**Preliminary Integration of Satellite and Forestry Inventory Data to Predict Fire Hazard in Estonian Forests**

**Introduction/Aim:**

Forests are vital ecosystems threatened by increasing disturbances due to global climate change, playing a crucial role in sustaining biodiversity, biogeochemical cycling, climate regulation, and various human activities. In the Baltic states, forests cover 43% of the total land area, with Estonia alone accounting for 63% of its land area, exhibiting a growth trend since 2000. Nevertheless, forests in the Baltic region face challenges posed by climate change, human settlements, and historical land use practices such as agricultural clearance and abandonment. These disturbances can significantly alter forest composition and functioning, affecting carbon sequestration capabilities.

Therefore, understanding and predicting fire hazards in Estonian forests is critical for effective forest management and conservation efforts. In this context, satellite-based and forestry inventory data were integrated to predict fire hazard classes in Estonian forests, using various modelling approaches.

**Methods:**

A Sentinel-2 collection including all images during the summers of 2018 and 2019 was created; we considered the historical average dates (i.e., between 4th June and 5th September) for the summer season for this filter. From this collection, the average value of 11 vegetation indices (VI) containing red, green, near-infrared and red-edge data was calculated and extracted for each entry. In addition, the same procedure of zonal statistic was employed on the Canopy Height Models (CHM) provided by the Estonian Land Board to obtain structural descriptors of the forest stands. Finally, we trained RF classification models to discriminate fire danger classes using forestry inventory, Sentinel-2 VIs, and ALS CHMs. We divided the datasets as follows: the multispectral dataset, which contained vegetation indices and their derived metrics (CV and GLCM dissimilarity); the CHM dataset, which contained height mean, CV, and dissimilarity of structural descriptors; and one dataset, integrating both of them.

**Results:**

The dataset included 251,738.2 hectares and 203,459 entries. Overall, 34.4% of plots were considered "low" fire hazard ("IV"). The dataset comprises 8.9% "very high", 14.8% "high", 27.5% "intermediate", and 14.4% "very low". The integrated dataset had the highest performance among the evaluated models. The average classifier accuracy was 73.2%. This fire hazard classifier was the most accurate, with 100% accuracy for class 1 and 74.5% for class 4. Class I fire hazard was the best detected. Class IV had the lowest and most inconsistent detection rates. The strongest contribution VIs were RTVI and SRRE. NDVI and OSAVI were unimportant for fire danger modelling. Models using ARVI2 and MSR670 dissimilarity indices had moderate performance. Lastly, CHM-based metrics enhanced model performance slightly but were crucial.

**Conclusion:**

Integrating multiple data sources, including satellite imagery and forestry inventory data, enabled us to understand moderate fire hazard dynamics in Estonian forests. Robust monitoring and management strategies are essential to mitigate disturbances' impact. Future research should explore the exclusive utilization of satellite optical data and incorporate drone data for enhanced monitoring and validation of fire hazard assessments.