



Overview of methodology applied in the drone assisted monitoring of *Phytophthora* in temperate broadleaved forests

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Introduction

Detecting *Phytophthora*-infected trees in the field is a time-consuming process. Remote sensing, particularly using multispectral imagery, provides an efficient alternative for assessing tree health and detecting stress symptoms associated with disease and vitality loss. The objective of project tasks T3.4.1. and T4.5 is to develop and validate methods for detecting *Phytophthora*-infected trees from drone-based multispectral data. The nine spectral bands, capturing information across the visible and near-infrared range, will be used to calculate vegetation indices sensitive to canopy stress and defoliation. The high spatial resolution of the multispectral imagery (around 10 cm/pixel) enables detection and monitoring at the individual tree-crown scale. Work activities are summarized below:

Selection of sites, and field inventory assessments

Sites were selected on the basis of previously known areas where *Phytophthora* damage had been observed. To initiate this study a crown vitality assessment of beech trees was done from the ground, in six Natura 2000 areas, Dalby Söderskog, DalbyNorreskog, Kullaberg, Stenshuvud, Söderåsen and Torup. The assessments were done for all beech trees standing/growing within approximately 10 meters from a walking path. Depending on size of the Natura 2000 area, all tracks/paths or some of the tracks/paths were covered (fig 1.).

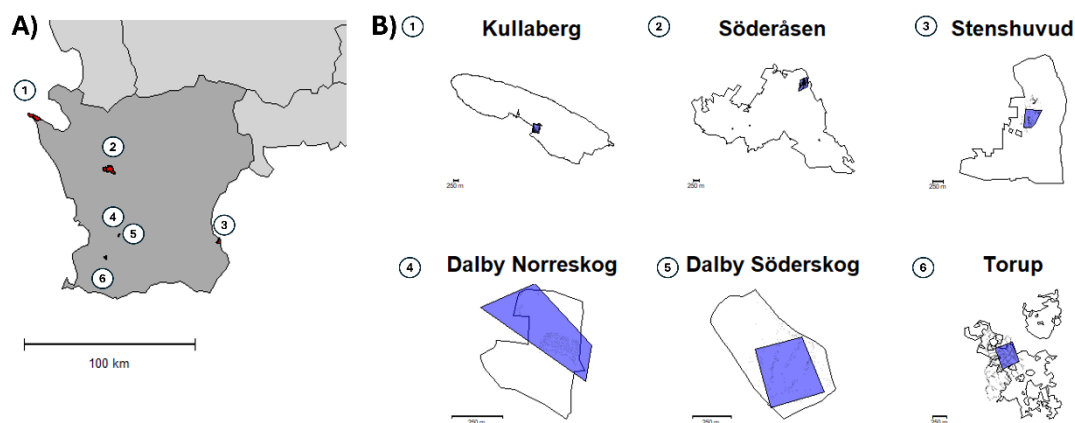


Figure 1: Map of the studied area. A) Distribution of the Natura2000 area in the Skåne region. B) Map of the Natura2000 area within blue the area flew by the drone and in the black dots indicate the locations of the inventoried trees.

The crown vitality was recorded by visually assessing how much light was coming through the crown according to following classes borrowed from the report “Ekonomisk värdering av urbana träd – Alnarpsmodellen” (Östberg *et al.* 2013):

- 1: Light transmittance through crown: 61-99%
- 2: Light transmittance through crown: 26-60%
- 3: Light transmittance through crown: 11-25%
- 4: Light transmittance through crown: 0-10%

A total of 4235 beech trees were assessed in all six areas (table 1). In all six sites, most of the trees (57-84%) were classified as vital (crown vitality classes 3 and 4). While less vital trees, class 1 and 2, summed up to between 3 and 18%.

Table 1. Number of observed beech trees in the four crown vitality classes, where 4 equals almost no light transmittance through the crown and class 1 a light transmittance through crown between 61-99%.

Site	1	2	3	4	Total
Dalby	12	45	75	179	311
Söderskog					
Dalby	16	31	78	178	303
Norreskog					
Kullaberg	14	21	80	630	745
Stenshuvud	27	35	89	291	442
Söderåsen	12	20	99	889	1020
Torup	6	90	323	995	1414

In addition to crown vitality, dieback of branches was recorded when visible as well as signs of disease/damage on the bark. Dieback was recorded as present or absent while bark damage was recorded as affecting 1-4 quarters of the stem's circumference. After the vitality assessment, a very precise location was recorded with an Emlid Reach RS3 (Multi-band RTK GNSS receiver), giving an accuracy down to 1cm depending on canopy cover and other environmental factors.

Drone inventories

Drone flights have been conducted across six Natura 2000 forest sites (Dalby Norreskog, Dalby Söderskog, Kullaberg, Söderåsen, Stenshuvud and Torup) using a DJI Matrice 210 RTK drone, equipped with a MAIA multispectral sensor, operating within the SWEREF 99 TM coordinate system in August. In the case of Dalby Söderskog and Torup, two additional flights were conducted during the season, thereby capturing images also in July and September. Each flight was performed around noon, at an altitude of 120 metres, and lasted on average 20 minutes. Days with a light overcast and low wind conditions were chosen to minimize shadows and moving tree crowns. To ensure radiometric consistency and allow reflectance calibration between sites and dates, four calibrated reflectance reference panels were placed within the drone's field of view before each flight. The raw images were radiometrically corrected and stitched using MAIA software, employing flight trajectory data and on-board GPS coordinates. In QGIS, the mosaicked images were georeferenced and aligned to a common spatial reference system through linear transformation and ground control landmarks. Finally, individual tree crowns will be delineated through image segmentation and linked with field inventory and ground-truth data for classification and validation.

Diagnostic work

To identify microorganisms associated with beech decline, including *Phytophthora*, soil samples have been taken from the root systems of 80 beech trees, approximately 1,5 meters from the stems at depths of around 15-20 cm. For each tree, samples were taken in each cardinal direction and pooled. A total of 16 trees per site were sampled from five Natura 2000 areas (Dalby Söderskog, Torup, Söderåsen, Stenshuvud and Kullaberg), out of which eight trees displayed high crown vitality (class 4) and eight trees displayed poor crown vitality (class 1 or 2, with dieback). This sampling was undertaken in October 2025.

DNA has been extracted directly from the soil, as well as from samples enriched for *Phytophthora* oospores through sequential filtration. The enrichment procedure filters away large debris (above 100 micrometers in diameter) while retaining and concentrating

oospore-sized particles (above 20 micrometers in diameter). This is expected to allow for identification of both *Phytophthora* and other microorganisms affecting beech vitality. Negative control samples (extractions and enrichments of cell-free water) and positive control samples (soil with addition of *Phytophthora* oospores) have been created to verify the performance of the methodology.

Next step

Field work will be conducted in January and February to resolve some cluster points from the field maps for the imaging analysis. Analysis of Dalby Söderskog and Torup will be completed. Planned flights for the remaining (Dalby Norreskog, Kullaberg, Söderåsen, and Stenshuvud, will be 2026 across the season, followed by analysis). Further steps in the diagnostic work will include PCR-free sequencing of the extracted DNA, to identify the members of the soil community through environmental DNA (eDNA) methods. This information will subsequently be used for machine learning, to pinpoint the soil microorganisms most indicative of high or low crown vitality.

References

Östberg, J., Sjögren, J. & Kristoffersson, A. (2013). *Ekonomisk värdering av urbana träd - Alnarpsmodellen*. (Landskap Trädgård Jordbruk). Fakulteten för landskapsplanering, trädgårds- och jordbruksvetenskap.
<http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-e-1327>



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