The Impact of Conservation Practices on Post Wildfire Recovery

Shima Shams

Collaborators: Jennifer Boehnert, David John Gagne, John Schreck, Kevin Sampson, and Olga Wilhelmi

Research application laboratory, National Center for Atmospheric Research, Boulder, CO

Contact info: sshams@ucar.edu
Outline

Project overview, Datasets and methods

Recovery diagnostics and recovery simulations

Conclusion, takeaways
Conservation Status

USA Protected Areas Database (PAD) provides conservation categories in terms of long-term protection of biodiversity called Gap Analysis Project (GAP).

- GAP Status 1: Areas managed for biodiversity where natural disturbances are allowed to proceed
- GAP Status 2: Areas managed for biodiversity where natural disturbance is suppressed
- GAP Status 3: Areas protected from land cover conversion but subject to extractive uses such as logging and mining
- GAP Status 4: Areas with no known mandate for protection
Can we quantify the impact of conservation activities on post-wildfire recovery using remote sensing data?

Can we simulate the post-wildfire recovery rates?

**Datasets**
- Characterization of wildfire event
- MODIS Burn products
- Time series of vegetation indices
- Landsat data collection
- Conservation Status
- The Protected Areas Database
- Forest Type
- LANDFIRE

**High resolution climate data**
- CONUS404

**Using ML to simulate recovery rates**
• Dominated by conifer and evergreen forested area.

• Dominated by fire regime group 1 (mix severity, interval less than 35)

• Diverse set of management and conservation status
Recovery Diagnostics

Normalized burn index (NBR) = \frac{NIR - SWIR}{NIR + SWIR}

dNBR = NBR (Pre wildfire) - NBR (post wildfire)

Percent NBR Recovery = \frac{NBR_{n+5} - NBR_n}{dNBR} * 100

- Where n' is the year that has the minimum of NBR between year of the wildfire (n) or the following year (n+1).
- The advantage of this ratio is normalizing each wildfire event based on its dNBR, which corresponds to the wildfire intensity.
Recovery based on conservation status and forest type

- Recovery is more lingering in unmanaged areas
- Forest type influence the impact of conservation activities on recovery
  - Large variabilities in recovery of Mesic mixed conifer
Driving factors of post wildfire recovery

Can we simulate the post wildfire recovery using ML?

<table>
<thead>
<tr>
<th>Predictors used in RF simulation</th>
<th>predictor</th>
<th>Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conservation index</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area (km²)</td>
<td>Conservation index</td>
<td>The total area of wildfire polygon</td>
</tr>
<tr>
<td>f_duration</td>
<td></td>
<td>The duration of wildfire</td>
</tr>
<tr>
<td>dNBR</td>
<td></td>
<td>Delta NBR as a measure of fire severity</td>
</tr>
<tr>
<td>f_NBR</td>
<td></td>
<td>The low NBR value after wildfire</td>
</tr>
<tr>
<td>std_f_NBR</td>
<td></td>
<td>Max NBR std after wildfire (between n, n+1)</td>
</tr>
<tr>
<td><strong>Burn scar/fire characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre_f_NBR</td>
<td></td>
<td>NBR value for the year prior to the wildfire</td>
</tr>
<tr>
<td>std_pre_f_NBR</td>
<td></td>
<td>mean std NBR for 5 years pre wildfire</td>
</tr>
<tr>
<td><strong>Pre-fire vegetation status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Landform</strong></td>
<td></td>
<td>physiographical characteristics (the % coverage)</td>
</tr>
<tr>
<td>peak_ridge_cliff</td>
<td>peak_ridge_warmer, peak_ridge, peak_ridge_cool, mountain_divide, cliff</td>
<td></td>
</tr>
<tr>
<td>flat</td>
<td>upper_slope_warmer, lower_slope_warmer</td>
<td></td>
</tr>
<tr>
<td>valleys</td>
<td>valley_narrow</td>
<td></td>
</tr>
<tr>
<td>cool_slope</td>
<td>upper_slope_cool, lower_slope_cool</td>
<td></td>
</tr>
<tr>
<td>neutral_slope</td>
<td>upper_slope, lower_slope</td>
<td></td>
</tr>
<tr>
<td><strong>Climate variable</strong></td>
<td></td>
<td>The anomalies of n, n+1, n+5 is used for each predictor for annual as well as monthly data (total 3<em>13</em>2 = 78 predictors)</td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td>2-meter temperature</td>
</tr>
<tr>
<td>Prec</td>
<td></td>
<td>Total precipitation</td>
</tr>
</tbody>
</table>
Random Forest Results

- For climate predictor, the monthly variables: “m” - the number of the months,
- Anomaly of climatology variables have Clm_z with either 0, 1, and 5 which represent the wildfire year, the following year, and 5 years following the wildfire.

100 ensemble runs of random selection of validation vs training data. Differences are estimated as the observed 5-year percent NBR recovery minus predicted by the model.
Summary: the preliminary results motivate further investigation

We studied moderate to highly severe burned forest larger than 1 km in subset of California and Oregon.

- The importance of conservation planning in post-wildfire recovery.
  - More lingering recovery in areas with no known mandate for protection
- The intensity of the impact of conservation status varies for different forest types
  - the importance of management intervention in post wildfire recovery and having priority plans.
- RF is able to reasonably simulate moderate recovery rates
- Incorporation of an automated framework of detecting burn areas (MODIS) and tracking vegetation indexes (Landsat), in combination with publicly available conservation status, could be used to track the impact of interventions across the world.
Questions?

Contact info:
sshams@ucar.edu

Tweeter account:
@Shima__Shams
Table 1. GAP status and their characteristics.

<table>
<thead>
<tr>
<th>GAP status</th>
<th>Long-term protection of biodiversity</th>
<th>Extractive usage</th>
<th>Descriptive name</th>
<th>Conservation index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>✓</td>
<td></td>
<td>Disturbance Allowed</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>✓</td>
<td>✓</td>
<td>Disturbance Suppressed</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>✓</td>
<td>✓</td>
<td>Excitative</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>No protection mandate</td>
<td>0</td>
</tr>
</tbody>
</table>
100 ensemble runs of random selection of validation vs training data. Differences are estimated as the observed 5-year percent NBR recovery minus predicted by the model.
Random Forest Results

100 ensemble runs of random selection of validation vs training data. Differences are estimated as the observed 5-year percent NBR recovery minus predicted by the model.

Low $R^2$ thus we did not discuss the premutation predictors of Mesic conifer.
The aggregated annual burned area of needleleaf forest where each fire event is larger than 1km in the study area, coverage of each GAP status for each year is shown by color coding for each bar.
Creating Annual Time Series of Vegetation Indices

- Landsat 4-5 Thematic Mapper (TM)
- Landsat 7 Enhanced Thematic Mapper Plus (ETM+)
- and Landsat Operational Land Imager (OLI)

Bandpass adjustments of OLI bands and Cloud and shadow masks

Medoid compositing method

Creating annual estimates of reflectances for each patch

Time series of vegetation indices for 38 years for each patch of the fire event