Late Holocene ecosystem change and disturbance dynamics in central European mountain forests

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Rationale

- Central European mountain forests are shaped by natural disturbances such as wind throws, insect outbreaks, and fires.
- Knowledge of the past disturbance regime and changes in forest ecosystem can provide better understanding of how these forests may respond to changing environmental conditions.

- In year 2004 severe windthrow occurred in mixed *Larix decidua*–*Picea abies* forest in the south slope of High Tatra Mountains and after this the area has been of interest of many ecological and dendrochronological studies.
Objectives

• Reconstruct the late Holocene temperate mountain forest dynamics and disturbance history

• Expand the knowledge of forest and disturbance dynamics beyond the extent of dendrochronological perspective in the area

• Assess the role of climate, human impact and natural disturbances as drivers behind the mountain forest dynamics
Study sites and data

- Sedimentary data from 4 small forest hollow sites
- Age-depth-models based on $^{14}$C dates
- Pollen, NPPs, macroscopic charcoal
- Temperature reconstruction from tree-rings for 1000 years (Büntgen et al. 2013, PNAS)

<table>
<thead>
<tr>
<th>Site</th>
<th>Altitude m.a.s.l.</th>
<th>Depth cm</th>
<th>Age cal yr BP</th>
<th>C14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velicka</td>
<td>1354</td>
<td>225</td>
<td>3290</td>
<td>7</td>
</tr>
<tr>
<td>Smokovec</td>
<td>1067</td>
<td>204</td>
<td>4800</td>
<td>8</td>
</tr>
<tr>
<td>Diera</td>
<td>982</td>
<td>90</td>
<td>1420</td>
<td>4</td>
</tr>
<tr>
<td>Lomnica</td>
<td>974</td>
<td>180</td>
<td>1160</td>
<td>3</td>
</tr>
</tbody>
</table>

Holeksa et al. 2016, Forest Ecology and Management
Results

• This is unpublished work and the data analysis is still ongoing.
• Here we present the results from the first analyses.
Disturbance and vegetation history

- Diagram comparing temperature reconstruction from tree-rings, macroscopic charcoal record, disturbance index (Kuneš et al. 2019) derived from pollen, *Picea* and herb pollen curve and human indicator pollen sum from all studied small hollow sites.

- Notice the peaks in macroscopic charcoal record between 1100 – 1400 CE and clear increase in herb pollen and human indicator pollen taxa around the same time.
Variation partitioning – Results

Variation partitioning:
- Was used to assess the relative importance of the explanatory environmental variables, which cause the variation in species assemblages. Method also reveals the amount of the variation which is not predictable by means of the known variables.

Response variable
- **Tree pollen taxa**: Abies, Acer, Alnus, Betula, Carpinus, Corylus, Fagus, Fraxinus, Juniperus, Larix, Picea, Pinus, Quercus, Salix, Tilia, Ulmus

Explanatory variables
- **Temperature**: May-Jun and measured difference from 1956-2009 mean.
- **Fires**: Macroscopic charcoal counts/cm³
- **Human impact**: Calculated as sum of human indicator pollen taxa following Reitalu et al (2013).
  - Cerealia-type, Avena, Hordeum, Secale, Triticum, Fagopyrum, Centaurea Cyanus, Cannabis-type, Artemisia, Chenopodium, Plantago sp., Rumex sp., Urtica

All studied small forest hollows pooled together

Unexplained variation = 87 %
Variation partitioning results for individual small hollow sites

Velicka Hollow
- Temperature: 1%
- Fires: 2%
- Human: 4%
- Unexplained variation: 93%

Smokovec Hollow
- Temperature: 1%
- Fires: 9%
- Human: 1%
- Unexplained variation: 65%

Lomnica Hollow
- Temperature: 1%
- Fires: 21%
- Human: 9%
- Unexplained variation: 67%

Diera Hollow
- Temperature: 3%
- Fires: 11%
- Human: 10%
- Unexplained variation: 75%
Conclusions

• Change in forest composition around 1100-1400s
  • Most pronounced in lower altitude sites
  • Grazing in mountain pastures, cultivation

• Period of fires along the mountain range at 1200-1400s
  • Connected to the increasing human activity
  • No fires in the three lower most sites during last 500 years

• Results suggest that impact of fires and human activity exceeds the impact of temperature on the variation in tree composition during last 1000 years
Thank you!

OUR TEAM (EUROPIA & PEDECO – projects in Charles university and Czech University of Life Sciences Prague)

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References

