Impact of climate anomalies on the functionality of beech trees in a mixed forest in the Italian south-eastern Alps

Luca Belelli Marchesini¹,³, Riccardo Valentini²,³, Lorenzo Frizzera¹, Mauro Cavagna¹, Isaac Chini¹, Roberto Zampedri¹ and Damiano Gianelle¹

¹Research and Innovation Centre, Fondazione Edmund Mach, Italy
²DIBAF, University of Tuscia, Italy
³RUDN University, Russia
Cembra forest site – Trentino, Italy
1250 m a.s.l (46.20 N, 11.21 E)

Uneven aged mixed alpine forest
(\textit{Abies alba, Fagus sylvatica} and \textit{Picea abies} as dominant species)
Late frost damage in spring 2019

Cold and wet late spring with frost events in early May 2019 (doy 124-130)

Beech (Fagus sylvatica L.) trees were damaged with different severity, depending on the distinct phenological stage of the leaf out. Damage level at tree level ranged from null (intact green leaves) to total (completely burnt leaves).

Data: Cembra weather station (550 m a.s.l)

Air temperature

Precipitation
Climate anomalies 2019

Data: Cembra weather station (550 m a.s.l.)
Tree functionality monitoring

Established in early June 2019 to evaluate the effect of the frost induced impairment and assess forest resiliency

1. **Tree stem radial growth**: measured using band dendrometers with readings taken every 10 days on average.

2. **Sap flow density (J)**: monitored by heat dissipation probes of Tree-Talker*, a multifunctional device for monitoring trees biological and physical features based on the Internet of Things (IoT) technology. Data collected at hourly frequency and J calculated according to Granier (1985) methodological approach.

# Tree stem cumulated radial growth

<table>
<thead>
<tr>
<th>Damage level</th>
<th>Seasonal growth [mm]</th>
<th>SEM [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0-1)</td>
<td>0.263</td>
<td>0.0274</td>
</tr>
<tr>
<td>(2-3)</td>
<td>0.146</td>
<td>0.0254</td>
</tr>
</tbody>
</table>

**Source of Variation**

<table>
<thead>
<tr>
<th>Factor</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage</td>
<td>1</td>
<td>0.0576</td>
<td>0.0576</td>
<td>9.935</td>
<td>0.009</td>
</tr>
<tr>
<td>Plot</td>
<td>2</td>
<td>0.0166</td>
<td>0.00828</td>
<td>1.428</td>
<td>0.281</td>
</tr>
<tr>
<td>Damage x Plot</td>
<td>2</td>
<td>0.00214</td>
<td>0.00107</td>
<td>0.185</td>
<td>0.834</td>
</tr>
<tr>
<td>Residual</td>
<td>11</td>
<td>0.0638</td>
<td>0.00580</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>0.139</td>
<td>0.00870</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Temporal patterns of radial growth**

- **Green line** represents radial growth in the **null/light** damage group.
- **Red line** represents radial growth in the **severe/total** damage group.

- ***** (P<0.001)**
- **** (P<0.01)**
- *** (P<0.05)**

**X-axis**: DOY (days of the year)

**Y-axis**: Daily radial growth [10^-4 mm d^-1]
Sapflow density (J)

day 158 - 173

- damage (0-1)
- damage (2-3)
- ± std. dev

day 218 - 233

- damage (severe/total)
- damage (null/light)

n
A severe frost event in late spring 2019 caused highly differentiated leaf damage during the leaf out phase on beech trees in an alpine forest.

Damaged trees showed:

1. Reduced radial growth (-45%) at seasonal level (June-October) yet with similar growth intensity after mid July, in comparison with undamaged individuals.
2. Reduced sap flow density rates up to -60% at the beginning of the monitoring period in June 2019, with total recovery after 3 weeks (doy 180)
3. A good level of resilience but monitoring should now focus on carry over effects.

Importance of evaluating the impact of climate anomalies on carbon uptake and transpiration in a climate change predicament with increasing frequency of extreme events in the alpine region, including frosts and heat-waves.