



1. About us

The FESTMETER Wöls GmbH founded in 2016 and offers vitality analyses with regard to bark beetle detection in conifer forests. The used technology makes restrictions in vitality visible, changes in the water content of the needles can be seen, but not the exact cause, such as the bark beetle itself. Since, however, image series from at least two staggered flights are compared, other causes such as drought stress can be excluded and the bark beetle can be traced very closely.

2. Project schedule

- **Definition of the area:** The AOI (Area-of-Interest) is defined by the customer and send to Festmeter. This can be done in different ways: In the simplest way, a polygon (GIS vector format) from the area is transmitted.
- **Image flight:** Festmeter organizes and coordinates the flight by an external partner. Depending on the size of the project, UAVs / drones (up to 300 ha) or surveying aircraft (up to 10,000 ha daily output) are used.
- **Multispectral Photography - Infrared Photography CIR:** Using a multispectral camera, the forests are photographed from above and the data in the infrared range is determined. Satellite images are also used on an experimental basis. The first flight / initial flight should done at the end of the season or very early in the new season; the second flight usually takes place at least 4 - 8 weeks afterwards, depending on location, temperature, rainfall and bark beetle evolution. The flight dates are coordinated together with the person responsible for the area. Up to 4 flights are carried out per season. The first flight in autumn as well as a fast second flight with "Change Detection" (i.e. a tree-precise comparison of the two data sets to each other) in spring have proved to be ideal in order to contain the spread of the 1st beetle generation.
- **Date upload:** After the flight, the data is immediately made available in the Festmeter computer centre.

- **Preprocessing:** Festmeter sighted the material, releases it internally for the processing. If the data quality is insufficient, images can also be rejected and a new flight must be accomplished.
- **Single tree detector:** A single tree detector is used as the first essential process step. Festmeter algorithms (based on deep learning - artificial intelligence) determine each individual conifer tree and locate or number it individually. Approximately 90% of all conifer trees are recognized. Substantials are not detected (not visible from above) and rarely other tree species are output.

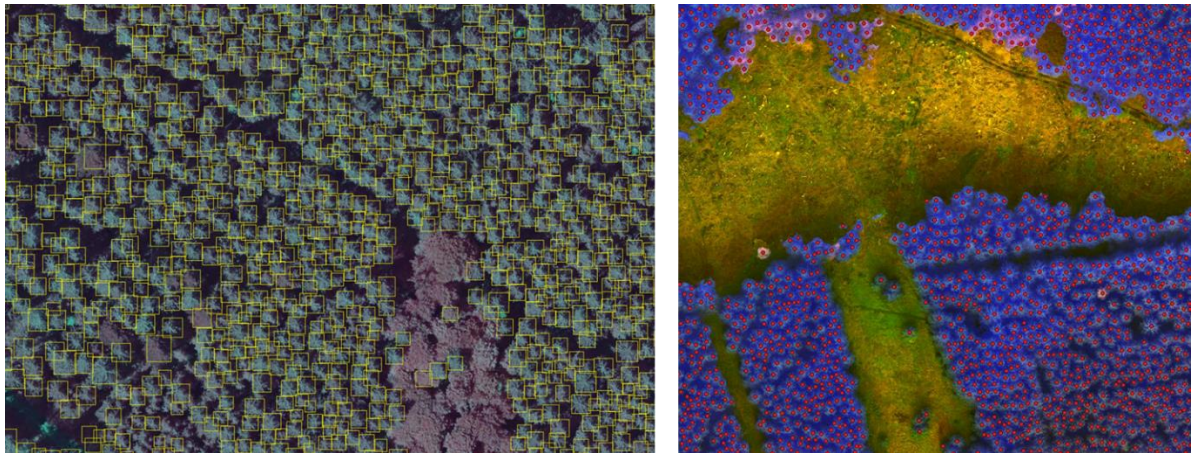


Figure 1: Single tree detector based on deep learning

- **Data output I:** During the first flight/ initial flight, all vitality restrictions are determined and delivered to the client on request - but this also includes dead trees from previous seasons. Depending on the size of the project, the results are available 4- 10 working days after the flight.
- **Data output II:** From the second flight over the same area and with the aid of the single tree detector, a change detection (comparison of the individual tree over the two flights with itself) and a neighborhood analysis (comparison of the individual tree with its 20 neighboring trees, see Figure 2) are applied and only clearly changed trees are shown - this puts the focus on more relevant points. Depending on the size of the project, the data output is within one working week of the flight (data delivery can also be supplied in batches).

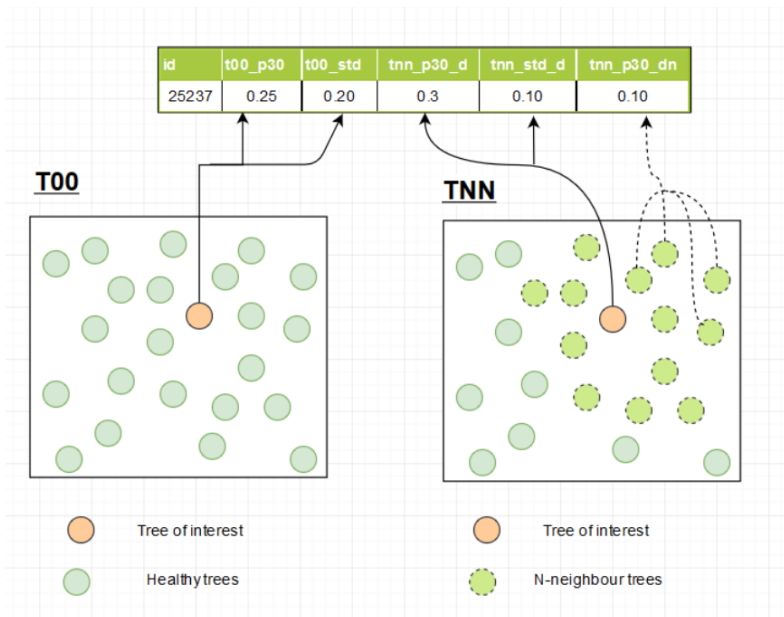


Figure 2: Tectimes neighborhood analysis

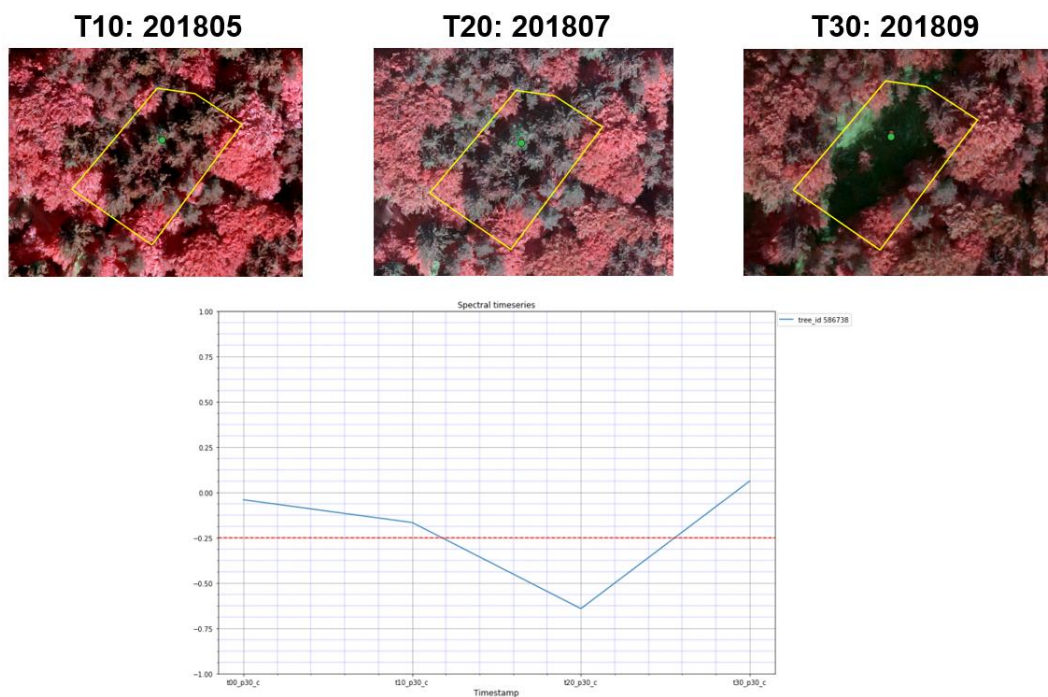


Figure 3: Tectimes Change Detection

- **Classification:** The finished evaluation is delivered to the forest owner (as a labelled GPS coordinate in file formats for vector geodata - shape file etc.) or in PDF / paper form), the underlying data pool remains by Festmeter. The vitality changes are divided into 4 classes (basic evaluation Change Detection, see appendix).
 - vita1 - Unchanged conifer tree (no output, because majority of trees)
 - vita2 - Strongly changed conifer tree
 - vita3 - A coniferous tree with severely reduced vitality



- vita4 - Slightly changed conifer tree
- **Search in population:** As an option, Festmeter offers high-precision GPS devices to make it easier to find the infected trees in the forest. Search dogs are also available as an option: Got to www.bodogs.at

3. What will be delivered

Orthophoto: One of the first process steps is the calculation of all single images from the flight into an overall scene, a high-resolution, up-to-date orthophoto in CIR (false color image CIR=Colored InfraRed) is produced, which we hand over to our customers. This make it easier to find the points in the field. (Better contrast between vita1 and vita2-4 trees)



Abbildung 4: Orthophoto CIR (false color image CIR - Colored InfraRed)

Vitality analysis / rating: Classification of vitality analysis into described classes vita1 to vita4. File format output for vector geodata (shape file etc., integration into GIS-based forest management programs is possible, see annex).

4. Optional (additional products)

RGB photo: On request, we can also provide the customer with image material in RGB (red-green-blue orthophoto).

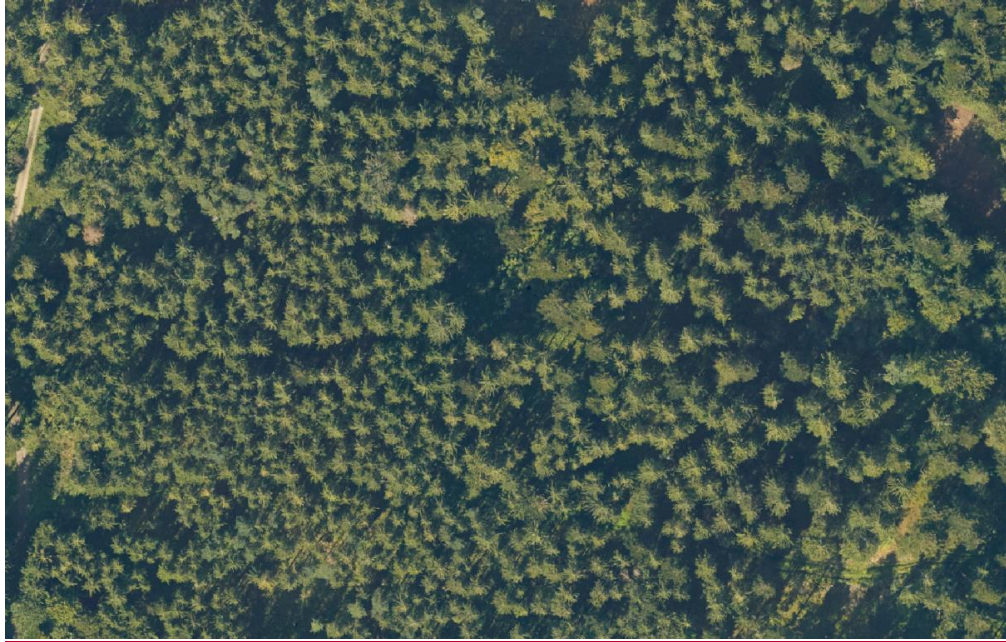


Figure 5: Orthophoto RGB

Overview map / Report: Overview of the issued trees. Output as PDF in the form of a map / report



Figure 6: Example Overview Map

Heatmap / Classification: In addition, accumulations of vita2-vita4 can be processed in the form of Heatmap overview plans. This is particularly advantageous in larger forest areas, where potential beetle nests are visible at a glance.

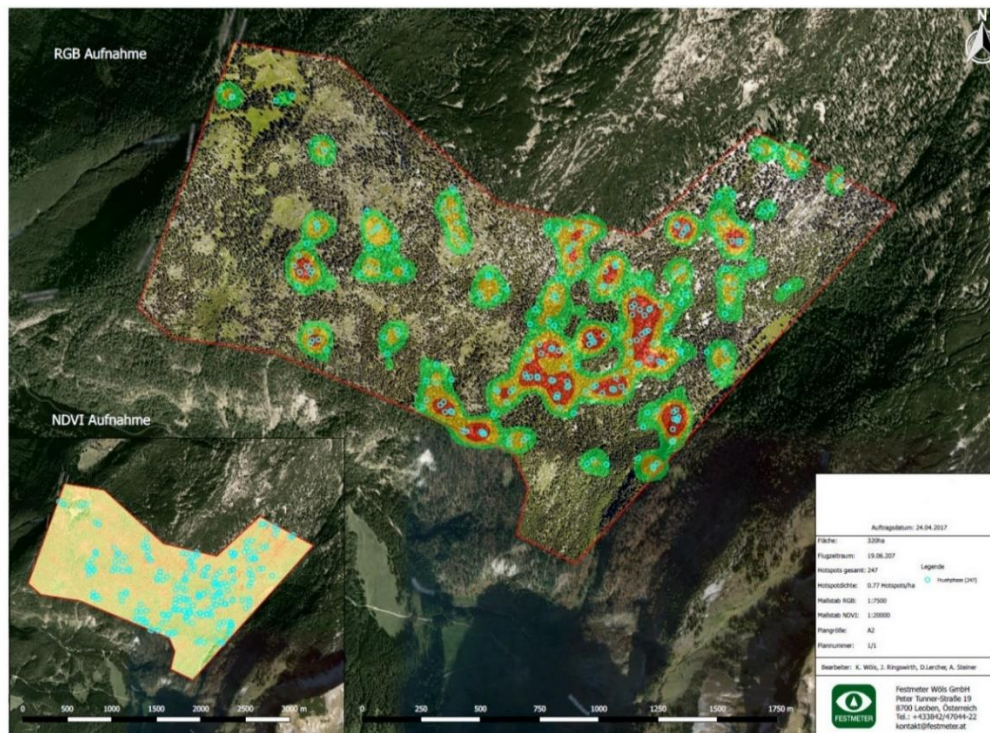


Figure 7: Example Overview plan - Heatmap

Zusatzprodukte

- Normalized Difference Vegetation Index (NDVI) – Reflectance map
- Digital surface model
- Canopy Height Model (various classes)
- Hillshade Visualization
- Aspect (Alignment by cardinal points, [0-360°] S-->S, clockwise), derived from the DGM
- Slope / Slope gradient map in %
- Point cloud - ALS data (above mentioned data with basic laser data set higher accuracy / resolution, additional charge for laser flight)
- Support module - support forest inspection
- Training GPS RTK device

We also offer additional analysis. We would be pleased to inform you about this!

After the analysis, the data is made available on an FTP server or transmitted digitally via an alternative platform.

5. Finding the points

Finding GPS coordinates in the inventory are not easy and requires practice. In the first step, an overview map/ orthophoto provides assistance so that orientation points can be read.

GIS-based APPs, which support the navigation in the terrain, can help to reach the relevant points faster in the inventory. We are happy to help you with the selection of an APP.

Devices that improve the location in the forest work on the basis of signal amplification and also bring advantages here. We will be glad to help you - please contact us!



Figure 8: Locating trees with GPS support

Bark beetle search dogs can also help to locate the trees precisely – go to www.bodogs.at

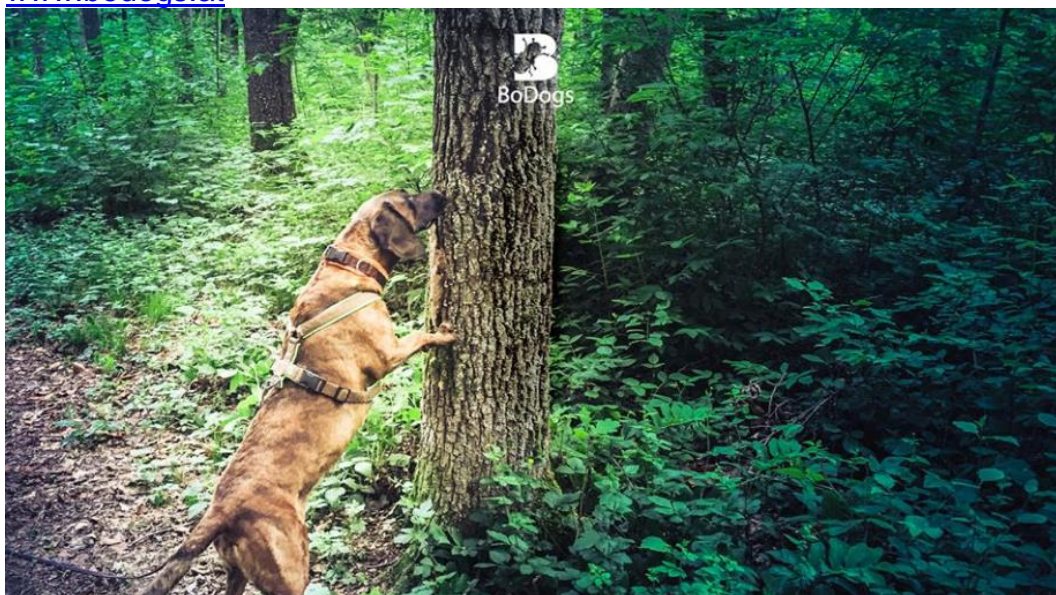


Figure 9: www.bodogs.at

6. Cost- benefit analysis

The forest ranger remains an essential decision maker when it comes to finding the best time to fly and must contribute his expertise and observations from the area.

Forest ranger has to check the surroundings (neighbouring trees). Generally we show the initial tree. Only the brood leads to changes in the material cycle of the tree and therefore in the vitality of the crown.

The time window to be able to act is very small, so the forest owner should immediately become active in the stand and start harvesting.

Parallel to the evaluation, the forest owner can start preparations for harvesting to actively use the small time window.

If it is possible with our support to harvest and market even one beetle tree per hectare in a still vital green tree phase, one currently avoids a direct loss of value from bloch wood to beetle wood in the range of € 35,- / solid cubic meter, therefore € 35,- / hectare (1 Solid cubic meters per tree) for a mature tree. (status 2019)

The further avoidance of the dissemination of the beetle in the herd, the prevention of the tearing open of crown covers and the associated wind throw risk is not even taken into account here yet.

Our service should therefore be affordable and calculable at prices below € 35,-/ hectare for the forest enterprise.

In addition, the sometimes time-consuming and therefore expensive terrestrial search, especially in large forests, must be taken into account. Our service should enable a substantial reduction of the search costs on the ground as well as a more precise control in the forest.



Figure 10: Barkbeetle problem 2018

Exact prices depend strongly on the individual project. Contact us and we will be happy to make you a non-binding offer!

7. Customer feedback

The FESTMETER service is a tool designed to help prevent excessive damage in the forest. A 100% hit rate is impossible. The aim should be to be able to act faster and more purposefully in the field. Forest rangers are irreplaceable.

We are able to adjust the sensitivity of the analyses. An increased sensitivity also shows minor changes, but this increases the number of trees in the area, which increases the effort of searching for these points (vita4).

Long-standing customers report positive hit rates of over 80% - we identify the majority of beetle infestations; based on the points reported, the forest rangers become active in the area (initial tree).

The picture below shows a typical scene in a Swiss project; green and red were our issued points, blue the additional (and harvested) infestation points identified by the forest ranger. Also shows up: The vast majority of the initial trees were reported by us. Within the scope of the inspection of the neighbouring trees on site (sibling brood), larger samples were taken:

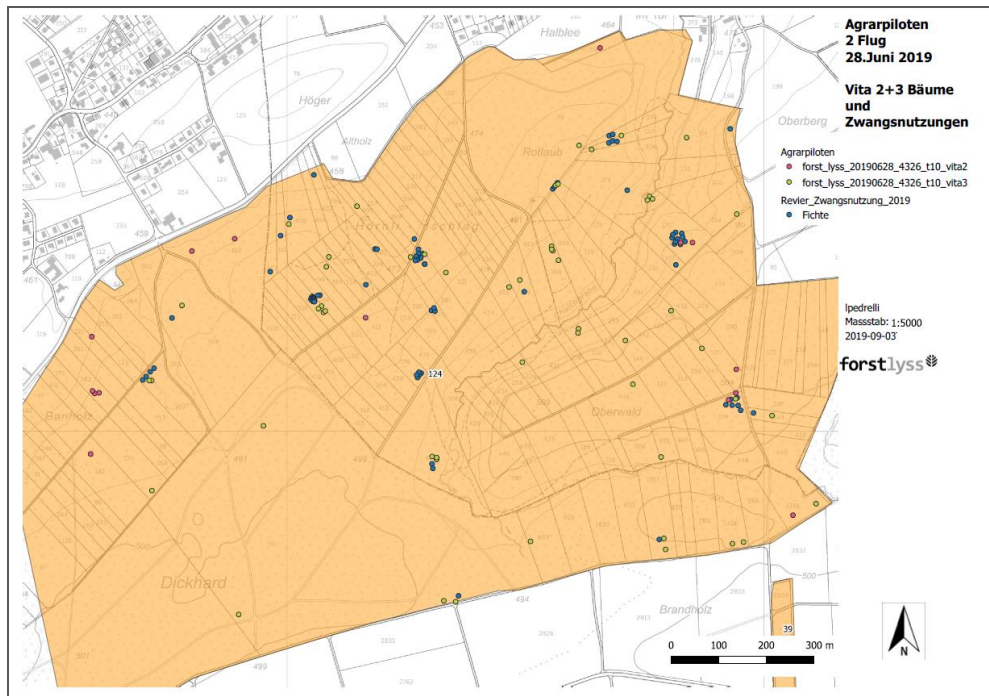


Figure 11: Overview map Forst Lyss

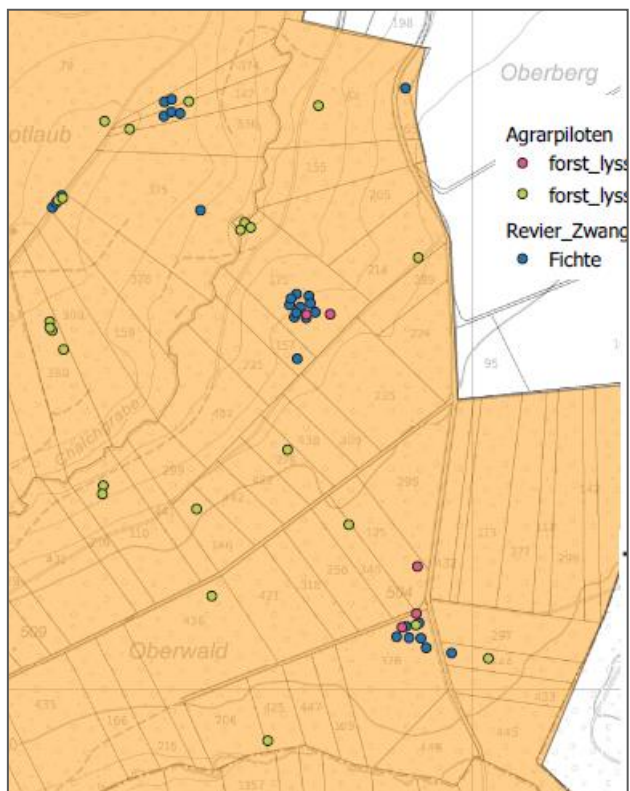


Abbildung 12: Detailed view Forst Lyss

8. Summary

Service for forest enterprises with larger areas (e.g.: Bavarian State Forests) and limited capacity for individual tree inspections; terrestrial search remains economical where tree-specific inspection is possible. We show initial trees, the decision about necessary measures continues to be made by the qualified on site staff.

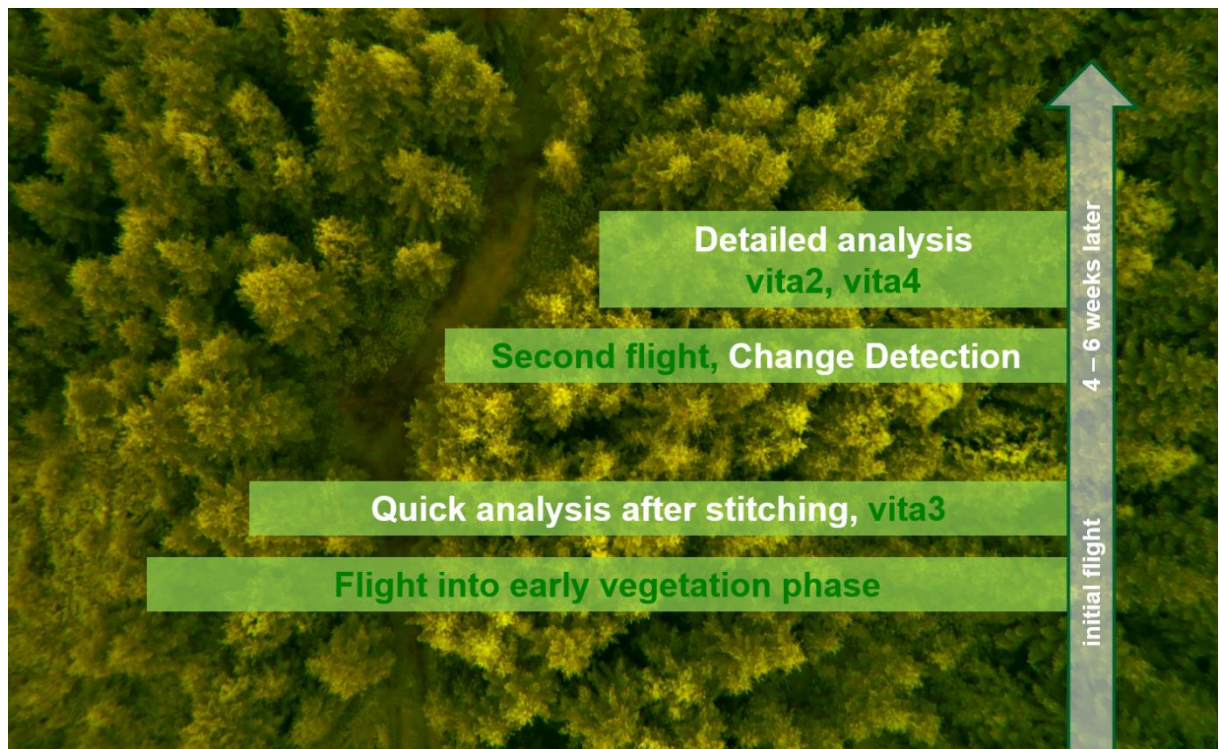


Figure 13: Vitality analysis procedure

ANNEX:

Application and interpretation of results

On the basis of two or more aerial photographs of the same forest areas, taken at the equal time interval, changes in the vitality of the conifers are searched for. The basis for this method is provided by a single tree detector, which mainly detects spruce trees, but occasionally also other coniferous tree species. The vitality changes are divided into 4 classes:

vita1 - Unchanged conifer tree (no output, because majority of trees)

vita2 - Strongly changed conifer tree

vita3 - A conifer tree with severely reduced vitality

vita4 - Weakly changed conifer tree

vita1

Unchanged conifer tree

Healthy tree or incipient beetle infestation or other damage at a very early stage, where no change in the supply of the tree crown has yet occurred.

Before changes in the needle dress can be multispectral read out, the nutrient supply must be at least partially restricted, e.g. by dryness or by interruption of pathways as a result of fungal infestation or feeding of the larvae. This can take from a few days to weeks after infestation by the fungus or drilling of the pioneer beetles.

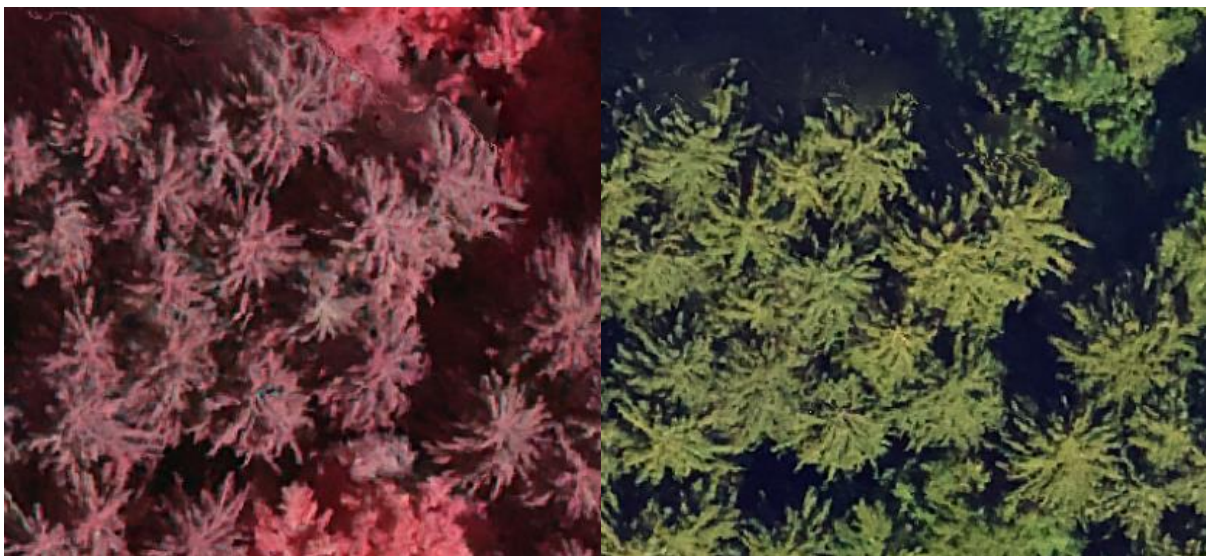


Figure 14: The picture shows the same forest at the same time, left as CIR image and right as RGB image

vita2

Strongly changed conifer tree

Clear change of the vitality of the tree between the temporally distant images due to bark beetle infestation, drought stress, hallimash, etc.

Occasionally, freshly dead trees are also displayed.

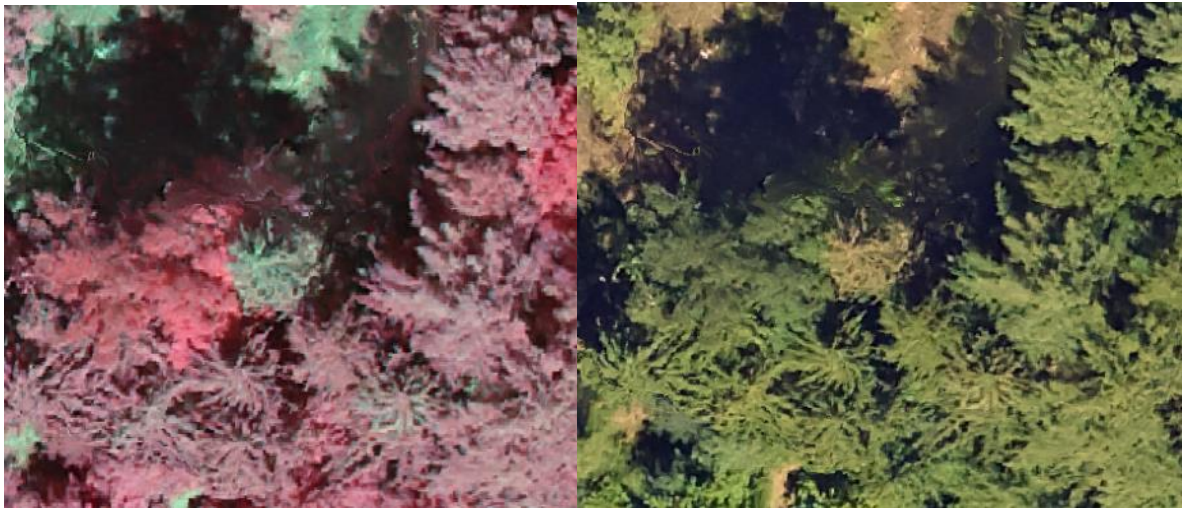


Figure 15: Example A at time 1

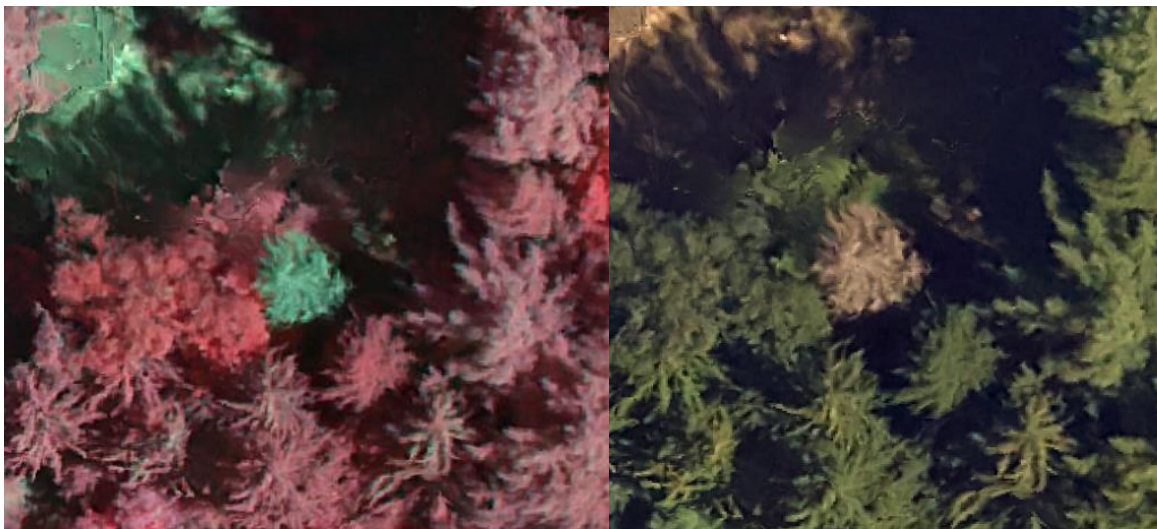


Figure 16: Example A at time 2

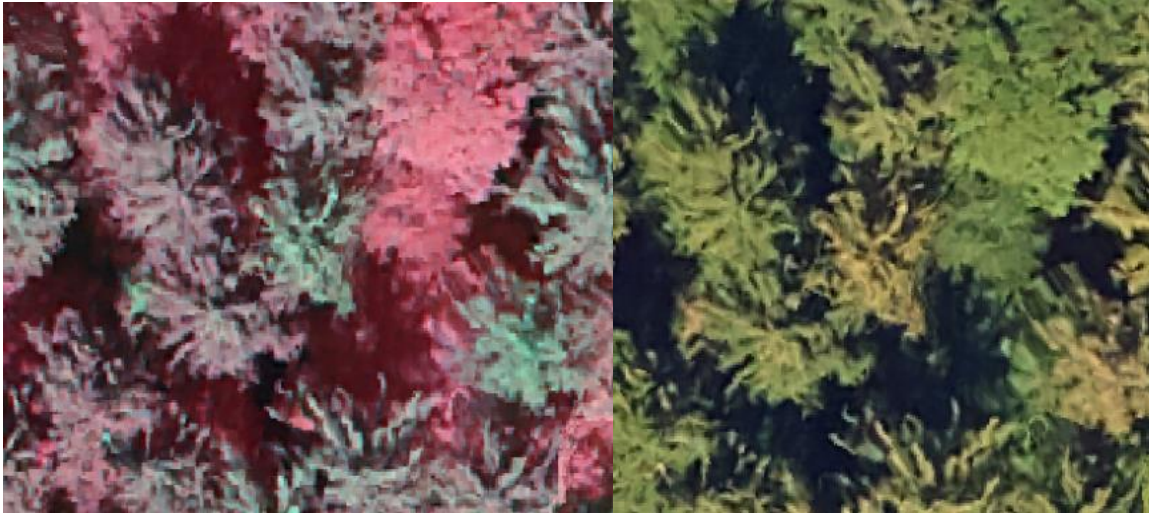


Figure 17: Example B at time 1

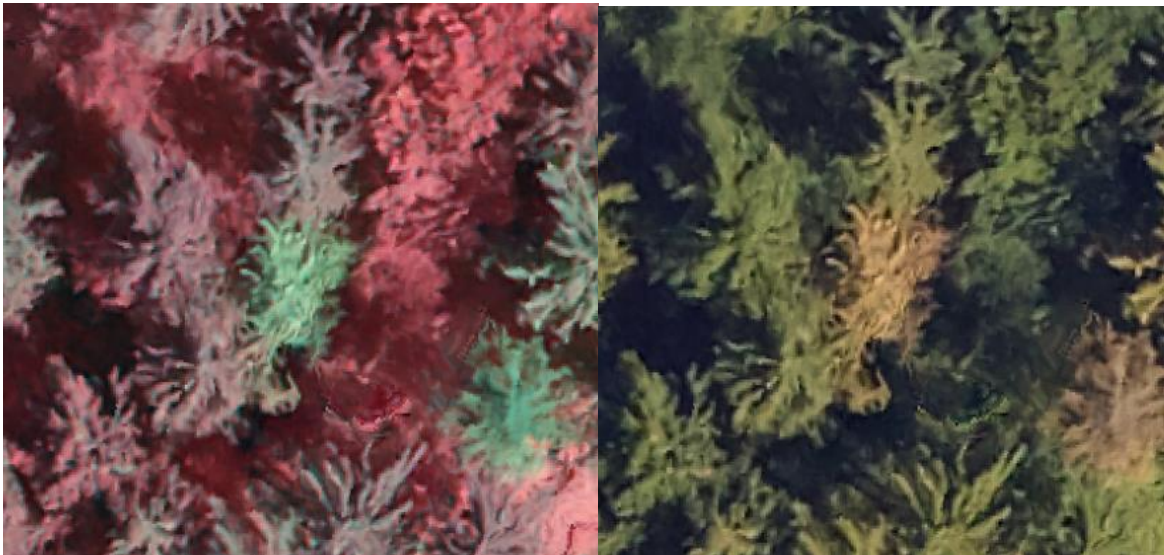


Figure 18: Example B at time 2

vita3

A conifer tree with severely reduced vitality

Conifers which already show a clear strong restriction of vitality at the first intake, e.g. diseased and dying trees, as well as early dead wood.

Old deadwood is not explicitly identified in order to minimise the number of points to be visited. However, these can also be displayed on request.

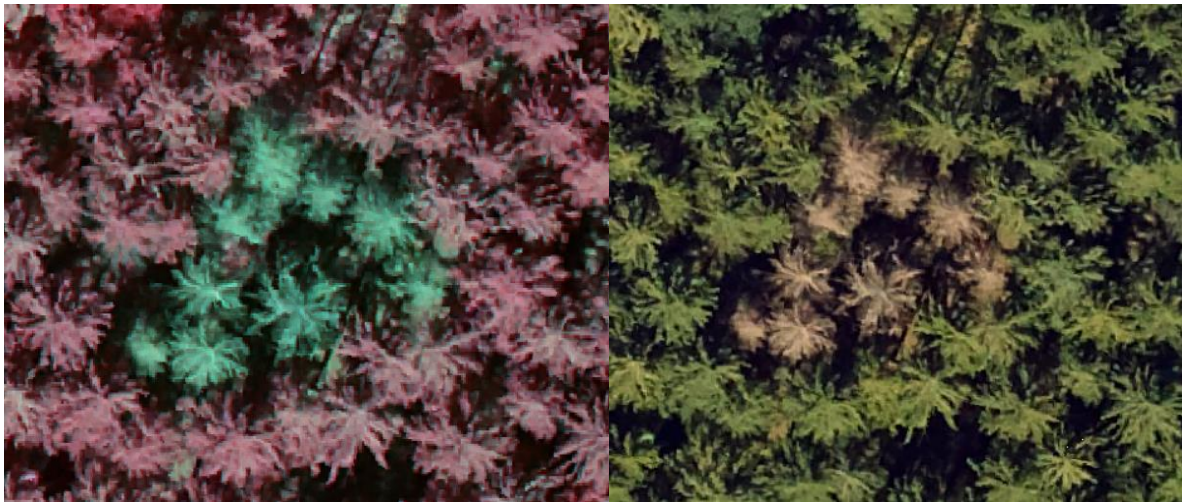


Figure 19: Example C at time 1

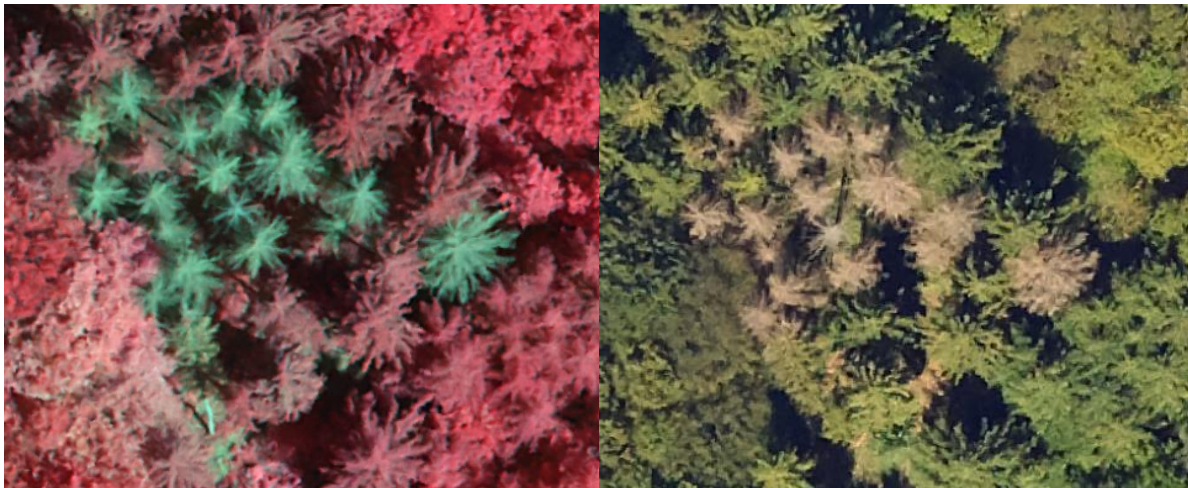


Figure 20: Example D at time 1

vita4

Weakly changed conifer tree

Conifer trees that show a slight loss of vitality at the first exposure and experience only a slight change until the next exposure. These trees show an increased potential for bark beetle infestation compared to healthy trees.

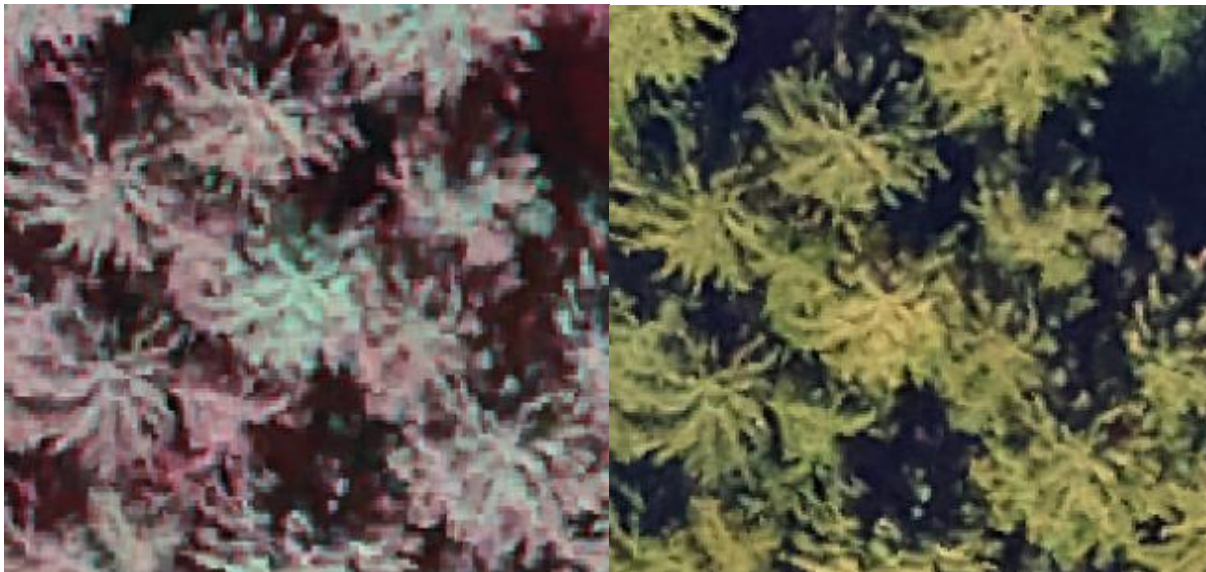


Figure 21: Example E at time 1

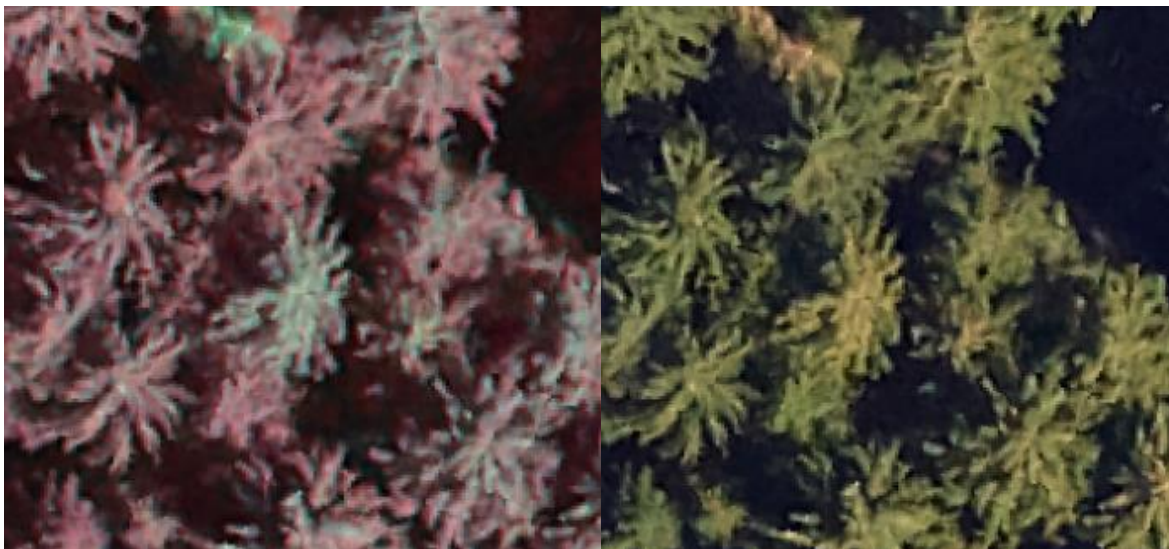


Figure 22: Example E at time 2

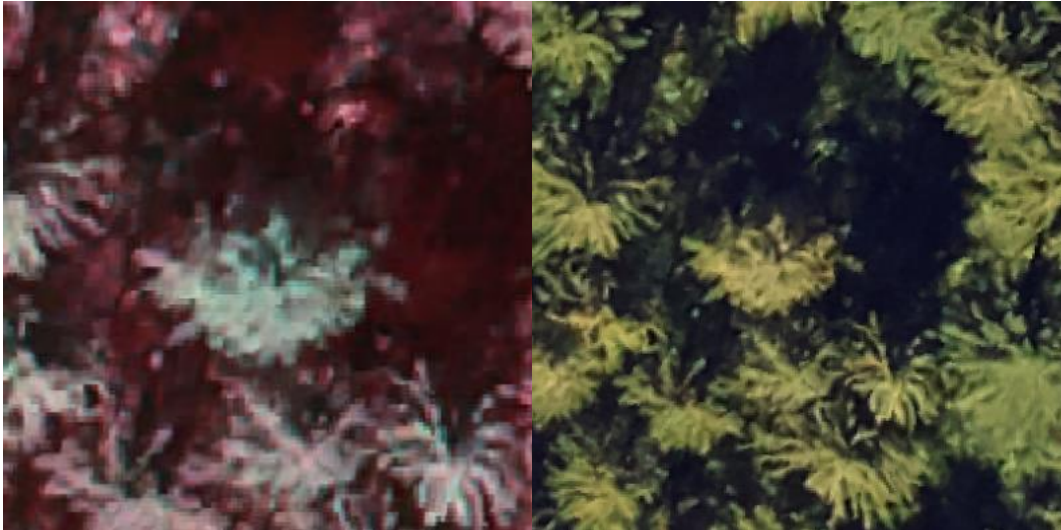


Figure 23: Example F at time 1

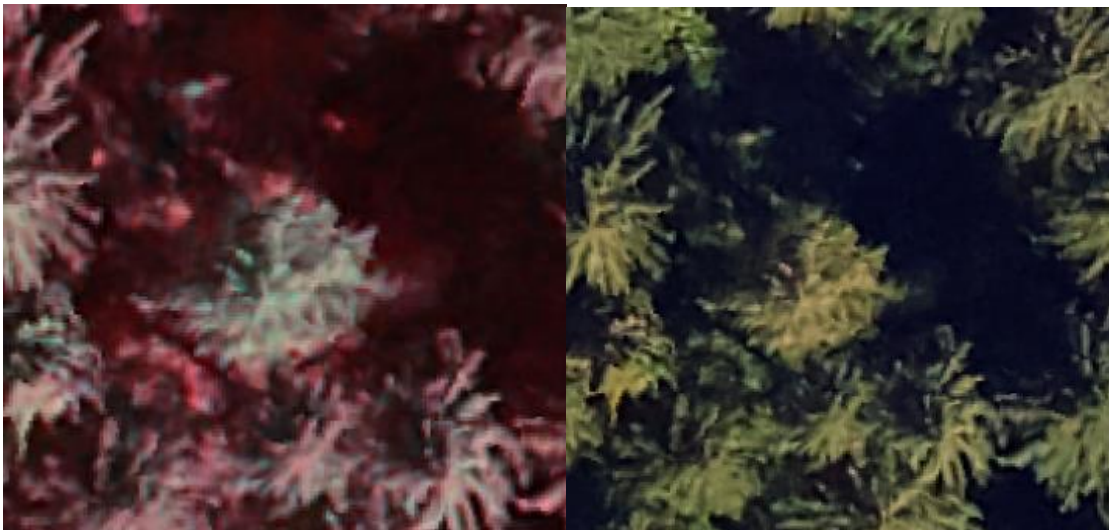


Figure 24: Example F at time 2