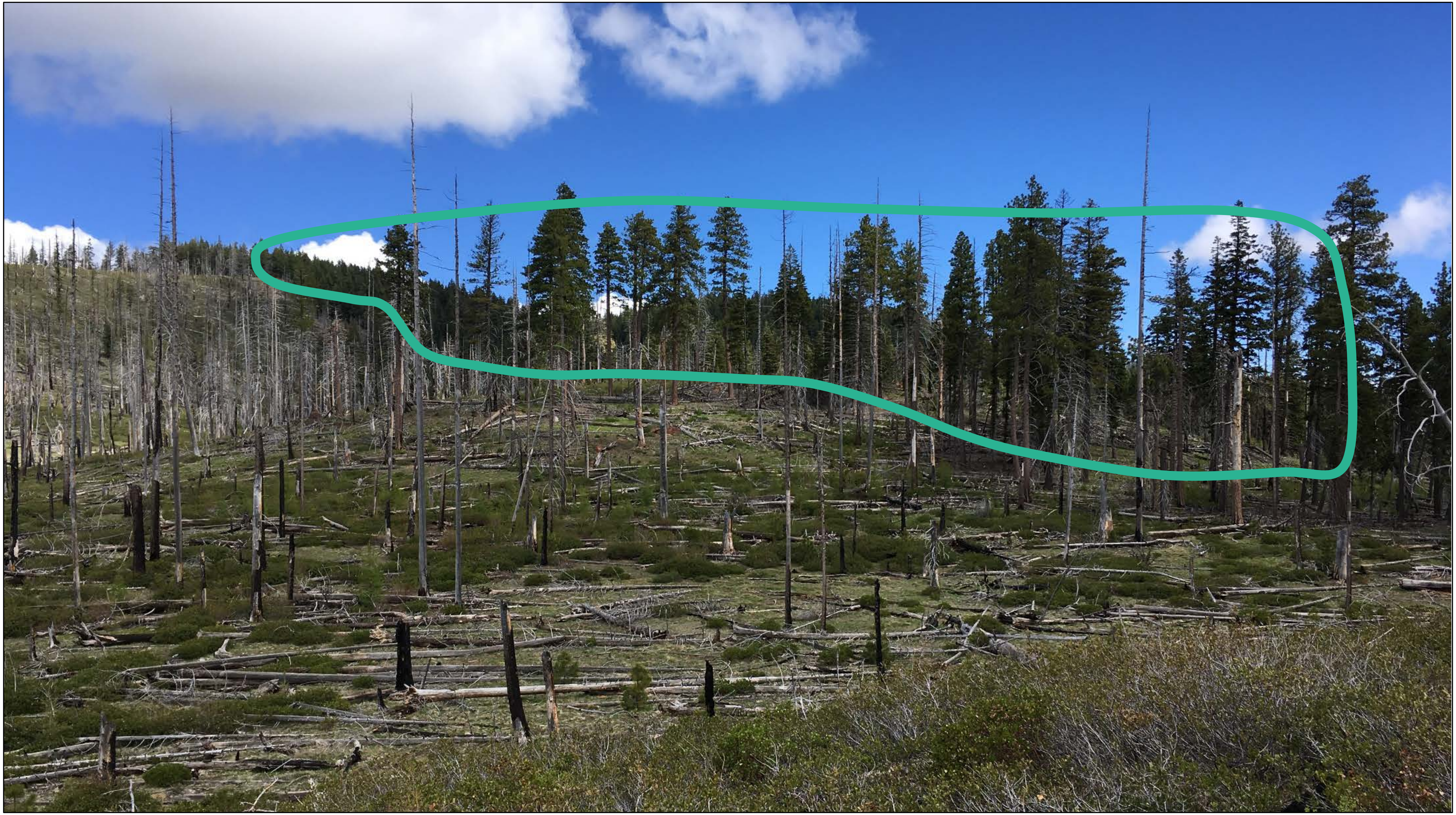


Fire refugia: A brief introduction

Unburned or low-severity burned patches of surviving forest within fire perimeters that did not experience stand-replacing fire effects

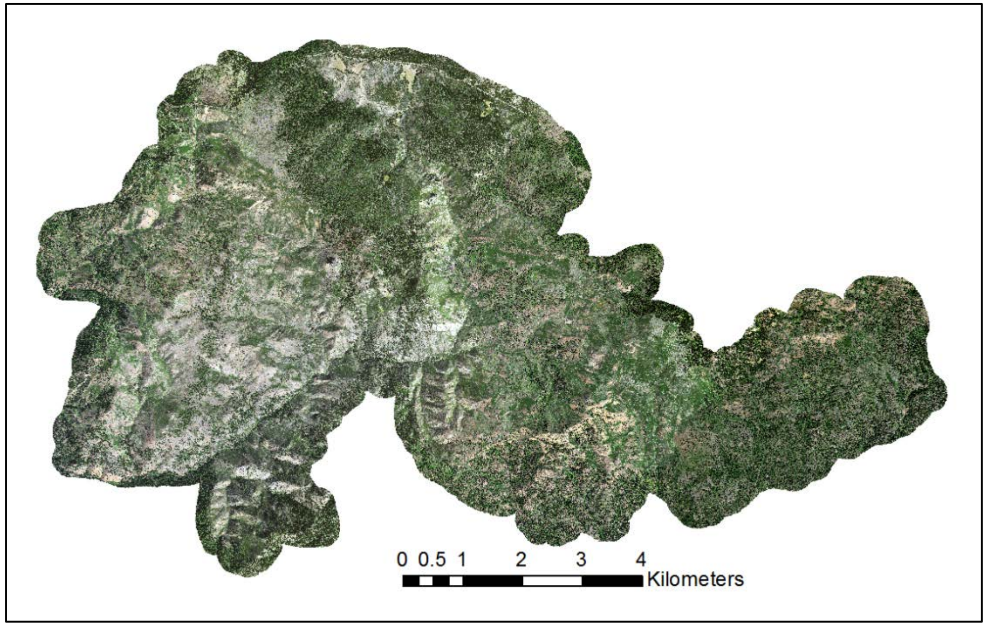






Fire refugia landscape pattern

1 meter aerial imagery



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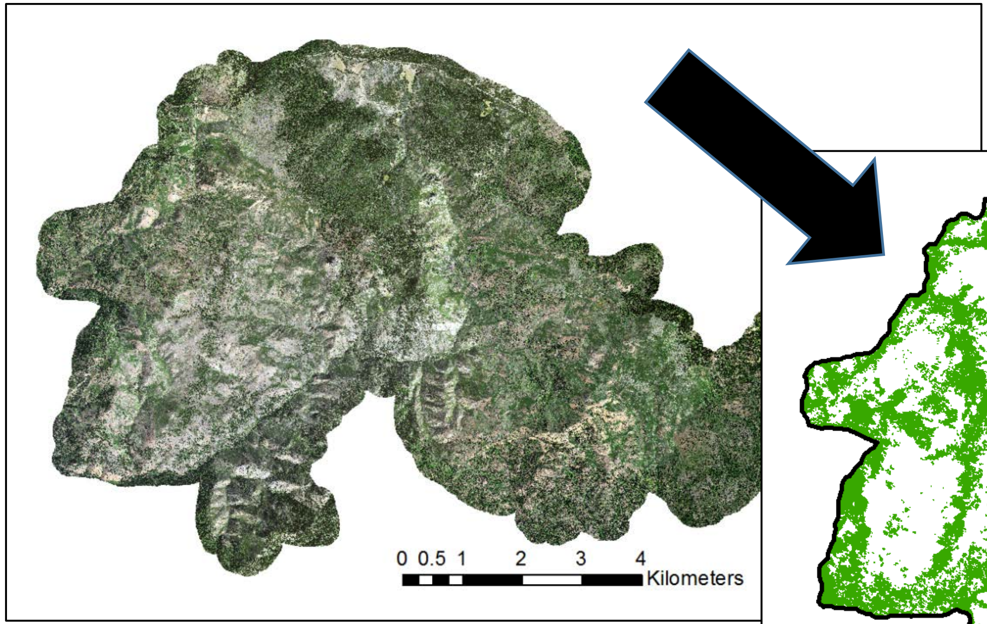
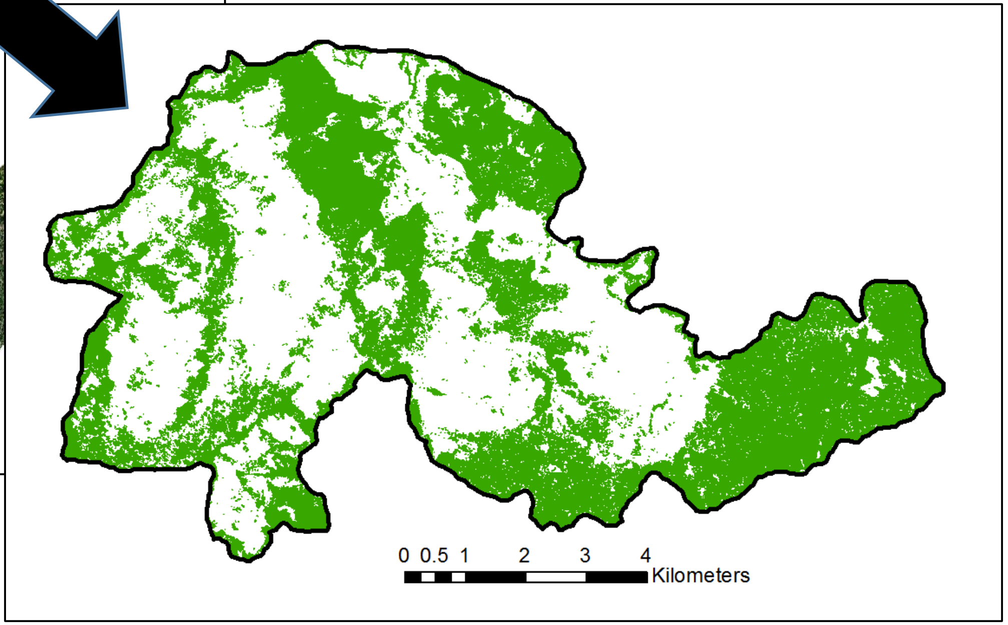
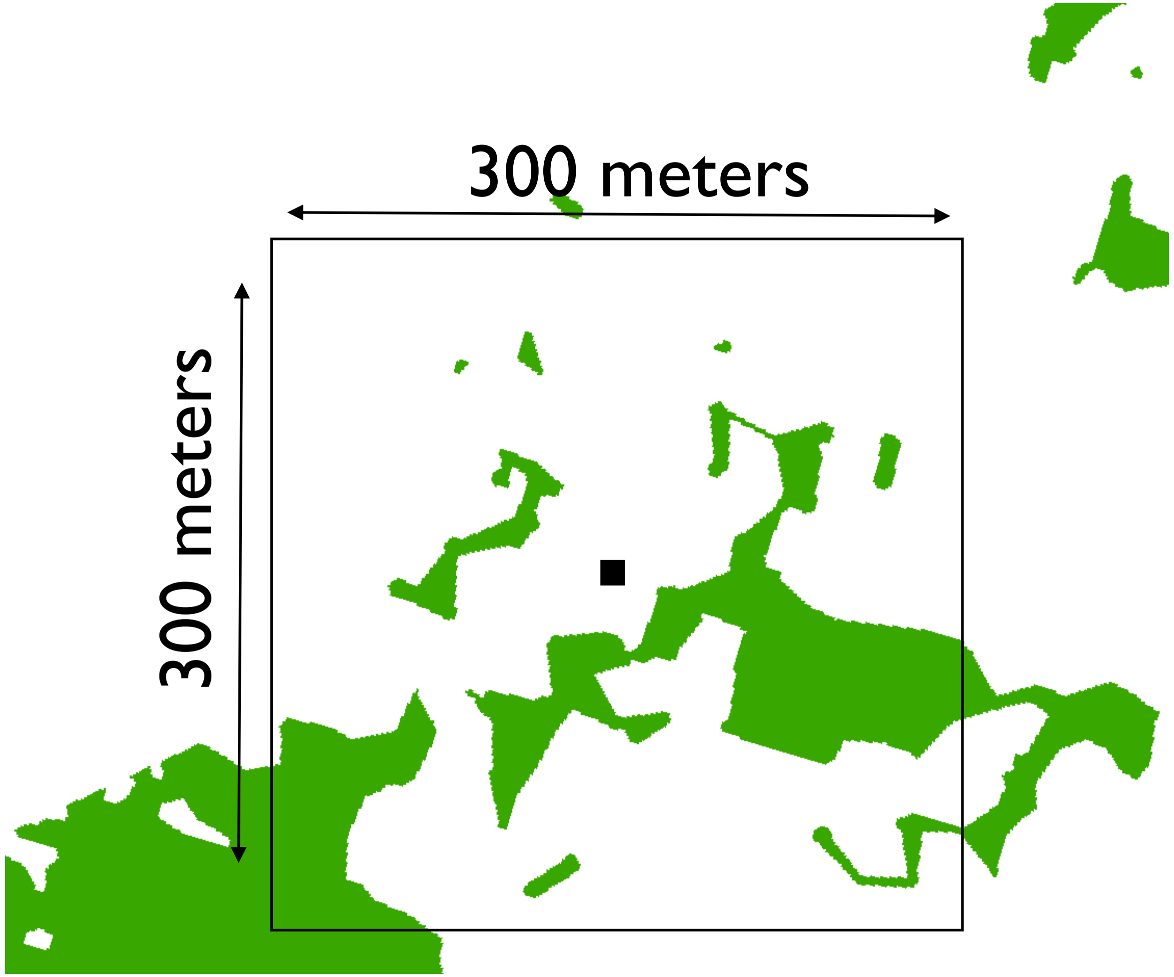


1 meter maps of fire refugia

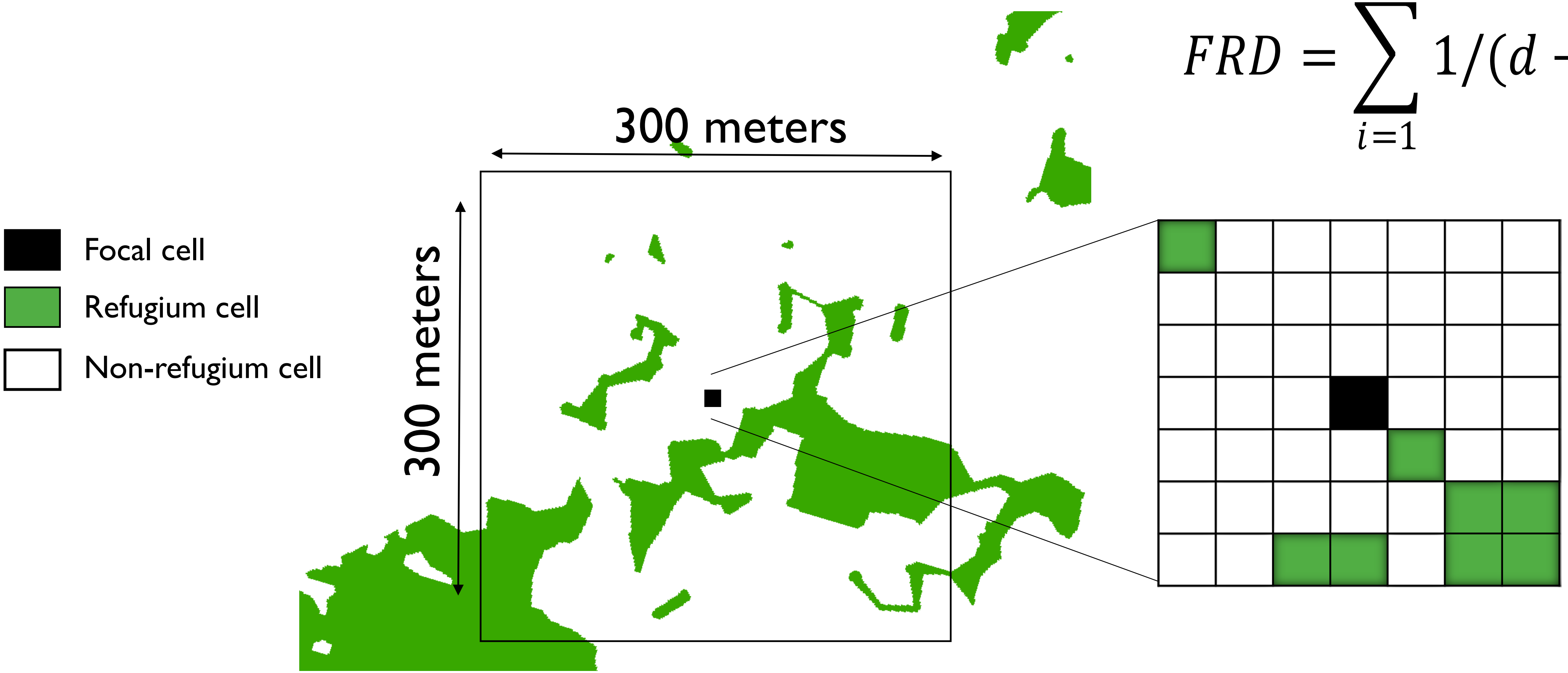


Landscape fire refugia density



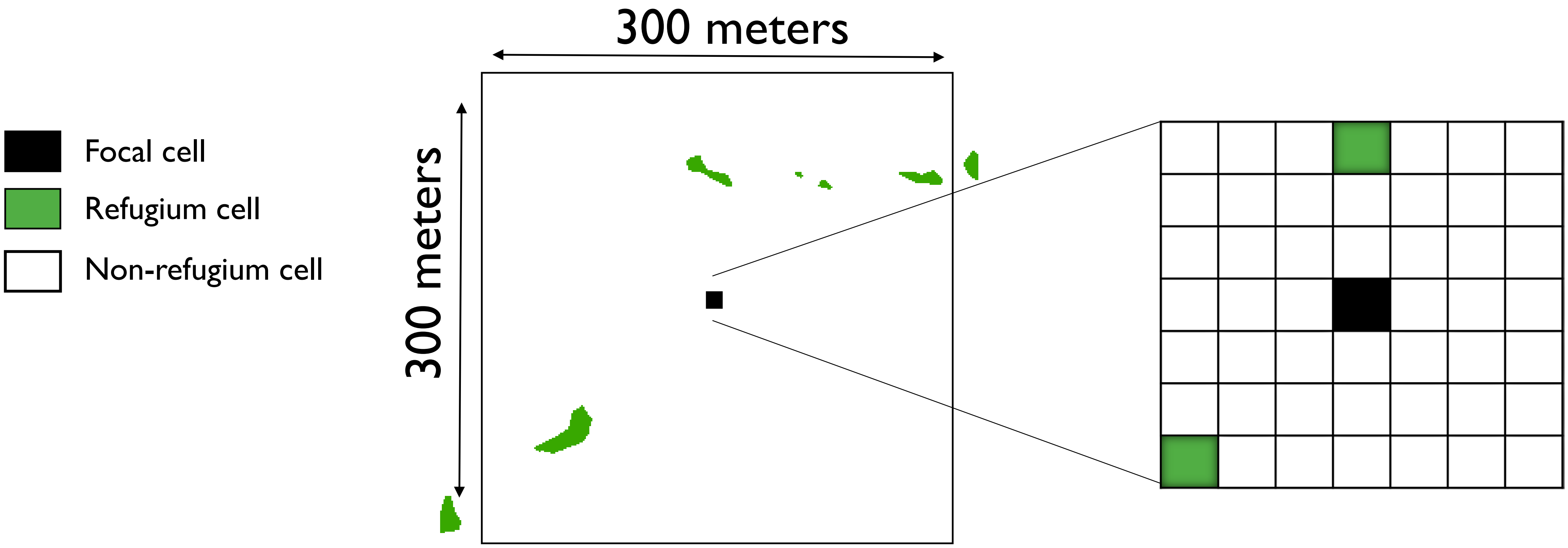
Landscape fire refugia density (FRD)

$$FRD = \sum_{i=1}^{n} 1/(d+1)$$

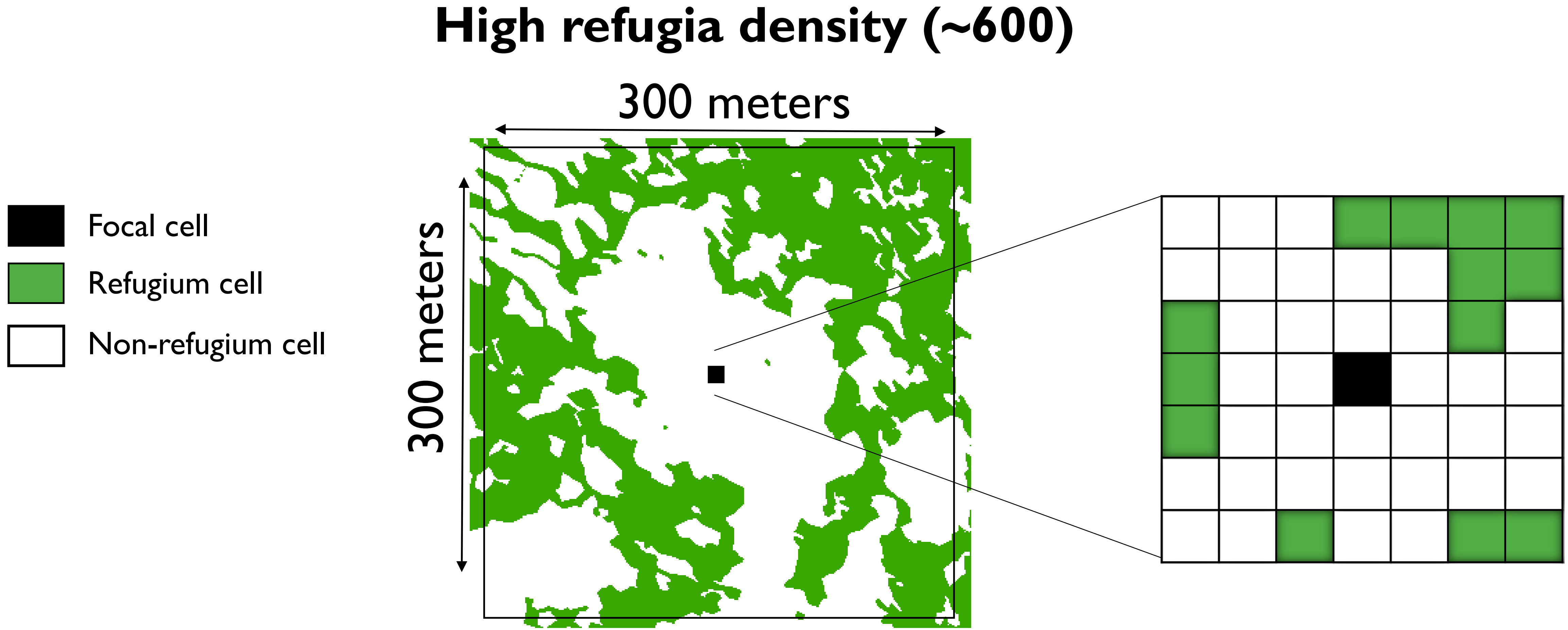


Landscape fire refugia density

Low refugia density (~50)

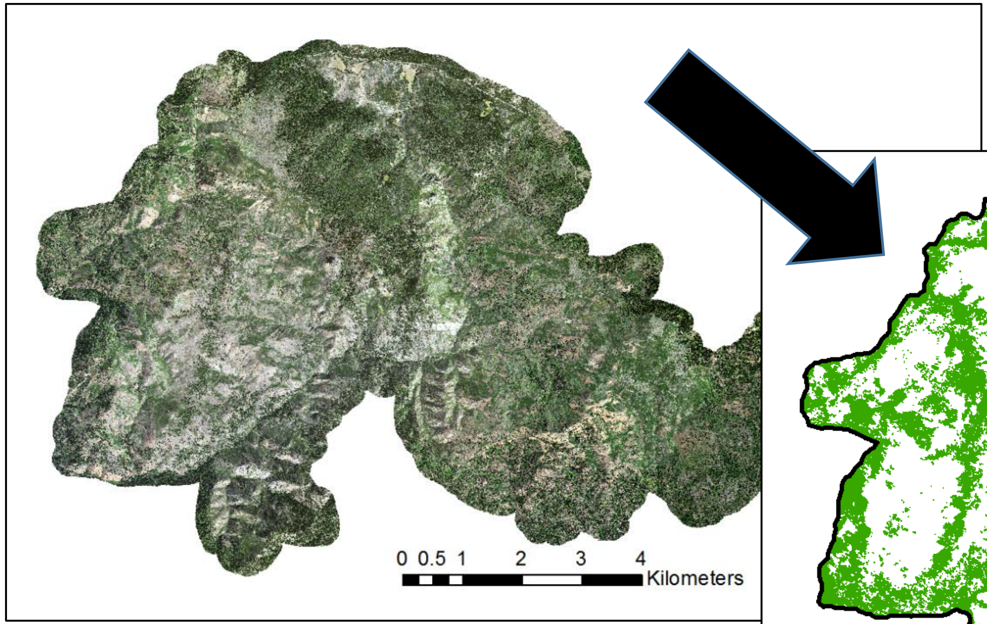


Landscape fire refugia density

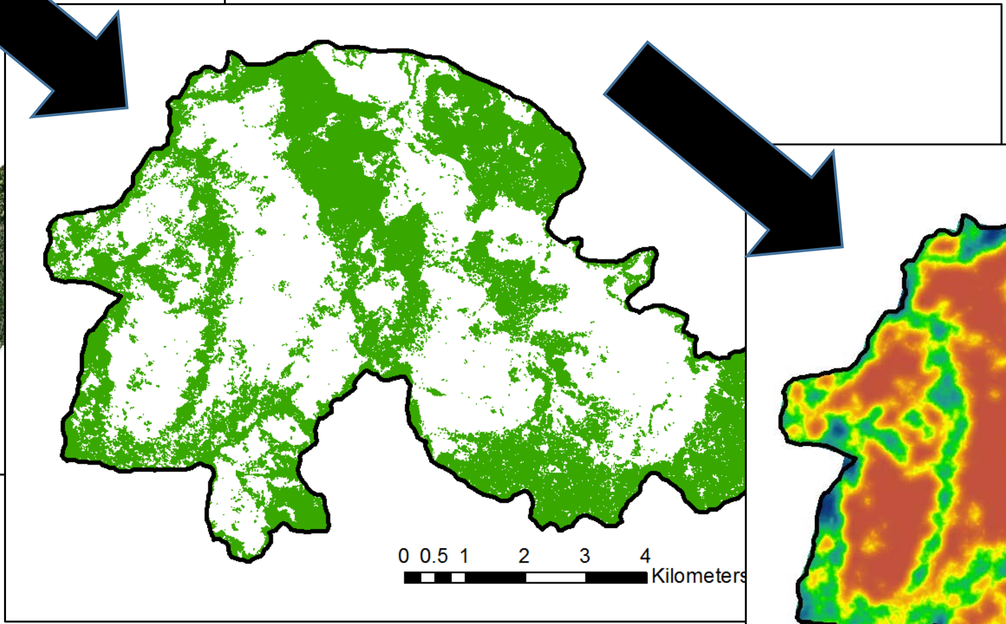


Landscape fire refugia density

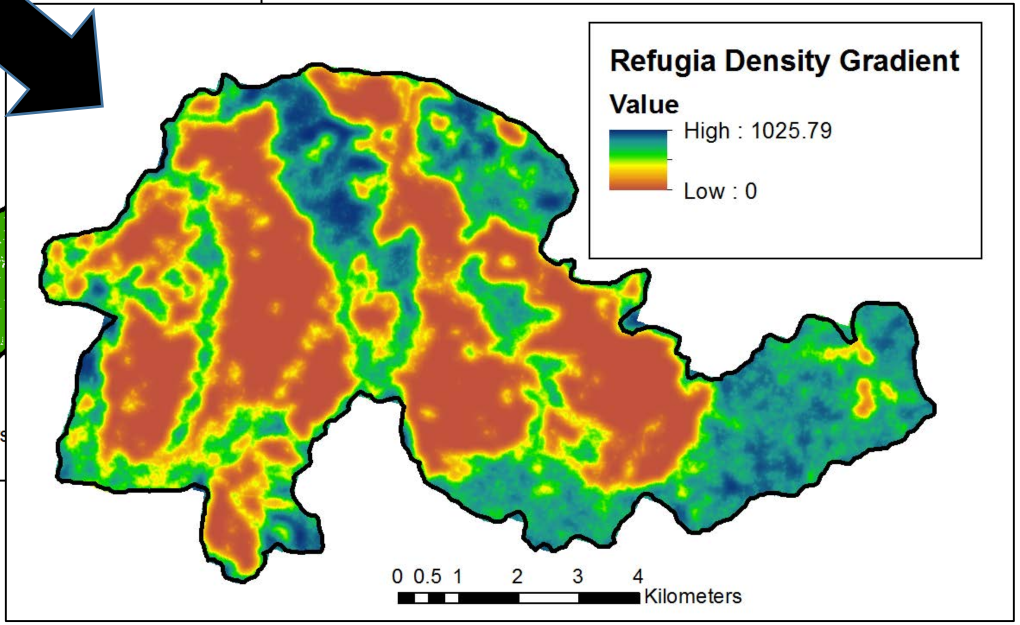
1 meter aerial imagery



1 meter maps of fire refugia



1 meter maps of fire refugia density



We did not find evidence that moisture deficit was a key limiting factor of post-fire regeneration

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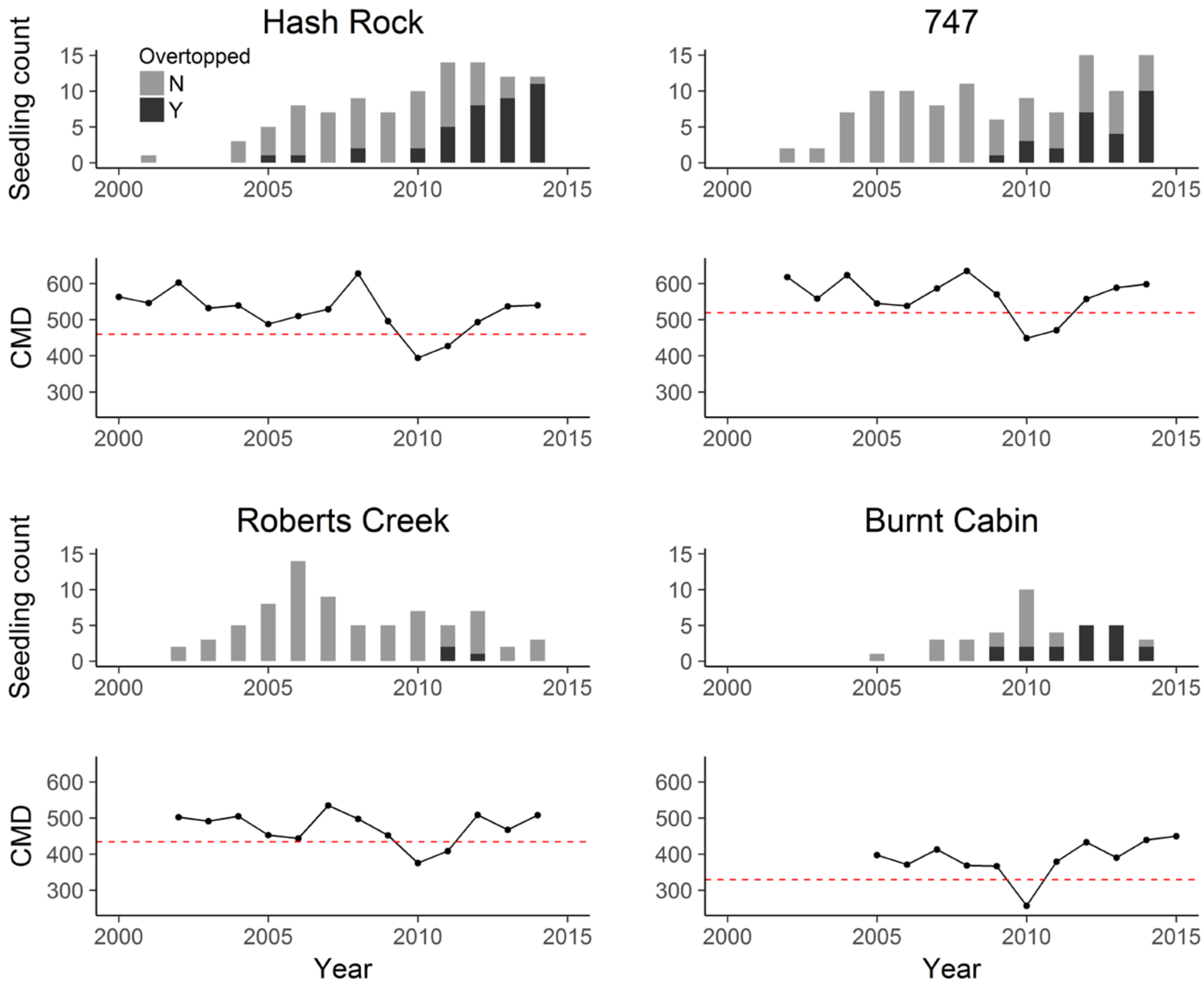
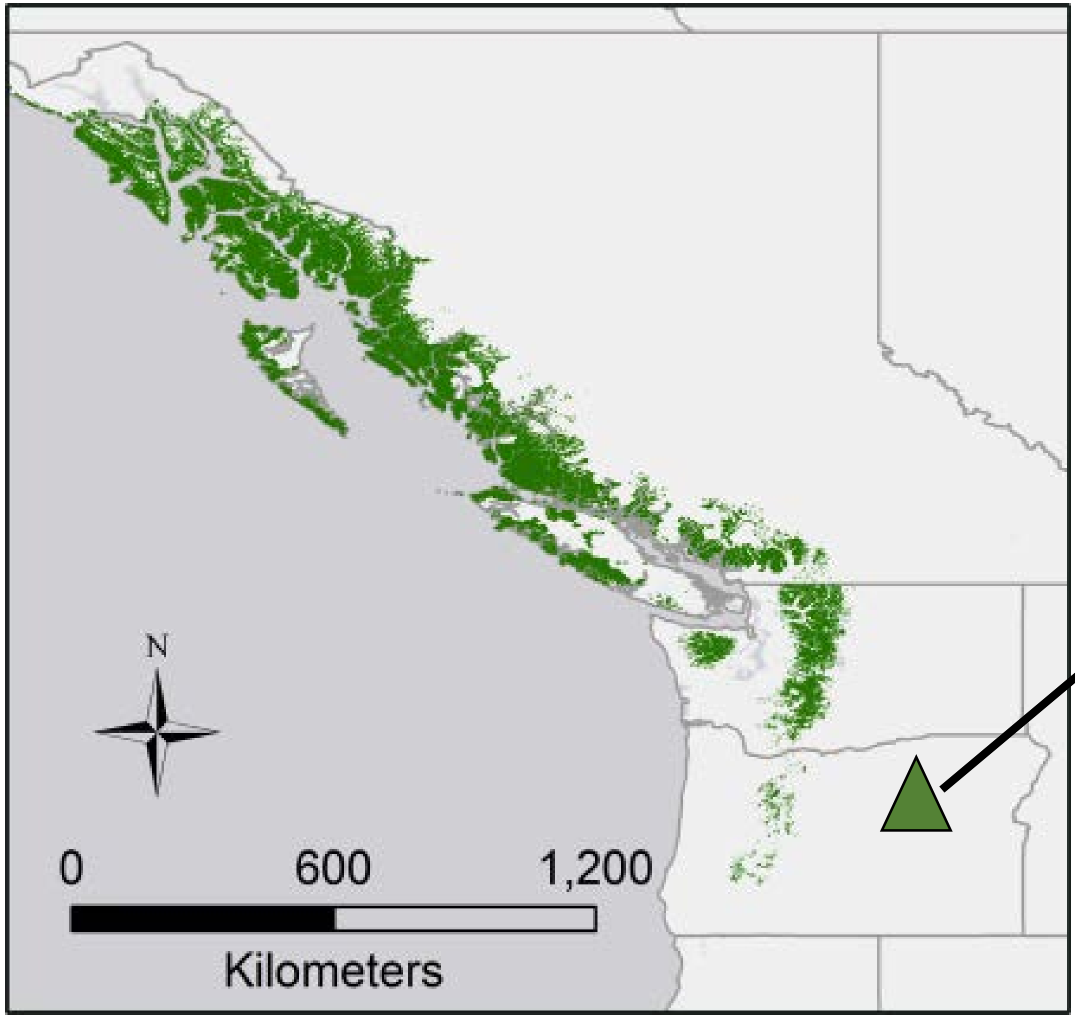
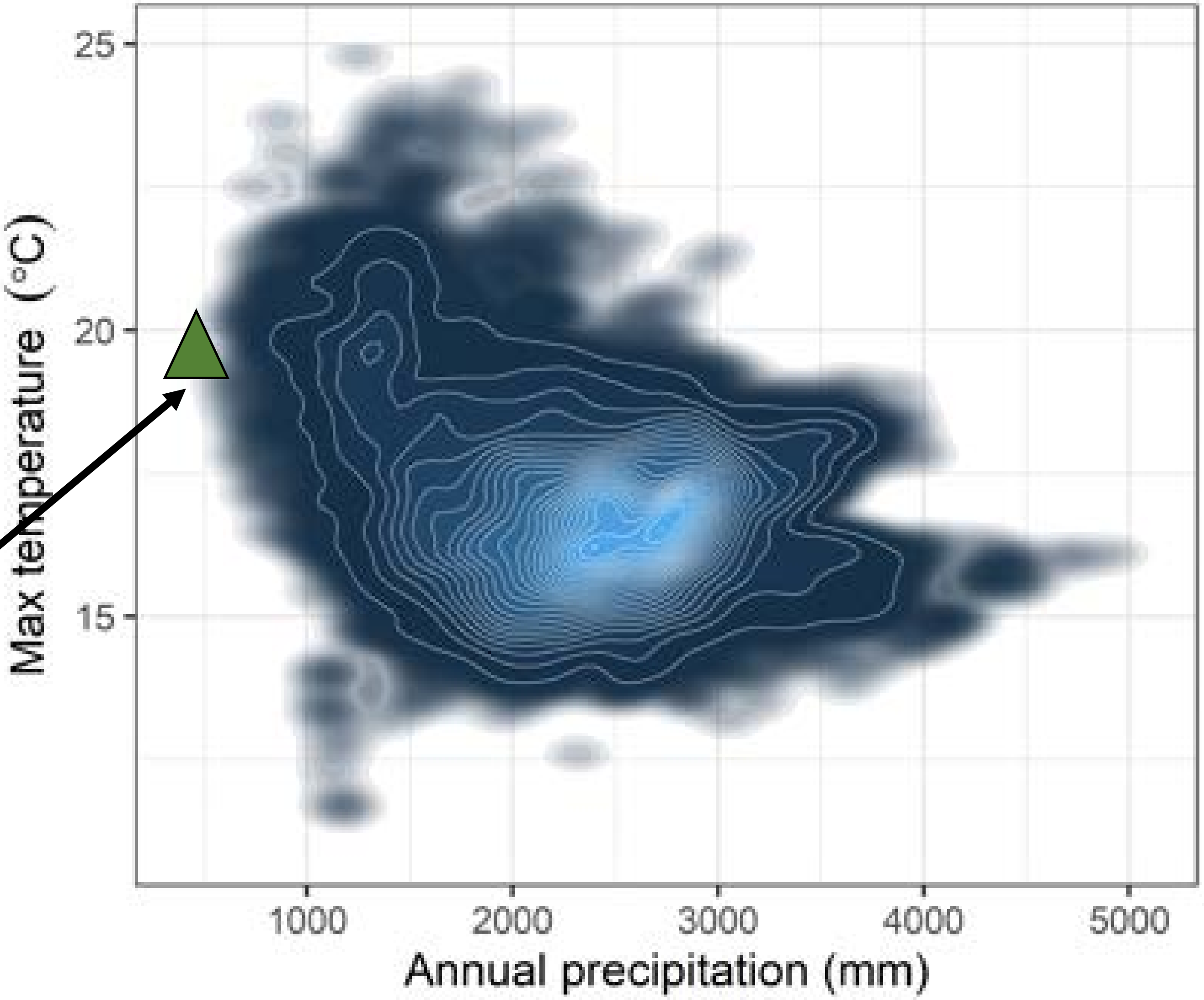


Both geographically and climatically disjunct

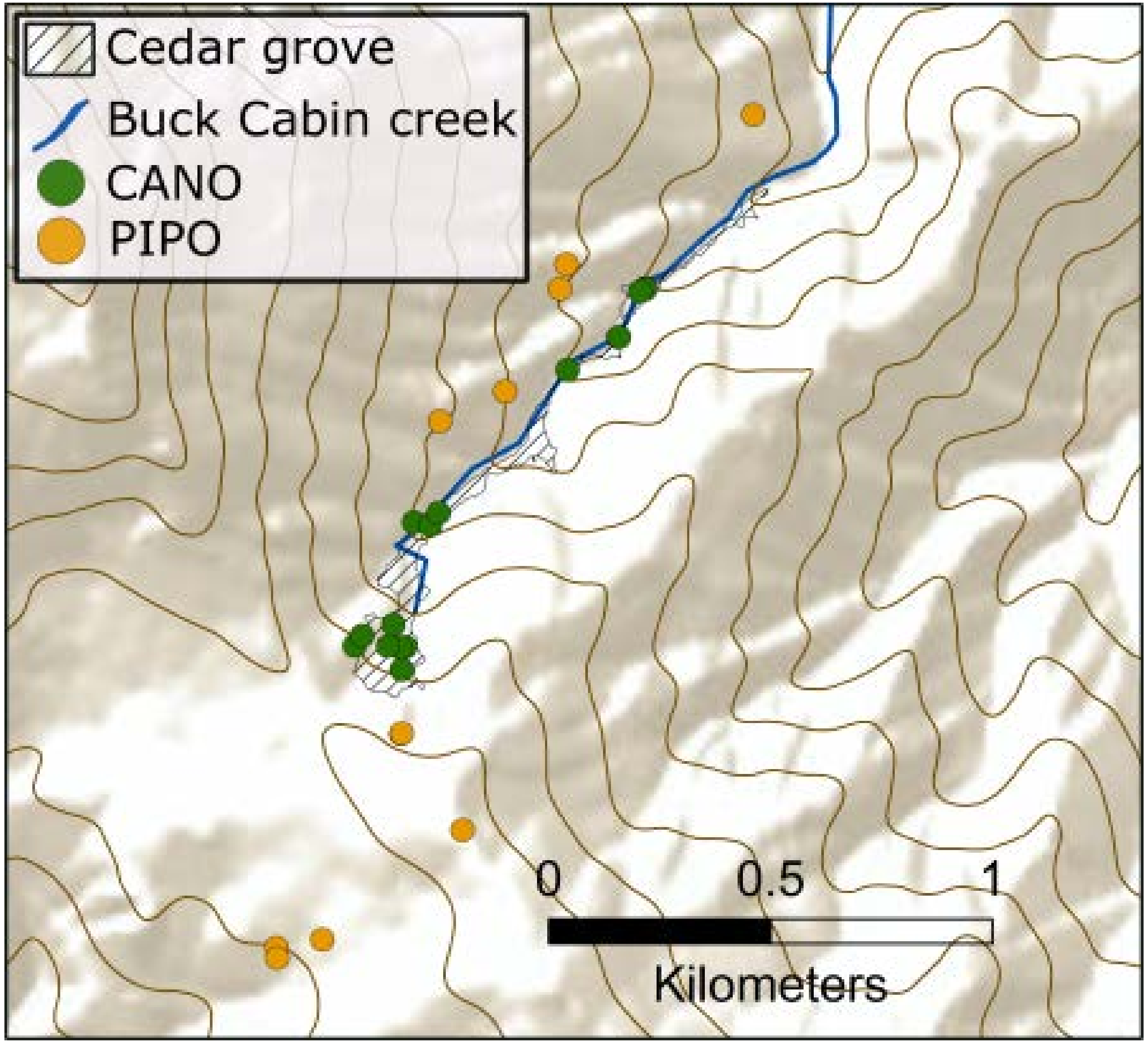




Species distribution data courtesy of Brian Buma

Results

Surface fire history



Results

Surface fire history

Alaska yellow cedar survives -

Results

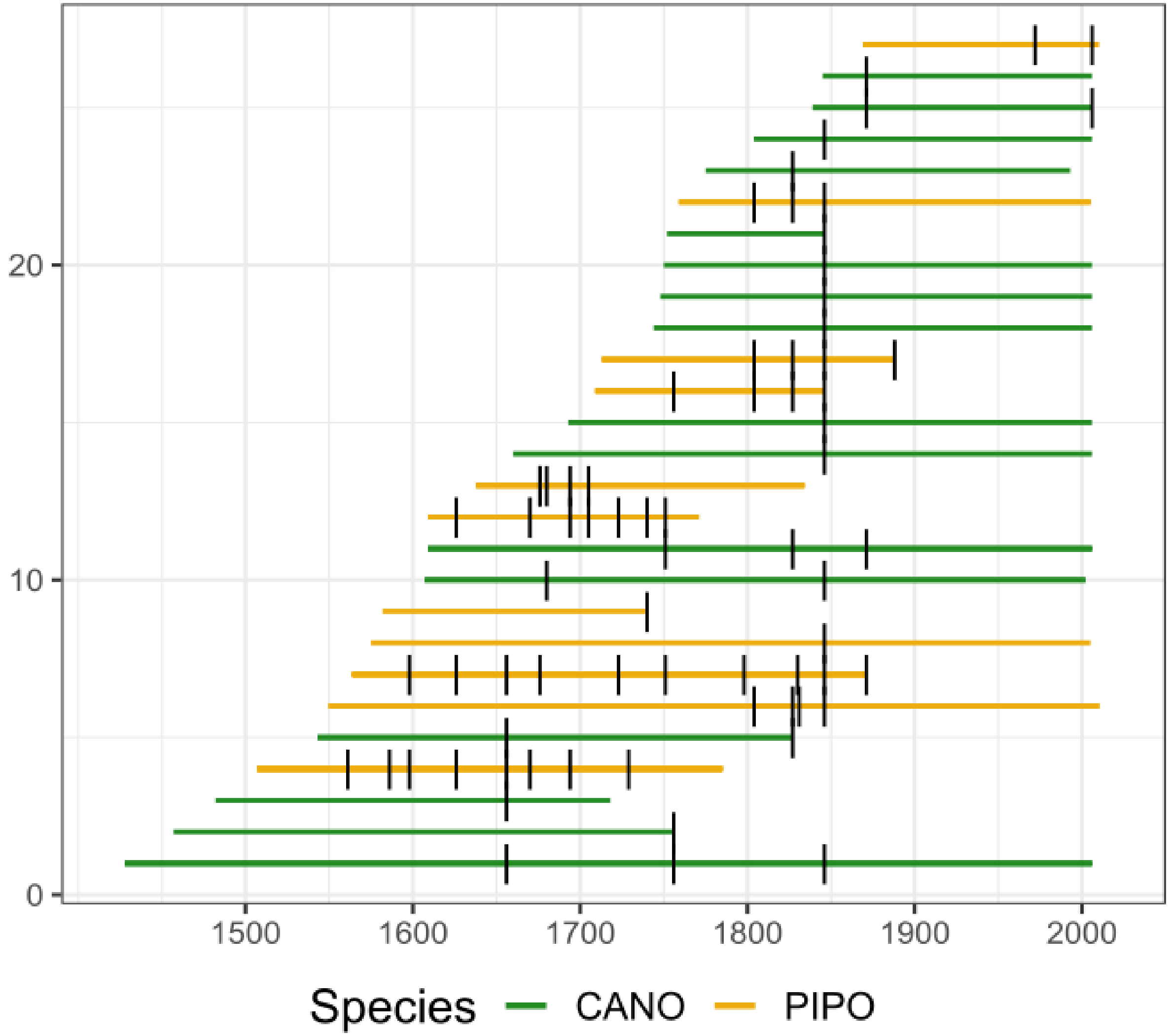
Surface fire history

Alaska yellow cedar survives - and records - fire!

Results

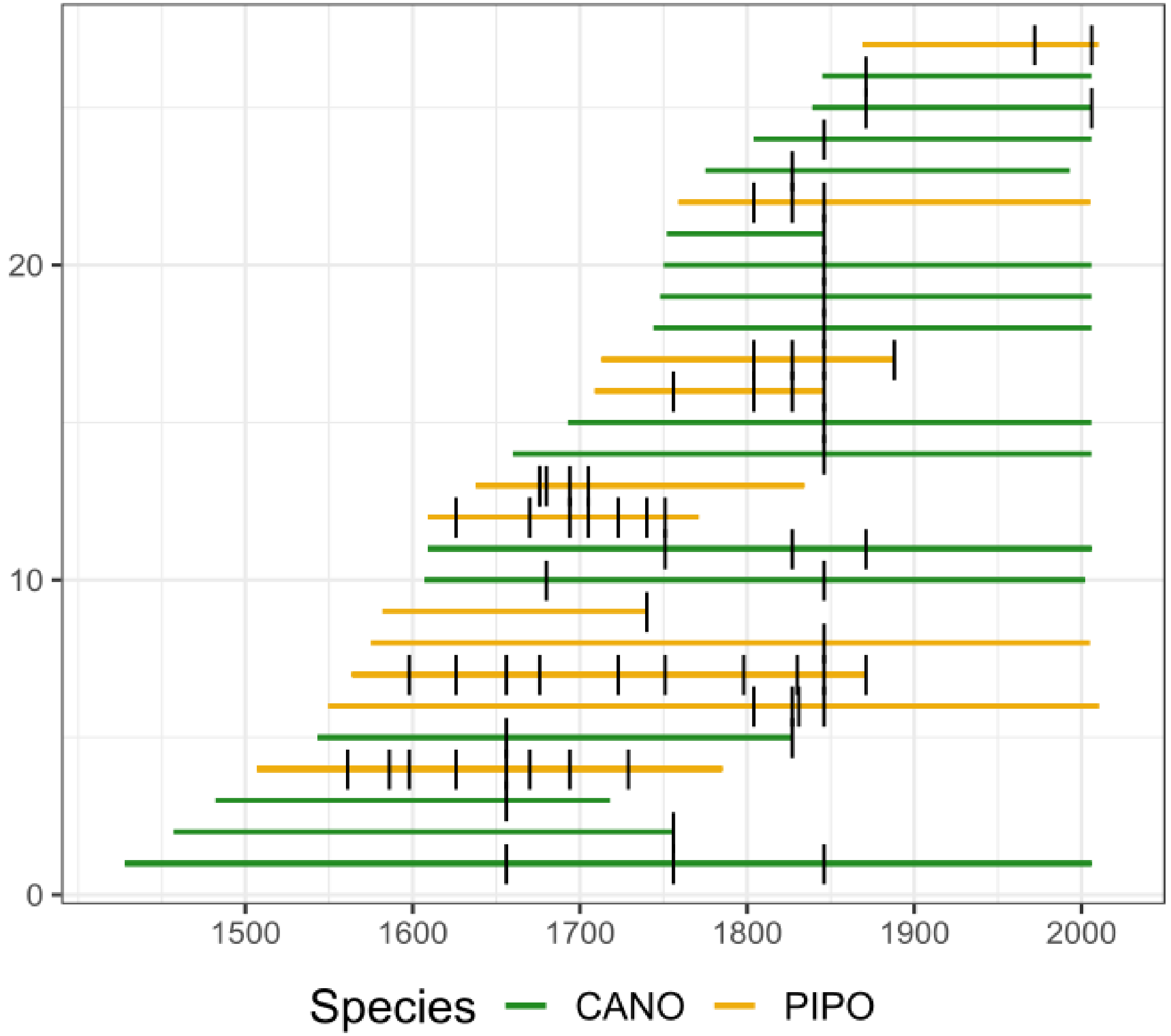
Surface fire history

The cedar grove burned periodically for hundreds of years

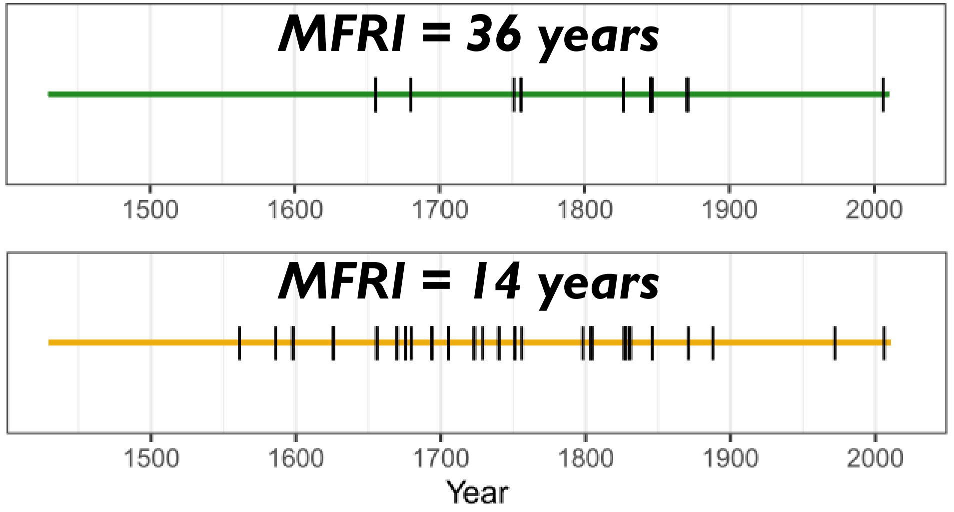


Results

Surface fire history



Cedar grove burned **2.5x** less frequently than the surrounding landscape

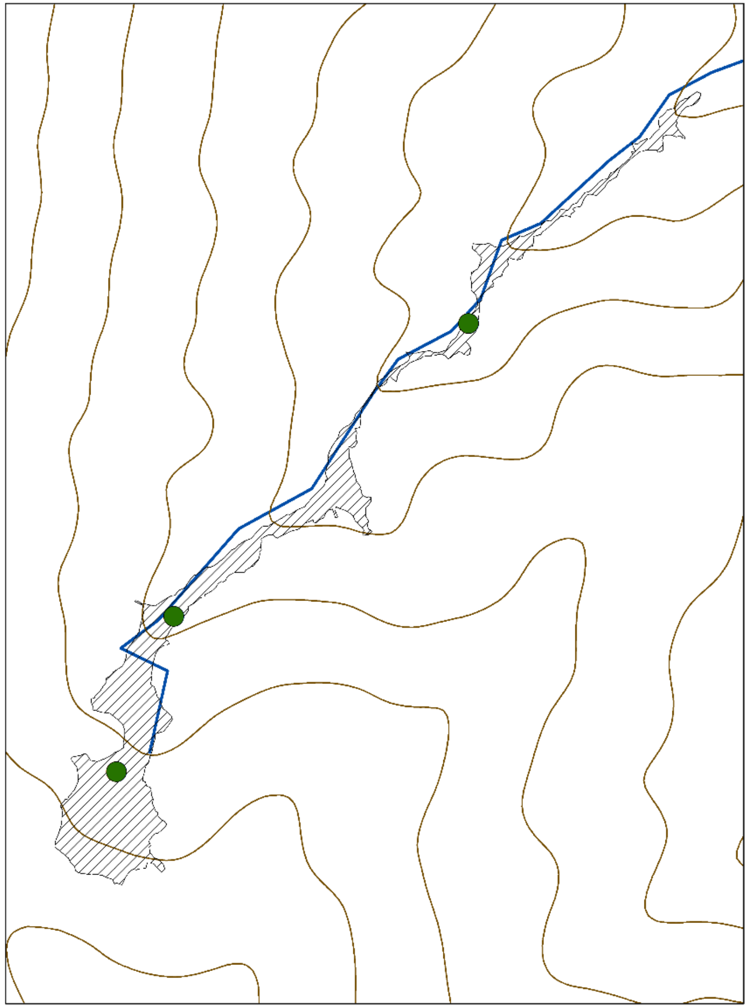


Results

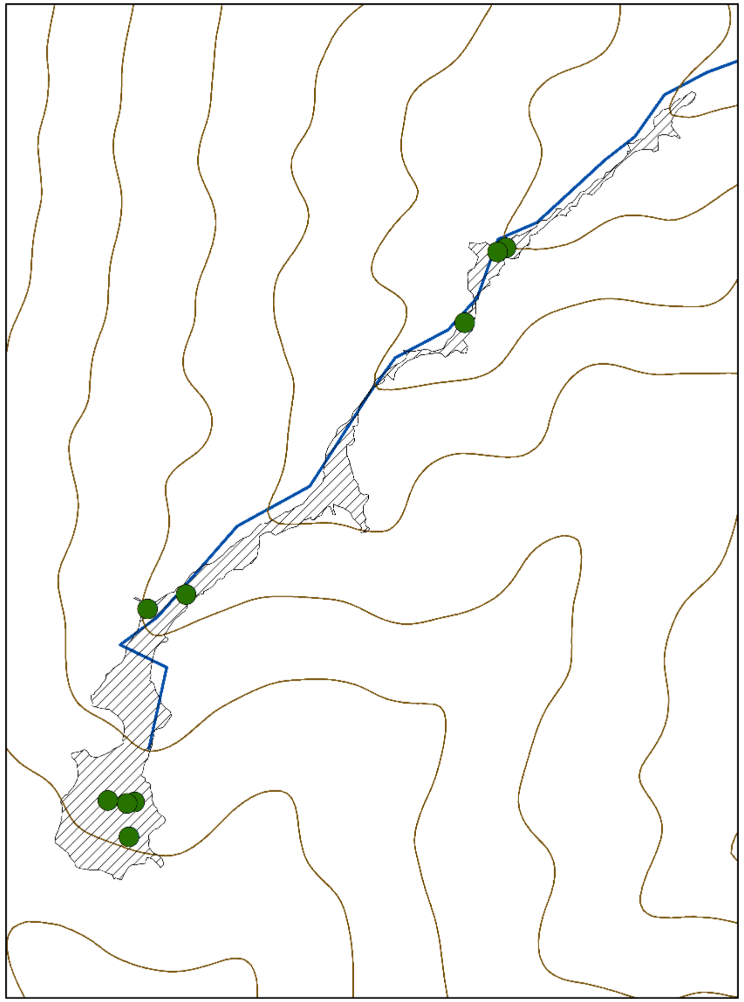
Surface fire history

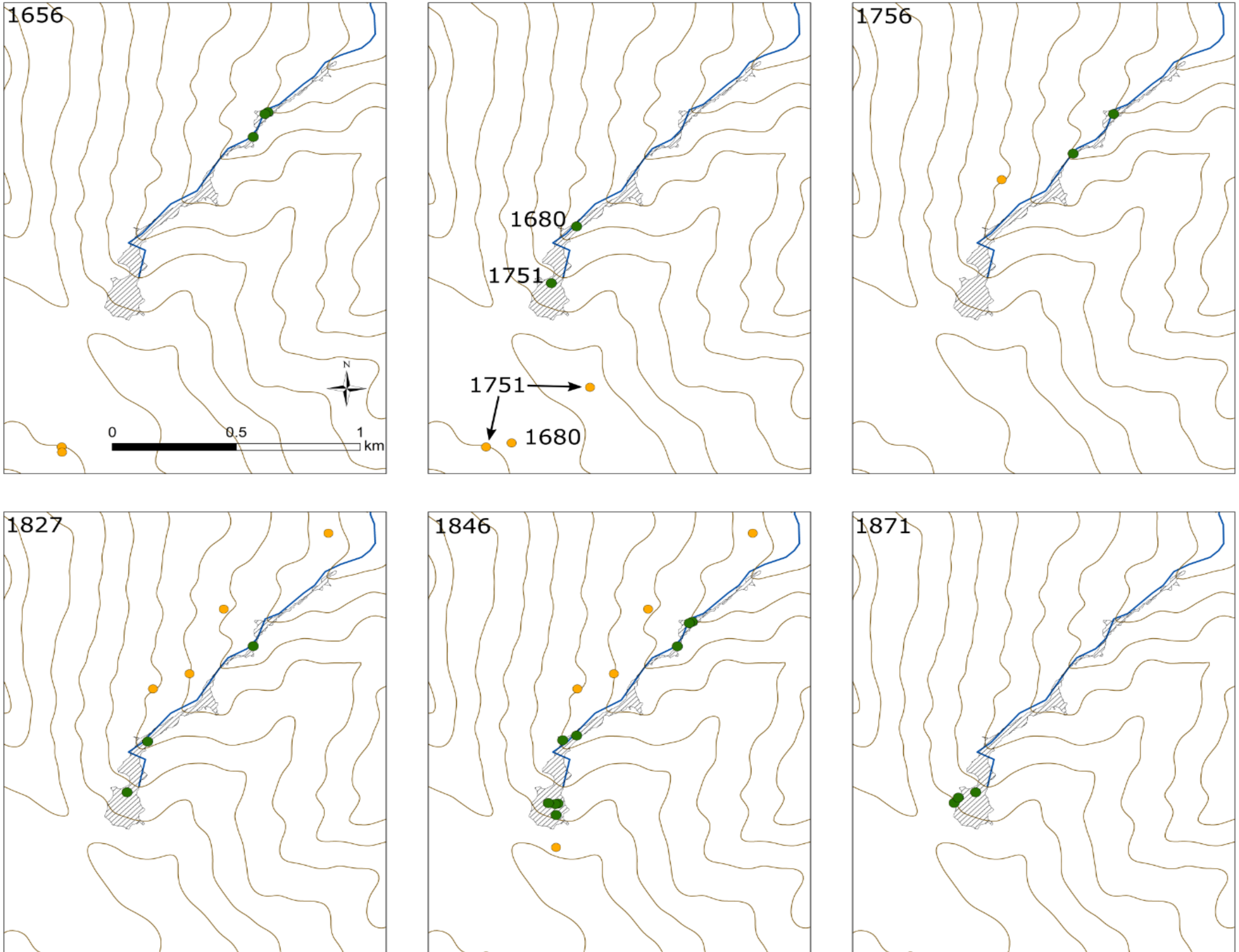
Widespread fire years

1827



1846

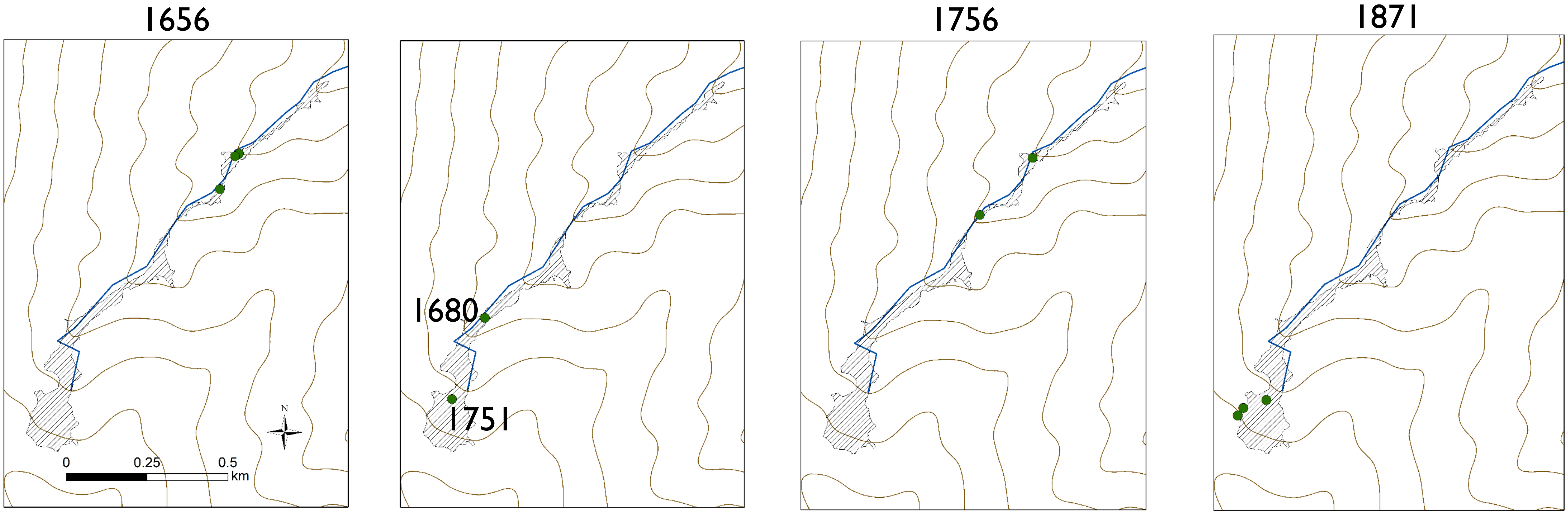



1656
N
0
0.5
1
km
1680
1751
1751
1680
1756
1827
1846
1871

Results

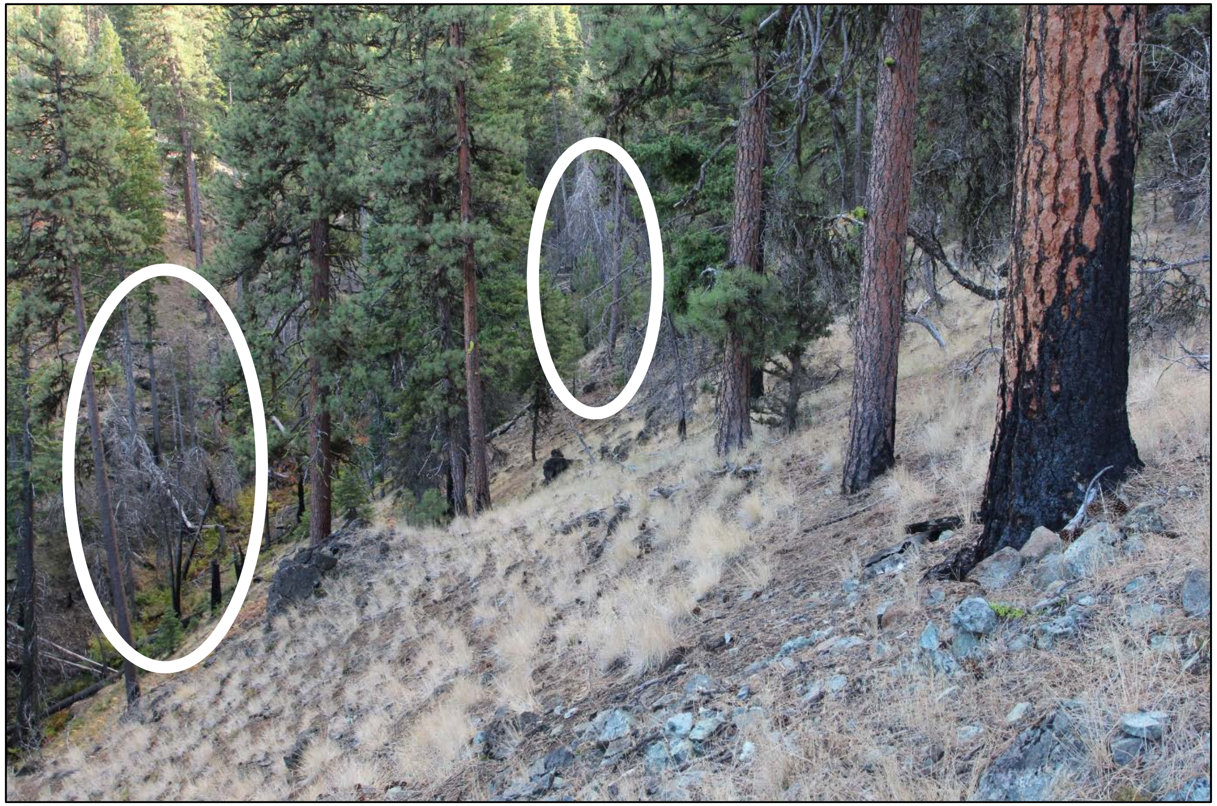
Surface fire history

Localized fire years



Key Points

1. Contemporary low-intensity fire resulted in substantial (>90%) cedar mortality, and future fire could result in the local extirpation of the species.



Weird scars…

Results

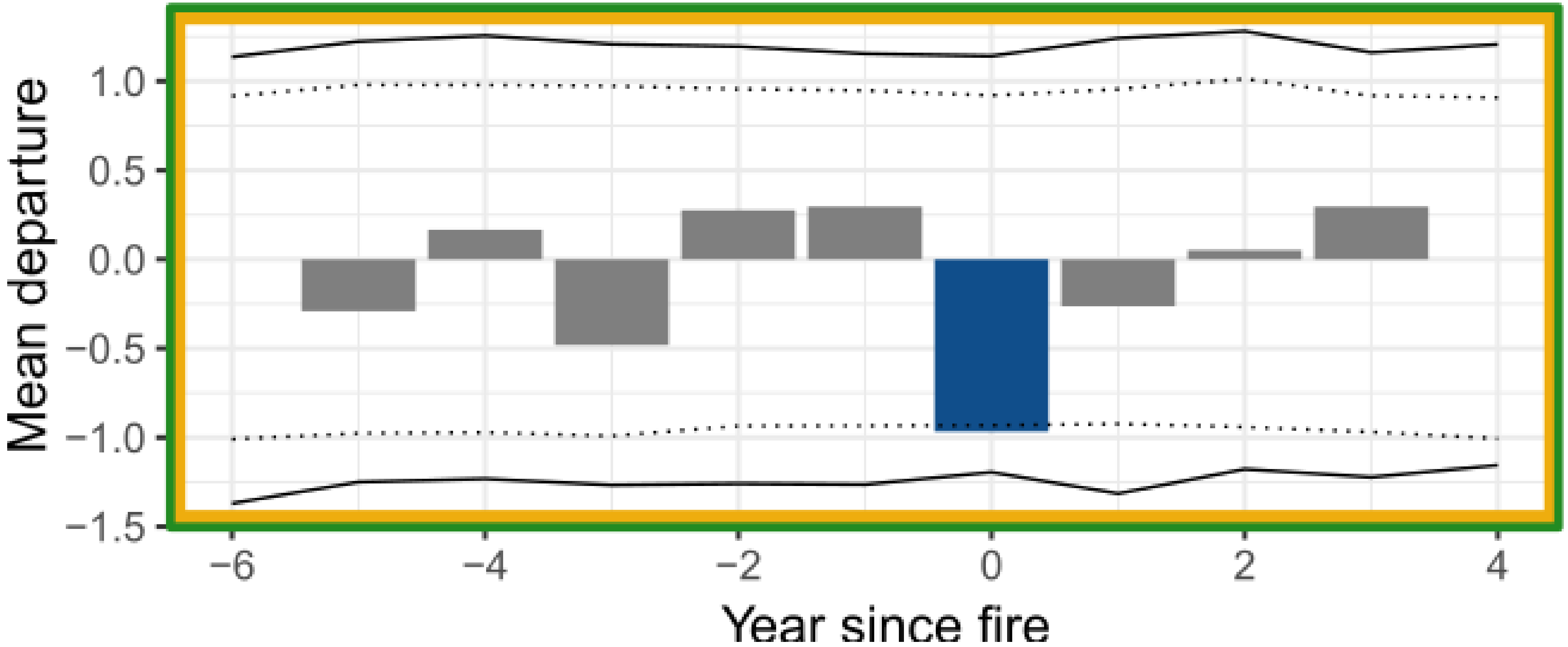
Fire-climate relationships

Fire years historically associated with hotter and drier conditions

Results

Fire-climate relationships

Fire years historically associated with hotter and drier conditions

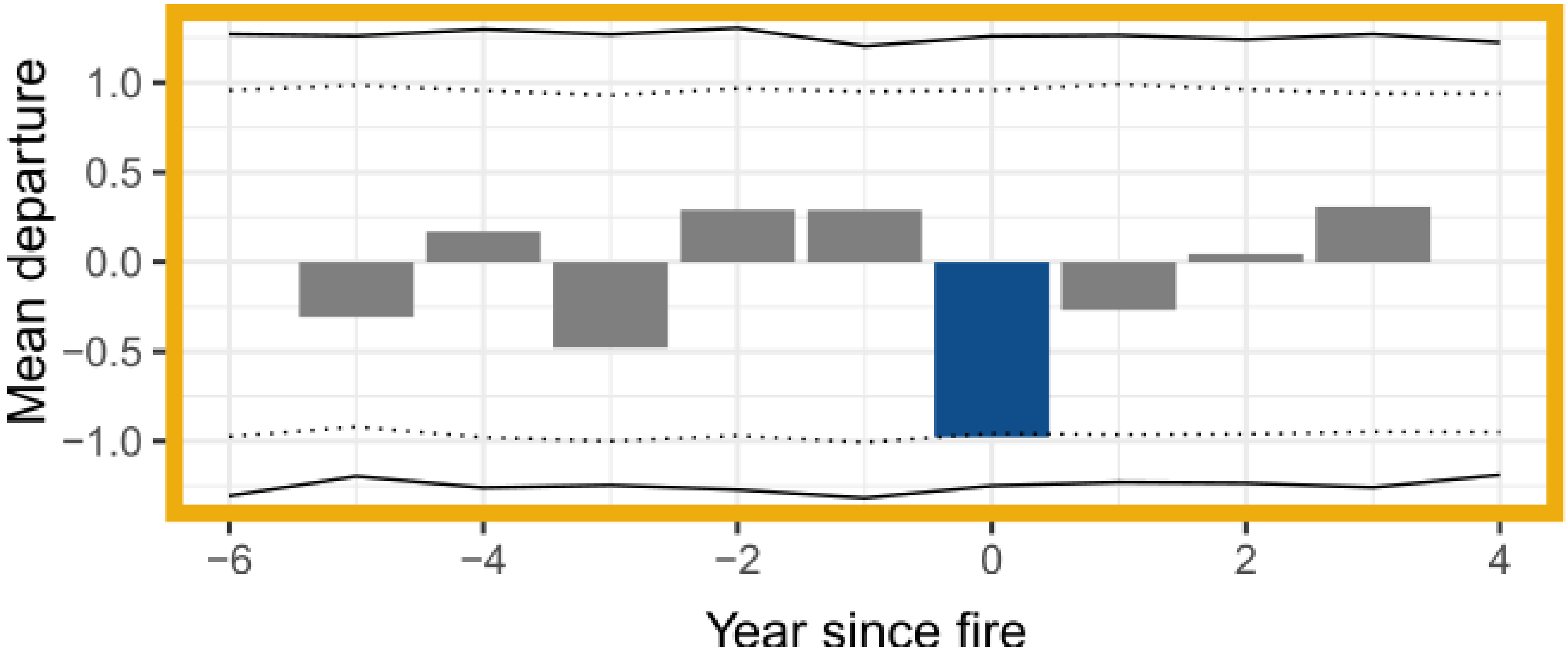


cedar + pine

Results

Fire-climate relationships

Fire years historically associated with hotter and drier conditions



pine

Results

Fire-climate relationships

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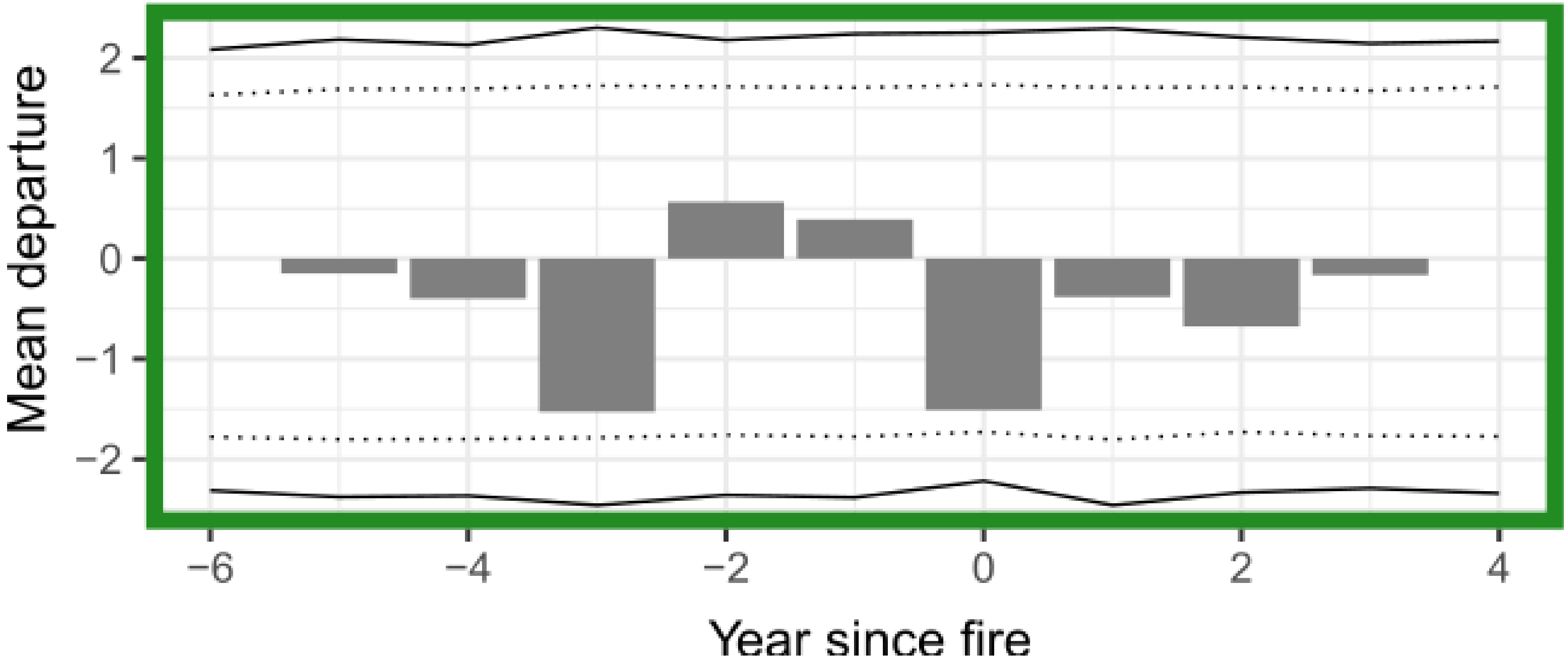

cedar