# **Wildfire** as an interplay between water deficiency, manipulated tree species composition and bark beetle.

## *A remote sensing approach*

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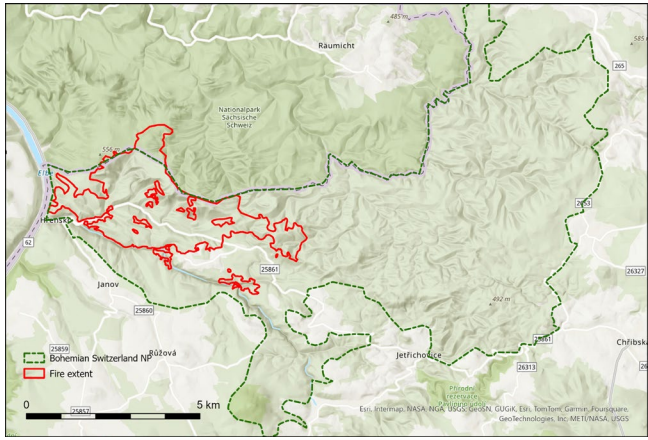
Faculty of the Environment

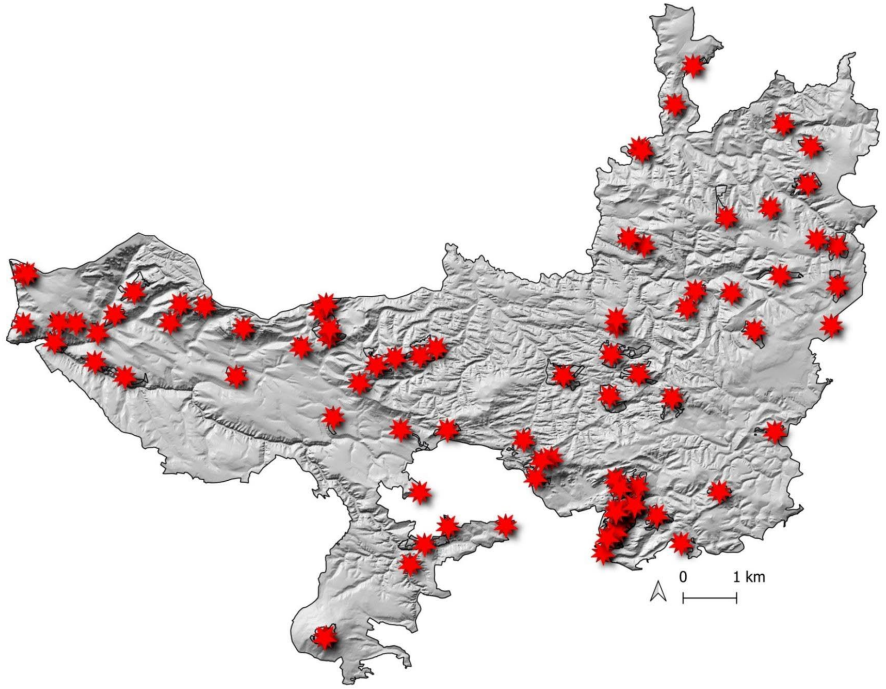
# Bohemian and Saxon Switzerland NPs

- border of Czech Republic and Germany
- sandstone area with rough topography formed of sandstone towers and deep narrow canyons
- covered by deep forests, originaly dominated by beech (*Fagus sylvatica*) with scattered fir (*Abies alba*), pine on the exposed and dry sandstone outcrops (Pinus sylvestris), and Norway spruce (*Picea abies*) only in the deep shaded cool and wet canyons (climatic inversion)
- but, manipulated tree species composition from the 19th century: plantations of N. spruce and alien invasive white pine (*Pinus strobus*) (mainly on Czech side)



# Background

- wildfires are rather uncommon in Central Europe, however, not in Bohemian Switzerland NP, Czech Republic
- In 2022 summer, NP was affected by the largest wildfire in the modern history of the country (1300 ha, 20 days of firefighting, over 700 fireman involved)
- few days later expanded accross the border to German Saxon Switzerland NP




*Adámek M. et al. (2015) Forest Ecology and Management*

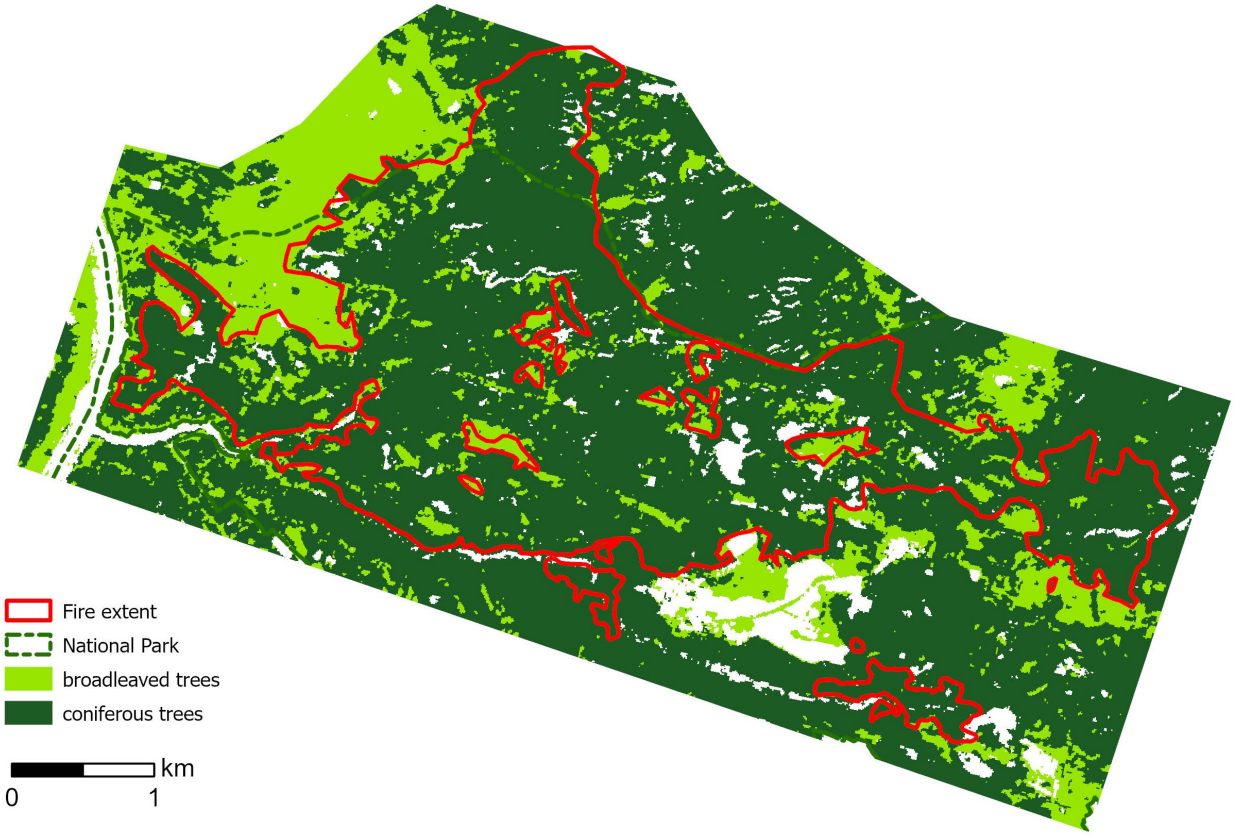
- wildfire occurence in 1982-2014 - 86 fires (2.7 per year)
- total burned - 35.6 ha
- mean size - 0.5 ha
- the largest recorded wildfire prior 2022 - 180 ha
- 2022 wildfire – 1100 ha

https://www.horosvaz.cz

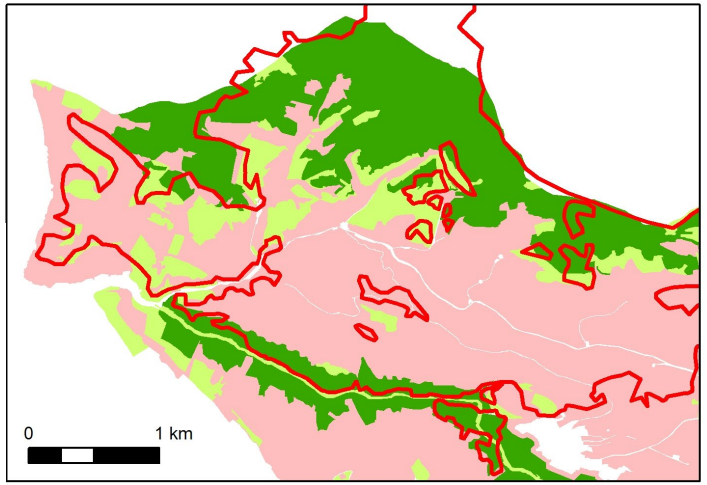
# Causes?

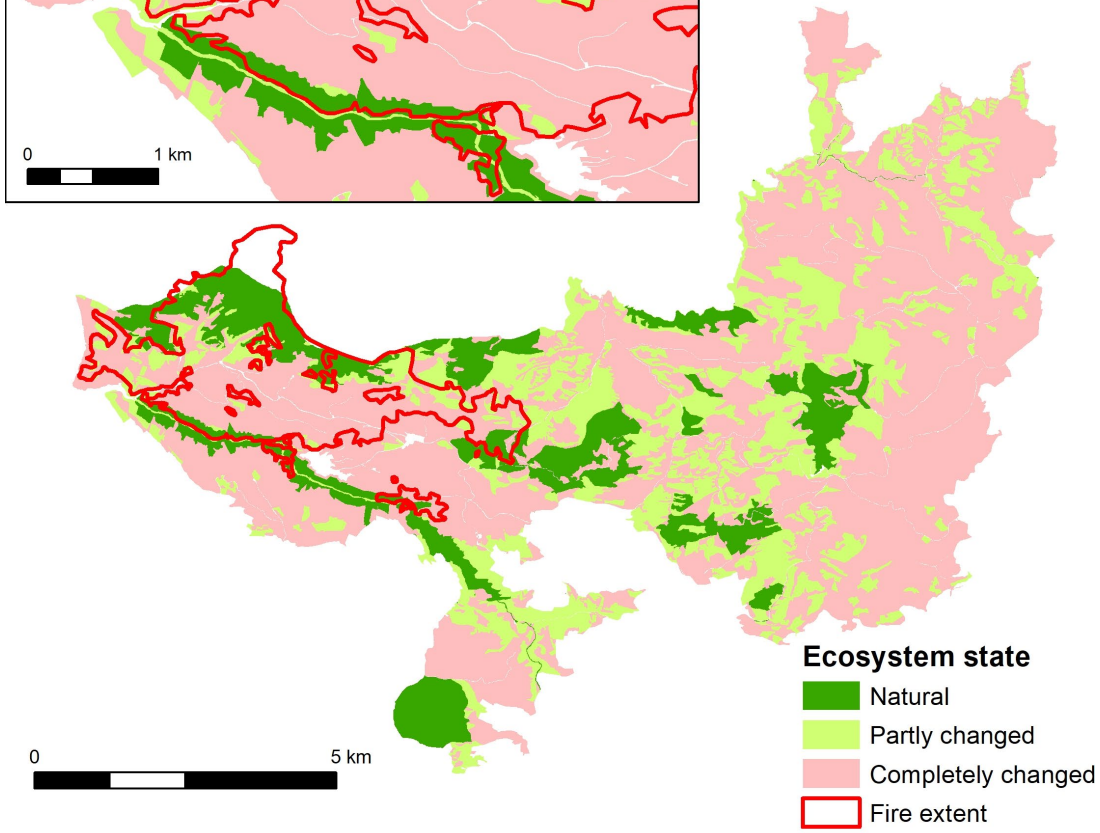
- Altered tree species composition

  SPRUCE (and white pine)




*Dominant Leaf Type (Copernicus Land monitoring service, 2018)*



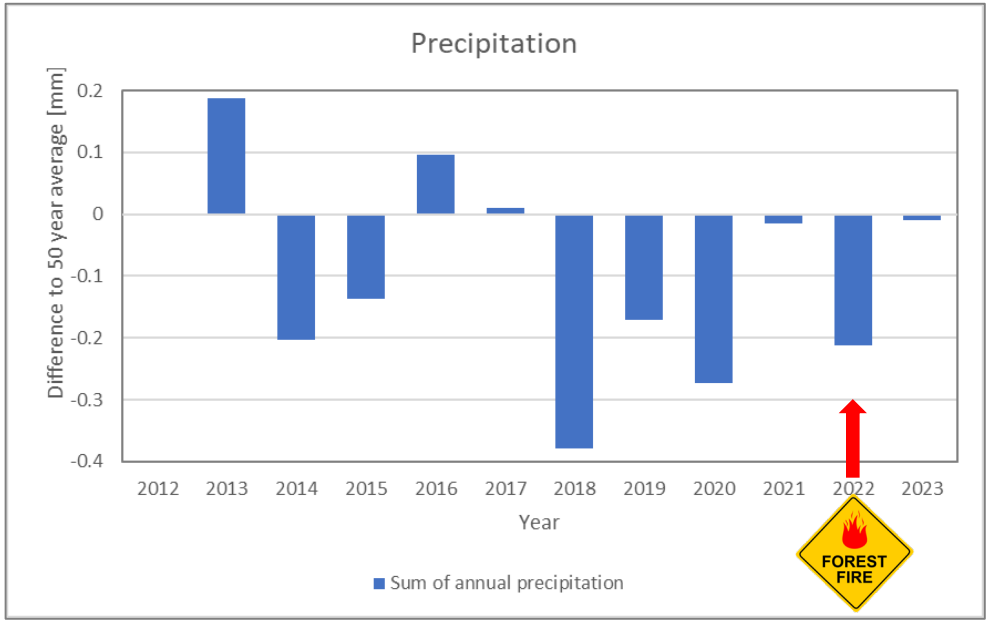



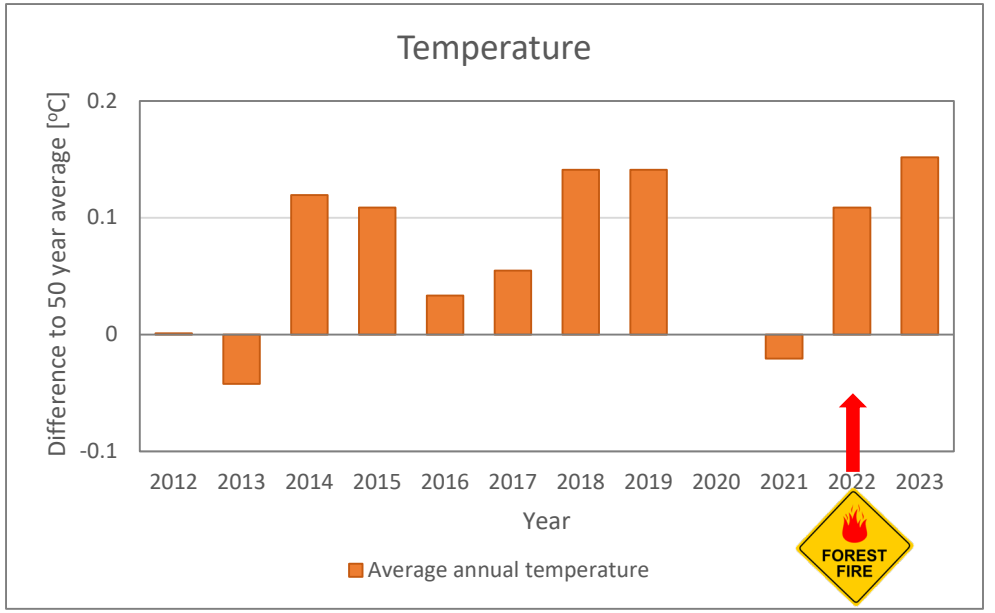

*NPČŠ (2019)*

# Causes?

- Weather extremes....

  SPRUCE + DROUGHT



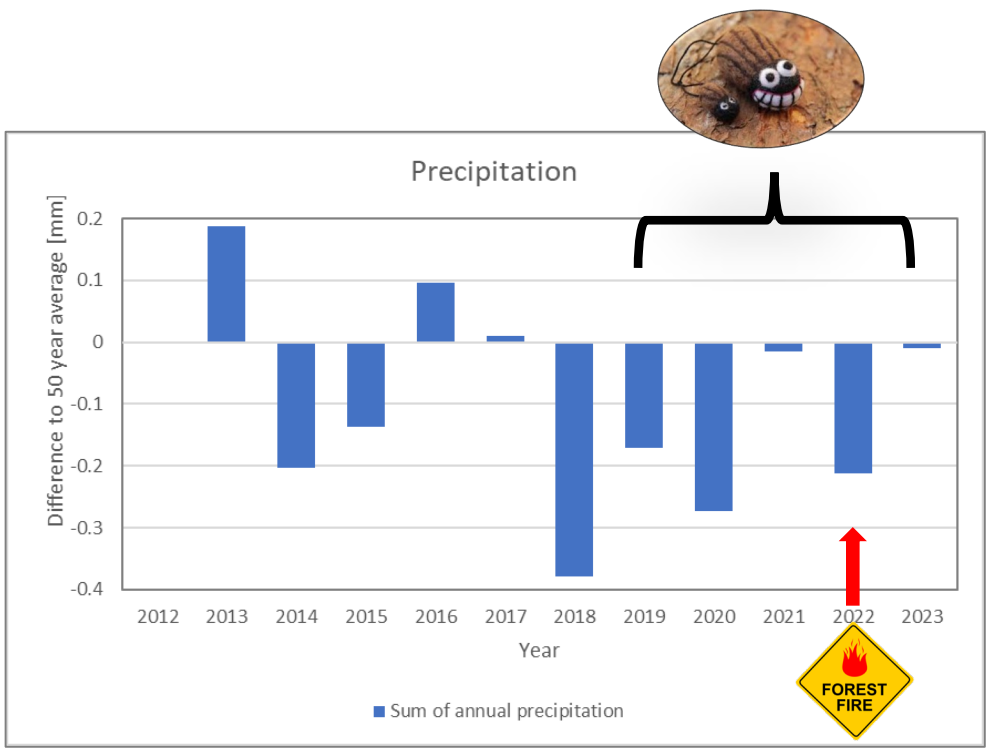



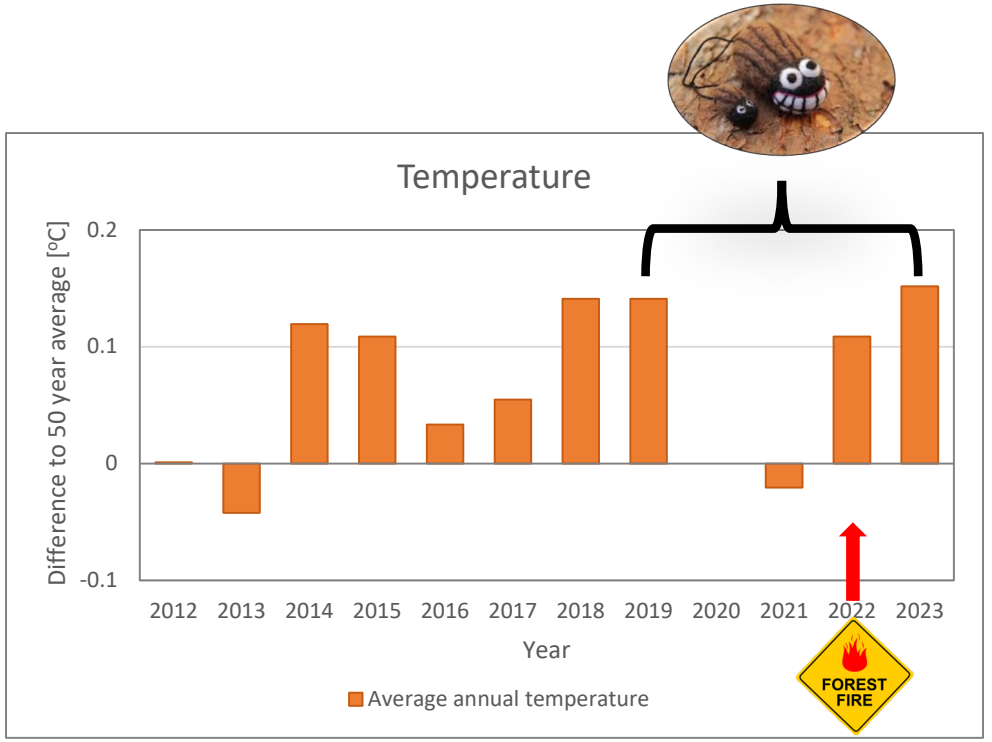

Source: Czech Hydrometeorological Institute, Děčín weather station

# Causes?

- Weather extremes....

  SPRUCE + DROUGHT + BARK BEETLE

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# Causes?

- Infestation....

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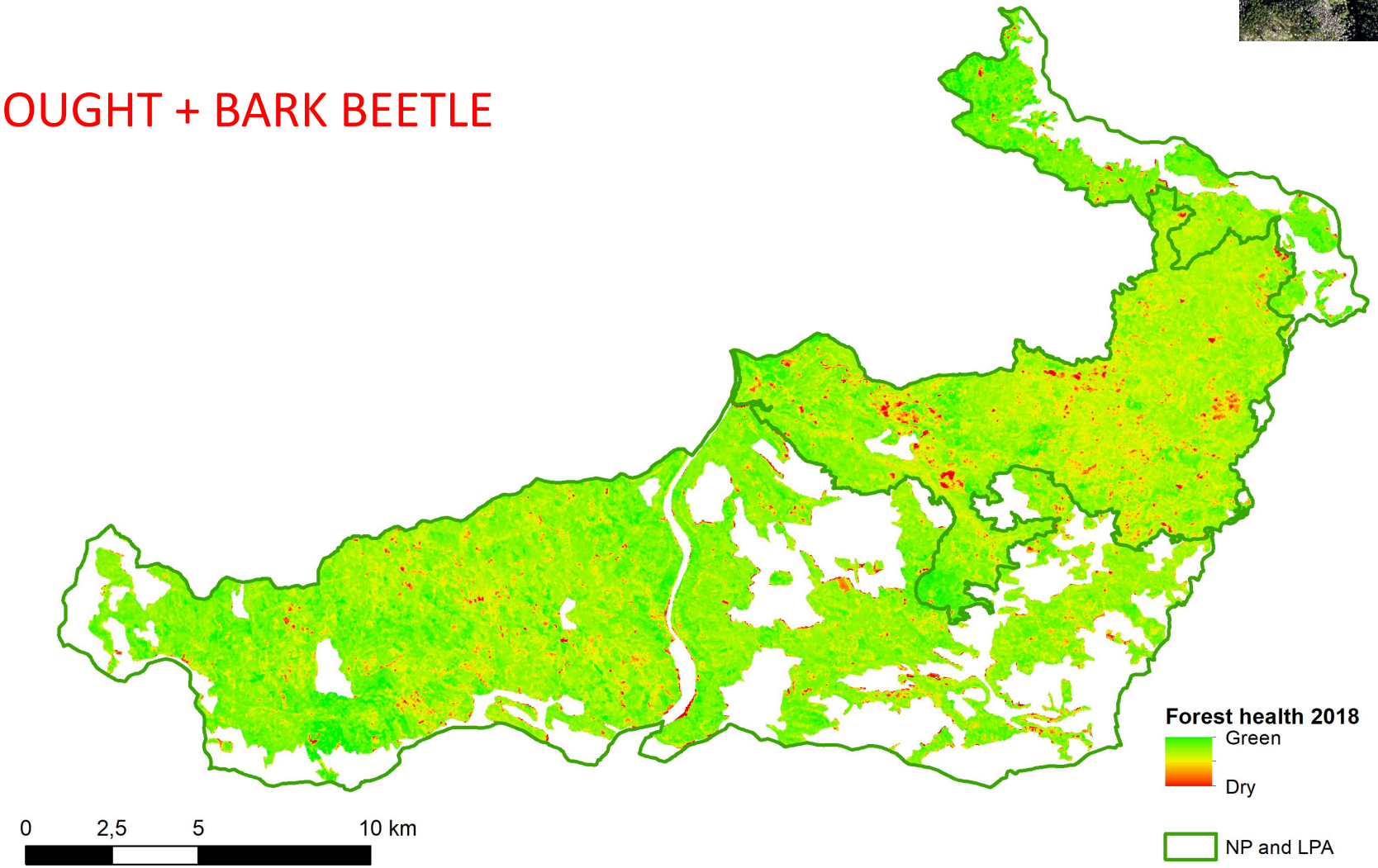


*N. spruce die-off in NP and LPA derived from Sentinel-2 time series (drop in maximum NDVI)*

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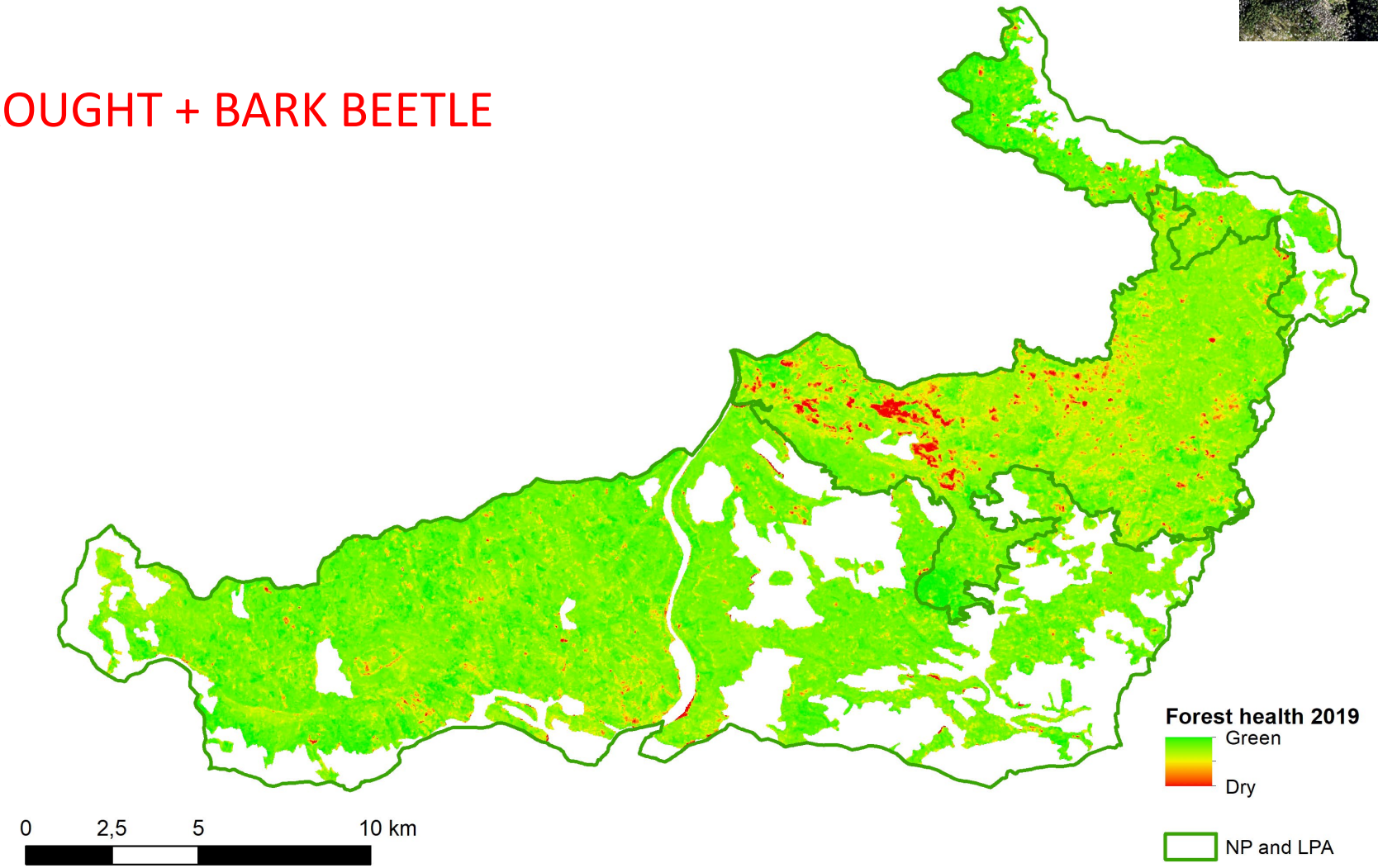


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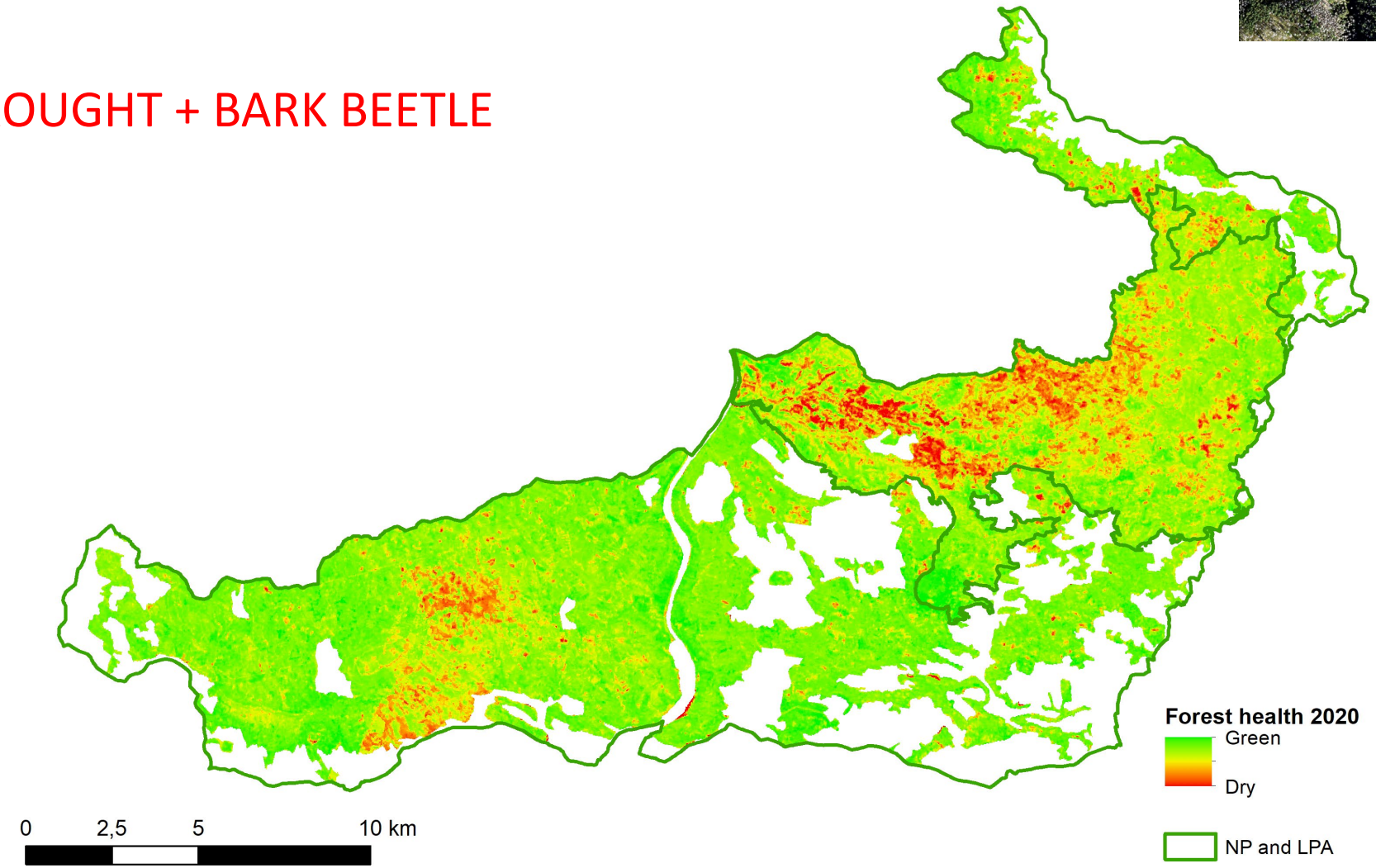


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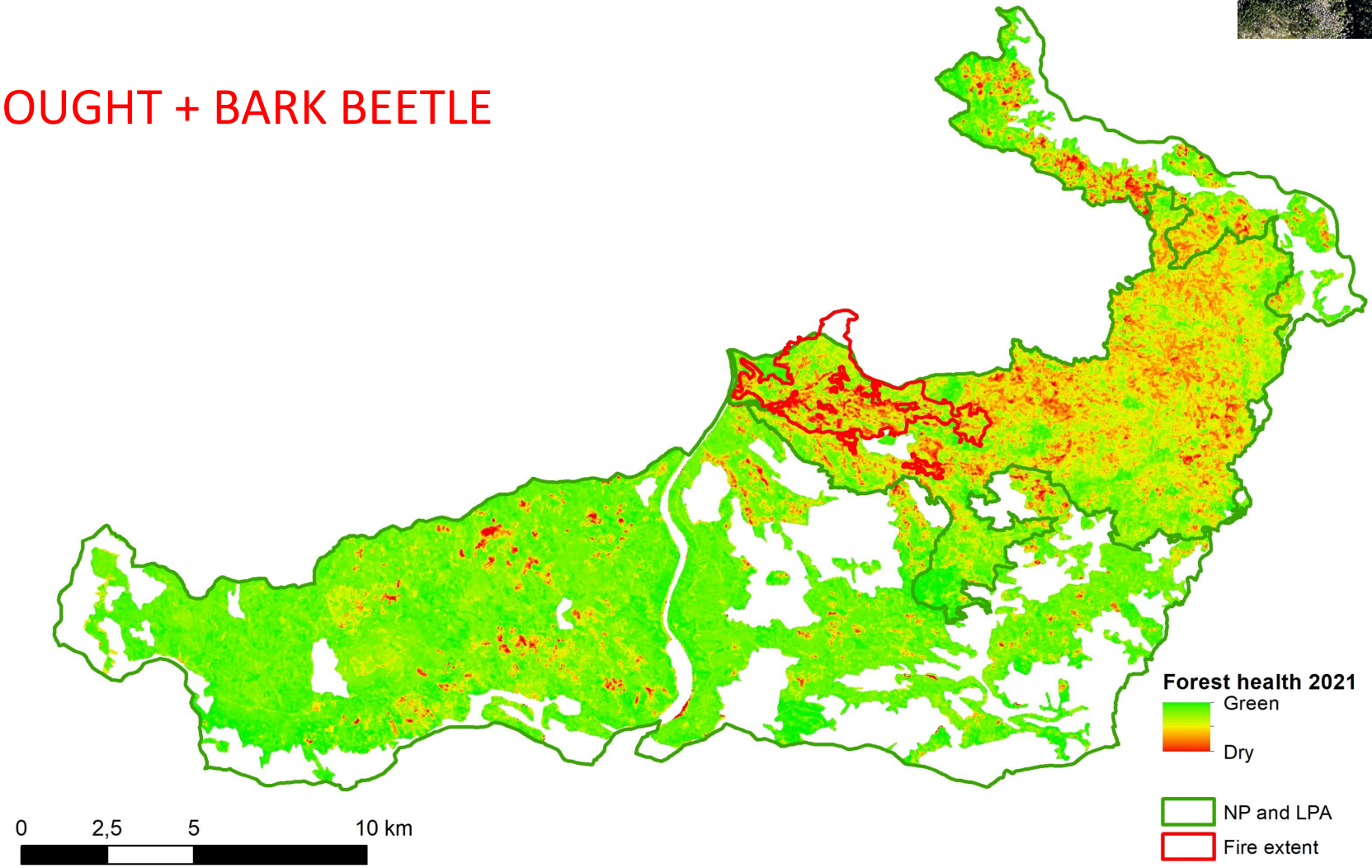



*N. spruce die-off in NP and LPA derived from Sentinel-2 time series (drop in maximum NDVI)*

## Datasets

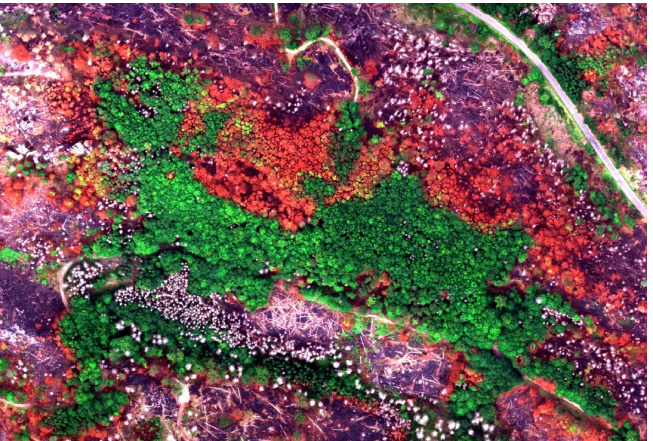
- RGB and multispectral imaging (aerial and drone)
- LIDAR (aerial and drone)
- field measurements
- Sentinel-2 satellite MSS imagery
- supporting data layers

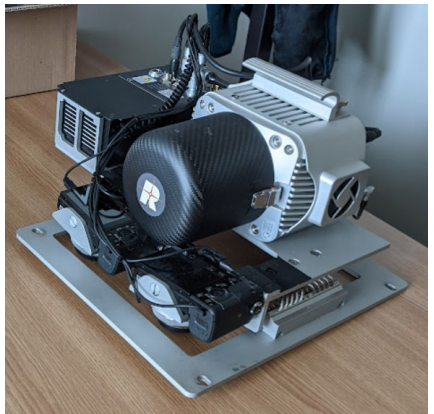
## Platforms

- adapted ultralight plane TL232 Condor (flying costs ca 1/5 of the „ordinary photogrammetric aircraft“)
- drone DJI Matrice 300 RTK

## Sensors

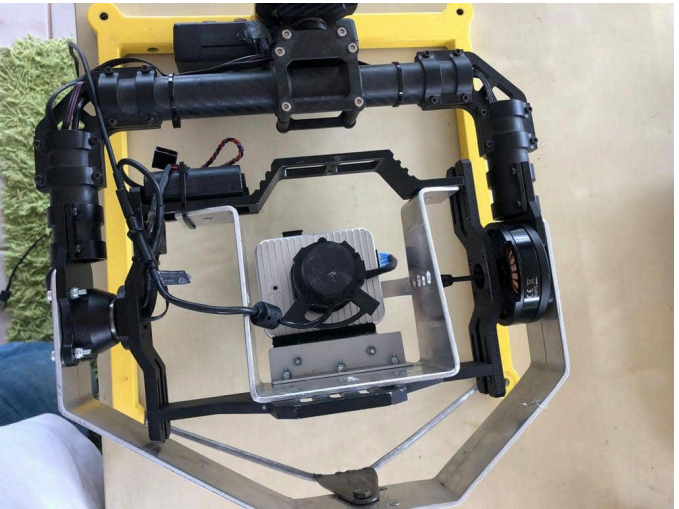
- multispectral - Micasense Altum camera, drone & plane mounted (FH ~ 600m, GSD 32 cm)
- RGB - Hasselblad A6D-100c medium format camera, plane mounted, FH ~ 700 m GSD 6.5 cm
- LIDAR - RIEGL VUX 1-LR, with two RGB cameras Sony Alpha 6000, plane mounted, FH ~ 300 m, 13 p/m$^2$
- LIDAR - DJI Zenmuse L1 - Livox Lidar module and RBG camera → full-col. point cloud, 3-axis stab. gimbal

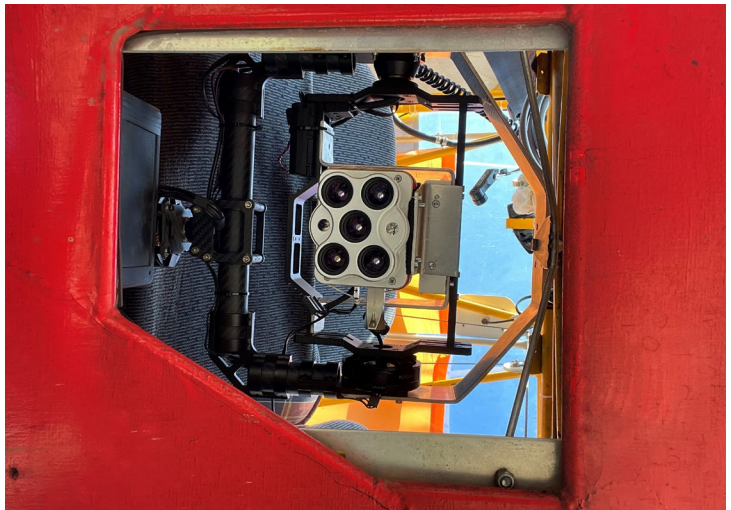


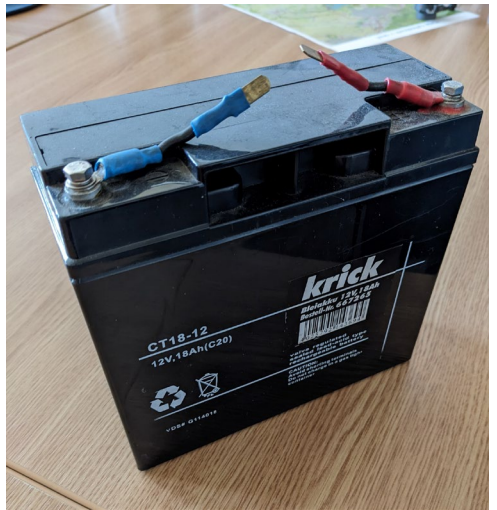


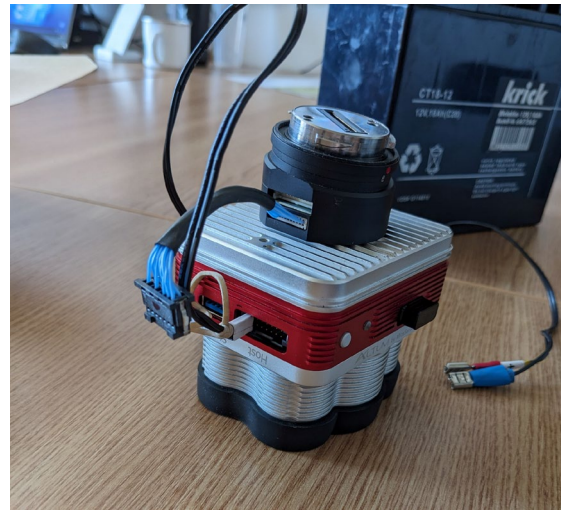
# Implementation of Micasense Altum

- Micasense Altum camera implemented onboard an ultralight plane TL-232 Condor
- implementation – solve power supply (external power source - 12V battery), design and build the customized gimbal, test the functionality, solve the automatic triggering of the imaging via WI-FI interface, etc
- but, lost sunshine sensor, GPS coordinates and acquisition time → future tests using skyport to keep the sensor functioning

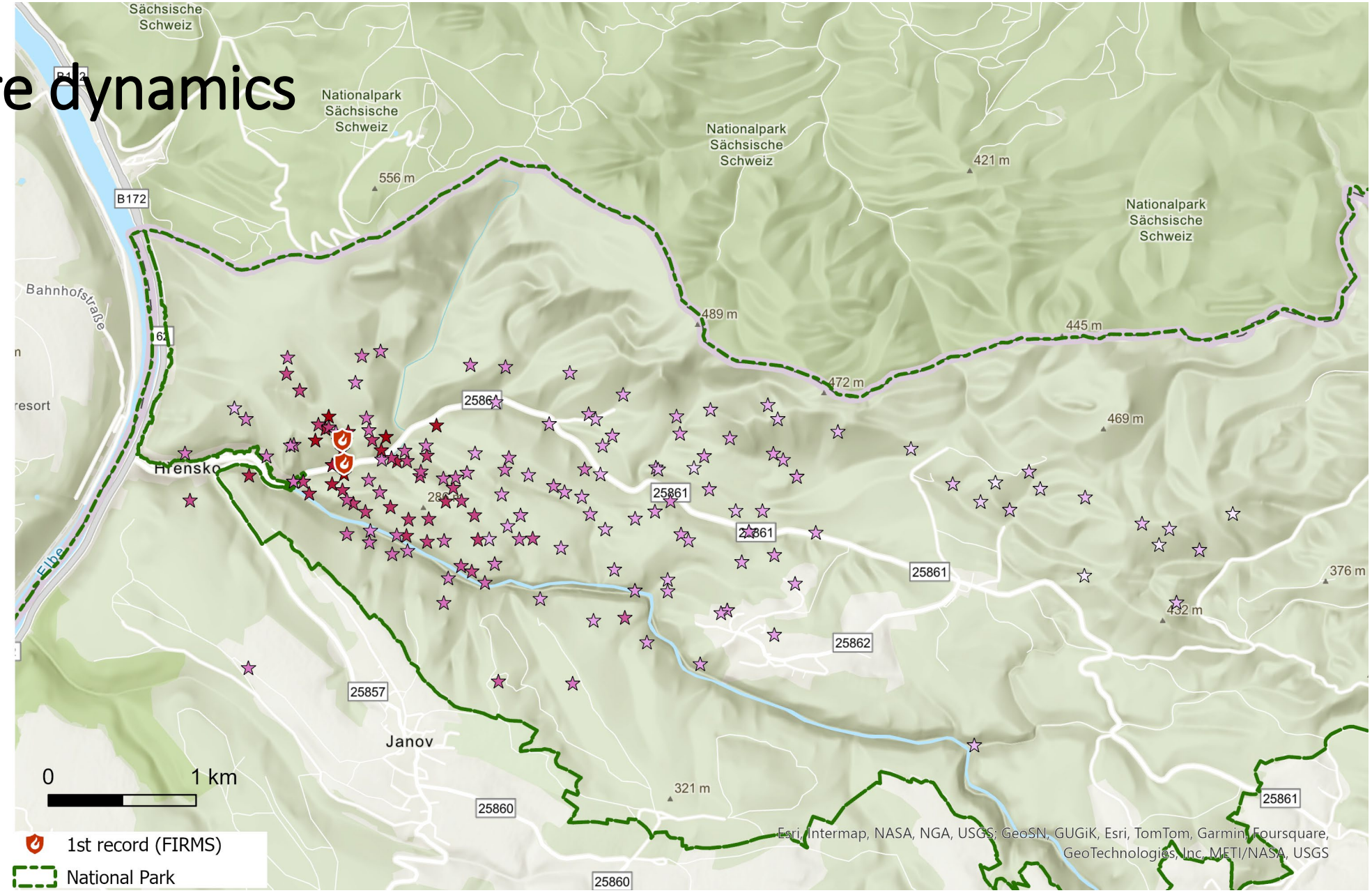






# Fire dynamics




*Fire Information for Resource Management System* (FIRMS, NASA, MODIS , VIIRS, 25 - 29 July 2023)

# Broadleaf trees and fire dynamics?

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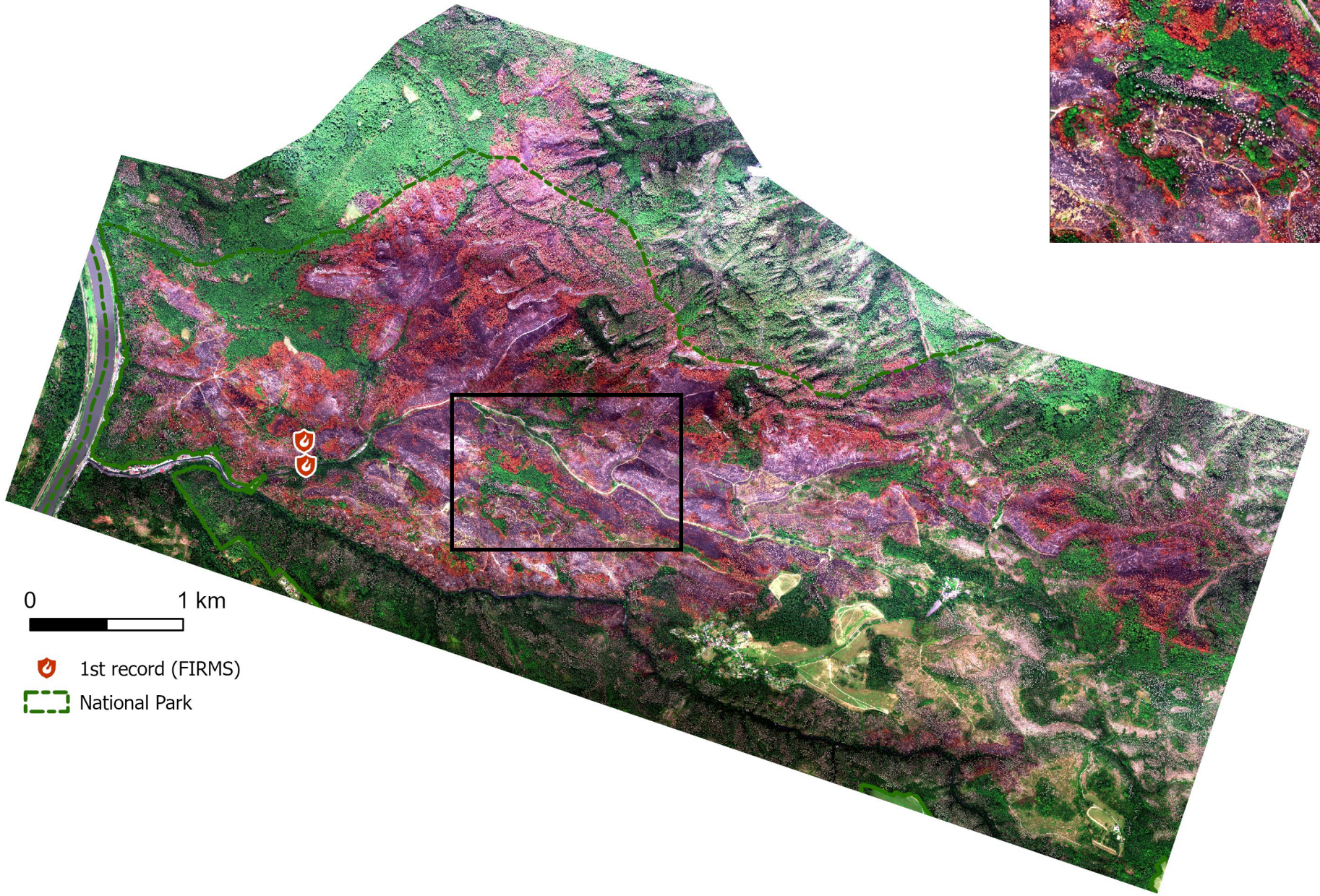


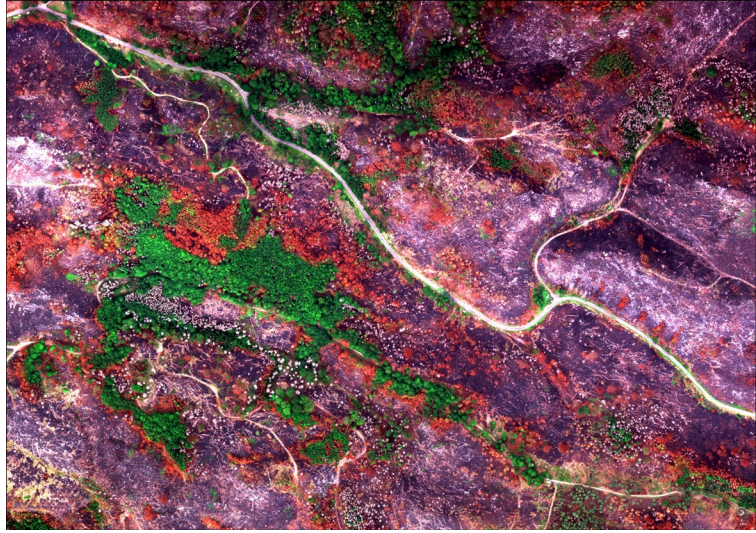

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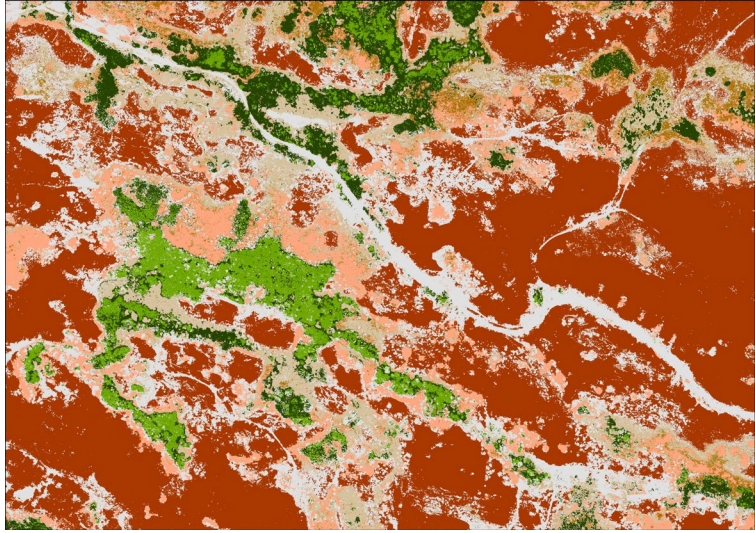
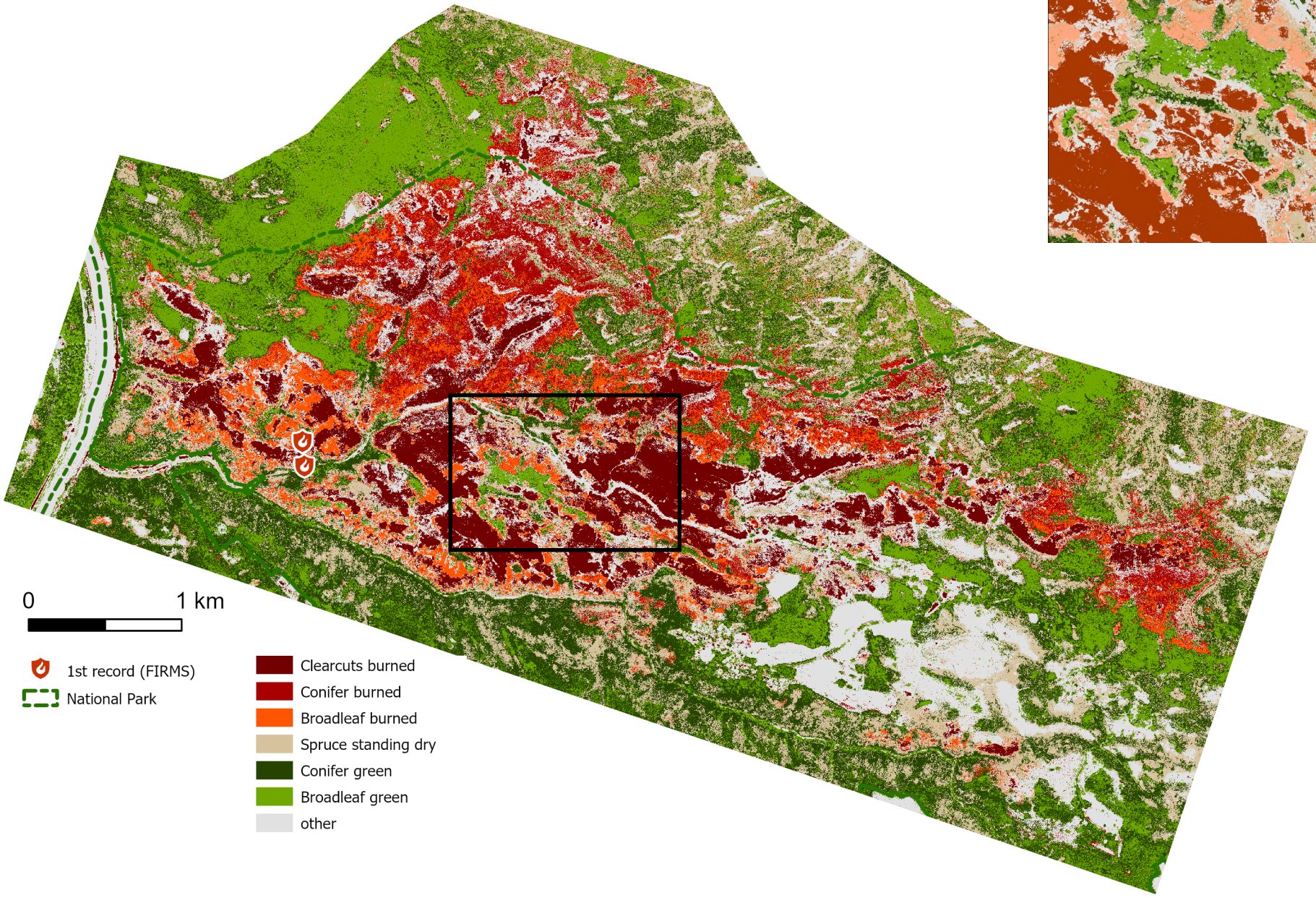
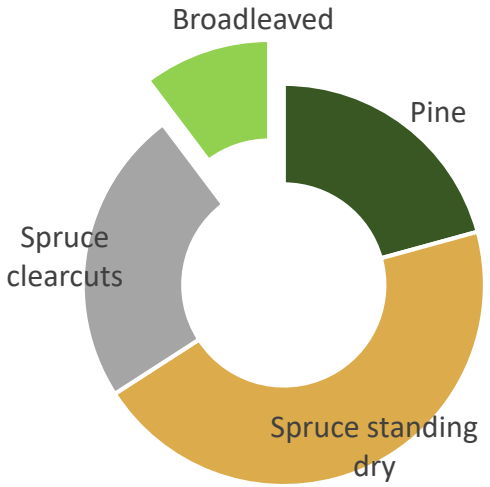
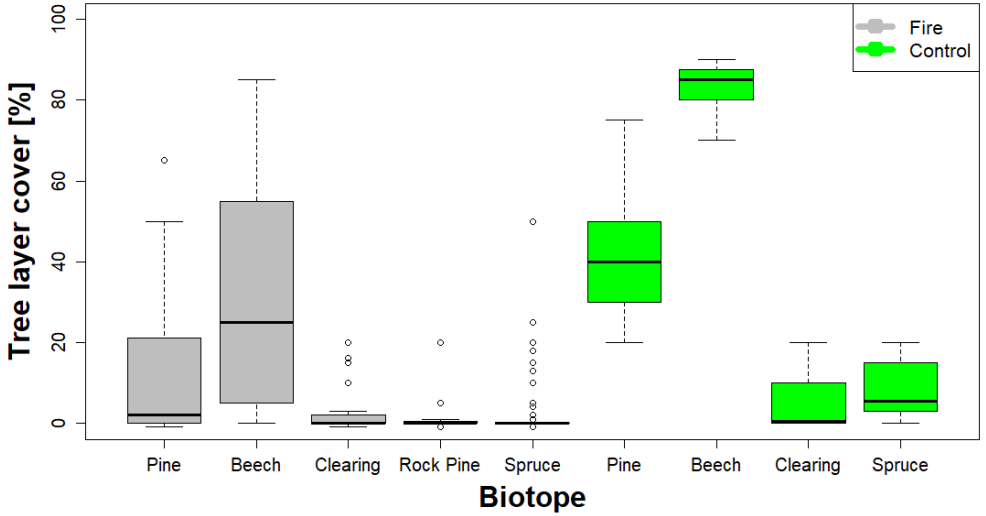


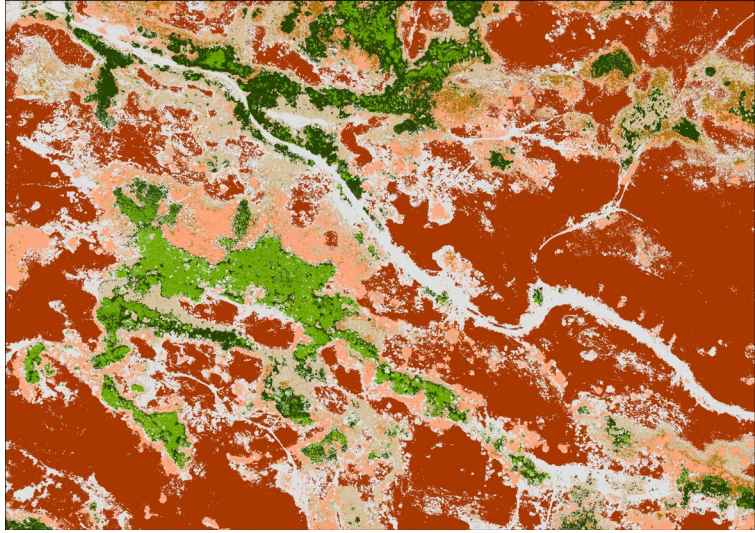


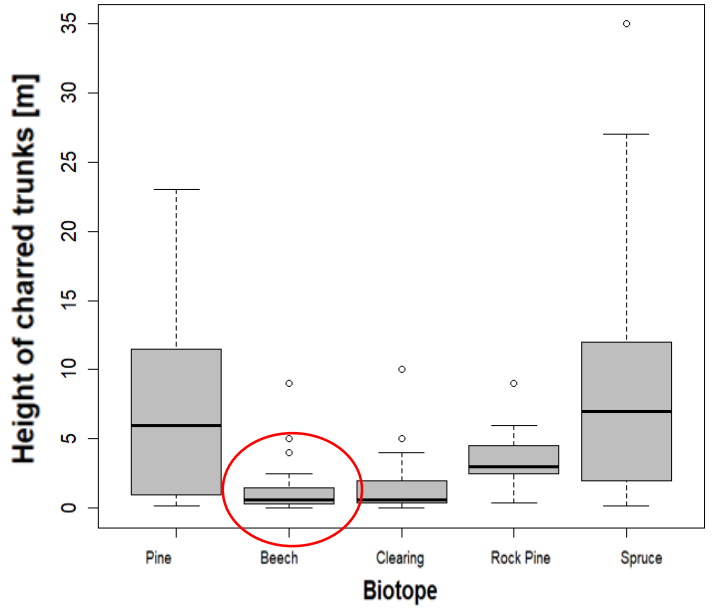
# Broadleaf trees and fire dynamics?

- Reduced risk of fire by native beech (only 14 % of deciduous trees burned)



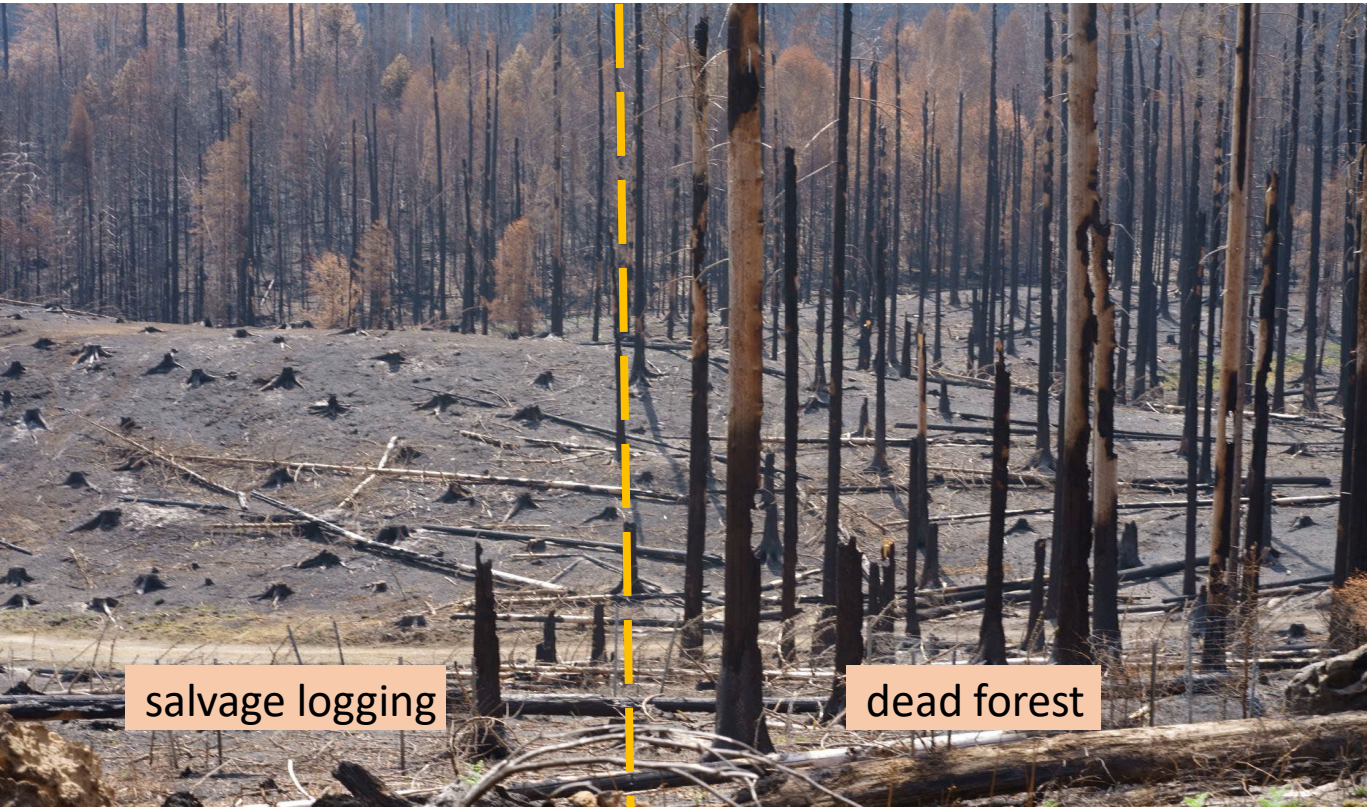



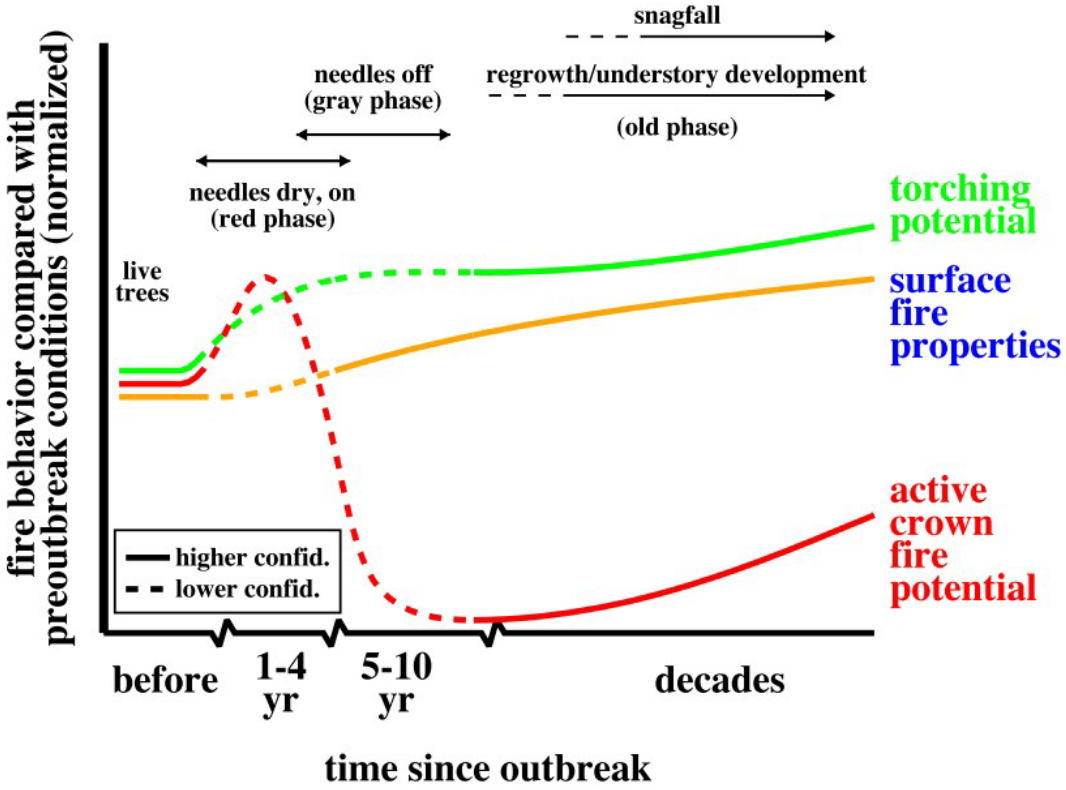





# Bark beetle and fire dynamics?

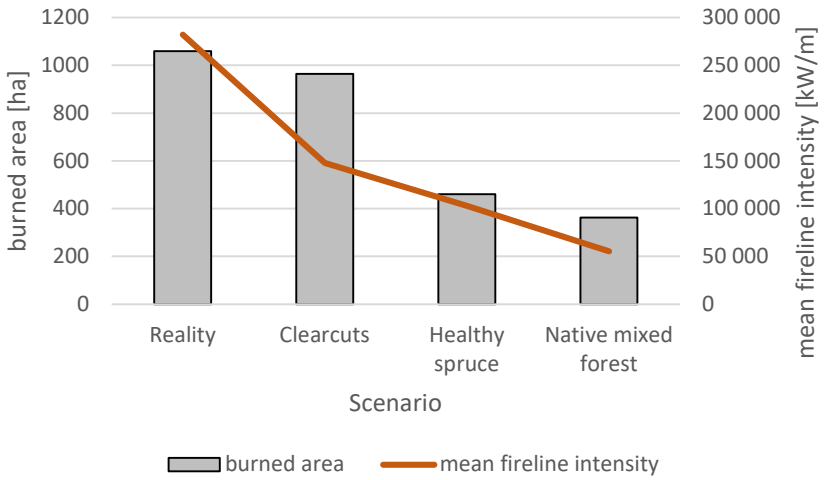
- Reduced risk of crown fire due to needle drop
- 36% of available wood fuel burned at maximum fire severity
- Dead biomass contributed to the increase in fire intensity,  but NOT to the fire spread
- What actually burned was an organic-rich topsoil...

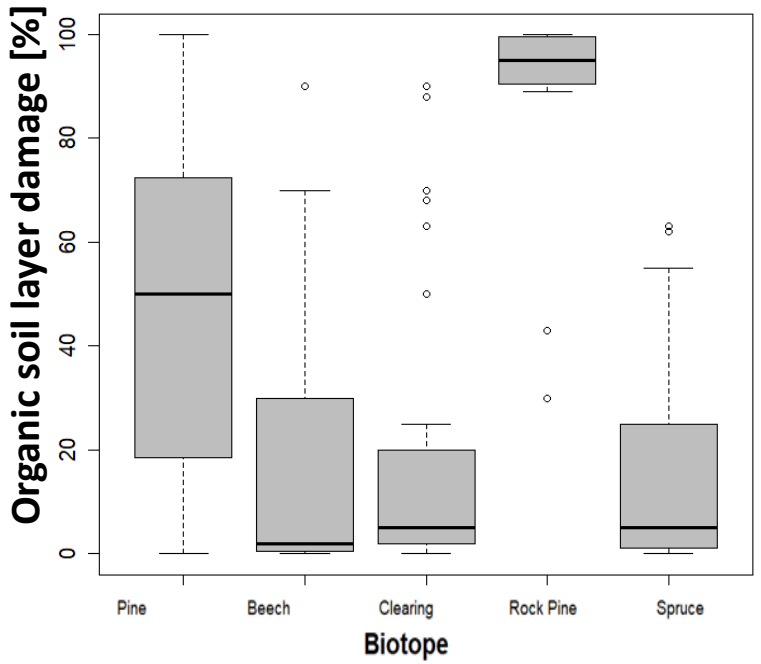


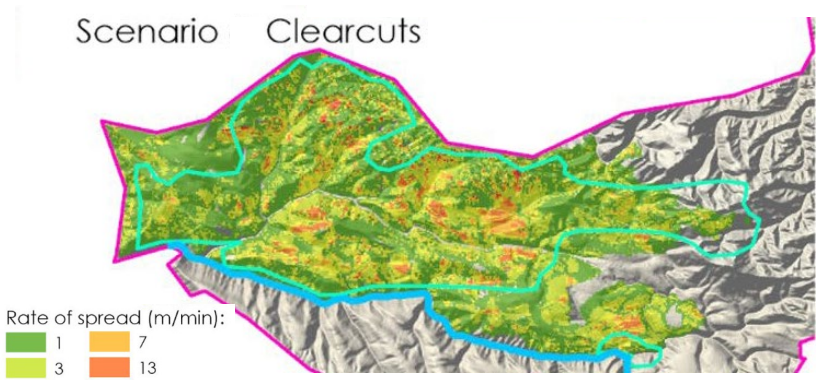



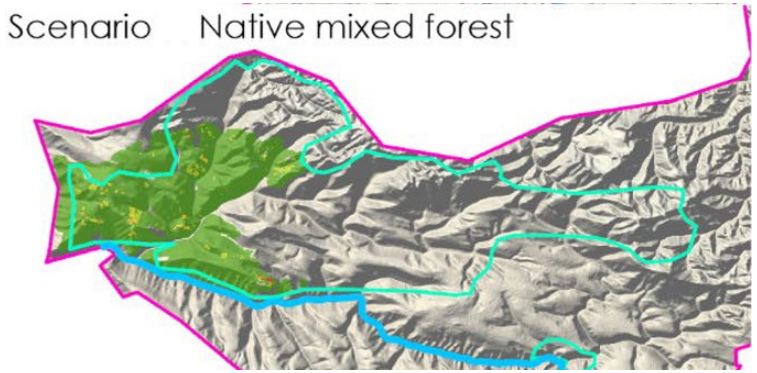

*Hicke et al. (2012). Forest Ecol Manag 271, 81-90*

# Would clearcuts stop the fire?



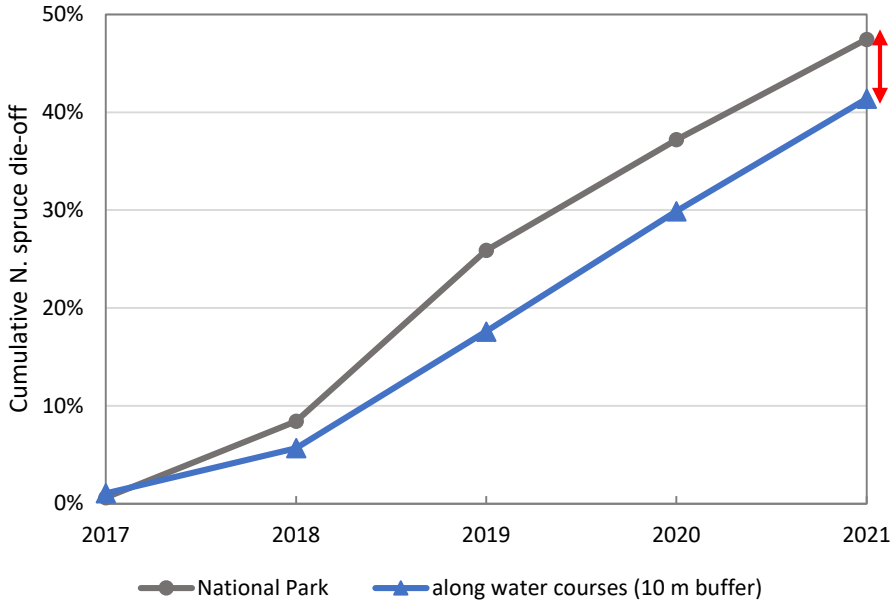


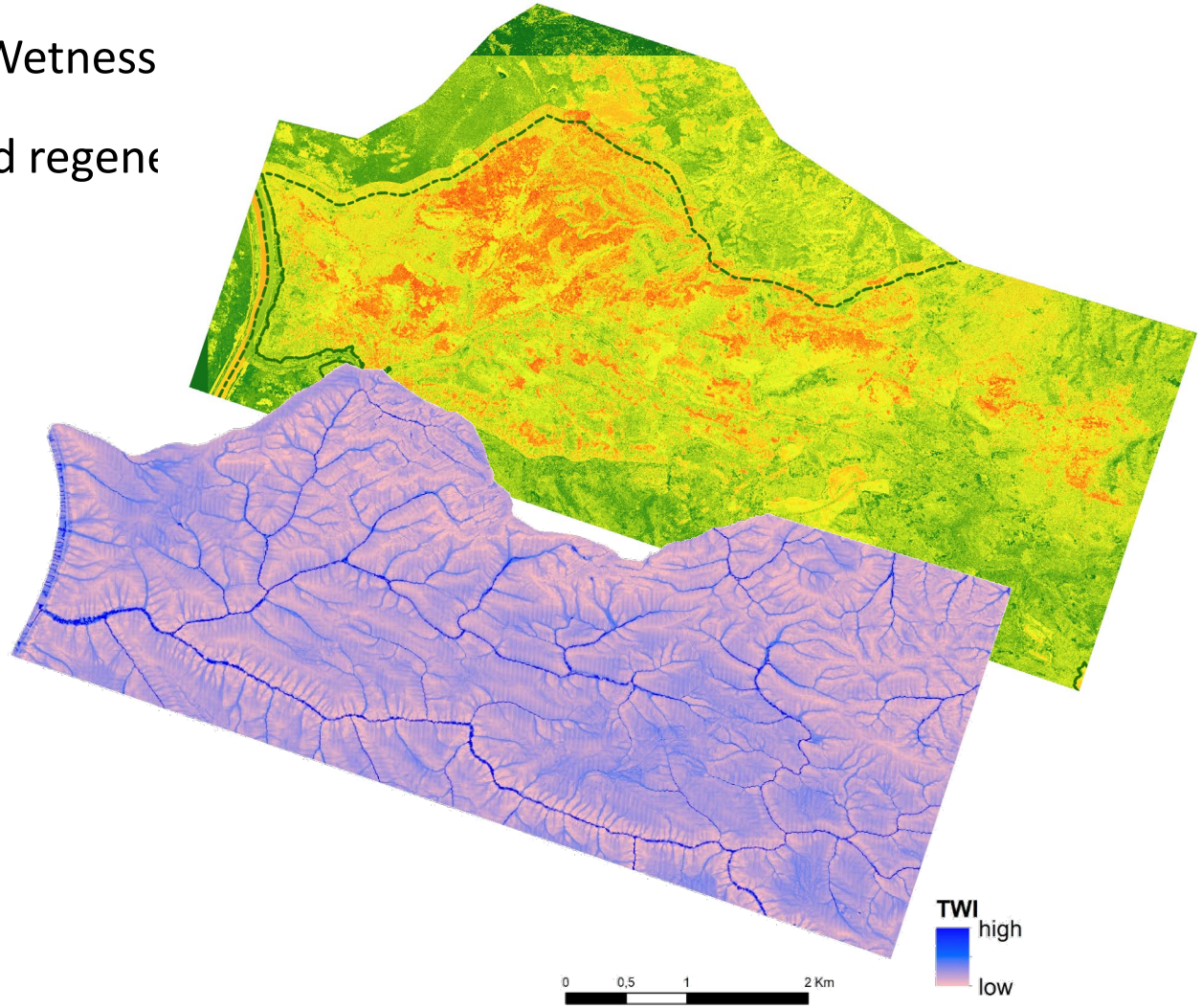

The fire modelled using FlamMap model under different scenarios, real fire extent in turquois (*Kudláčková et al., 2024, Natural Hazards)*

# Water availability and fire dynamics?

Water availability (waterlogged sites, Topographic Wetness

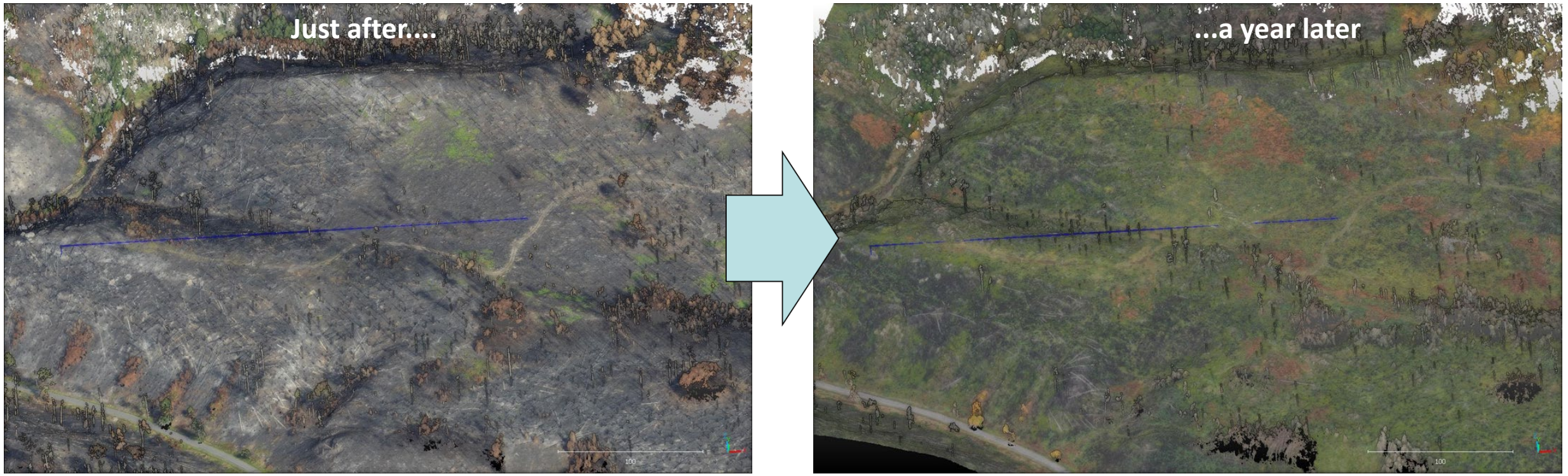
- only weak correlation with both fire damage and regene
- but, played a role in bark beetle calamity



# Post-fire regeneration

- regeneration after the disturbance is very fast




*Post fire regeneration – 3D visualization from aerial optical coloured point cloud*

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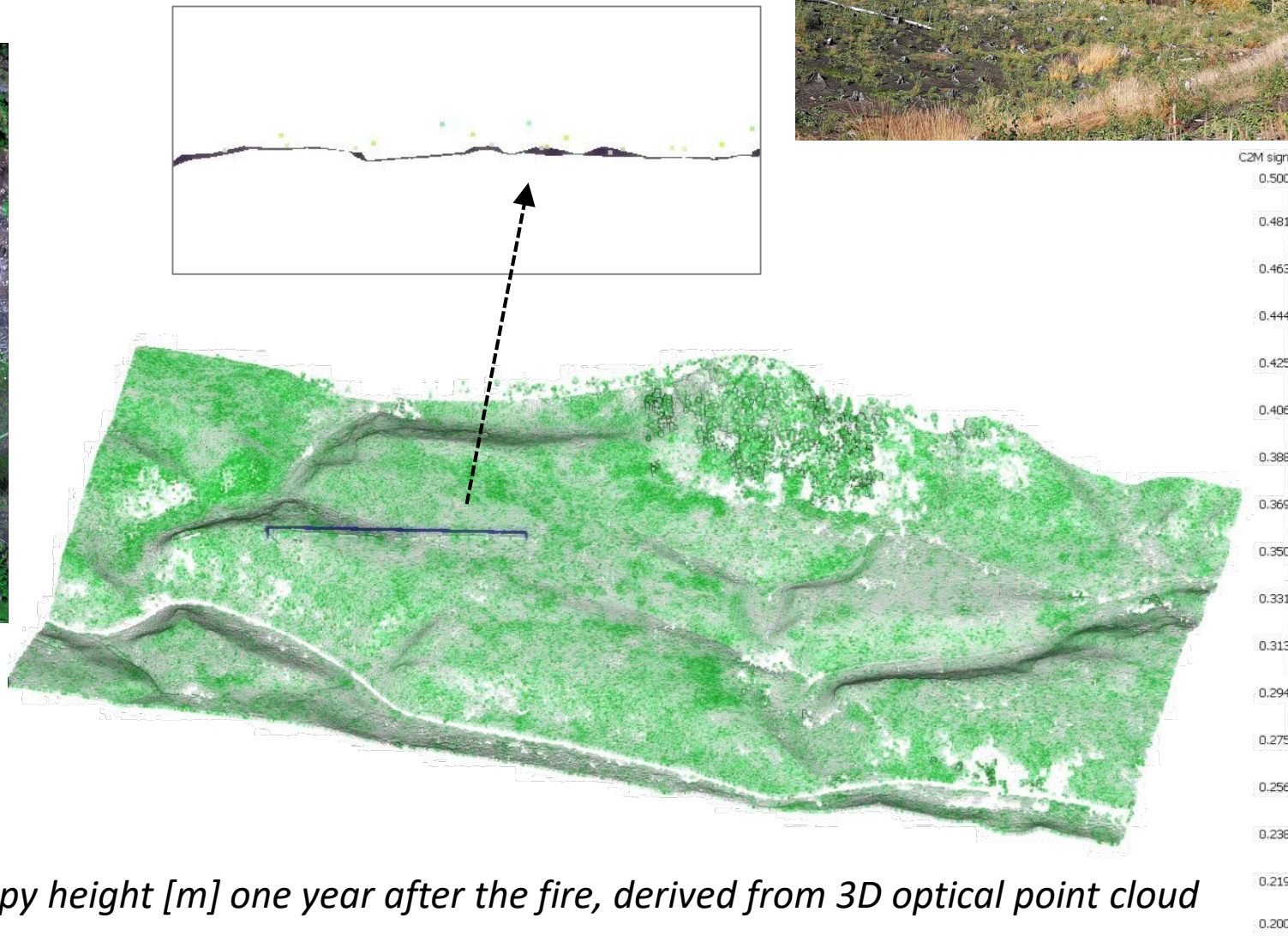


*Increase in canopy height [m] one year after the fire, derived from 3D optical point cloud*

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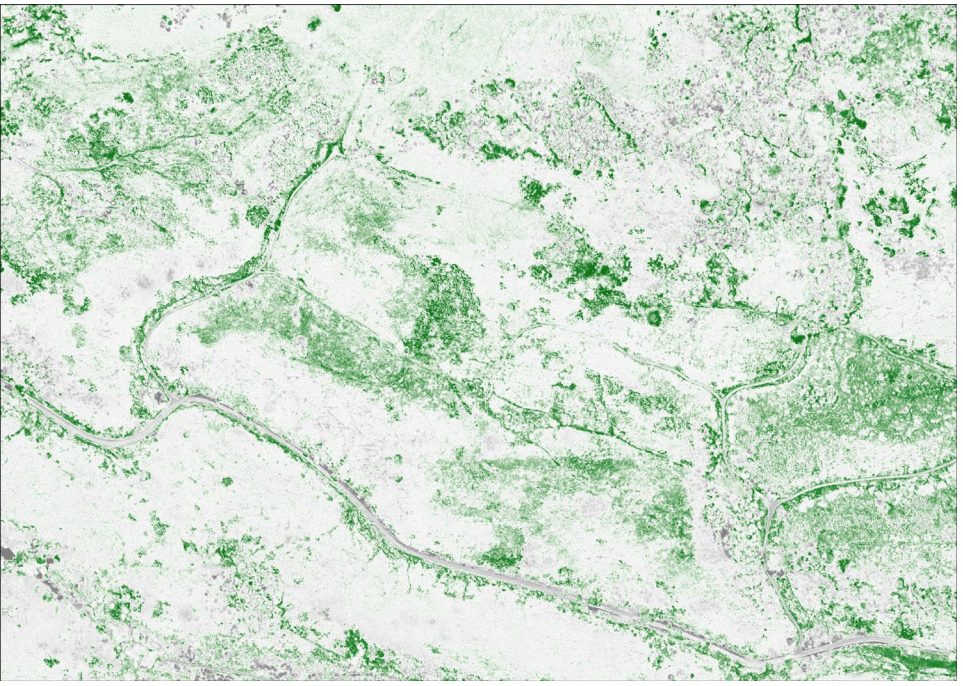
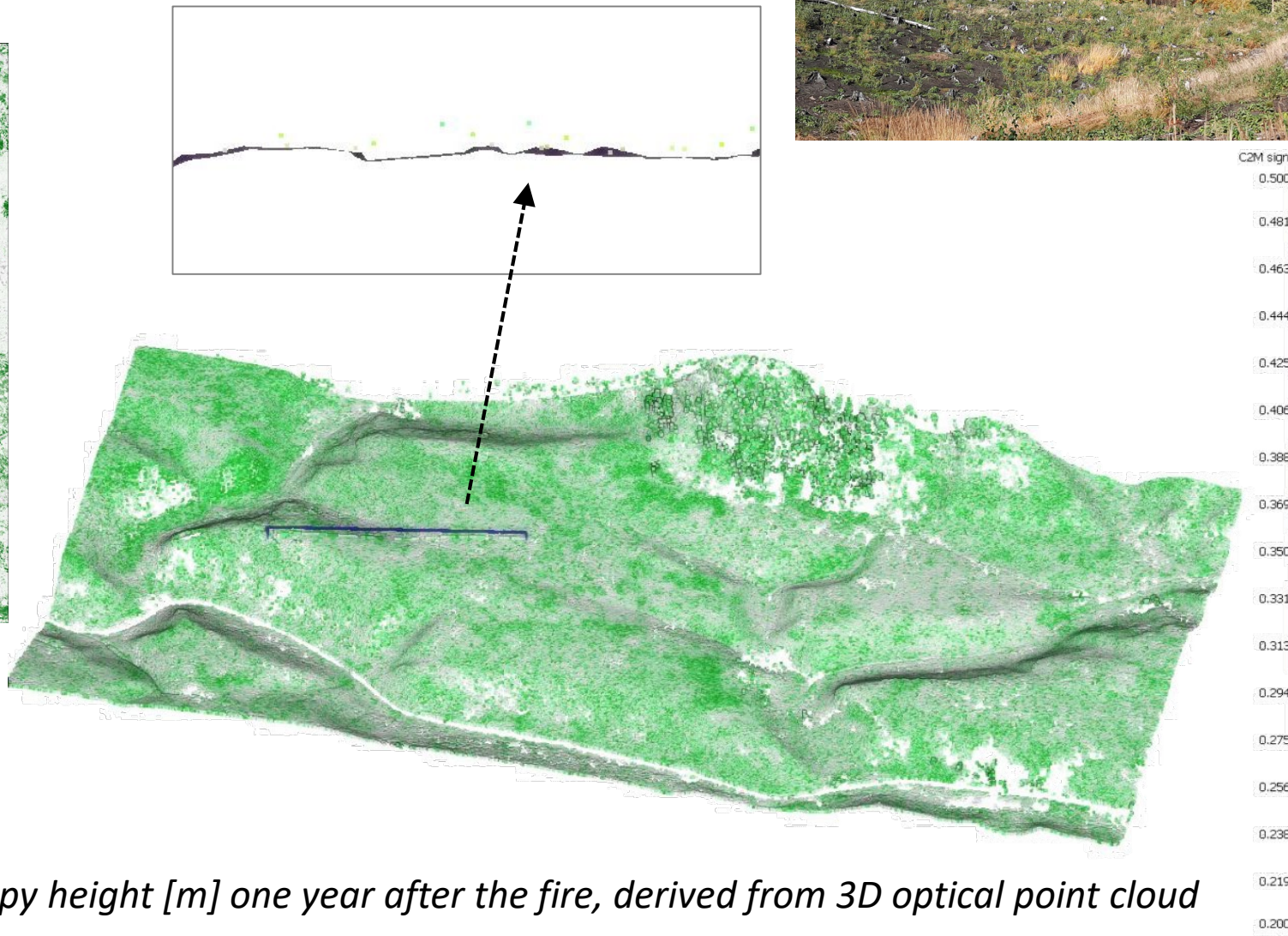
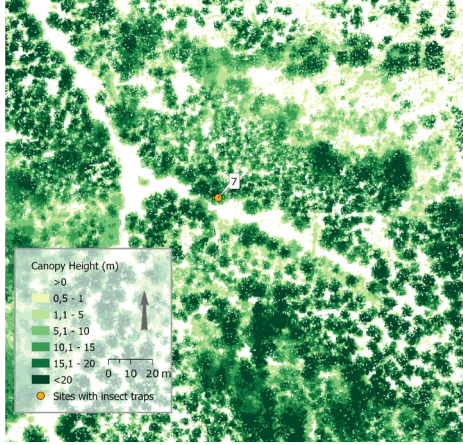


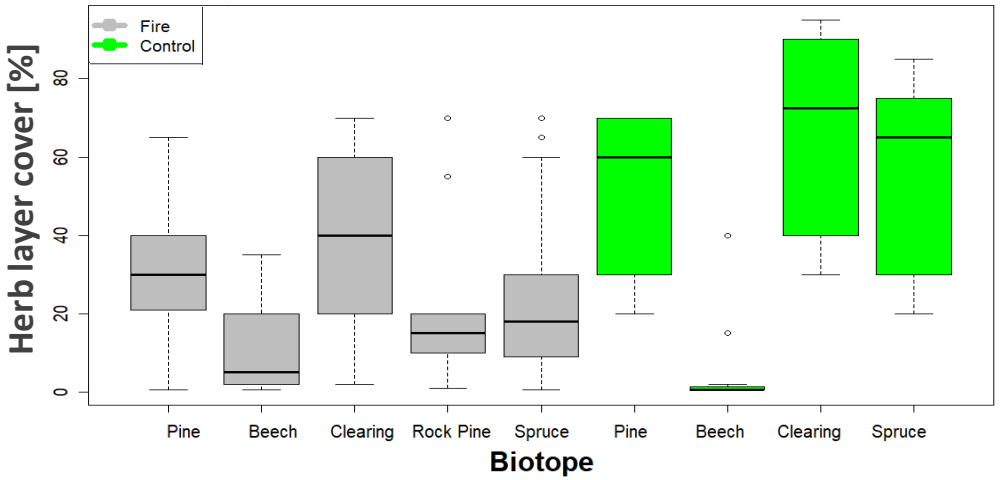


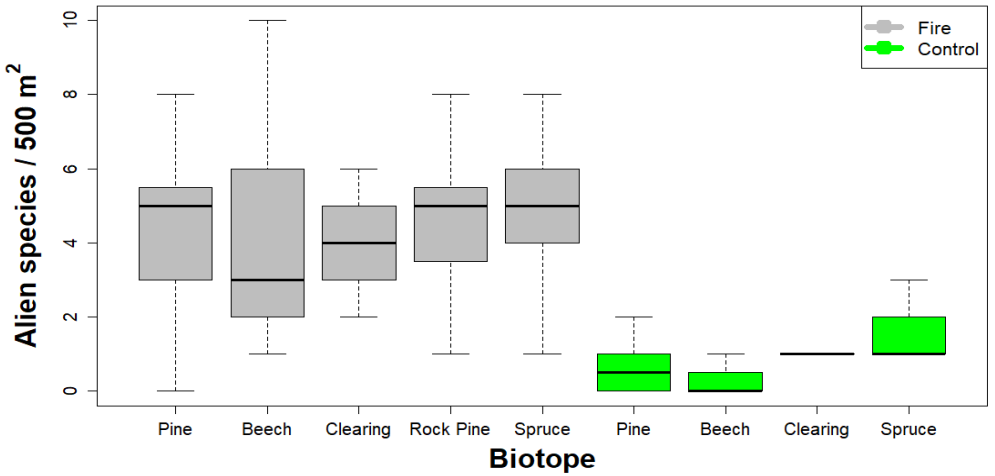

*Increase in canopy height [m] one year after the fire, derived from 3D optical point cloud*

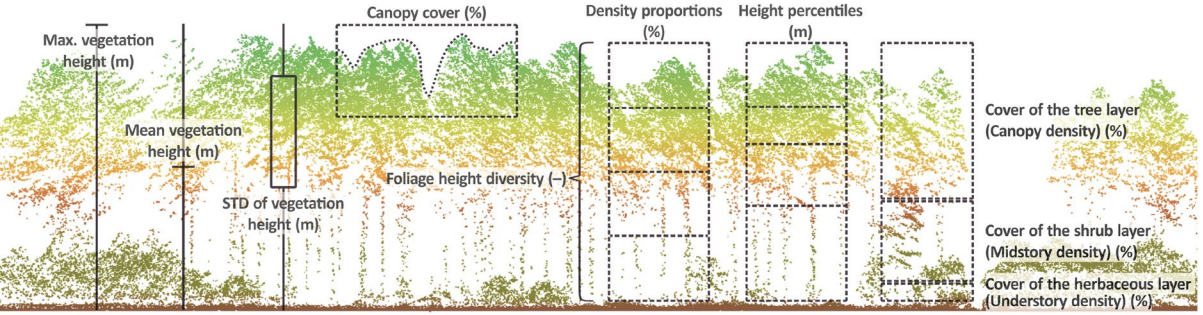
# Biodiversity

- field data
- geomorphology
- vegetation structure and health status (Lidar and optical point cloud, fish eye, vegetation indices) – ongoing work

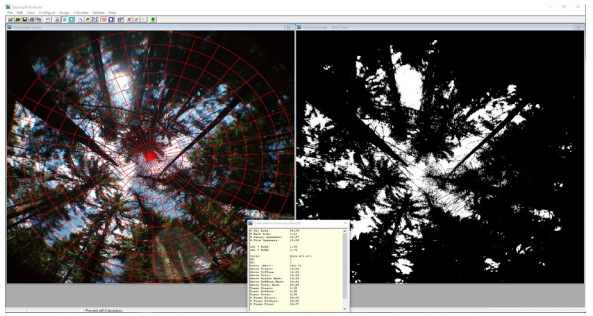



*Moudrý et al. (2022) Divers Distrib*



# Take-home message

- Wildfire dynamics depended on forest composition, bark beetle damage, water availability and management
- Fire was slowed down by native deciduous trees (and less to waterlogged sites)
- Salvage logging of dry spruce produced clear-cuts covered by thick layer of needle litter
- Such clear-cuts did not prove as successful fire prevention
- Regeneration is very fast
- ....and, remote sensing represent an excellent tool for studying the phenomenon...

# Questions?

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Running projects:

**Water in the Landscape of Czech Switzerland** (Technology Agency of CR SS05010090, 2022 – 2025)

**The Effect of Fire on Biodiversity and Forest Ecosystems in the Bohemian Switzerland National Park** (TA CR SS06010261, 2023 – 2026)