Effects of Spatial Heterogeneity on Understory Solar Radiation in a Mixed Conifer Forest

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Background

- Large, high severity wildfires have lasting ecological impacts on water quality, tree regeneration, understory composition and pose risk to the wildland urban interface.
- Forest managers in the western U.S. attempt to reduce fire risk through fuel reduction treatments that decrease canopy density, decrease ladder and surface fuels, and promote fire-resistant species.
- Restoration treatments aim to push forest structure and composition towards that of pre-European settlement by creating a heterogeneous landscape with a patchy mosaic of different sized clumps of trees, individual trees, and varying gap sizes.
- Restoration treatment goals often aim to alter the spatial arrangement of forests, which can have effects on fine-scale ecological processes
- **The effects of these changes in spatial variability on abiotic components, such as light, is not yet well understood.**
- Total solar radiation is an important driver of biotic and abiotic conditions and can be greatly altered by changes in spatial patterns throughout the forest.

Research question

How do modeled forest restoration treatments that differ in spatial patterns effect understory solar radiation?

Research Objectives

1. Characterize microsite light environment across a gradient in overstory structure
2. Model effects of restoration treatments with different spatial patterns on microsite solar radiation

Hypotheses

1. Forest restoration treatments result in light environments with distinct light regimes (i.e., mean and variability in solar radiation)
2. The moderate clumping treatment will create the most variability in solar radiation

Study site

- Mixed conifer forest in the Pike San Isabel National Forest (figures 1-3)
- 16ha (400x400m) plot near Woodland Park, CO
- 2810m elevation
- Study site stem mapped by CSU researchers and crews in 2016
- Concurrent research at this site provides information on understory vegetation, soil nutrients, soil moisture and temperature, etc.

Figure 1: Collecting hemispherical canopy photos with a view of Pike's Peak in the background

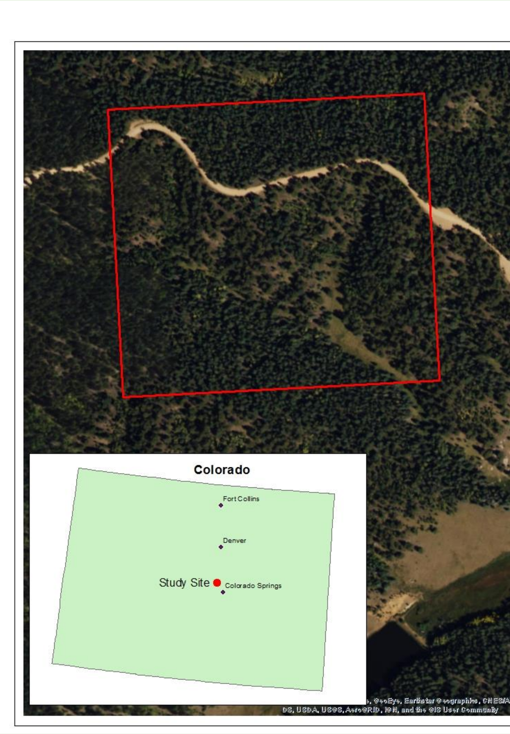

Figure 2: Satellite imagery of the study site

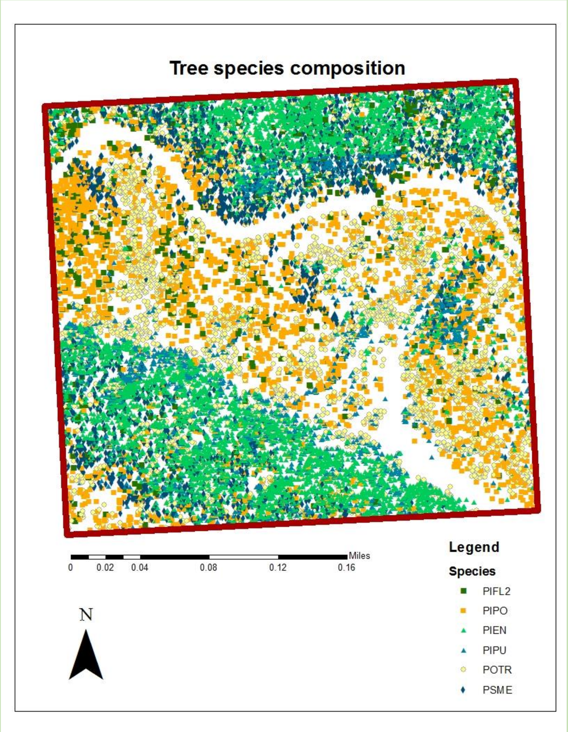

Figure 3: Tree species composition map of study site

Methods

60 sample plots were chosen and stratified over a Stand Density Index (SDI) gradient ranging from 0 to ~1700 stems per ha. Hemispherical canopy photos were taken at each plot using a DSLR camera (figure 4). Images were analyzed in Winscanopy for total solar radiation values (figure 5). Solar radiation and SDI values were used to model the relationship between overstory structure and solar radiation using a non-linear model (figure 7).

Figure 4: Original image captured on DLSR hemispherical camera

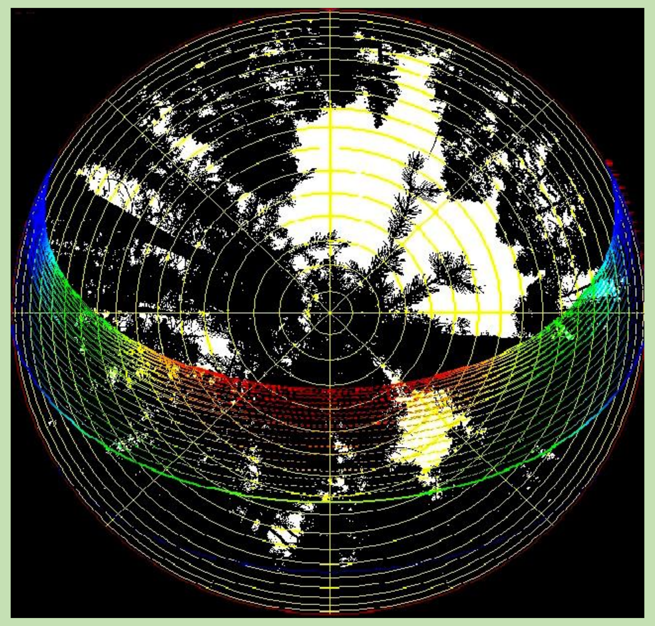

Figure 5: The same image being analyzed in the Winscanopy software

Restoration treatments were simulated using a site stem map and a Python script to simulate 4 different post-treatment stem maps (figure 6) across a gradient of spatial arrangements, each with the same residual basal area of 9.18 m^2 ha^{-1}

- **Moderate clumping-** individual trees, clumps of trees, & openings
- **Thin from below-** preferentially cut smallest trees first
- **Random thin-** choose trees at random for thinning
- **Untreated** (control)

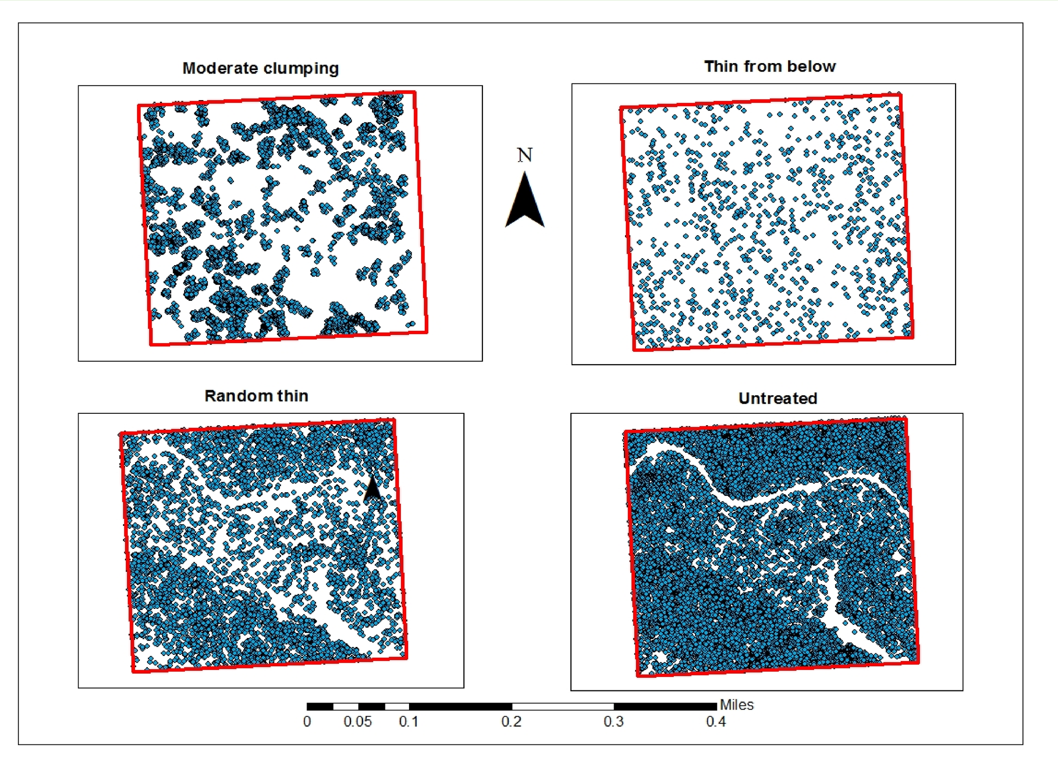

Figure 6: 4 simulated restoration treatments across varying spatial gradients

The model derived from the relationship between solar radiation and SDI (figure 7) was applied to each simulated stem map to model the potential light environment of each simulated treatment. Next, we characterized how each spatial arrangement effected the distribution of understory solar radiation (figure 8).

Results and Discussion

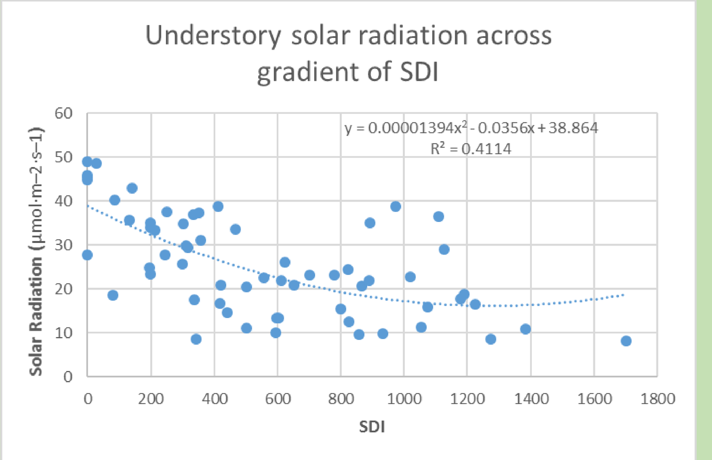

Figure 7: Relationship between light & SDI

- SDI and solar radiation were negatively correlated with a non-linear relationship (figure 7)
- **Spatial patterns of restoration treatments can greatly impact mean and variability of solar radiation**
- The moderate clumping treatment had highest variability in SDI and solar radiation (figure 8)
- Findings can inform management decisions to create suitable conditions for desired species composition, such as creating higher light levels to favor shade intolerant ponderosa pine

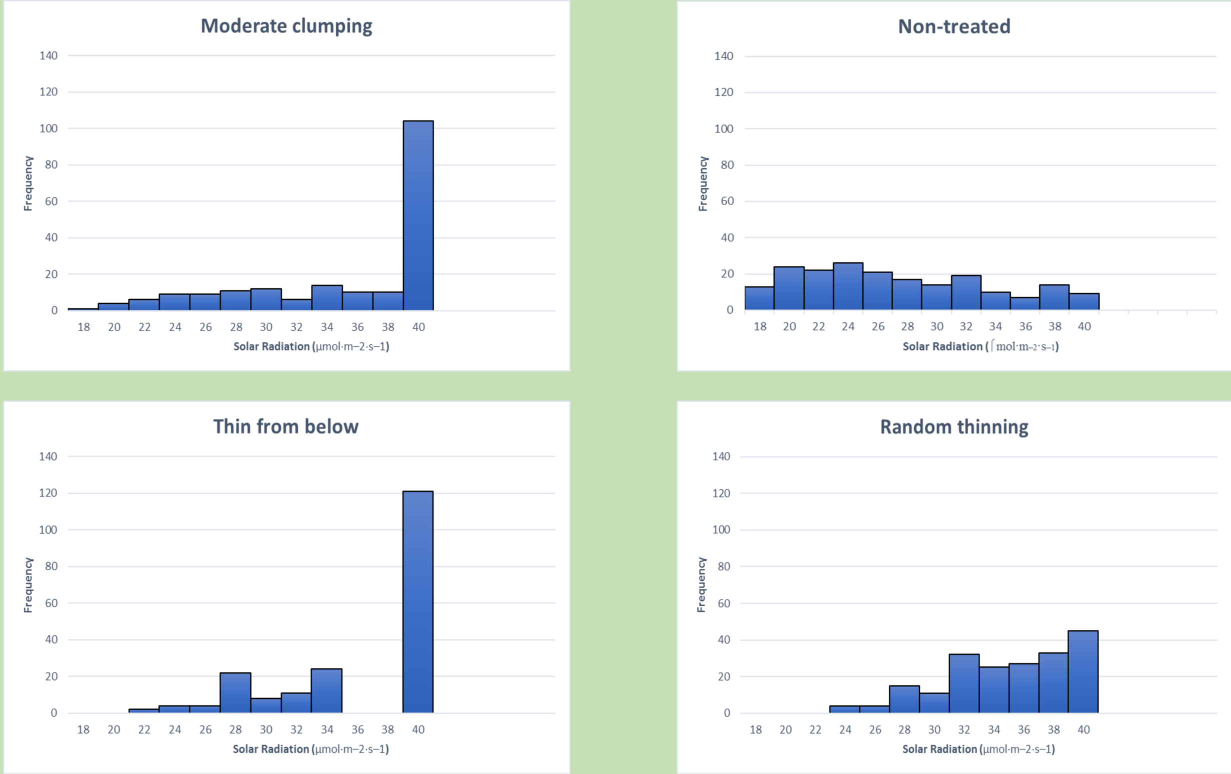

Figure 8: Histograms displaying the variability of light across the simulated restoration treatments

Future research

- Include additional sample plots and include co-variate for forest type improve model fit.
- Link light data to other data such as tree regeneration, understory response, air and soil moisture and temperature, soil microbial and fungal communities
- Initiate seed sowing experiment to understand how light levels directly effect tree regeneration

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