

# Restoring Stand Structures to Promote Sugar Pine (*Pinus lambertiana*) Regeneration

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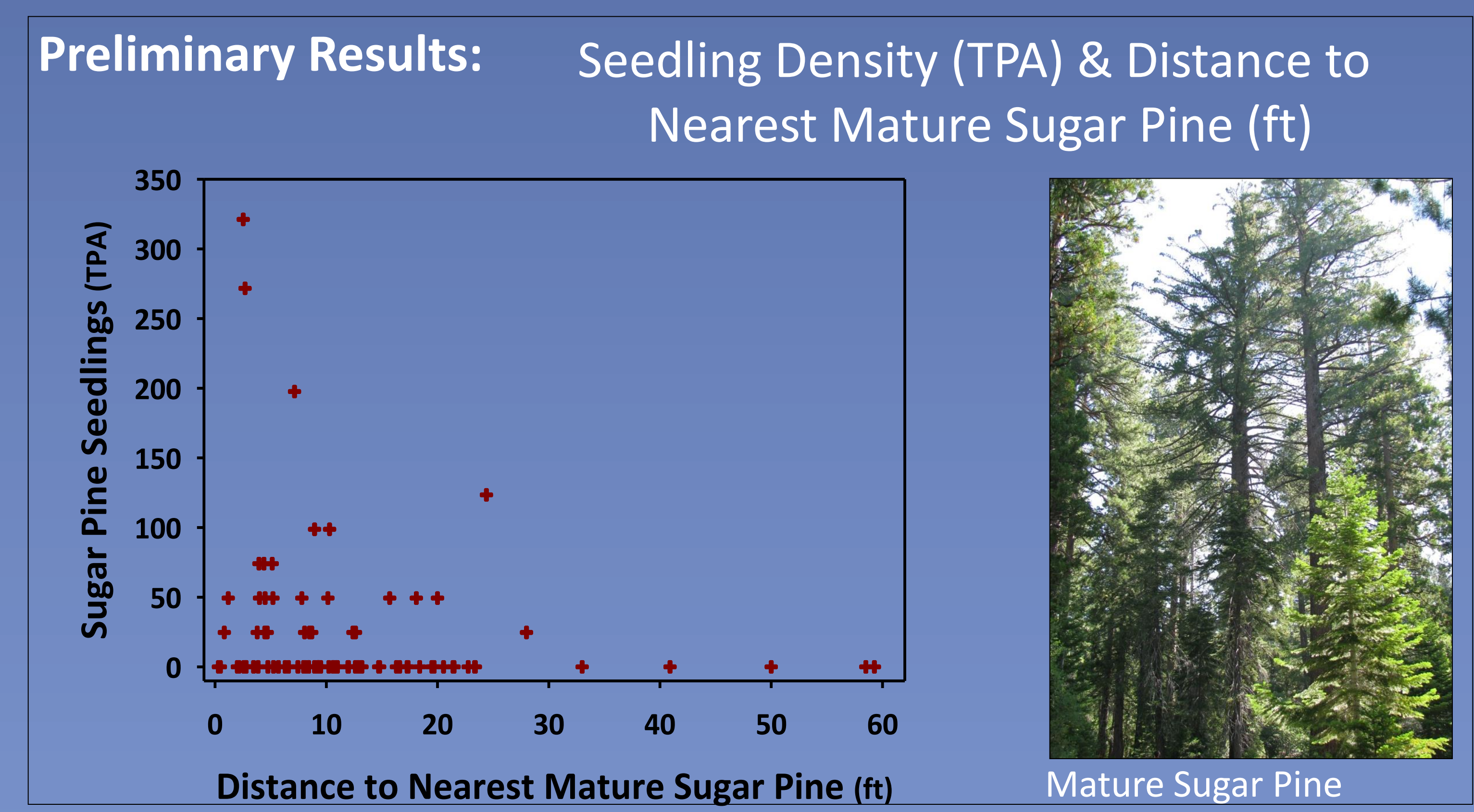
**Introduction:**  
There is increasing concern that sugar pine might not survive as a significant component of Sierra Nevada mixed-conifer forests<sup>1</sup>. Recent studies indicate low sugar pine regeneration and recruitment rates in parts of California<sup>2,3</sup>. Proposed causes for this lack of regeneration and low recruitment include: extensive overharvesting, fire exclusion and suppression practices, and the introduced pathogen white pine blister rust (*Cronartium ribicola* Fisch.)<sup>2,3</sup>.

- Objectives:**
- Define relationships between canopy closure, stand structure and sugar pine height growth rates in treated and untreated stands in the Lake Tahoe Basin
  - Develop multiple regression models to maximize sugar pine height growth at individual seedling and stand level
  - Create preliminary stocking control guide to enhance sugar pine regeneration
  - Produce management guidelines to promote sugar pine regeneration and overstory recruitment

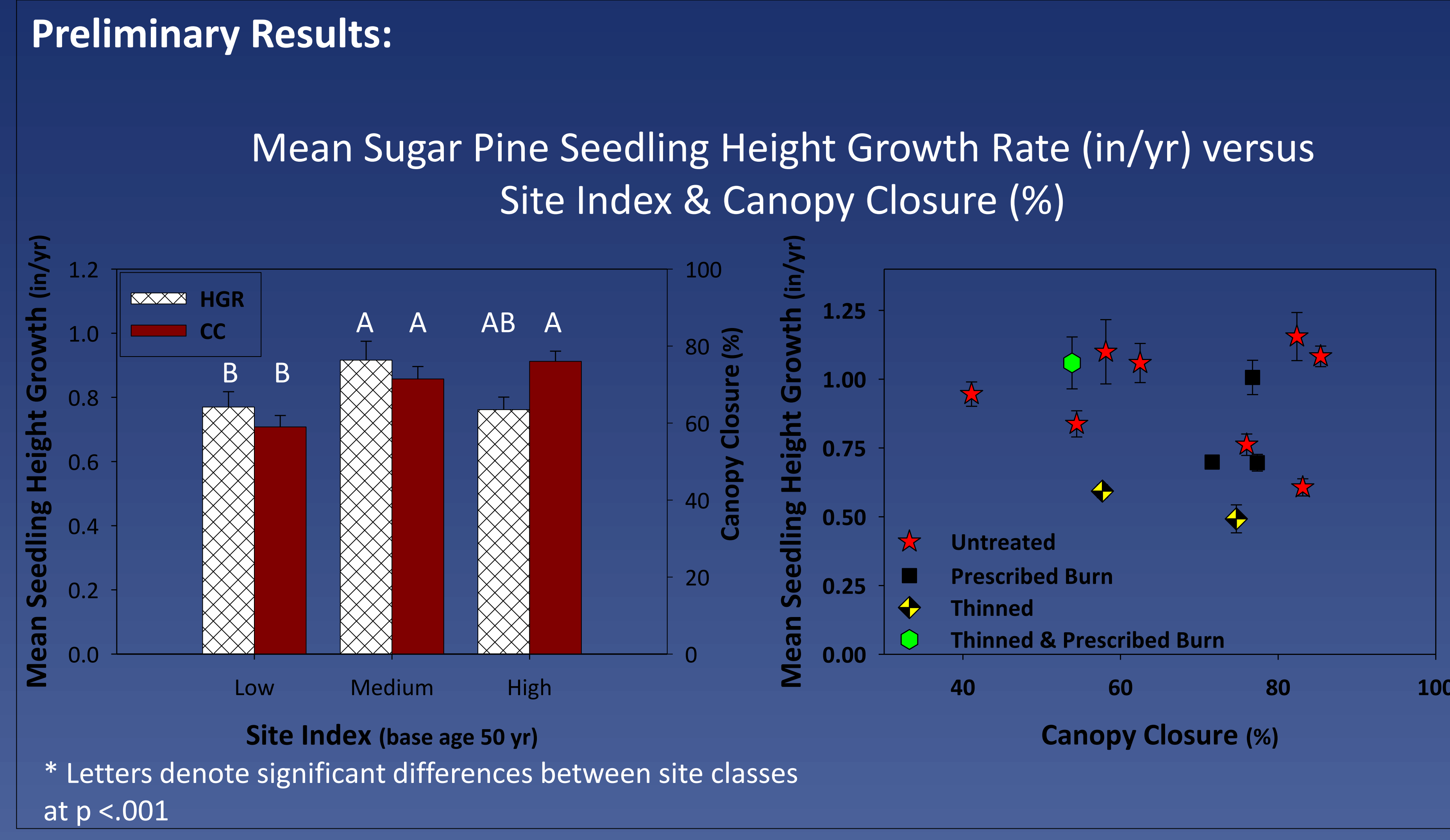


**Preliminary Results:** Multiple Regression Model to Maximize Sugar Pine Seedling Height Growth (in/yr)

Term	Estimate	Standard Error	P-Value	R <sup>2</sup>
Intercept	-0.770	0.074	<.0001*	.280
Site Index (Low)	-0.120	0.033	0.0002*	
Site Index (Medium)	0.130	0.028	<.0001*	
Avg. Canopy Closure	0.004	0.001	<.0001*	
Seedling Height	0.790	0.061	<.0001*	



- Field Protocol:**
- Data Collection- Sampled 14 mixed-conifer stands with varied structures and diverse management histories in the Lake Tahoe Basin in 2008 & 2009
  - 10 plots per stand on a systematic/ randomized grid- Fixed plots (1/8<sup>th</sup> ac) with nested regeneration plots (r=18.5ft)
  - Brown's Fuel Transects- (55.77ft - 0°, 120°, 240°)
  - Parent Tree Measurements- 100ft (tally) & 200ft (presence/ absence) from plot center



- Preliminary Results:**
- Data: There is a large amount of variation between stands and treatments. Height growth rates are highest at intermediate canopy closures and site index values, with a significant difference between seedling height growth rates, canopy closure and site index. Relationships between height growth and canopy closure are variable between stands and treatments. Seedling density is greatest at distances <20ft from the nearest mature sugar pine & there are no seedlings located more than 30ft from a parent tree.
- Conclusions:**
- Intensity of treatment and sample size may be contributing to the large differences observed between stands and treatments. Current management may not be effective in reducing canopy closure enough to promote sure pine regeneration.

- Management Implications:**
- Regeneration may be maximized with creation of 2-3 cohort stand structures utilizing a fire & mechanical treatment similar to the prescription in Moghaddas et al. (2008)<sup>4</sup>:
    - Thinning from below, down to 122-148 ft<sup>2</sup>/ac Basal Area
    - Prescribed burn (Oct - Nov) with a temperature of 0–50°F, relative humidity of >35%, and winds <3.1 mi/h
  - Treatments should be placed in areas with a high concentration of mature sugar pine with interspersed gaps to provide canopy closure conducive for regeneration. Sugar pine may benefit from gaps >1.2 acres in size, as found by York et al. (2004)<sup>5</sup>.
  - Continued urbanization and future predictions of climate change indicate that it may not be feasible for managers to reintroduce the historic fire regime in many forests. Since fire disturbance is imperative to create conditions conducive to the regeneration of sugar pine, managers will have to create these conditions with active management.
  - Multiaged management and prescribed fire may promote regeneration and overstory recruitment of sugar pine and several additional species of pine, and can be used to create stand structures similar to historic conditions, reduce competition from more shade tolerant species & minimize the risk of crown fire.

**Preliminary Results:**

Stand (n=14)	Stand Characteristics					Treatment
	Canopy Closure (%)	Mature Sugar Pine (%)	Basal Area (ft <sup>2</sup> /acre)	Fuels (tons/acre)	Site Index (ft, base age 50 yr)	
Untreated (8)	41.1 - 85.4	1.8 - 30.8	62 - 378	25 - 109	35 - 62	Untreated since harvesting between 1860-1930's
Thinned (2)	57.7 - 74.7	6.7 - 8.7	120 - 160	29 - 42	35 - 36	Salvage Harvest: Basal area reduction mid 1990's
Prescribed Burn (3)	71.6 - 77.4	2.1 - 13.29	185 - 259	53 - 99	40 - 43	Prescribed Burn mid 1990's
Thinned & Prescribed Burn (1)	54	15.9	186	49.15	59	Basal area reduction in 2004 & Prescribed Burn 2005

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**Literature Cited:**  
<sup>1</sup>Ferrell, G. T. 1996 The influence of insect pests and pathogens on Sierra forests. Pgs. 1177-1192 in Sierra Nevada ecosystem project: final report to Congress. University of California, Centers for Water and Wildland Resources, Davis, CA, USA.  
<sup>2</sup>Van Mantgem, P.J., Stephenson, N.L., Keller, M.B. and J. Keeley. 2004. Effects of an introduced pathogen and fire exclusion on the demography of sugar pine. Ecological Applications 14 (5): 1590-1602.  
<sup>3</sup>Amley, J.A. and J.J. Battles. 1998. Forest Composition, structure, and change in an old-growth mixed conifer forest in the northern Sierra Nevada. J. of the Tor. Bot. Soc. 125 (4): 297-308.  
<sup>4</sup>Moghaddas, J.J., York, R.A. and S.L. Stephens. 2008. Initial response of conifer and California black oak seedlings following fuel reduction activities in a Sierra Nevada mixed conifer forest. Forest Ecology and Management 255: 3141-3150.  
<sup>5</sup>York, R.A., Heald, R.C., Battles, J.J. and J.D. York. 2004. Group selection management in conifer forests: relationships between opening size and tree growth. Can. J. For. Res. 34: 630-641.