Estimation of Red Clover Flowering using Drone Imaging

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Drones can help mitigate risks in red clover seed production

Wider adoption of nitrogen-fixing species such as red clover could substantially improve nitrogen self-sufficiency in Finnish cattle farms, but adoption is constrained in part by the limited seed availability of adapted cultivars. This study aimed to develop drone-based methods to evaluate factors affecting red clover seed yield, including pollination dynamics and the relationship between flowering traits and yield formation, thereby supporting the development of red clover seed production in Finland.

Data collection

Five fields in North Savo, Finland in 2024.

Reference data

- pollinator counts (transect method)
- seed yields and flower counts at transect end points
- seed yield on field level

Drone-based data

Collected for two primary purposes:

- locating potential habitats in the surrounding environment that affect pollinator abundance near the fields
- estimating flowering intensity and dynamics.

Images for flowering intensity estimation were collected 4 times per growing season using **DJI Matrice 350 RTK** drone equipped with **H20t camera** collecting simultaneously accurate zoomed-in images for flower recognition and images with wide-angle lens for photogrammetric field mapping. Flights were carried out at a height of 60 meters.

Figure1. Within-field variation in flowering intensity was estimated by calculating the area covered by flowers in the images. In the example field shown above, 109 images were used to create the heatmap. Flowering intensity will later be compared with pollinator abundance and realised seed yield in selected areas to assess the influence of pollinator activity on seed production.

Image processing was carried out using RootPainter (Smith et al. 2022), which is an interactive deep learning segmentation tool that employs a corrective annotation approach. A set of 100 cropped (864 x 972 px) images was generated from original images and used for training the segmentation model. This approach provided sufficient accuracy for estimating total flower coverage in the dataset (see Figure 2.).

Method development and first insights

The developed method for assessing red clover flowering from close-up drone images taken at higher altitude proved sufficiently accurate for further analyses. These data can now be compared with pollinator observations and other environmental factors influencing pollination and red clover seed formation.

Data collection continued in 2025 and will be extended in 2026, allowing further validation of the method.

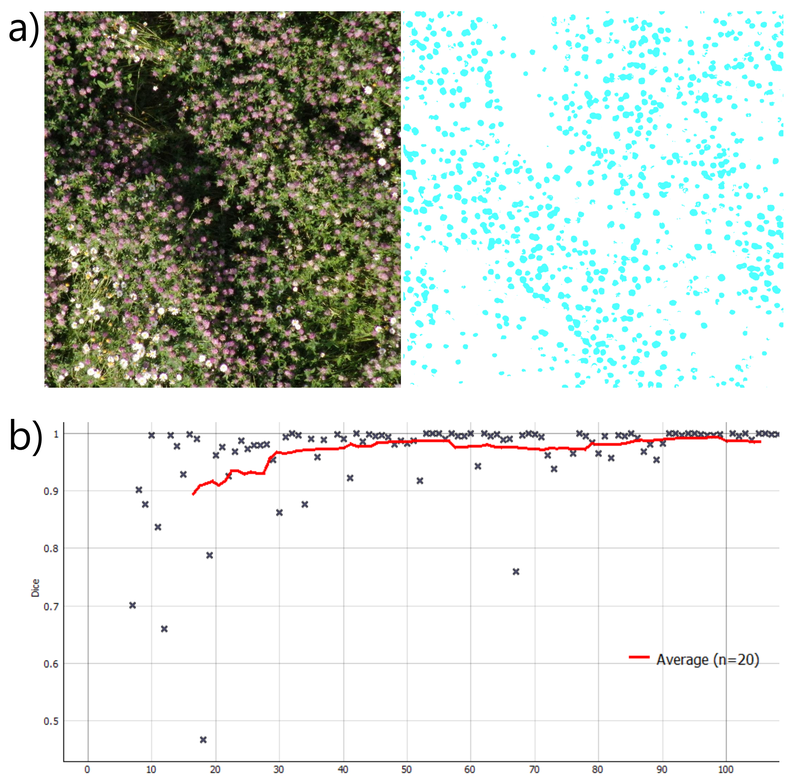

Figure 2. Image segmentation was carried out using RootPainter, where a) flowers were recognized from images (resolution 5184x3888 pixels) collected using DJI H20t camera's zoom lens and flying height of 60 meters, and b) segmentation model was trained using 100 images in corrective annotation, achieving a Dice score over 0.98.

Combining drone-derived flowering data with pollinator counts and habitat mapping provides a novel opportunity to understand how surrounding landscapes influence pollinator availability and efficiency.

Acknowledgements and references

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Smith, R. N., & Jones, L. M. (2022). RootPainter: Deep learning segmentation of biological images with corrective annotation. New Phytologist, 234(3), 1234–1245.

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