Investigating heterogeneous fuels and fire behavior in the Uncompahgre Mesas Project

Justin Ziegler[1], Chad Hoffman[1],Mike Battaglia[2]

[1] Dept. of Forest & Rangeland Stewardship, Colorado State University, Fort Collins, CO [2]Rocky Mountain Research Station, USDA Forest Service, Fort Collins, CO

Background

Historic structural arrangement in western, dry forests is thought to be spatially aggregated at the stand scale with elements of unforested gaps, single trees, and patches. In recognition, the Unc Mesas project area included fuels treatment prescriptions aimed at maintaining or increasing heterogeneity through altering stand structure and pattern (Fig. 1). However, the effectiveness of treatments on spatial arrangement has not been well documented.

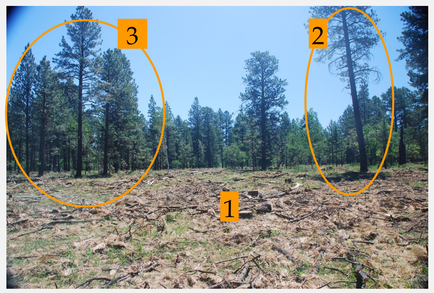

Figure 1. Restoration of historic forest structure includes:

1 Unforested gaps

2 Single trees

3 Patches of trees

Objective 1: Assess changes in tree pattern at both the stand and within-stand scale following fuels treatments in a treatment unit of the Unc Mesas project.

Approach

Sites/Measurements

- Located 4 ha plot in Unit 1 of Unc Mesas project
- Mapped and measured all leave trees and cut stumps (fig. 2)
- Reconstructed stumps using built regressions from leave trees to estimate pre-treatment structure

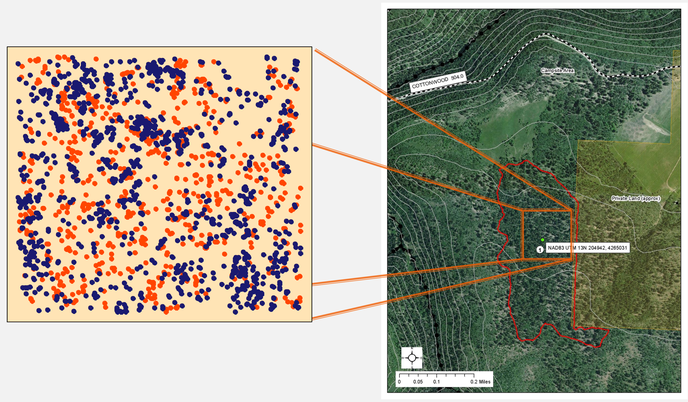

Figure 2. Stem-map of leave trees (blue) and stumps (orange) for 4 ha plot within Unit 1 of Unc Mesas project

Pattern analysis:

- Tested whether treatments changed the degree of aggregation at the stand scale.
  - Used O(t) difference test (*Wiegand & Moloney 2004*).
  - To determine level of aggregation, O(t) calculates the mean number of trees observed within a given distance (t) of a tree relative to the number of trees expected if trees were distributed randomly.
- Examined if areas of aggregation (i.e. patches) within a stand changed.
  - Assumed patches are areas of overlapping crowns.
  - Calculated changes in patch size (trees/patch) distribution.

Results

Pattern analysis (stand scale)

- The plot post-treatment was more aggregated than pre-treatment at scales of up to 4 m away from a tree (fig. 3).

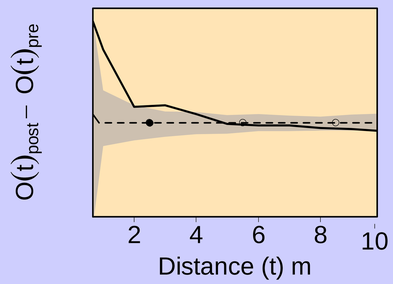

Figure 3. Observed difference of O-ring statistics (black line) graphed against null range of no treatment effect on spatial pattern (shaded grey). Shaded circles represent significantly increased aggregation via GoF test at 3m scale intervals.

Pattern analysis (within stand)

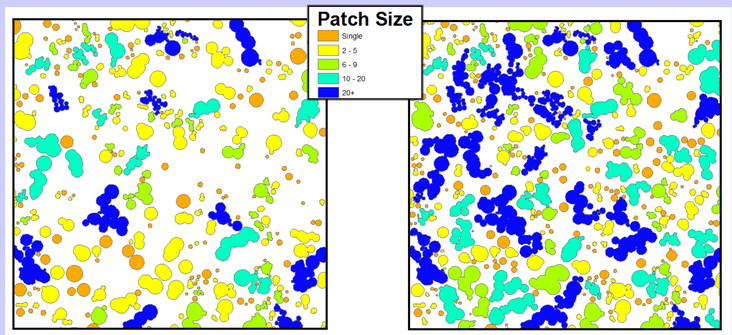

Figure 4. Map of patches before (left) and after treatment (right) colored by size (trees/patch) class.

- Treatment reduced the number of patches from 52 to 45 patches/ha (fig. 4).
- Single trees and large sizes patches (>10 trees/patch) were reduced and became relatively less common as smaller patches came to make up a greater share of patch size distribution (fig. 5).

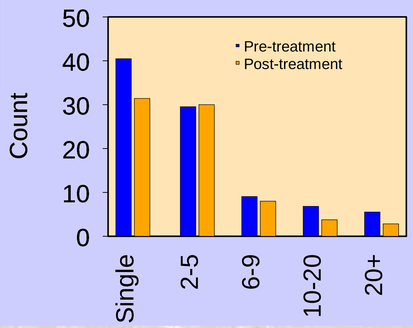

Figure 5. Number of patches per hectare classed into trees per patch before and after fuels treatment.

Conclusion

Our findings suggest the fuels treatment in Unit 1 of the Unc Mesas project did meet prescription objectives by increasing the degree of aggregation. This is encouraging for managers who seek to manipulate patterns for objectives such as forest restoration.

Statistical methods such as the O(t) function are valuable as an evaluation tool in determining the change in aggregation following restoration treatments.

Marking methods that utilize patch level statistics as shown in figure 5 may provide a framework to consider changes in spatial heterogeneity during the planning phase.

Future work

Many restoration treatments are also designed to reduce potential fire behavior; however little work has explicitly considered the influence of heterogeneity on fire behavior. Recently developed physics-based models such as Wildland Urban Interface Fire Dynamics Simulator (WFDS) can account for fire-fuels-atmosphere interactions through time and space. We will use WFDS to predict fire behavior across a range of wind velocities to evaluate fuel treatment effectiveness explicitly accounting for heterogeneity.

Expected effects, dependent on wind speed, include:

- Increased surface fire behavior. Wind speeds are projected to be higher due to lower canopy drag and increased entrainment of wind through gaps (Fig. 6).
- Decreased crown fire activity. The reduction in large patches reduce crown fuel connectivity (Fig. 7).

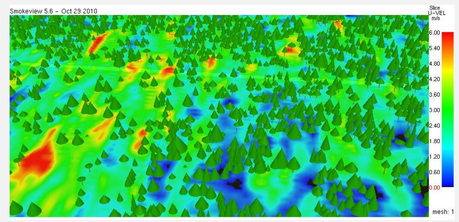

Figure 6. Horizontal slice of wind velocity at 2m above the surface. Note the contrast of wind velocity between gaps (up to 6m/s) and the larger forested patches (as low as 0.6 m/s).

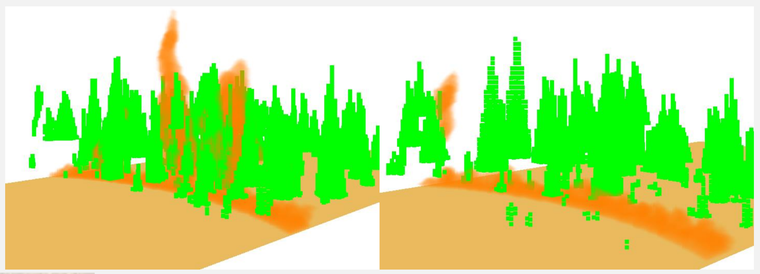

Figure 7. Example WFDS simulation showing a fireline moving through an untreated stand(left) and treated stand (right).

For more information on this project, contact:
Justin Ziegler, M.S. student in Forest Sciences
Justin.Ziegler@colostate.edu

References:
Churchill D., M. Dahlgreen, A. Larson, J. Franklin. 2013. The ICO approach to restoring spatial pattern in dry forests: Implementation guide. Version 1.0. Stewardship Forestry, Vashon, Washington, USA.
Kint V., N. Lust, R. Ferris, A.F. Olsthoorn. 2000. Quantification of forest stand structure applied to scots pine (Pinus sylvestris L.) forests. *Invest Agrer: Sist Recur For* 1:147-163.
Wiegand T. and K. A. Moloney. 2004. Rings, circles and null-models for point pattern analysis in ecology. *Oikos* 104:209-229

Acknowledgements: Matt Tuten for field site identification. Larry Huseman, CFRI field staff, and Yvette Dickinson for field help. Thorsten Weigand for access to *Programita*.