Exploration of FARO Freestyle 3D Laser Scanners as a Method for Estimating Surface Fuel Loading for Wildland Fire Management

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In a July 2016 report from the Office of Inspector General, the Forest Service was noted as lacking a “consistent, cross-agency process for selecting its highest priority hazardous fuels reduction projects for completion”.

The report noted that land management agencies were tasked with developing a “cohesive wildfire management strategy that included assessing the level of risk to communities and allocating hazardous fuels reduction funds based on the priority of hazardous fuels reduction projects.

This needs to be based on the “best available science, knowledge and experience”
Why Is This Important?

- One of the ways to prioritize fuel reduction projects is by accurately assessing the fuel loading in a given area. Remote sensing can help in this endeavor. However, remote sensing has some difficulty in gathering information about the shrub layer in forests (2 meters to ground level).

- Furthermore, the IG report states that the Forest Service does not have an effective way to measure the success of the prescribed burn (pre-burn fuel vs post-burn fuel).

- Current methods of quantifying fuel loading in the shrub layer are time and labor intensive, with transects and destructive harvests being two examples.

- Could remote sensing be used to quantify fuel loading in a way that is quicker and allows for more coverage due to smaller labor needs?

- Could the FARO Freestyle 3D Scanner be used to quantify shrub biomass in the field? Could it be used pre-burn and post burn to determine the effect of the burn?
The Tool

- FARO Freestyle 3D Handheld Laser Scanner
The Plan

- **Objective 1:** Determination of ambient, natural light condition for Faro Freestyle scanning.
  - The idea is to see how the amount of ambient light affects the scanning accuracy, using time of day as a proxy.

- **Objective 2:** Calibration of Faro Freestyle scans to upland pine-oak forests surface fuel biomass
  - What relationship exists between the pixels in the scan and the dry biomass of a harvest cut plot?

- **Objective 3:** Effect of leaf presence on scanning accuracy
  - What effect does the removal of leaf cover have on the relationship between the pixels in the scan and the dry biomass of a cut plot
The Process

Objective 1 - Effect of Ambient Light

- Chose 5 number of sites at the Silas Little Experimental Forest
- Tested at 1m and 2m scan heights as well as moving/stationary scanning (4 scans total per plot per time period)
- Partly Cloudy conditions; sunrise = 5:52am; sunset = 8:15pm
- Recorded the time of the scan and whether the scan worked or not
- Attempted the scan throughout the day (7am, 9am, 11am, 1pm, 3pm, 5pm, 7pm)

Anecdotal evidence confirmed that the time of day matters. In some cases, the scanner was unable to detect any objects to scan. Direct light vs. diffuse light also matters.

The scans were done near a flux tower that collects data on the light conditions. The hope is compare the number of successful scans to the lighting conditions at the time of the scan and explore any relationships that exist in the data between light levels and scan success.
The Process
Site Selection

- For Objective 2 and Objective 3, I chose sites based on the time since last fire.

- This provided me a proxy to ensure that I had some gradient of shrub complexity and biomass as previous research (Clark 2014) established this relationship.

- I chose sites that were 1, 2, 4, 10, and 21 years since last fire
The Process

- **Objective 2 - Calibration of FARO Scanner**
  - Chose five different sites based off the time since last fire
  - Chose six plots within those five sites to isolate, scan, and harvest for drying. The process takes a week or so to complete.
  - After plot was chosen, 1 meter PVC square dropped and all shrubs outside of the plot were trimmed back six to twelve inches.
  - Using the information gleaned from Objective 1, all scans took place between 7am and 8am under cloudy conditions.
  - After scan, shrub biomass was harvested and then dried for 48 hours at 70℃.
  - Dry biomass was then weighed and discarded.

- **Objective 3 - Effect of leaf presence on scanning.**
  - The same process as above is slated to be done on different plots within the same sites once all of the leaves have fallen off the shrubs.
The Process
The Process
The Process (con’t)
The (Very Preliminary) Results

Number of Successful Scans

<table>
<thead>
<tr>
<th>Time</th>
<th>Scans</th>
</tr>
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<tbody>
<tr>
<td>7:00 AM</td>
<td>19</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>16</td>
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<tr>
<td>5:00 PM</td>
<td>10</td>
</tr>
<tr>
<td>7:00 PM</td>
<td>19</td>
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</tbody>
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What’s Left to be Done?

- Once Objective 2 is finished (one site remaining), I can explore the relationship between the flux tower data and the scan success for Objective 1.

- One the leaves fall off, I can complete Objective 3

- In terms of analysis, I will be using Bayesian Regression to explore the relationship between the scan pixels and dry biomass of each plot.

- Data Collection and Analysis will (hopefully) be completed by December.
Lessons Learned

- Asking the right question is really, really hard.
- Be prepared for false starts.
- Mother Nature does not always cooperate with the weather.
- Don’t be afraid to say “I Don’t Know”
Acknowldegements

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