Assessment of fire damage in a peatland using Unmanned Aerial System data

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1. Study Purpose

This study aims to develop models for estimating aboveground biomass and soil surface moisture and to assess the ability of UAS data for predict them in a peatland affected by fire.

2. Study Area

- Lavassaare Nature Reserve (Fig. 1).
- The fire occurred on 31.05.2020.
- ca. 87 hectares of peat vegetation were affected.
- Vegetation is composed mainly by *Sphagnum spp.*, *Calluna vulgaris*, *Rhynchospora alba*, and *Andromeda polifolia.*

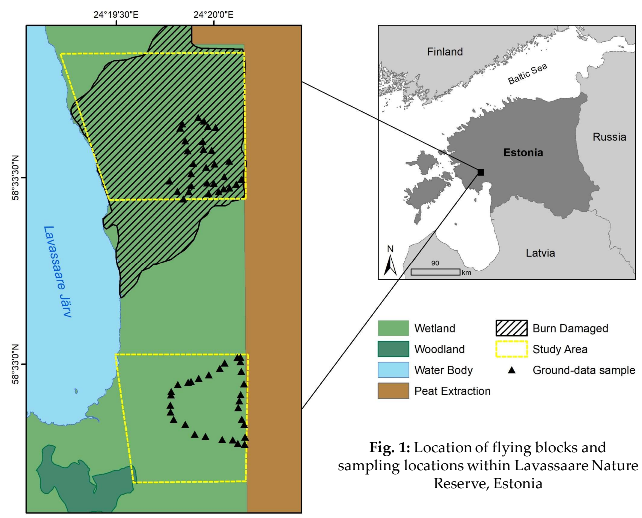

Fig. 1: Location of flying blocks and sampling locations within Lavassaare Nature Reserve, Estonia

3. Method

1) Data Acquisition:
   - Ground data from 30 cm x 30 cm quadrats in 60 sampling locations (Fig. 1)
     - **Aboveground biomass** (AGB).
     - **Soil Moisture Content** (0-10cm) using a Delta-T WET Sensor (Delta-T Devices Ltd, London, England).
   - UAS data:
     - **Multispectral** [RED, GREEN, Red-Edge (REG) and NIR] imagery using a Parrot Sequoia.
     - **RGB** imagery using a Sensefly S.O.D.A.
     - **Thermal** imagery using a ThermoMap camera.
2) Model Calibration:
   - Random Forest Regression.
     - Response Variables: **AGB** and **Soil Moisture Content.**
     - Explanatory variables: **Land Surface Temperature (LST), Canopy Height Model (CHM), Reflectance of Multispectral Bands, and Spectral Indexes (Table 1)**.
3) Model Assessment and Validation:
   - Predictions compared to the **validation dataset.**
     - Coefficient of Determination (R^2).
     - Variable Importance (Node Purity).

Table 1: . List of vegetation indices used in the present study.

Index	Abbreviation	Equation
Normalized Difference Vegetation Index	NDVI	(NIR-RED)/(NIR+RED)
Green Difference Index	GDI	NIR-RED+GREEN
Green Red Difference Index	GRDI	(GREEN-RED)/(GREEN+RED)
Datt4	DATT4	RED/(GREEN*REG)
Green Normalized Difference Vegetation Index	GNDVI	(NIR-GREEN)/(NIR+GREEN)
Simple Ratio	SR	NIR/RED
Red-edge Vegetation Stress Index	RVSI	((RED+NIR)/2)-REG
Red-edge Greenness Vegetation Index	REGVI	(REG-GREEN)/(REG+GREEN)
Red-edge simple ratio	SR_{RE}	NIR/REG

4. Results

The average AGB in the study area was 277.00 g/m²; in the burned site, average was 240.89 g/m², and in the reference site, it was 313.11 g/m². The average Soil Moisture in the area was 37%; 34.24% in the burned site and 39.77% in the reference site.

CHM and GRDI were the most important variables in the AGB model (Fig. 2). The model explained 33.1% of the validation dataset, and 57.9% of the calibration dataset (Fig. 3). Fig. 4 shows the prediction map of AGB in the study area.

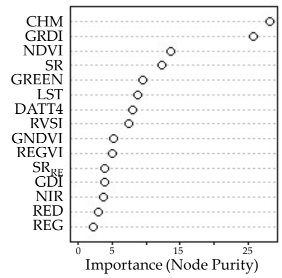

Fig. 2: Importance values for the input variables in the RF Regression for AGB.

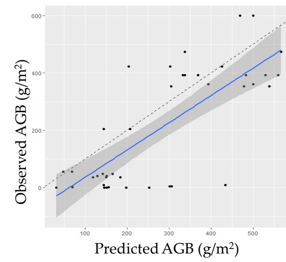

Fig. 3: Scatterplot of observed and predicted values for validation dataset of AGB. 1:1 dashed line. Slope = 0.949, Intercept = -58.1, R^2 = 0.579

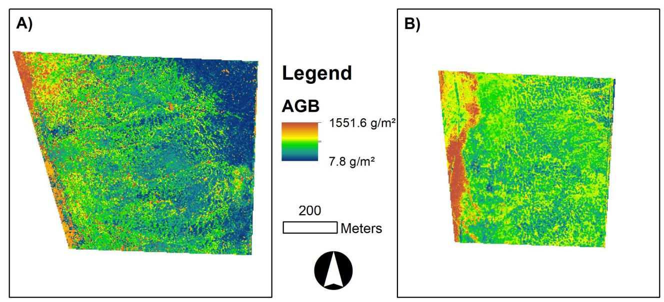

Fig. 4: Prediction maps of Aboveground biomass (AGB) in the study area based on the RF model. A) burned site, and B) reference site.

NDVI and SR were the most important variables in the Soil Moisture model (Fig. 5). The model explained 82.1% of the validation dataset, and 75.8% of the calibration dataset (Fig. 6). Fig. 7 shows the prediction map of Soil Moisture in the study area.

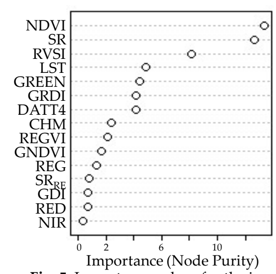

Fig. 5: Importance values for the input variables in the RF Regression for Soil Moisture.

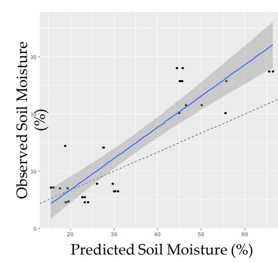

Fig. 6: Scatterplot of observed and predicted values for validation dataset of Soil Moisture. 1:1 dashed line. Slope = 1.642, Intercept = -12.7, R^2 = 0.758

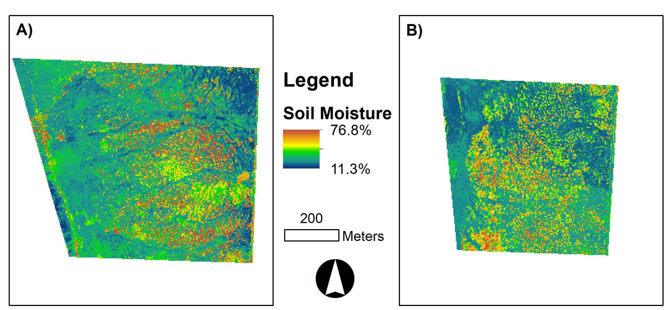

Fig. 7: Prediction maps of Soil Moisture in the study area based on the RF model. A) burned site, and B) reference site.

5. Conclusions

- Ratio-based and Normalized Indexes performed better for both variables.
- Soil Moisture predictions were better than AGB predictions.
- 3D data performs better for estimating AGB; and multispectral for Soil Moisture.

6. Acknowledgements

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