Remote sensing approaches to forest resource inventories for resin yield modelling

R. Alonso Ponce

rafa.alonso@fora.es
Remote sensing approaches to forest resource inventories for resin yield modelling

What can remote sensors do to predict resin production?

Estimate stand attributes and individual-tree variables at lower costs ensuring accuracy
Sources of remote data

- Active sensors: LiDAR (airborne, terrestrial)
- Passive sensors: multispectral images

Stand and individual-tree variables

Classifications (species identification)

NOT ONLY!!
LiDAR inventory methodologies

- Stand level
- Individual tree
Stand level method
Phases

Data surveys

- Plot calculation
- LiDAR data processing
- LiDAR metrics in plots
- Model fitting
- Validation
- Calibration

Thematic cartography
(SV, Ho, G, Dg, N, VI)

Stand level Forest Inventory flux
Stand level method

Results

V = 860.71 m³
V/ha = 18.5 m³/ha
Individual tree method
Individual tree method
Individual tree method
Approaches

Crown raster models
- Variable-window filtering
- Watershed segmentation
- Region growing

Crown delineation
Valbuena et al., 2016
Crown delineation approach

Ecuación

\[
\begin{align*}
H &= 0.78375 + 0.98429 \times H_{\text{Lidar}} \\
H_g &= 0.9663 + 0.9835 \times H_{\text{Lidar}} \\
D_n &= 53.7181 + 1.1949 \times H_{\text{Lidar}} - 6.6853 \times \text{LN}(\text{densidad}_{\text{Lidar}} + 6) \\
N_{\text{pies/ha}} &= 0.9885 \times \text{Pies}^{1.0055} \\
VCC &= 1.0166075 \times e^{-1.119 + 0.4354 \times \text{LN}(\text{densidad}) + 0.9007 \times \text{Raiz}(H_{\text{Lidar}})} - 0.6761 \times \text{PC/PP} \\
A_B &= -11.3469 + 3.3122 \times (H_{\text{Lidar}}/OA) + 19.7399 \times \text{PC/PP}
\end{align*}
\]

\[
\begin{array}{|c|c|c|}
\hline
& R^2 & \text{RMSE} \\
\hline
H & 0.952 & 0.85m \\
H_g & 0.964 & 0.76m \\
D_n & 0.882 & 2.66cm \\
N_{\text{pies/ha}} & 0.986 & 34.7 \text{pies/ha} \\
VCC & 0.879 & 38 \text{m}^3/\text{ha} \\
A_B & 0.762 & 5.5 \text{m}^2/\text{ha} \\
\hline
\end{array}
\]
Crown delineation approach
Indivual tree method
Results
Results

\[ V = 824,23 \text{ m}^3 \]

\[ \frac{V}{ha} = 17.38 \text{ m}^3/ha \]
Indivual tree method
Results
Indivual tree method
Results

Competition indices
## Temporal, spatial and spectral resolution

<table>
<thead>
<tr>
<th>Platform</th>
<th>Resolution</th>
<th>#Bands</th>
<th>Revisit</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAA</td>
<td>1.1 km</td>
<td>5</td>
<td>12 hours</td>
</tr>
<tr>
<td>Resurs-01</td>
<td>200m</td>
<td>4</td>
<td>3-5 days</td>
</tr>
<tr>
<td>LandSat 4-5</td>
<td>30m</td>
<td>7</td>
<td>16 days</td>
</tr>
<tr>
<td>LandSat 7</td>
<td>15m (PAN)</td>
<td>8</td>
<td>16 days</td>
</tr>
<tr>
<td>LandSat 8</td>
<td>15m (PAN)</td>
<td>11</td>
<td>16 days</td>
</tr>
<tr>
<td>Spot 4</td>
<td>10m (PAN)</td>
<td>4</td>
<td>4-6 days</td>
</tr>
<tr>
<td>Sentinel 2</td>
<td>10m</td>
<td>12</td>
<td>3-7 days</td>
</tr>
<tr>
<td>Spot 5</td>
<td>2.5m (PAN)</td>
<td>5</td>
<td>1-4 days</td>
</tr>
<tr>
<td>Spot 6-7</td>
<td>1.5m (PAN)</td>
<td>5</td>
<td>1-2 days</td>
</tr>
<tr>
<td>Ikonos</td>
<td>1m (PAN)</td>
<td>4</td>
<td>2 days</td>
</tr>
<tr>
<td>QuickBird</td>
<td>61cm (PAN)</td>
<td>4</td>
<td>3 days</td>
</tr>
</tbody>
</table>
# Vegetation indices

<table>
<thead>
<tr>
<th>Vegetation Index</th>
<th>Equation</th>
<th>Reference</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference Vegetation Index (DVI)</td>
<td>$NIR - red$</td>
<td>Jordan (1969) [22]</td>
<td>Sensitive to soil background</td>
</tr>
<tr>
<td>Ratio Vegetation Index (RVI)</td>
<td>$NIR/red$</td>
<td>Pearson and Miller (1972) [23]</td>
<td>Sensitive to soil background</td>
</tr>
<tr>
<td>Normalized Difference Vegetation Index (NDVI)</td>
<td>$\frac{NIR - red}{NIR + red}$</td>
<td>Rouse et al. (1974) [16]</td>
<td>Enhances contrast between soil and vegetation</td>
</tr>
<tr>
<td>Modified Simple Ratio (MSR)</td>
<td>$\frac{NIR}{\sqrt{NIR + 1}}$</td>
<td>Chen and Cihlar (1996) [1]</td>
<td>Improves vegetation sensitivity</td>
</tr>
<tr>
<td>Transformed Vegetation Index (TVI)</td>
<td>$\sqrt{\frac{NIR - red}{NIR + red}} + 0.5$</td>
<td>Deering et al. (1975) [32]</td>
<td>Modifies NDVI with only positive values; &lt;0.71 as non-vegetation and &gt;0.71 as vegetation</td>
</tr>
<tr>
<td>Modified Transformed Vegetation Index (MTVI)</td>
<td>$\sqrt{\frac{c \times NIR - red}{c \times NIR + red}}$</td>
<td>Skianis et al. (2007) [3]</td>
<td>Used with poor vegetation</td>
</tr>
</tbody>
</table>

where $c$ is a weighing factor
Vegetation indices
Vegetation indices

Spectral indices

FALSE COLOR: 8,4,3
Vegetation indices

NDVI: \( \frac{(B8 - B4)}{(B8 + B4)} \)
Vegetation indices

NDWI: \( \frac{(B3-B8)}{(B3+B8)} \)
Combining low density LiDAR and satellite images to discriminate species in mixed Mediterranean forest

Distinguishing between two species of the same genus is particularly tricky!!

<table>
<thead>
<tr>
<th>Training Models</th>
<th>Nº of variables</th>
<th>OOB %</th>
</tr>
</thead>
<tbody>
<tr>
<td>LiDAR model</td>
<td>6</td>
<td>13.56</td>
</tr>
<tr>
<td>Spectral model</td>
<td>6</td>
<td>20.34</td>
</tr>
<tr>
<td>Complete model</td>
<td>12</td>
<td>6.78</td>
</tr>
</tbody>
</table>

Table 5. Confusion matrix obtained from the validation of the individual trees in mixed stand dataset.
Thanks!

rafa.alonso@fora.es
Rafael Alonso Ponce