Impacts of European spruce bark beetle (*Ips typographus*) on Norway spruce (*Picea abies*) BVOC emissions

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Spruce bark beetles are causing large disturbances to forests in Europe, with increases in forest disturbance up to 600% during the twentieth century compared to 1971-1980, and a projected increase of around 760% by 2030[1]. Bark beetles normally seek and then attack Norway spruces with lowered defense, i.e. trees that are wind-felled or experience prolonged drought stress[2]. However, since the number of bark beetles are increasing the possibility of attacking already healthy trees is increasing, making them a larger threat to forestry, as well as, to the climate in terms of carbon sources to the atmosphere[1,2]. Norway spruce trees normally defend themselves by drenching the beetles in resin. The resin in turn contains different biogenic volatile organic compounds (BVOCs), which can vary if the spruce is attacked by bark beetles or not, however, only a few studies so far have investigated this phenomenon[2,3].

BVOCs are naturally emitted to the atmosphere by terrestrial plants and other organisms. The majority of the emissions from the biosphere are contributing to around 5-10% of the total carbon exchange to the atmosphere[4]. BVOCs are generally considered hydrocarbon trace gases, excluding methane, and the naturally emitted BVOCs constitutes about 85% of the total atmospheric volatile organic compounds (VOCs)[5]. They are emitted from both above- and below-ground and from different plant organs[4]. Several different compounds of BVOCs exist, like terpenoids (isoprene, monoterpenes and sesquiterpenes). The most abundant compounds are the group of terpenoids, which are most commonly emitted from conifers, such as Norway spruce[5].

The forest surrounding the ICOS station in Hyltemossa consists mostly of Norway spruce trees making it an ideal area for this study[6]. To analyze the bark beetles' impact on Norway spruce trees a method was developed using tree trunk chambers and adsorbent tubes. Three different sites with different environmental conditions were chosen, the first site with higher elevation and thus assumed a drier soil, the second with lower elevation and wetter soil and a third site located next to a lake surrounded by deciduous trees. Four spruces on each site were chosen for the analysis. The measurements were and will be performed from May to October to capture the full season of the bark beetle outbreaks. This includes measurements taken diurnally with three measurements per spruce during these campaigns. Filtered air was flushed through the chamber and the BVOCs extracted into the tubes using a pump system. The tubes will be analyzed in a lab using an automated thermal desorber coupled to a gas chromatograph and a mass spectrometer to determine retention times and mass.

Due to the timeframe of the study being the summer season of 2019, the first samples have not yet been analyzed and there are thus not yet comprehensive results. However, three trees were already infected with bark beetles between the first two campaigns, making a comparison of BVOC emissions for healthy and infested spruce trees possible. Lab analysis will be initiated within the coming weeks, and a first draft of results will be expected as soon as October. Anticipated results include different BVOC compounds and emissions from Norway spruces suffering from bark beetle infestation compared to healthy spruces not infested with bark beetles. This data will facilitate better comprehension of how afflicted spruce trees are affected by insect stress from bark beetles, and if bark beetle infestation will result in a carbon source into the atmosphere in the form of BVOCs, thus filling some knowledge gaps as this has not yet been fully investigated using chamber techniques in Sweden.

References

[1] Seidl, R., Schelhaas, M., Rammer, W., & Verkerk, P. (2014). Increasing forest disturbances in Europe and their impact on carbon storage. Nature Climate Change, 4(9), 806-810. doi: 10.1038/nclimate2318
[2] Raffa, K. F. (1991). Induced defensive reactions in conifer-bark beetle systems. Photochemical induction by

herbivores. pp. 245-276
[3] Ghimire, R., Kivimäenpää, M., Blomqvist, M., Holopainen, T., Lyytikäinen-Saarenmaa, P., & Holopainen, J. (2016). Effect of bark beetle (Ips typographus L.) attack on bark VOC emissions of Norway spruce (Picea abies Karst.) trees. *Atmospheric Environment, 126*, 145-152. doi: 10.1016/j.atmosenv.2015.11.049
[4] Niinemets, U. and Monson, R. (2013). Biology, controls and models of tree volatile organic compound emissions. 5th ed. Springer. ISBN 978-94-007-6606-8
[5] Kesselmeier, J. and Staudt, M. (1999). Biogenic Volatile Organic Compounds (VOC): An Overview on Emission, Physiology and Ecology. Journal of Atmospheric Chemistry, 33(1), pp.23-88
[6] ICOS Hyltemossa (2019). Retrieved from https://www.icos-sweden.se/station_hyltemossa.html