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 wind throws, insect outbreaks and fires

- Knowledge of the past disturbance regime and changes in forest ecosystem can provide better understanding of how these forest may respond to changing environmental conditions

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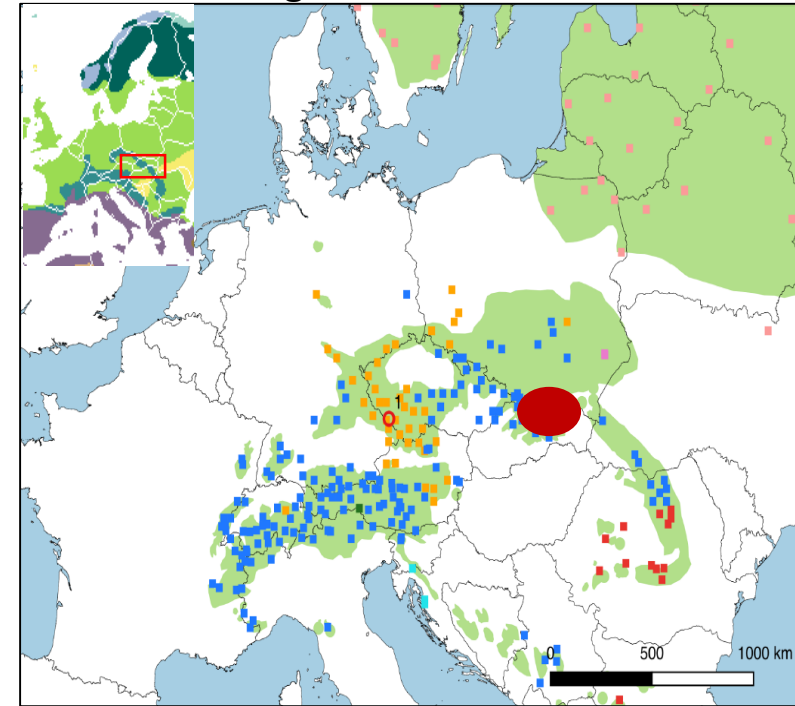
- In year 2004 severe windthrow occured in mixed *Larix decidua–Picea abies* forest in south slope of High Tatra moutains and after this the area have been interest of many ecological and dendrochronological studies.

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

- Asses 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)

Site	Altitude m.a.s.l.	Depth cm	Age cal yr BP	C14
Velicka	1354	225	3290	7
Smokovec	1067	204	4800	8
Diera	982	90	1420	4
Lomnica	974	180	1160	3
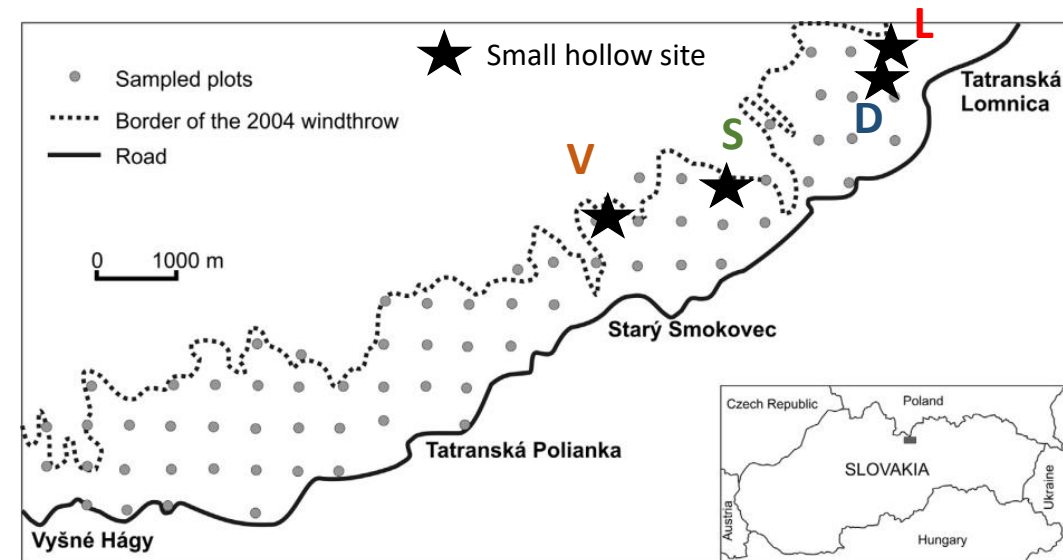
Holeksa et al. 2016, Forest Ecology and Management

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- **This is unpublished work and the data analysis is still ongoing.**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, macrosopic charcoal recod, 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.
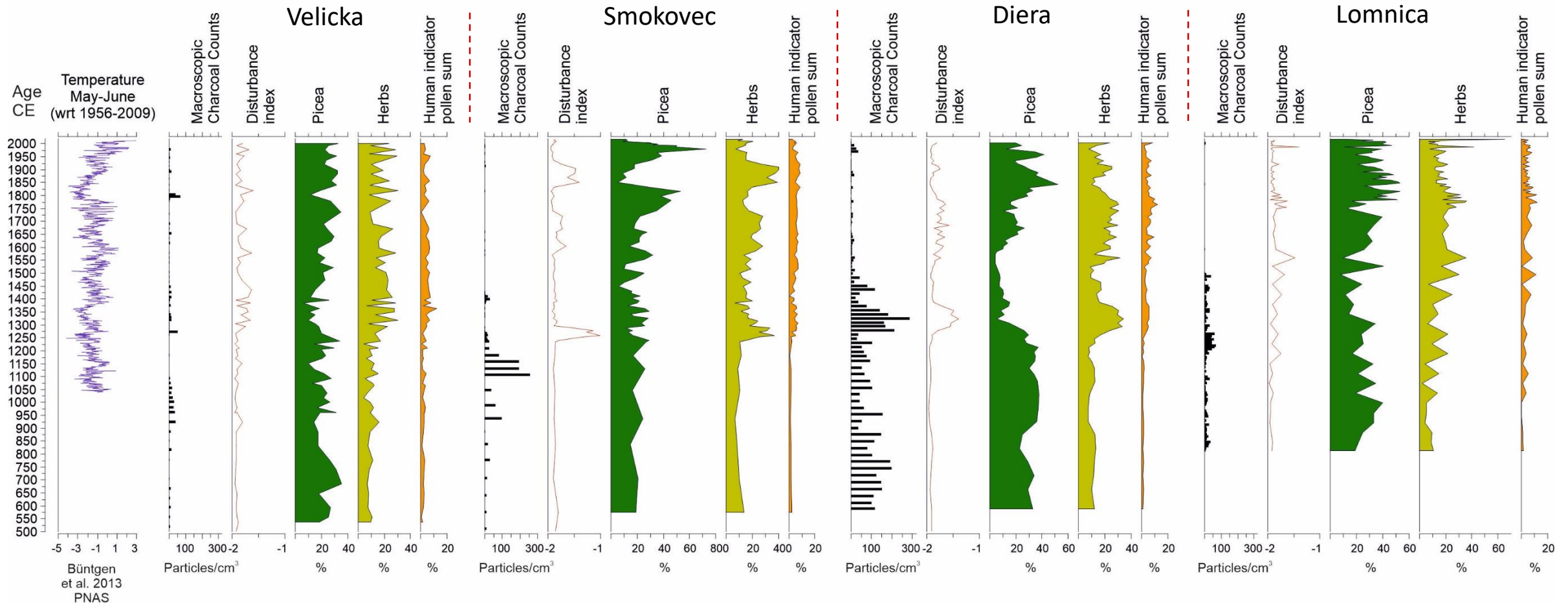
Variation partitioning – Results

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.
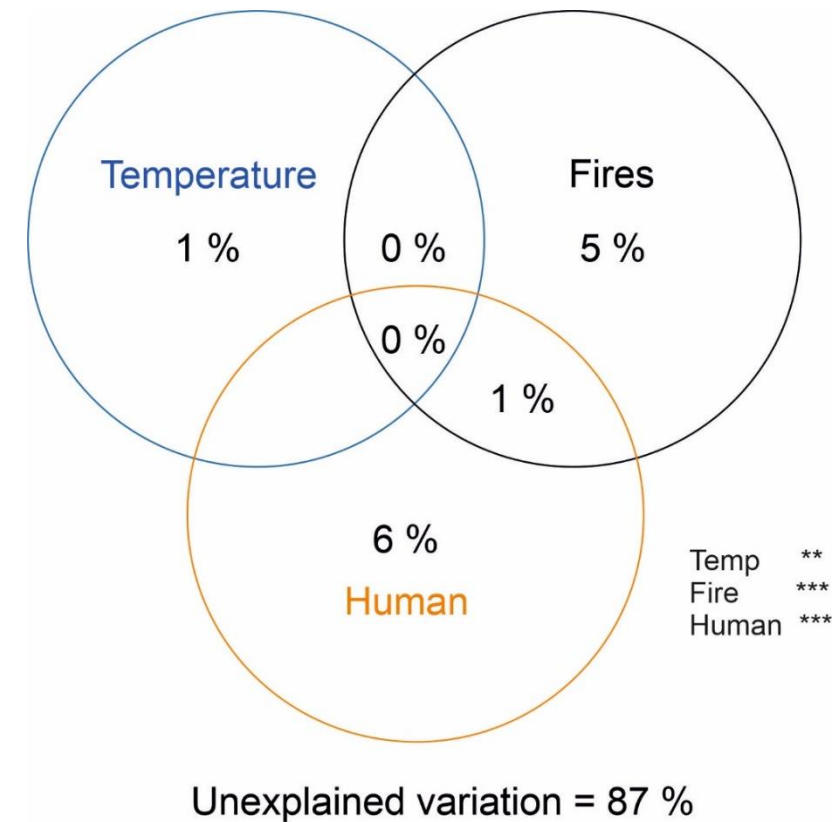
Response variable

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

Explanatory variables

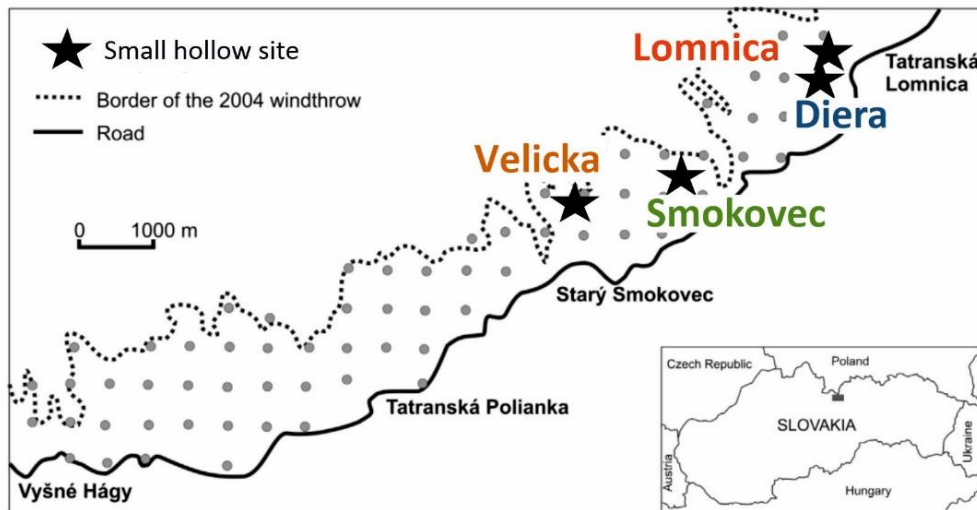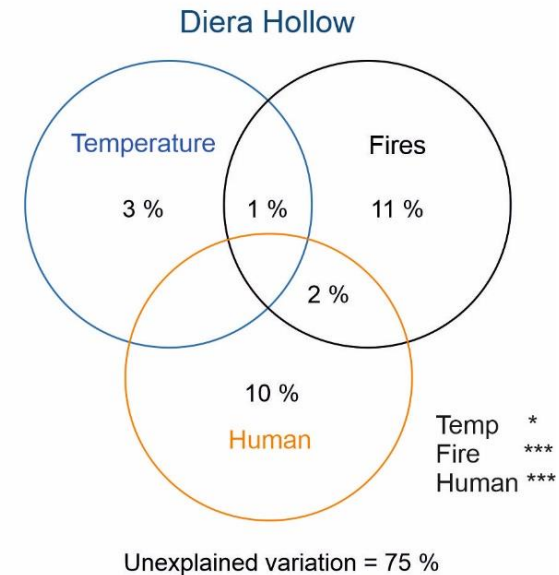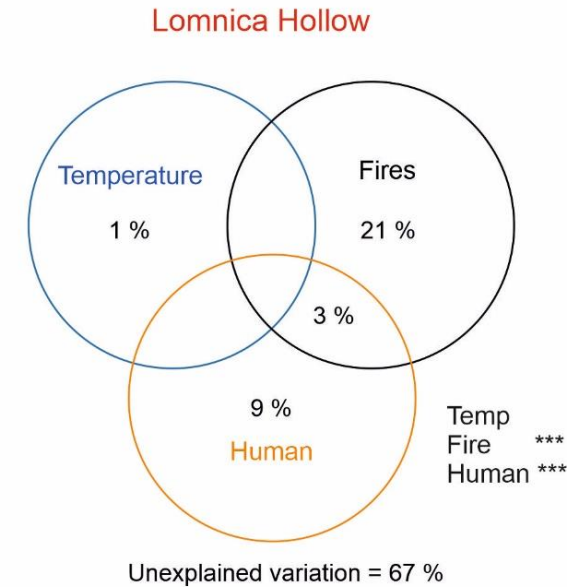- **Temperature**: May-Jun and measured difference from 1956-2009 mean.

- **Fires:** Macroscopic charcoal counts/cm^3

- **Human impact:** Calculated as sum of human indicator pollen taxa following Reitalu etal (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

Temperature 1 %

0 %

Fires 5 %

0 %

1 %

6 %

Human

Temp **
Fire ***
Human ***

Unexplained variation = 87 %

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Variation partitioning results for individual small hollow sites

Velicka Hollow
Temperature 1 %
Fires 2 %
0 % 0 %
4 %
Human
Temp
Fire .
Human *
Unexplained variation = 93 %

Smokovec Hollow
Temperature
Fires 6 %
9 %
1 %
Human
Temp
Fire
Human **
Unexplained variation = 85 %

Lomnica Hollow
Temperature 1 %
Fires 21 %
3 %
9 %
Human
Temp
Fire ***
Human ***
Unexplained variation = 67 %

Diera Hollow
Temperature 3 %
1 %
Fires 11 %
2 %
10 %
Human
Temp *
Fire ***
Human ***
Unexplained variation = 75 %

★ Small hollow site
.... Border of the 2004 windthrow
— Road

Lomnica
Tatranská Lomnica
Diera
Velicka
Smokovec
Starý Smokovec
Tatranská Polianka
Vyšné Hágy

0 1000 m

Czech Republic   Poland
SLOVAKIA
Austria   Ukraine
Hungary

Holeksa et al. 2016, Forest Ecology and Management

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!

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- Triin Reitalu, Heikki Seppä, Shyinya Sugita, Mihkel Kangur, Tiiu Koff, Eve Avel, Kersti Kihno, Jüri Vassiljev, Hans Renssen, Dan Hammarlund, Maija Heikkilä, Leili Saarse, Anneli Poska & Siim Veski. 2013. Long-term drivers of forest composition in a boreonemoral region: the relative importance of climate and human impact. *Journal of Biogeography* 40(8): 1524–1534.