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Combining UAS and PlanetScope data for large scale vegetation monitoring: A case study in the Krkonoše mountains

Adam Kulich, Lucie Kupková, Jakub Lysák, Lucie Červená, Záboj Hrázský, Markéta Potůčková, Alex Šrollerů, Mojmír Polák

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Introduction and motivation

- Sensitive and dynamic landscape above treeline in central Europe
- Multiple management problems
- Need to monitor at species level – small-scale and large-scale

→ Use of combined Remote Sensing approach

Introduction and aims

- Main aims of the research:
- Evaluate and compare potential of UAS and satellites for vegetation mapping
- Evaluate potential of combined approach
- Develop reliable methods to monitor the changes in vegetation and implement them
  - Data acquisition workflow
  - Feature engineering
  - Choosing a classifier
  - Results evaluation
- Propose and implement a methodology for alpine vegetation monitoring

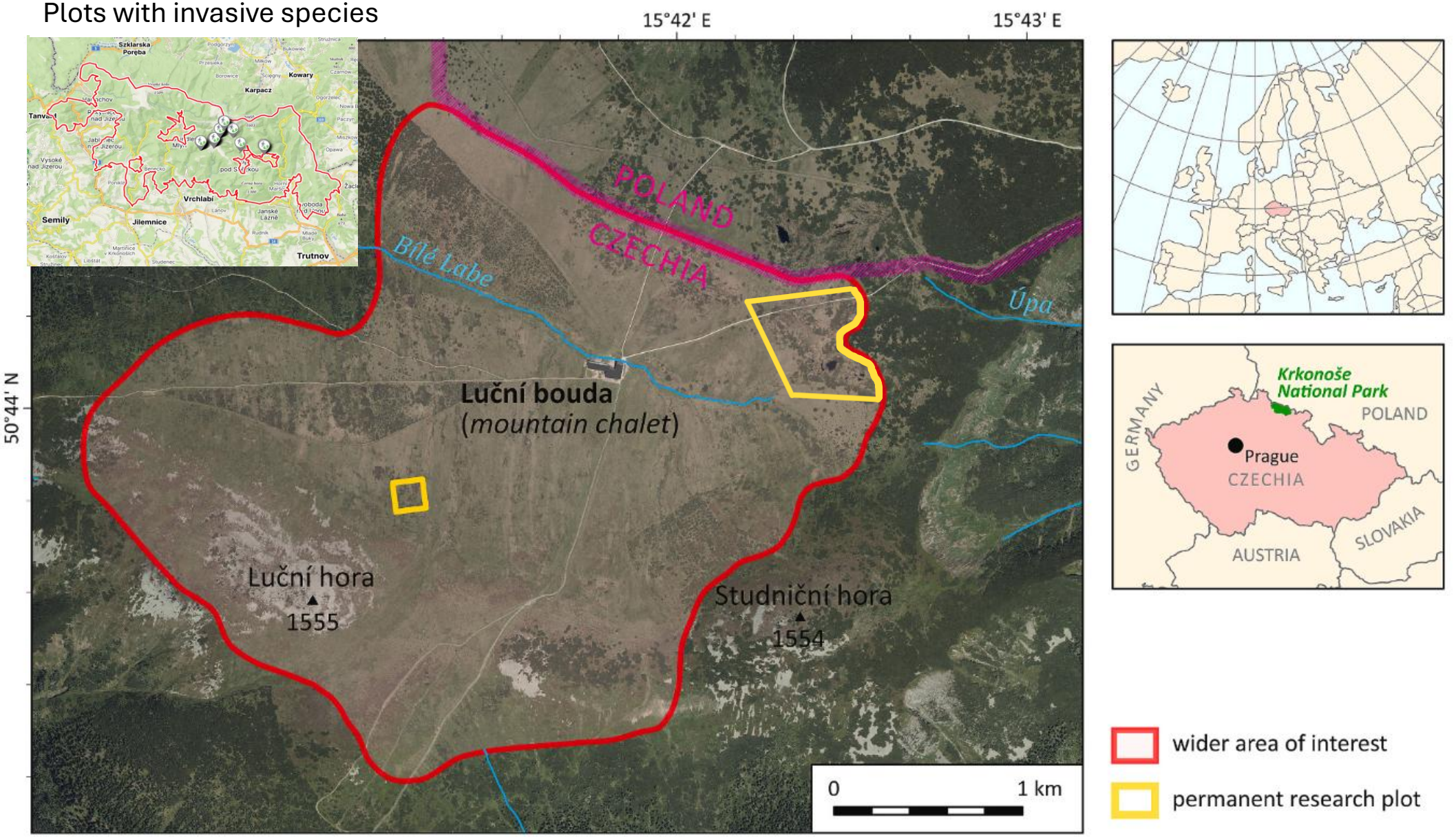
Study sites

- Krkonoše – highest mountains in Czechia
- Arctic-alpine tundra and alpine peat bogs – very valuable ecosystems full of endemic and rare species

- Multiple management problems:
  - reedgrass (Calamagrostis villosa) and purple moor-grass (Molinia caerulea) expand into the mat grass (Nardus stricta) stands
  - Dwarf pine (Pinus mugo) expansion
  - Peat bog human-induced drainage

- Problems with invasive species in other valuable parts of the mountains (*Rumex alpinus*, *Lupinus polyphyllus* and *Senecio nemorensis* agg.)

Plots with invasive species

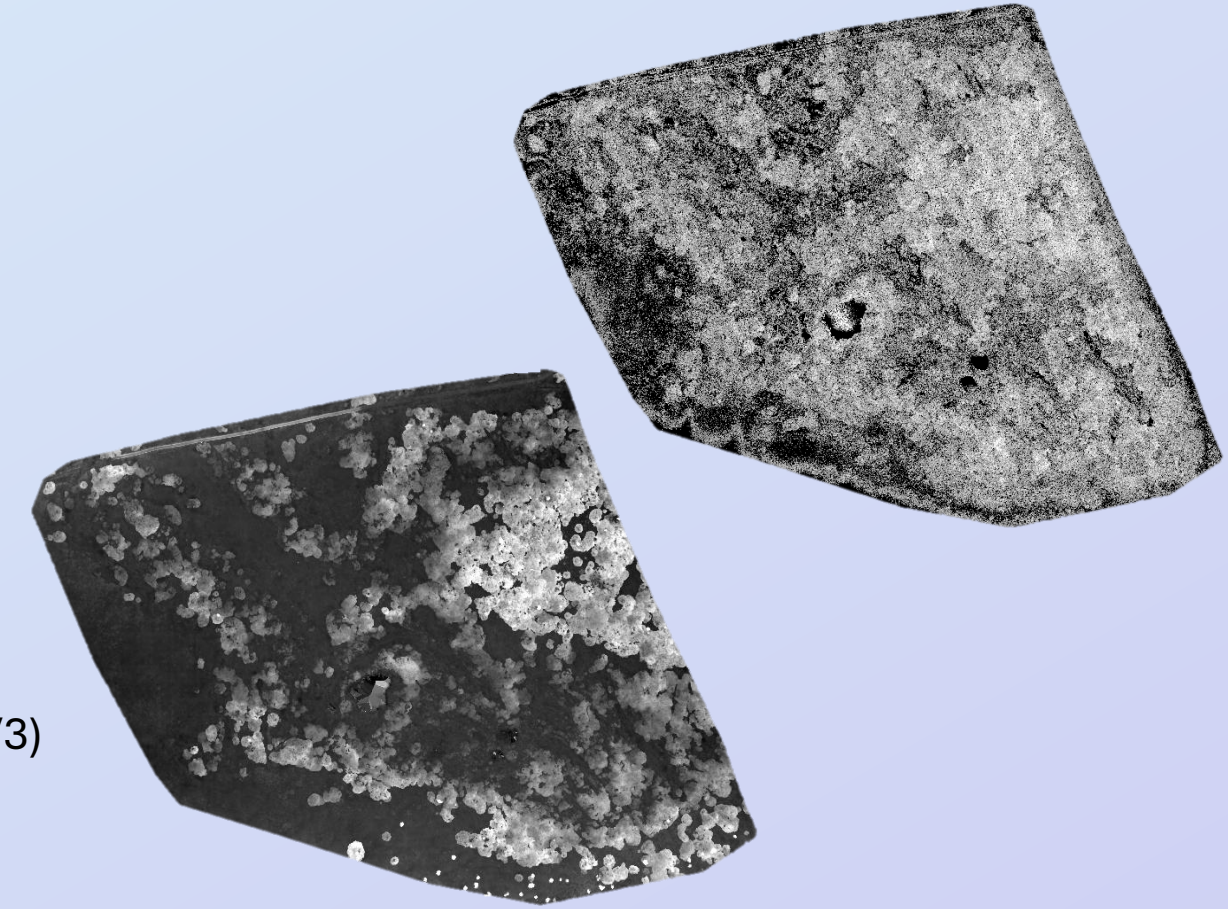


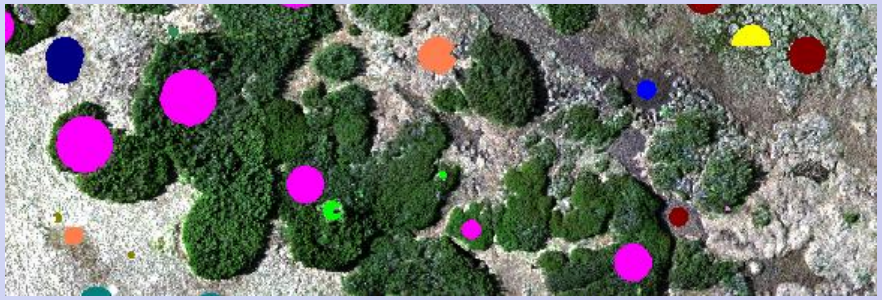
Methods – data acquisition

- Small permanent research plots
  - Bílá louka plot
  - Úpské peat bog plot
  - UAS – multispectral (MS) and hyperspectral (HS) cameras
  - 4 times in a season (mid of June, July, August, September)
  - Pixel size 3-5 cm
  - 8 plots of invasive species occurrence
- Large area
  - Data from PlanetScope – multispectral 3 m satellite data
- Areas with invasive species
  - multispectral and RGB data 1 cm, 7 dates in 2 years (2024, 2025)
- Vegetation data acquisition
  - Manually using GNSS recievers (under 2 cm accuracy)

Methods - Analysis

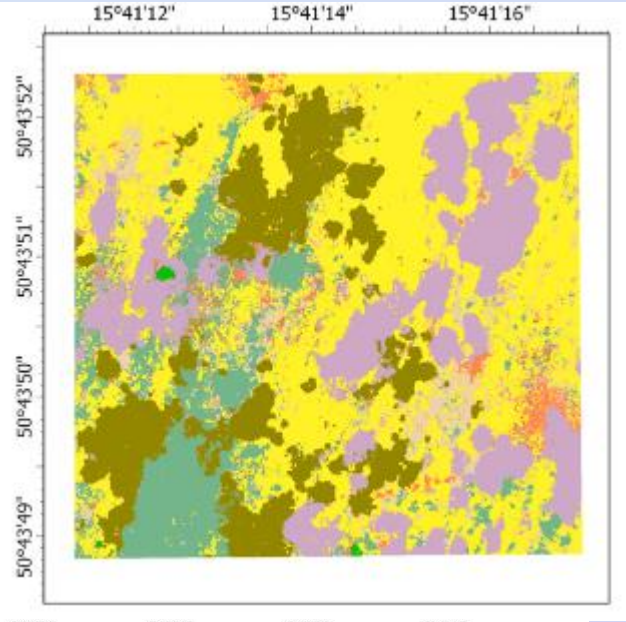
- Feature engineering
  - Texture features
  - Canopy height layers
- Choosing classifier
  - Comparing RF, SVM, OBIA and XGB
  - Comparing and fine tuning for each dataset
  - Deep Learning in ArcGIS (UNet and DeepLabV3)
- Producing training labels from UAS classification to classify PlanetScope data
  - Using algorithm to find homogenous pixels
  - Tested only on Úpské peat bog plot

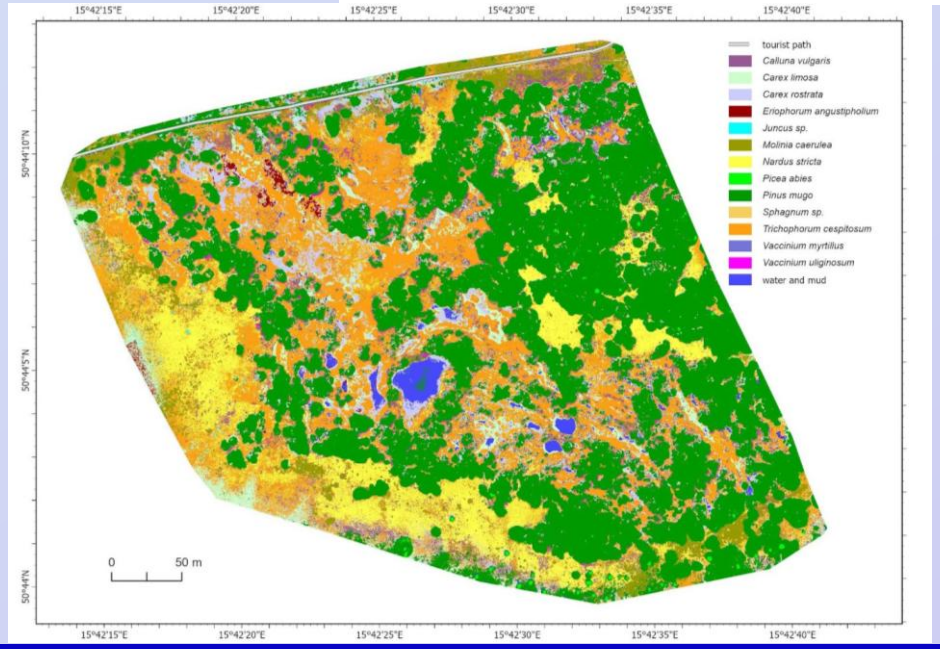




Alpine vegetation UAS results

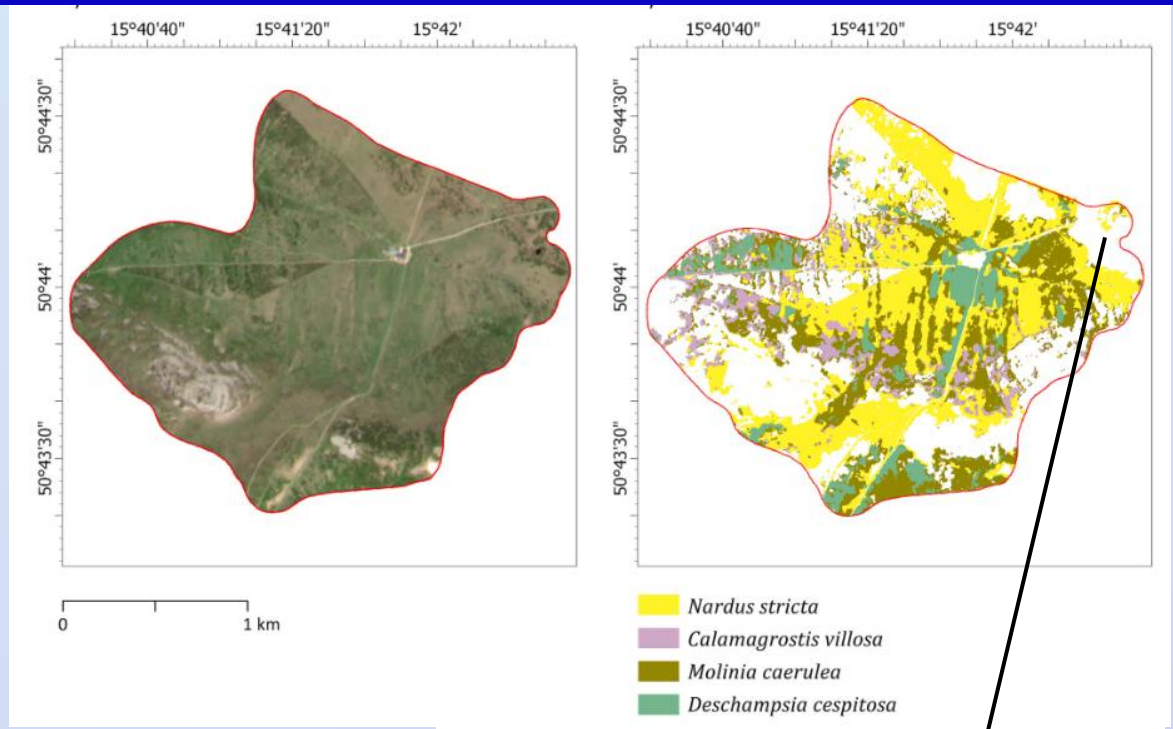
- 95.9 % accuracy in Bílá louka permanent research plot (OBIA, 7 classes, 2019 data)
- 94.2 % accuracy in Úpské Peat bog plot (XGB, 14 classes, 2024 data)
- MS and HS approaches didn't differ much
- Combining multi-temporal data with texture features and canopy height feature improved the accuracies by up to 10%
- F-1 scores > 90% for the most common species (e.g. *Callamagrostis villosa, Molinia caerulea, Deschampsia cespitosa, Trichophorum cespitosum, Nardus stricta, Pinus mugo*)

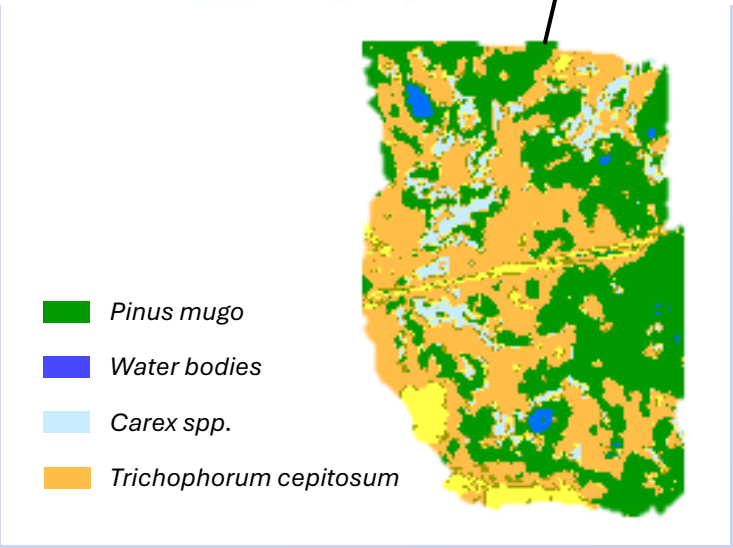




PlanetScope results

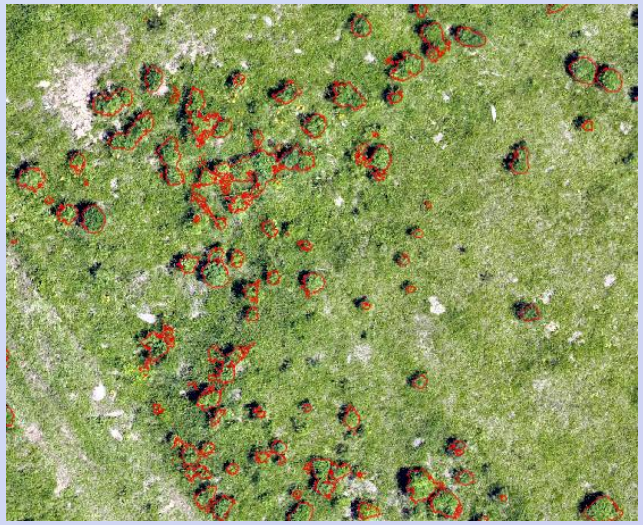
- Best result for the large-scale PlanetScope data was 82.1% accuracy (4 classes)
  - MT composite of 3 dates
  - *Nardus stricta* achieved best F-1 score of 85.1%
- Using the UAS classification to label pixels in the Úpké Peat Bog resulted in 86.0% accuracy (6 classes)
  - Better accuracy for more common species
  - *Pinus mugo* – 97.6%, *Trichophorum c.* – 83.3%

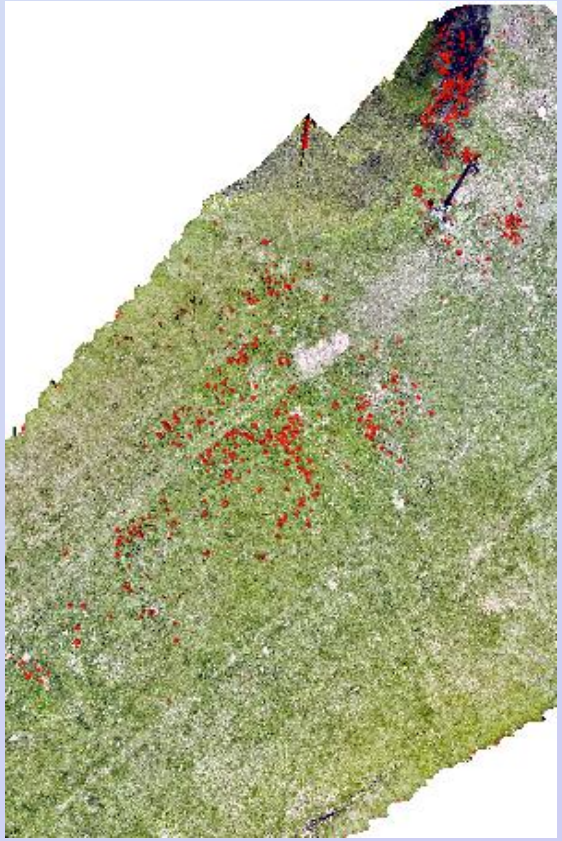




Results for invasive species

- Detection of *Lupinus polyphyllus*, Modřín site, May 2025
- Best results achieved using U-Net with backbone ResNet-34
- Overall accuracy 91%, Users accuracy 98%, Producers accuracy 83%
- Validated with combination of field data and manual collection from image
- Problems with false positive detections – shadows, trees





Conclusions

- The UAS achieved very accurate results and they have lots of advantages (operability, cost, spatial resolution), but they can not cover large areas
- PlanecScope data classification was promising, but still far from the accuracy of the UAS results
- More improvements depend mostly on better training datasets for the satellite data
  - Sometimes the vegetation might be too heterogenous for a 3 m pixels
  - The data derived from UAV classification might be more promising than manual acquisition in the field or from orthomosaics

Room for discussion

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