Monitoring trends in forest spatial patterns: Uncompahgre Collaborative Landscape Restoration Program

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Forest management treatments (e.g., reduction and/or removal of forest vegetation through mechanical, manual, or managed fire methods) in dry conifer forests of the Uncompahgre Plateau Collaborative Forest Landscape Restoration Project (UP-CFLRP) and the western U.S. in general intend to restore forest structural patterns, such as tree composition and density, and the complex spatial patterns of tree groups, openings, and 'mini-meadows' that historically characterized these stands. Analysis of satellite and aerial imagery over time provide a simple method to monitor the effect of forest restoration treatments on spatial patterns of forests of the UP-CFLRP.

Desired Conditions

Desired conditions of the UP-CFLRP outlined in the Monitoring Plan, the Uncompahgre Mesas Forest Restoration Project Environmental Assessment, and the Escalante Forest Restoration and Stewardship Project Environmental Assessment focus on reducing forest densities, favoring Ponderosa pine, establishing meadows and open conditions, and improving spatial heterogeneity. We assess changes between pre- and post-treatment spatial patterns of canopy cover of four UP-CFLRP projects, and compare restoration outcomes to Megan Matonis's historic conditions study of the UP-CFLRP area (Matonis and others 2014).

Measuring size and structure of openings

Aerial imagery classification provides a method to remotely evaluate elements of forest structure before and after restoration treatments. We used supervised classification to classify aerial imagery in the treatment areas. Delineation of large canopy openings or "mini-meadows" is problematic when individual trees are embedded in a continous matrix of openings. Classifying openings based on distance from the nearest canoy provides a simple metric to evaluate whether thinning treatments are creating openings that approach historical reference conditions. After classifying imagery, we applied a simple distance-to-edge algorithm to identify meadows that have a minimum diameter of 80 ft (Figure 1).

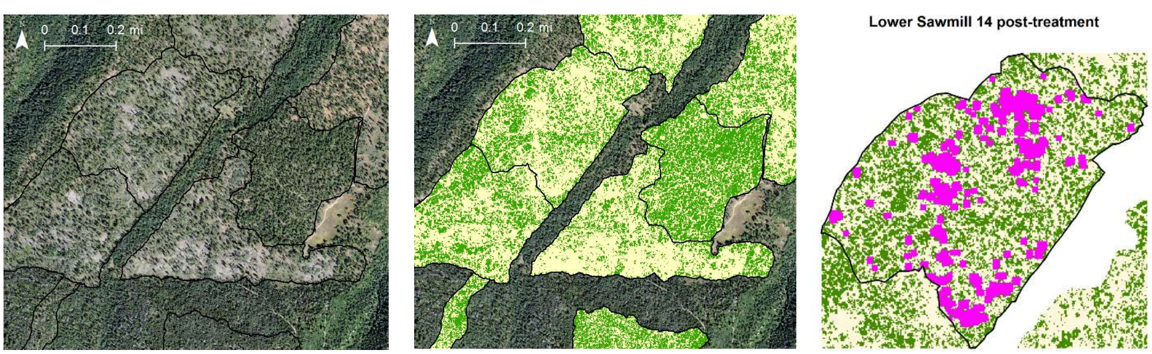

Figure 1. *Left*: Post-treatment (2015) imagery of Lower Sawmill from National Arial Imagery Program (NAIP) overlaid with CFLRP treatment boundaries. *Center*: Classified map illustrating forest pattern following restoration treatments. Green=canopy, Yellow=opening. *Right*: Classified map illustrating delineation of "mini-meadows" (openings with > 80 ft diameter). Green = canopy, Yellow = opening, Magenta = meadow. Treatment unit in right panel corresponds to the northwestern most unit in the left and center panels.

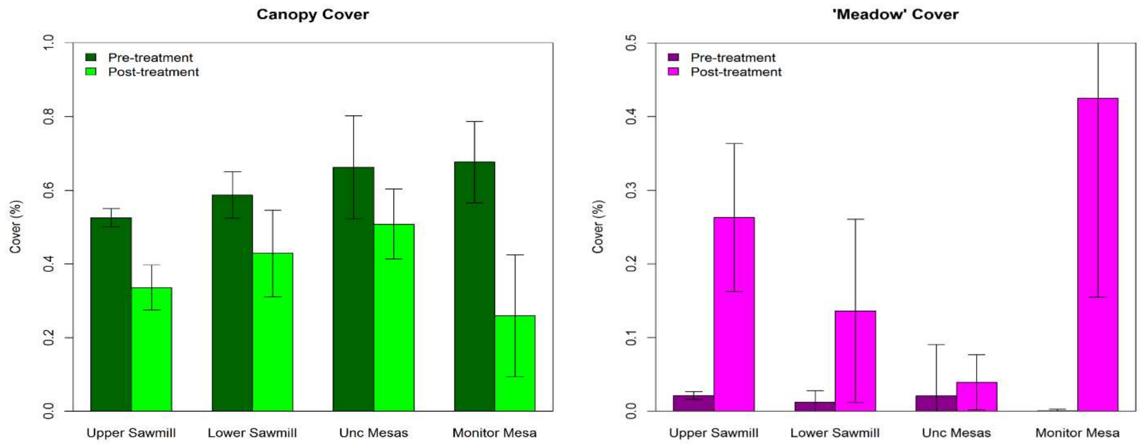

Figure 2. Comparison of pre- and post-treatment canopy cover (*left*) and meadow cover (*right*) for four CFLRP treatments. Results presented as simple averages within delineated units for each treatment. Erorr bars represent ± 1 standard deviation of the mean.

Treatment impacts on canopy cover and meadows

For this study, we focused on four treatment areas where pre- and post-treatment imagery was available (NAIP 2011 and 2015). The restoration treatment units included were (1) Unc Mesas, (2) Upper Sawmill, (3) Lower Sawmill, and (4) Monitor Mesa units. In general, treatments dramatically decreased canopy cover from 62–41% (Figure 2). Reduction in canopy cover varied between treatments and was most notable in the Monitor Mesa treatment area where canopy cover was reduced from 75 to 35%. Correspondingly, coverage of meadows increased from 1.5% to 16% cover over all treatments. Creation of meadows was most dramatic in the Monitor Mesa treatment (0.05 to 24%), but changed much less in the Unc Mesas treatment (2.5 to 4.5%). The variation in meadow cover was small in the pre-treatment condition, where meadow coverage was consistent within units and treatment areas. However, following treatment, much greater variability in meadow cover was evident both within treatments and between them suggesting increased landscape heterogeneity.

The number of meadows increased from 0.1 per acre (1 meadow every 10 acres) to 0.5 per acre (5 meadows every 10 acres) following treatments. Meadow size also increased following treatments from 0.08 acres up to 0.25 acres. This change was most pronounced in the Monitor Mesa treatment units and less pronounced in the Unc Mesas treatment units.

Comparison to historical conditions

Analysis of trends of pre- and post-treatment spatial pattern allows evaluation of whether restoration treatments are moving forests toward desired conditions (and away from undesirable conditions). However, additional comparisons of post-treatment spatial metrics of treated areas to likely historical conditions add important context for understanding the magnitude of change caused by restoration treatments. Data to estimate structural and spatial conditions of historical forests of the Uncompahgre Plateau were collected and analyzed by Matonis and others. The analysis above suggests that changes in meadow coverage following treatment were dramatic—where coverage by meadows increased to approximately 16% (increased by a factor of 10 relative to post-treatment units). However, historical forests on the Uncompahgre may have contained “meadows” which

Table 1. Pre- and post-treatment measurements of canopy cover and meadow cover, mean density, size, and shape index. Shape index is calculated as an area-weighted mean according to gap size. All result summaries are weighted by the area of treatment units.

Treatment	Area (ac)	Canopy Cover (%)		Meadow Cover (%)		Meadow density (per acre)		Mean Meadow size (ac)		Meadow Shape Index*	
		Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Upper Sawmill	392	52.4%	34.3%	2.099%	25.247%	0.181	0.704	0.102	0.392	1.18	2.24
Lower Sawmill	879	59.2%	40.9%	1.122%	16.031%	0.089	0.553	0.116	0.230	1.12	1.67
Unc Mesas	561	64.0%	51.2%	2.524%	4.590%	0.130	0.289	0.063	0.122	1.13	1.30
Monitor Mesa	359	74.8%	34.9%	0.051%	24.363%	0.006	0.683	0.012	0.391	1.02	2.00
Overall	2,190	61.8%	41.4%	1.480%	16.115%	0.102	0.534	0.083	0.258	1.13	1.73

covered over 65% of forested area, due to the much lower historical density of trees which allowed for connectivity between gaps and greater gap sizes. It should be noted that different methods were used to estimate coverage in these studies, so direct comparisons between results from remote sensing and stand reconstruction methodologies should be interpreted with caution.

Additionally, recent study of historic fires and effects on forest conditions across the Uncompahgre Plateau by Bill Baker using General Land Office surveys and field methods suggest that low forest densities in the late 1800's are the result of widespread moderate- to high-severity fires. Further monitoring, deliberation, and adaptive management over time is warranted to understand the role and function of these meadows in achieving ecological and social goals and objectives for the Uncompahgre Plateau.

In sum, reducing tree density and increasing the complexity of tree spatial patterns of forests through management can impact a number of important processes such as temperature, moisture, light, and nutrient availability. These changes can promote re-establishment of diverse grass and forb communities, and contribute to ecosystem diversity and function such as habitat for birds and wildlife, plant–pollinator interactions, fire dynamics, and tree regeneration for the future forest. Continual monitoring of these effects can help managers and stakeholders gauge the extent to which goals and desired conditions of the UP-CFLRP are being attained.

References Cited

Matonis, Megan S., Dan Binkley, Matt Tuten, and Tony Cheng. 2014. The forests, they are a-changin': ponderosa pine and mixed-conifer forests on the Uncompahgre Plateau in 1875 and 2010-13. Fort Collins, CO: Colorado Forest Restoration Institute, Colorado State University. Available online at https://cfri.colostate.edu/wp-content/uploads/2016/05/2014_UP-Forestry-Forensics-Final.pdf