What can we learn from conifer regeneration in Sierra Nevada old growth with restored fire regimes?

Growth and spatial patterns of natural regeneration in Sierra Nevada mixed-conifer forests with a restored fire regime

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Forest Ecology and Management 519: 120270.

Why Study Regeneration in Old-Growth Forests with Restored Fire Regimes?

Impractical—

Unlikely that frequent fire will be restored on a large scale in many forests

The dominant pattern, clumps aren't practical when nursery stock is already severely limited

These forests have much smaller shrub coverage (≈20%) and shrub patches (<200ft^2) than typical conditions several years after high severity fire

But—

Fire size and severity is increasing and these regeneration patterns have proven resilience

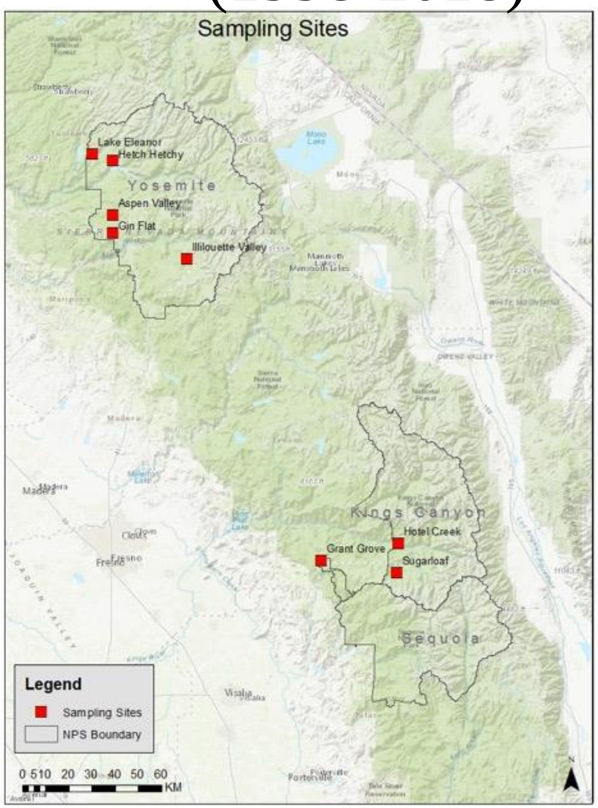
Prescribed burning is a lower cost, potentially large-scale silvicultural tool for influencing stand development

Current large wildfires have substantial (often >50%) areas of low/moderate severity 'treatment'

Study Sites and Design

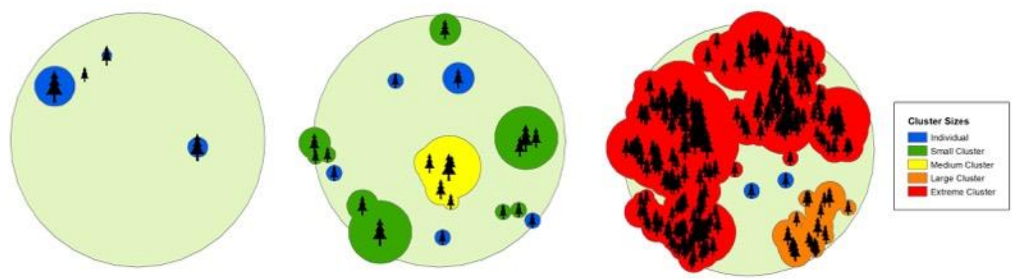
Study Site Criteria:

Old-growth (no logging)
Ponderosa and mixed conifer
≥2 low-moderate intensity fires in ≤60 yrs
Most recent fire <20 yrs ago (1998-2018)



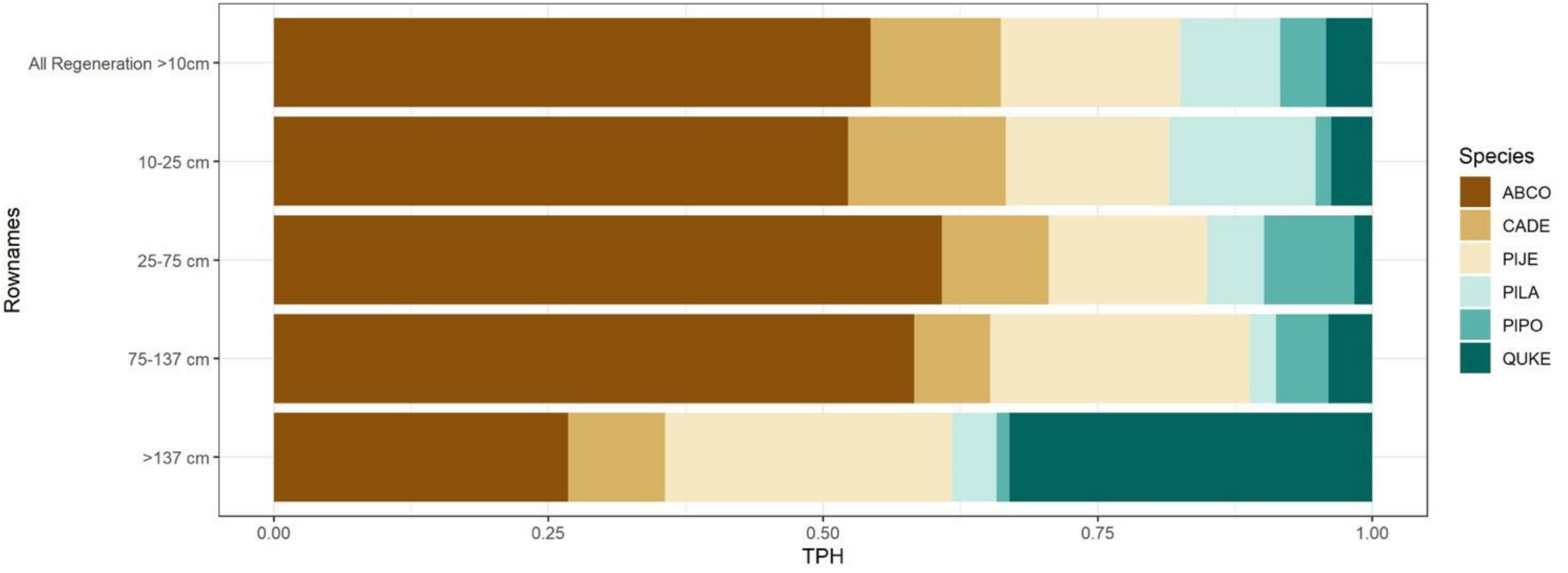
Sampling Design

- >10,000 seedlings each measured for species, height, dbh, surrounding shrub cover, topo conditions
- Seedlings measured along transect to assess topo conditions
- Seedlings mapped and measured in circular plots to assess clumping, growth rates, density, etc.

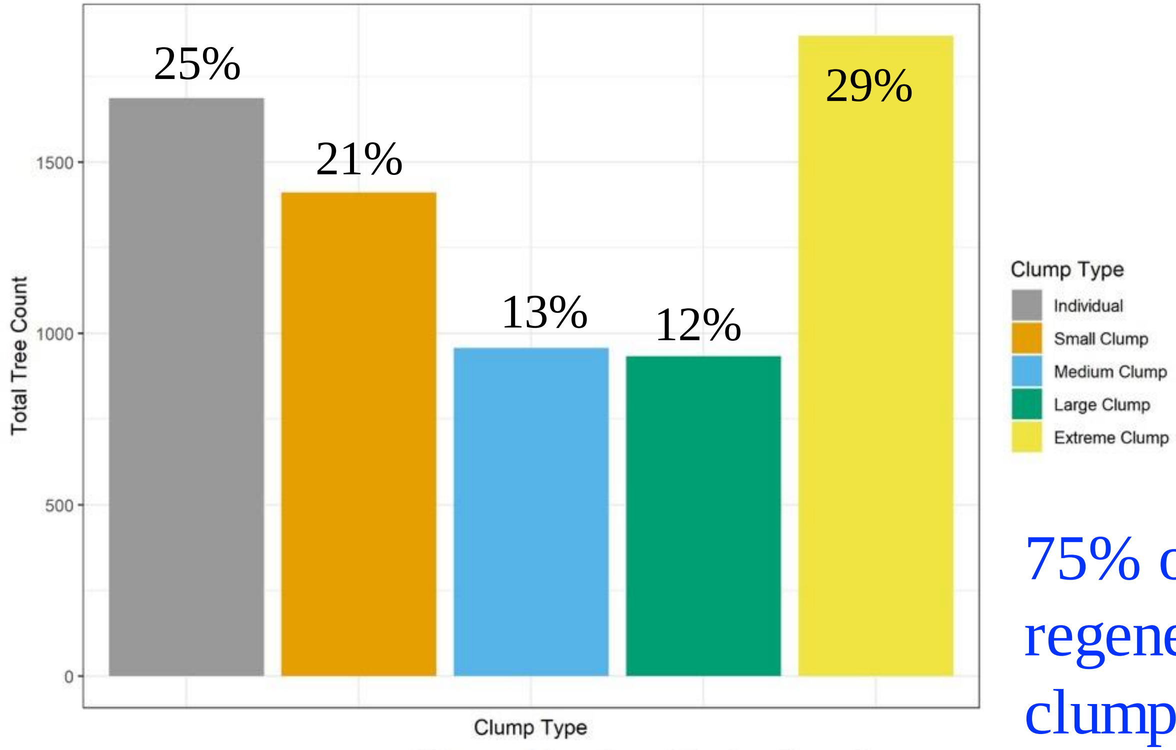


Descriptive Statistics: Seedling Density and Composition by Height Class

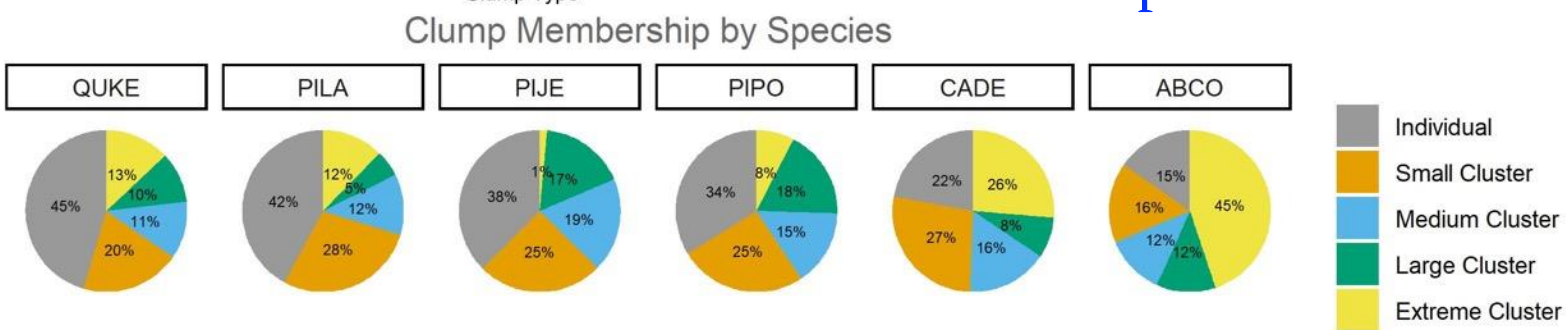
Estimated Trees Per Hectare Values by Height Class									
	Age Estimates (years)		Species TPH Estimates						
Height Class	Mean(Median)	Range	ABCO	CADE	PIJE	PILA	PIPO	QUKE	All Species
All Regeneration >10cm	7 (6)	1-44	510	111	153	85	39	39	1,074
10-25 cm	3 (3)	1-33	241	66	68	61	7	17	520
25-75 cm	8 (8)	2-30	187	30	44	16	25	5	351
75-137 cm	13 (13)	4-35	48	6	19	2	4	3	93
>137 cm	18 (18)	5-44	12	4	12	2	1	15	65



Clump membership overall and for each species



75% of the regeneration is in clumps



1
2-5
6-14
15-49
>50

Mostly individuals ⟷ Mostly larger clumps

Influence of Tree Spatial Patterns on Fire Severity

Koontz, M.J., M.P. North, C.M. Werner, S.E. Rick and A.M. Latimer. 2020. Local forest structure variability increases resilience to wildfire in dry western U.S. coniferous forests. Ecology Letters.

Within tree clumps, densities > 1 seedling/2ft^2 reduce growth
However, all seedlings in clumps grow faster and taller than those growing as individuals

Estimated differences in growth rates of clumped versus individual trees by species

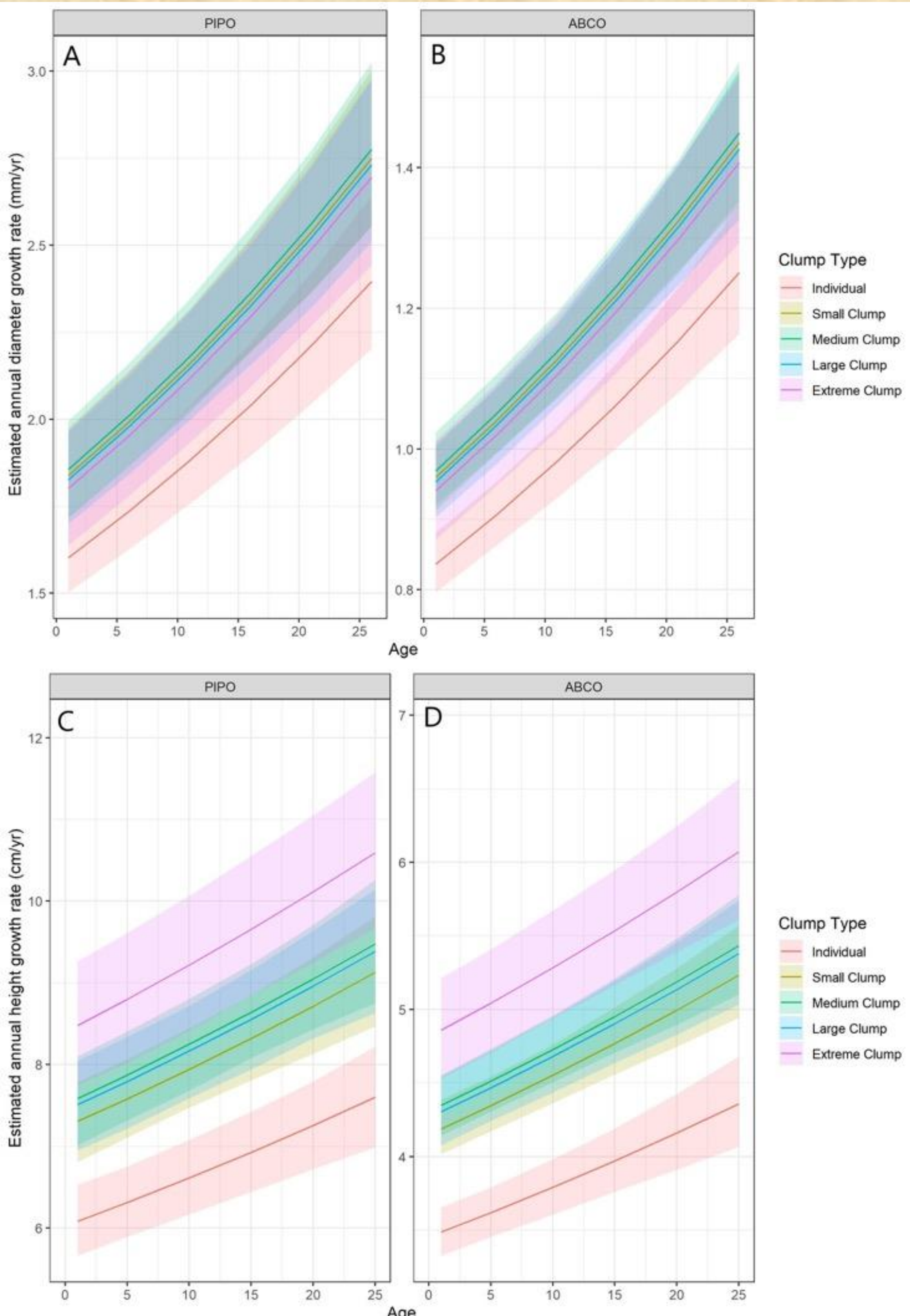
	Diameter			Height			
Species	Diff. Est.	P		Diff. Est.	P	N Individual Trees	N Clumped Trees
ABCO	0.053	**0.032**		0.6901	**<0.001**	505	2810
PIJE	0.2483	**<0.001**		1.884	**<0.001**	416	692
PILA	0.0647	0.135		0.490	**0.004**	214	296
PIPO	0.5232	**0.007**		1.669	**0.010**	89	174

Estimates are mean differences (mm/yr) between Clumped and Individual tree growth rates.

Why?

Clump has microclimate benefit?
Extensive mycorrhizal network?
Litter benefits soil moisture retention?
Less fire stress for interior seedlings?

Dead saplings on a clump edge killed by fire



Over the initial 30 years of seedling growth sampled, both diameter and height growth of seedlings growing in clumps were significantly higher than for seedlings growing as individuals

Diameter (top row) and height (bottom row) growth rates for ponderosa pine (left column) and white fir (right column) by age (x axis).

Shadings around each line are confidence intervals generated by bootstrap modeling.

Shrub cover effects on seedlings and saplings

Shrub cover (within a 2m radius) did not have a significant negative effect on seedling growth

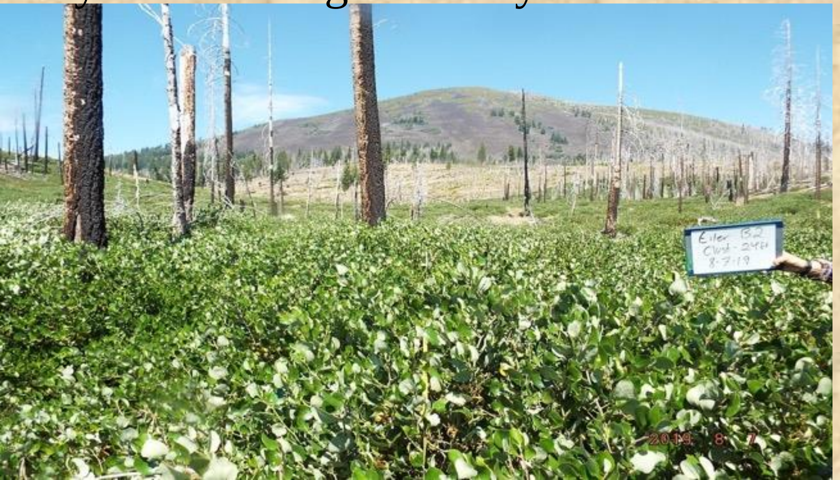
Seedlings growing in higher (>50%) shrub cover had significantly greater height growth rates

Why?

Shrubs may act as heat sinks reducing fire severity?

Shrub cover and extent is much lower in frequent-fire forests than after high severity fire?

5 years after high-severity Eiler Fire



Typical shrub cover in our sample stands

Conclusions:

- Regeneration dynamics in active-fire old growth appear to substantially differ from current reforestation practices
- Seedlings planted after high-severity fire need to maximize growth to reduce the risk of being ‘swallowed’ by the rapid expansion of competing shrubs
- However, in frequent-fire forest conditions, seedling survival may depend more on mechanisms that reduce microsite fire severity, such as growing in clumps and the heat-sink effects of moderate shrub cover
- Reforestation strategies for optimizing seedling survival and growth may well need to locally differ by expectations of future fire conditions.