Changes in forest structure in Ponderosa pine-dominated ecosystems following restoration treatments

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INTRODUCTION

Background:
• Increased large, high-severity wildfires in the West have had devastating effects on water resources such as post-fire erosion and sedimentation.
• This has prompted Colorado-based restoration collaborative Peaks to People Water Fund (P2P) to implement restoration treatments in priority watersheds.
• P2P focuses on increasing forest resiliency to future wildfires by meeting the following objectives:
  • Reduce canopy cover
  • Increase large openings (gaps)
  • Increase forest heterogeneity
• The purpose of this study was to measure the success of forest restoration treatments using remote sensing methods.

Research Question:
• Do P2P restoration treatments reach management objectives aimed at increasing forest resiliency?

STUDY DESIGN

Two areas within priority watersheds were selected as demonstration sites:
1. Ben Delatour Scout Ranch (BSR) – Cache La Poudre River
2. Ramsay-Shockey (RSY) – Big Thompson River
• Sites are within lower montane, Ponderosa pine-dominated forests with high wildfire risk.
• Treatments included mechanical thinning and prescribed burn. This study evaluates post-treatment conditions following mechanical thinning only.

METHODS

• We examined pre- and post-treatment satellite imagery for BSR and RSY collected by WorldView-2 and Quickbird-2 satellites with ~3m spatial resolution and 4- or 8-band spectral resolution.
• Approximately 110 training areas were stratified across treatment unit boundaries in each image.
• Supervised random forest classification was utilized to classify imagery to assess canopy cover changes:
  • Training areas were classified as either opening (yellow), canopy (green), or shadow (gray).
  • Shadows were re-classified into opening or canopy using Normalized Difference Vegetation Index (NDVI) thresholds.

RESULTS

Table 1: Confusion Matrix for BSR Pre-Treatment. Overall classification accuracy is 97.2%

<table>
<thead>
<tr>
<th>Classification Method</th>
<th>Overall Accuracy</th>
<th>Training Error</th>
<th>Mean Error (cm)</th>
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<tbody>
<tr>
<td>BSR Pre-Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample 1</td>
<td>82</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sample 2</td>
<td>0</td>
<td>31</td>
<td>1</td>
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<tr>
<td>Sample 3</td>
<td>0</td>
<td>0</td>
<td>64</td>
</tr>
</tbody>
</table>

Figure 1a: Image classification of RSY pre-treatment.
Figure 1b: Image classification of RSY post-treatment.

• Using the classified imagery, we delineated large openings (defined here as “all contiguous regions with <5% canopy cover over a 0.1-acre area**) which were used to calculate the following:
  • Gap cover: Percent cover of large openings as they are defined above.
  • Gap decay coefficient: the rate of decay for the interior area of an opening.
  • Gap size variability: variability of the size of openings, measured by the coefficient of variation.
• Classification accuracy was tested for each site using a confusion matrix.

Figure 2: Final classification of treatment units at BSR and RSY. Maps show cover of openings (yellow), canopy (green), and large openings (gaps) (magenta) at BSR pre-treatment (upper left), BSR post-treatment (lower left), RSY pre-treatment (upper right), and RSY post-treatment (lower right).

DISCUSSION

• Overall, P2P restoration treatments met management objectives:
  • Canopy cover decreased at both sites (Table 2).
  • Large openings increased at both sites (Table 3).
  • Decreased gap decay coefficients at both sites and increased gap size variability at RSY contribute to increased forest heterogeneity (Tables 4, 5).
• Meeting these objectives should result in improved forest resiliency to and decreased frequency of high-severity wildfires.
• Remote sensing was integral in assessing fine-scale spatial patterns at a landscape-scale before and after restoration treatments.
• P2P’s collaborative approach to restoration and use of demonstration sites allowed for interagency cooperation that makes future restoration treatments aimed at resilience possible.