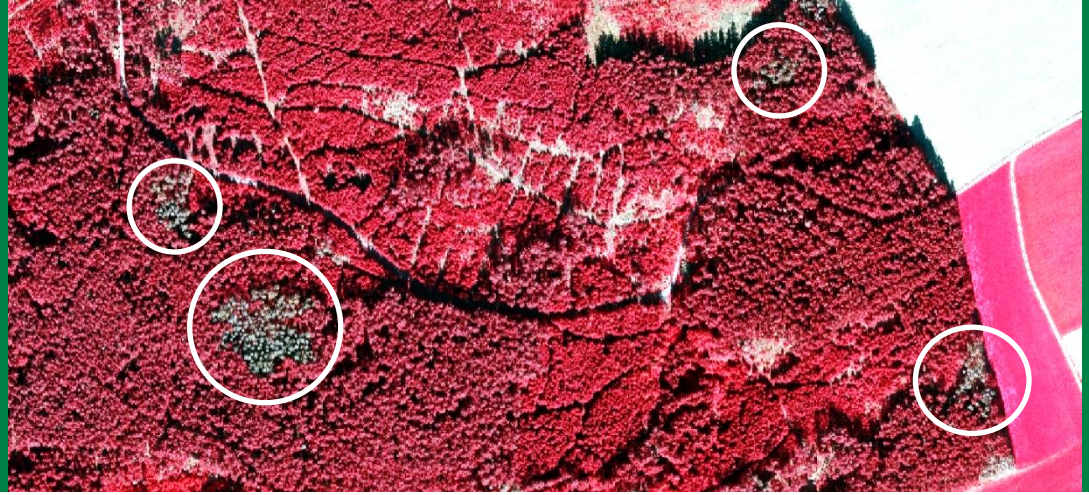


Bark beetle damage detection in Bavaria

Christoph Straub

Dept. Information Technology, LWF

Remote Sensing Lectures 2022

„Remote sensing of forest disturbances”

Bayerische Landesanstalt
für Wald und Forstwirtschaft

BAYERISCHE FORSTVERWALTUNG

ZENTRUM WALD FORST HOLZ
WEIHENSTEPHAN

Introduction

During the past years large-scale damage caused by bark beetles in Bavaria

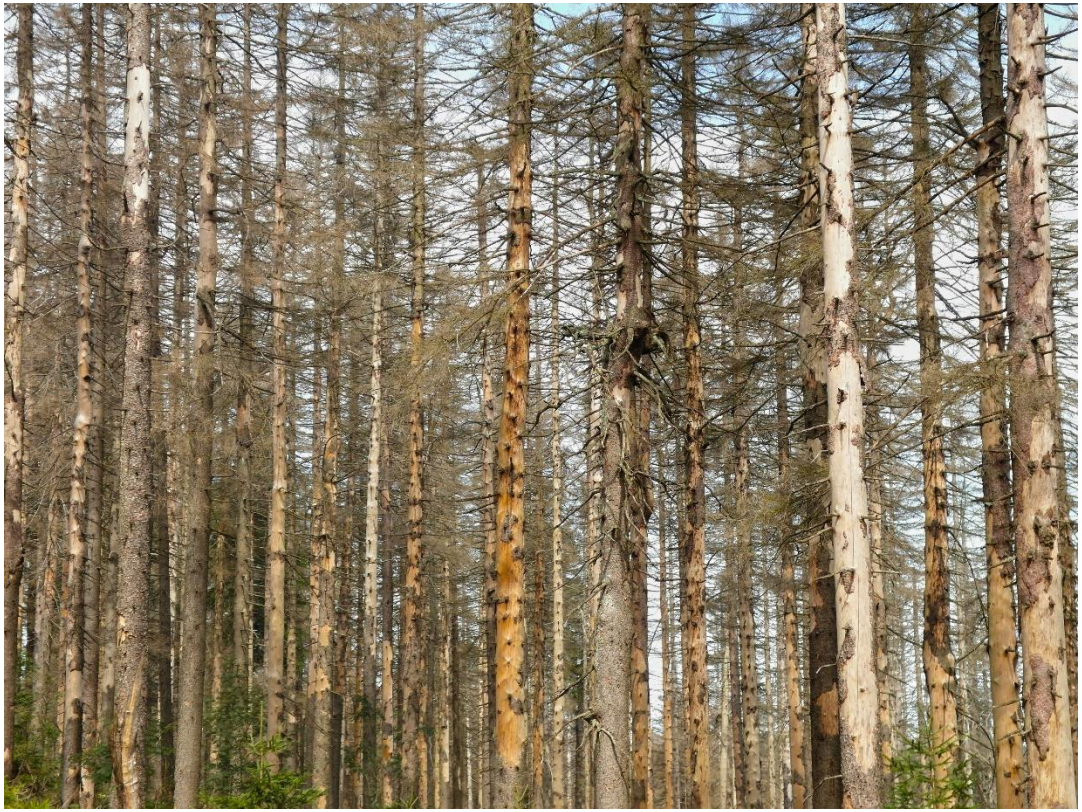
Bildautor: Rudolf Vornehm

European spruce bark beetle, Buchdrucker (*Ips typographus*), Size: 4 – 5,5 mm

Introduction

Large-scale damage during mass propagation

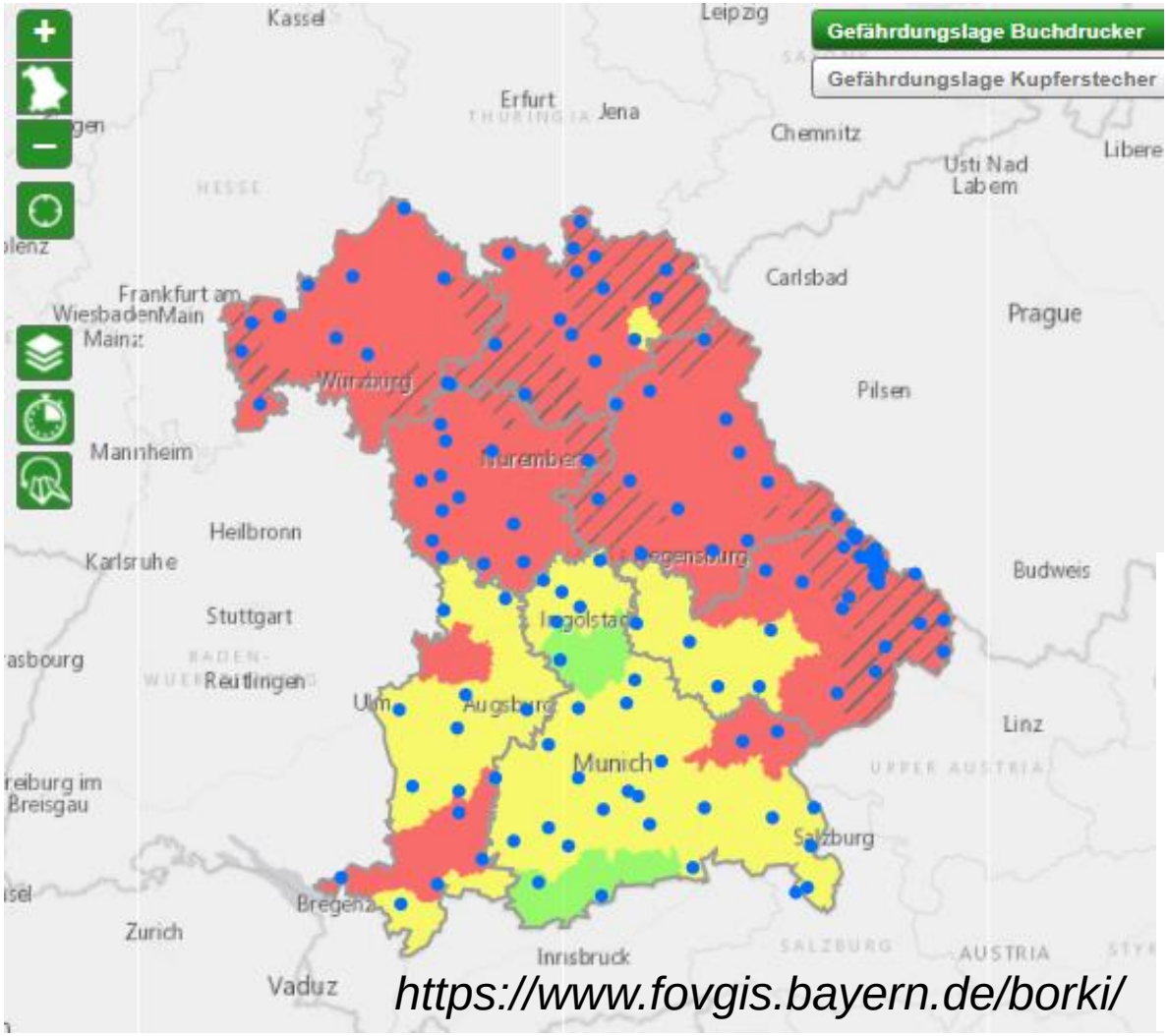
Many infested sites



Bildautor: Klaus-Peter Janitz

Introduction – bark beetle monitoring program

Threat for European spruce bark beetle infestation in Bavaria on 31.08.2020



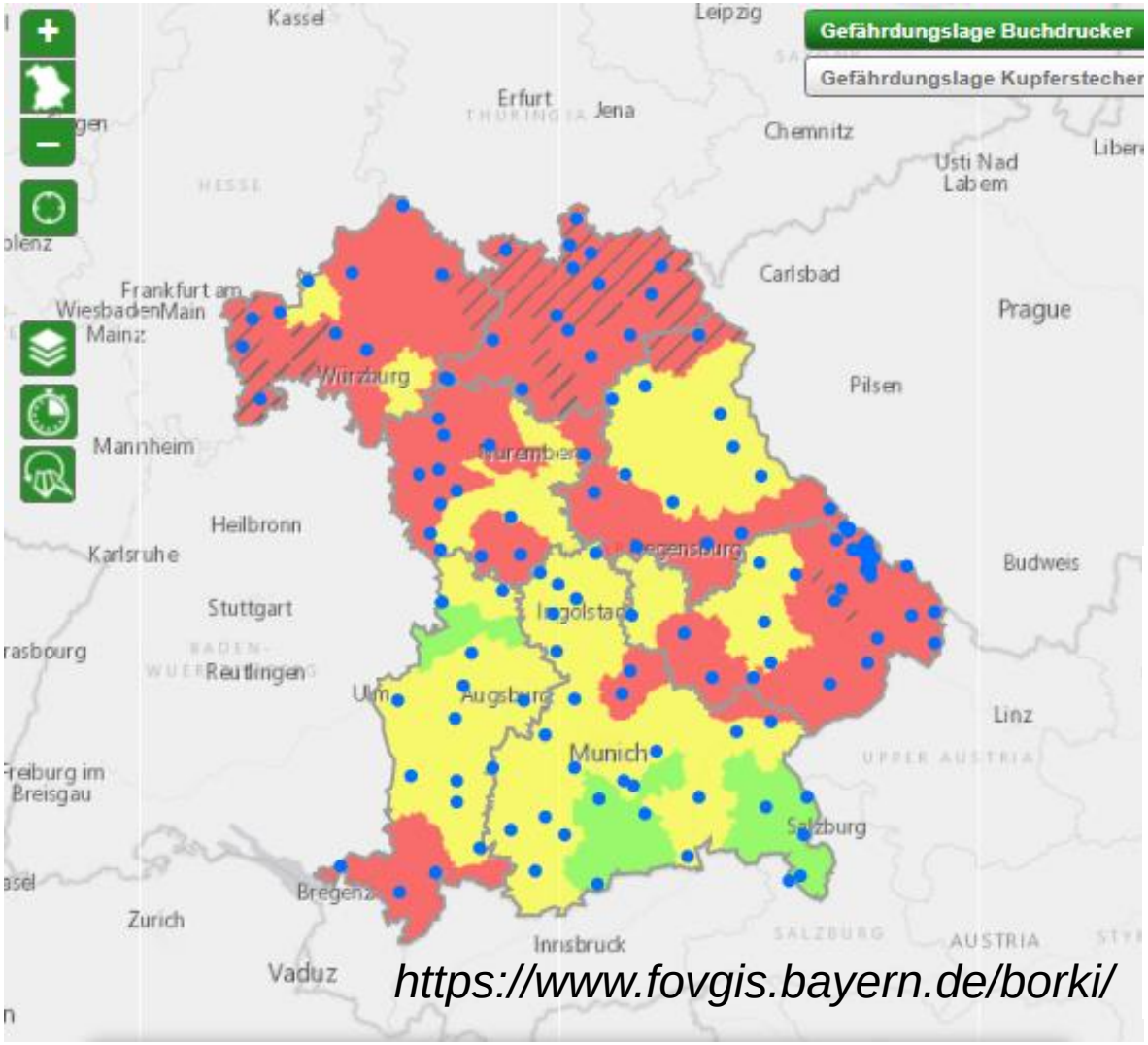
pheromone traps are checked once a week

Gefährdung Buchdrucker

- **keine Warnstufe**: noch kein Hinweis auf erhöhte Populationsdichte
- **Warnstufe**: Ausbreitung des Befalls zu erwarten
- **Gefährdungsstufe**: schnelle Ausbreitung bestehender Befallsherde ist zu erwarten
- **Gefährdungsstufe mit akutem Stehendbefall**

Introduction – bark beetle monitoring program

Threat for European spruce bark beetle infestation in Bavaria on 30.08.2021



pheromone traps are checked once a week

Gefährdung Buchdrucker

- **keine Warnstufe**: noch kein Hinweis auf erhöhte Populationsdichte
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- **Gefährdungsstufe**: schnelle Ausbreitung bestehender Befallsherde ist zu erwarten
- **Gefährdungsstufe mit akutem Stehendbefall**

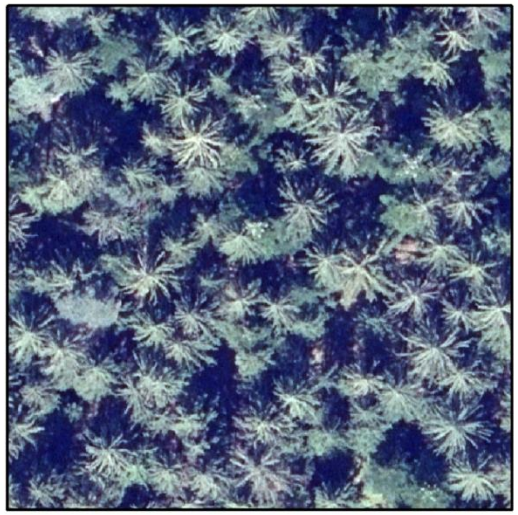
Introduction

- Increasing request for remote sensing data from the regional forestry offices
  - detection of spruce trees and stands infested by bark beetles
  - assessment of the extent of the damage

→ Development of methods and evaluation of remote sensing data together with the forestry practice

Bark beetle infestation in remote sensing data, here: aerial photography

a) keine Verfärbung:



Green-attack stage:
Early phase in which tree crowns do not show visual signs of infestation

b) rotbraune Verfärbung:

Red-attack stage:
Needle discolouration, reddish brown colour of the crowns

c) graue Verfärbung:

Grey-attack stage:
Loss of needles, grey colour of the crowns

https://www.waldwissen.net/de/waldwirtschaft/schadensmanagement/satelliten-fuer-den-wald

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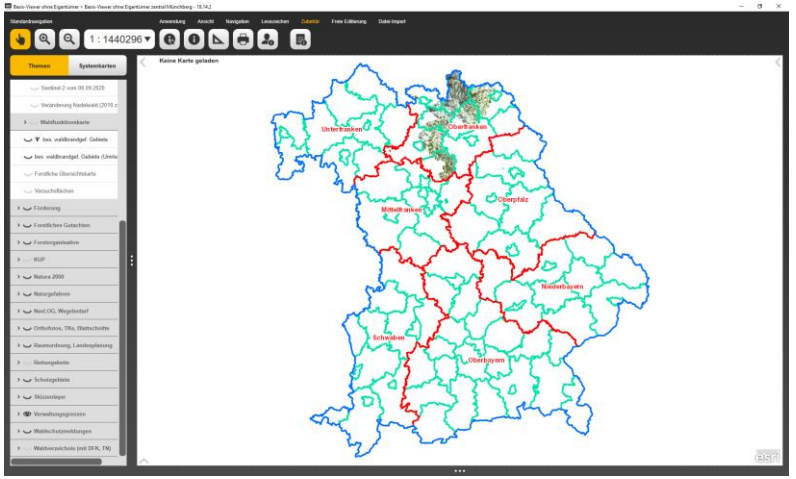
Introduction

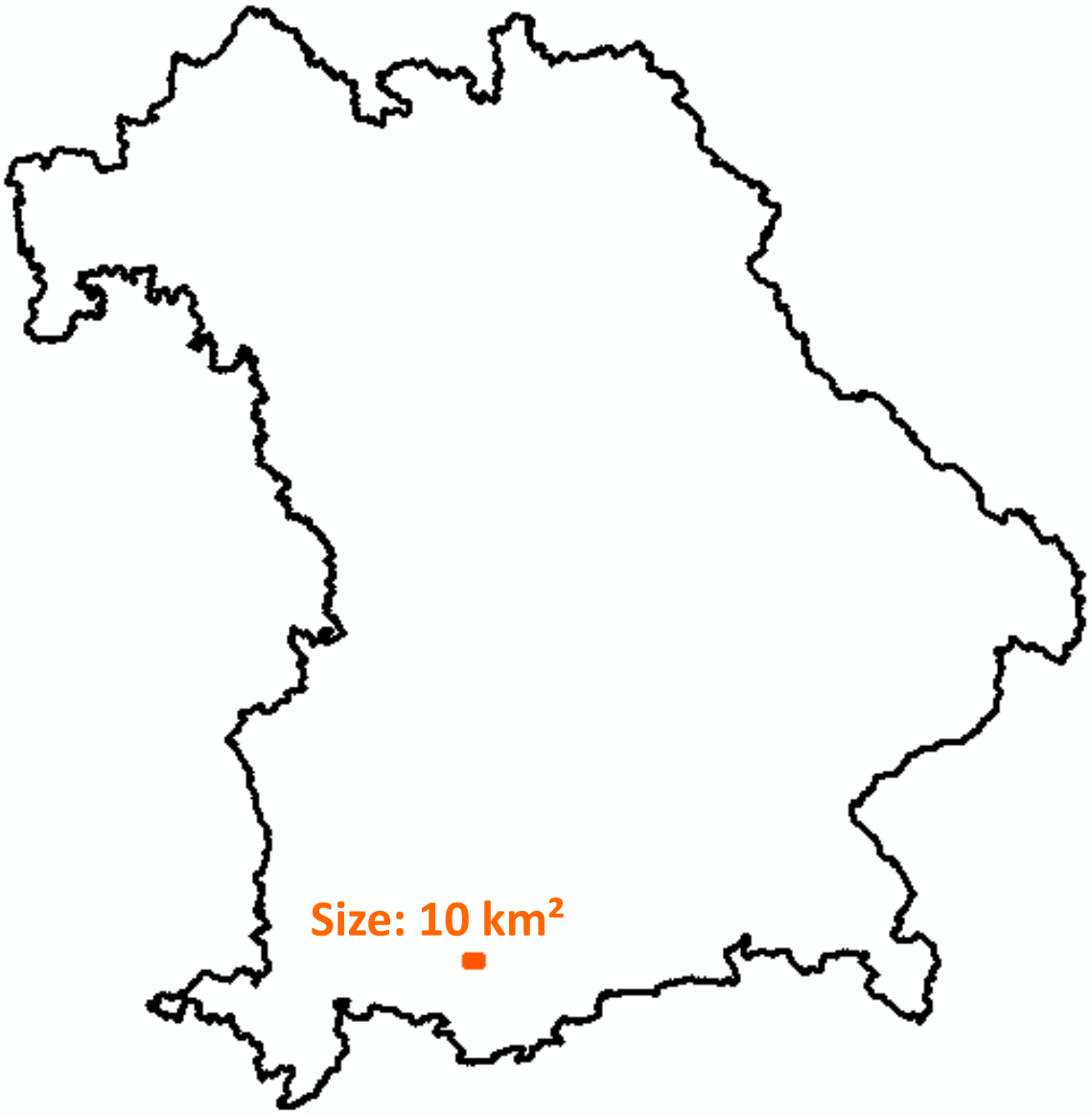
Requirements from forestry practice:

- Detection of the bark beetle infestation as early as possible
- Data supply as quick as possible
- The separation of red-attack and grey-attack is needed
- Data supply within the Bavarian Forest Information System

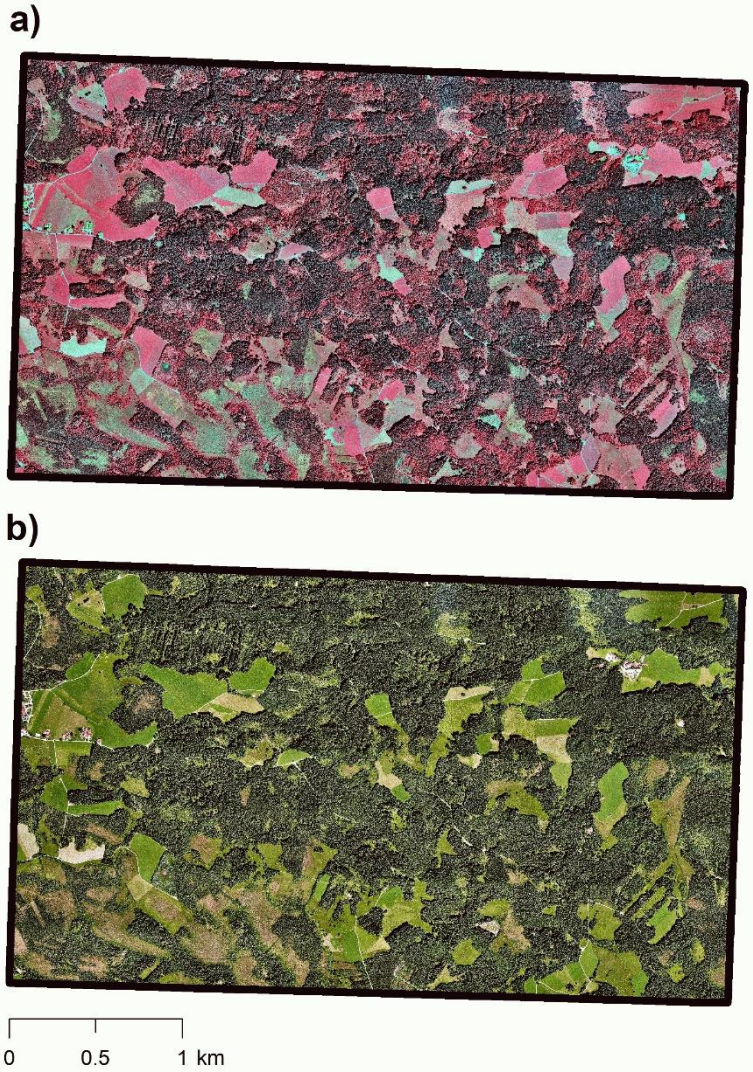
Bildautor: Tobias Hase



Project ST 331:
Test site north of Bad Kohlgrub



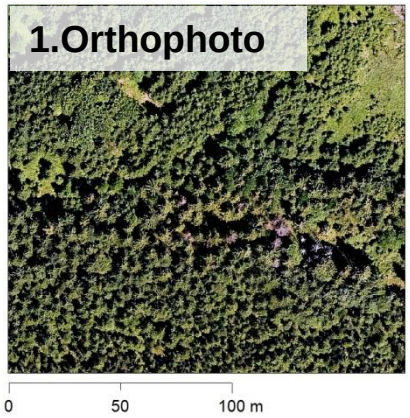
Project ST 331:
Test site north of Bad Kohlgrub

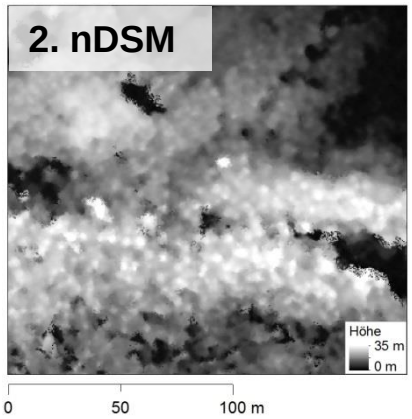


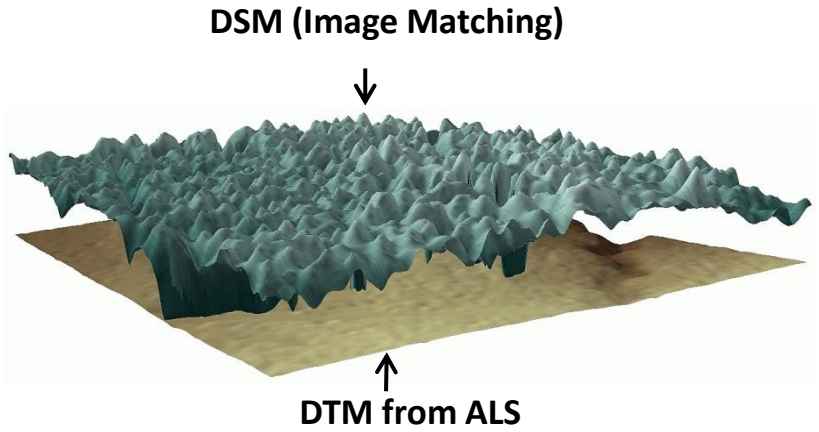
- Phase One camera system
- True-Orthophotos
- GSD: 10 cm
- Spectral bands: blue, green, red, red edge & near infrared

Project ST 331: Methods

Input data

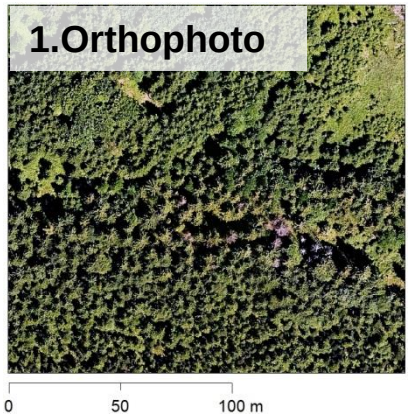


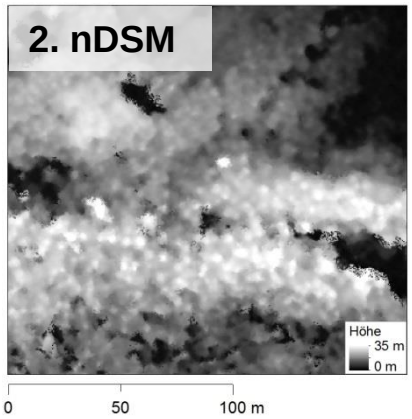




Project ST 331: Methods

Input data

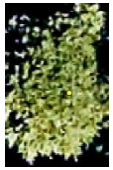




Selection of training data:

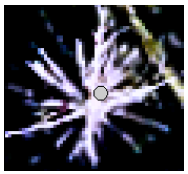
1. Conifers (green):

2. Deciduous (green):



3. Red-attack:

4. Grey-attack:



5. Shadow

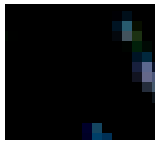
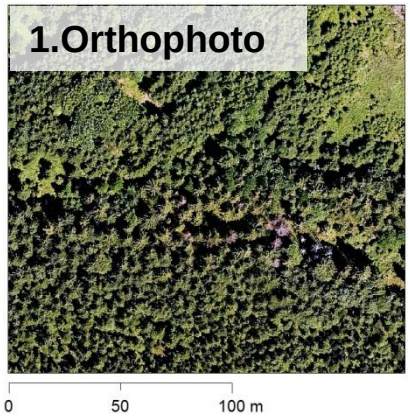
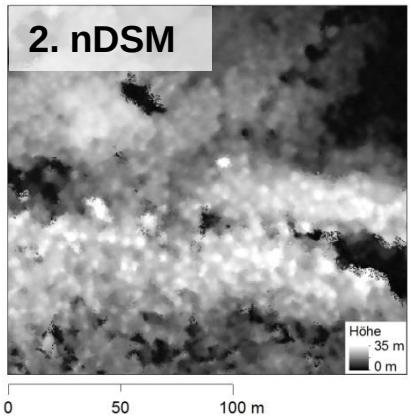


Foto: Tobias Hase

Project ST 331: Methods

Input data

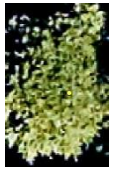




Selection of training data:

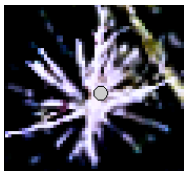
1. Conifers (green):

2. Deciduous (green):

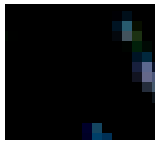


3. Red-attack:

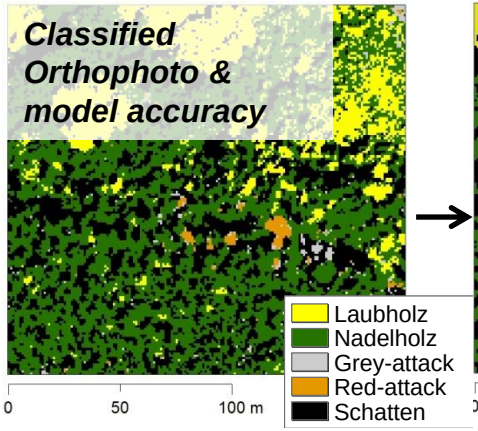
4. Grey-attack:



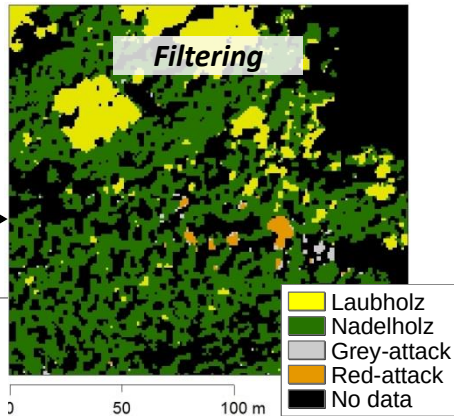
5. Shadow



Machine Learning:



Postprocessing



Elimination of ground and small vegetation

Project ST 331: Methods

- Classification with **Random Forest** (Breiman 2001) and **Recursive Feature Elimination RFE**; *caret* package in R (Kuhn 2017)
- Computation of predictors in 1 m × 1 m cells.
  → mean and standard deviation of the original spectral bands and from 10 different vegetation indices:
  - *Normalized Difference Vegetation Index (NDVI)*
  - *Green NDVI*
  - *Ratio vegetation index*
  - *Green ratio vegetation Index*
  - *Chlorophyll vegetation index*
  - *Chlorophyll index Green*
  - *Normalized Difference Green/Red*
  - *Normalized difference RedEdge index*
  - *Chlorophyll index RedEdge*
  - *Green leaf index*

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Project ST 331:
Independent reference data

Validation with field samples
Obtained from the regional forestry office

		Reference data			
		Conifers (green)	**grey-attack**	**red-attack**	***Sum***
Supervised classification	**Conifers (green)**	**368**	1	21	*390*
	grey-attack	0	**82**	*27*	*109*
	red-attack	0	17	**146**	*163*
	Sum	*368*	*100*	*194*	***662***

Overall accuracy: 90%

Cohens-Kappa-coefficient: 0,83

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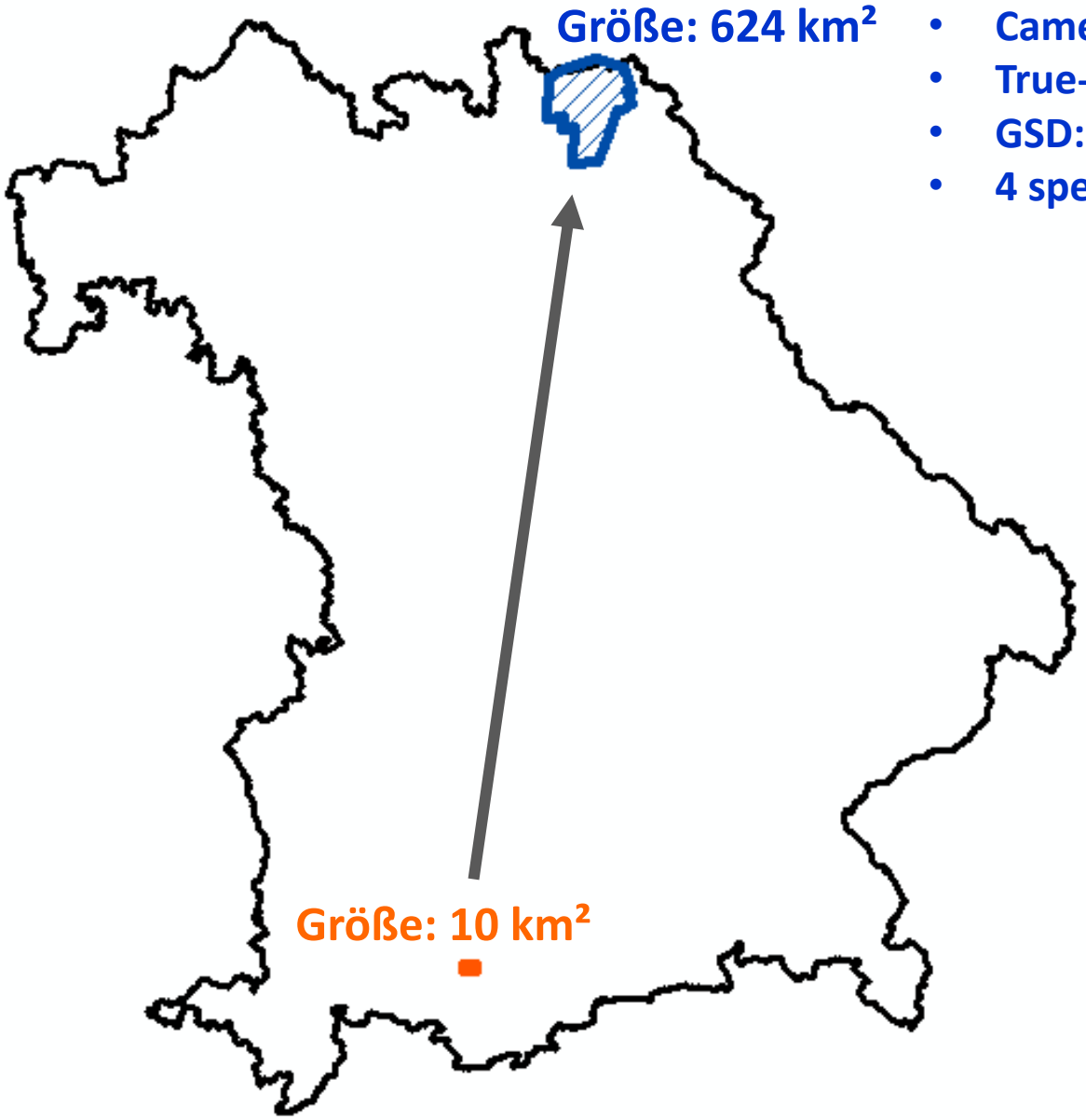
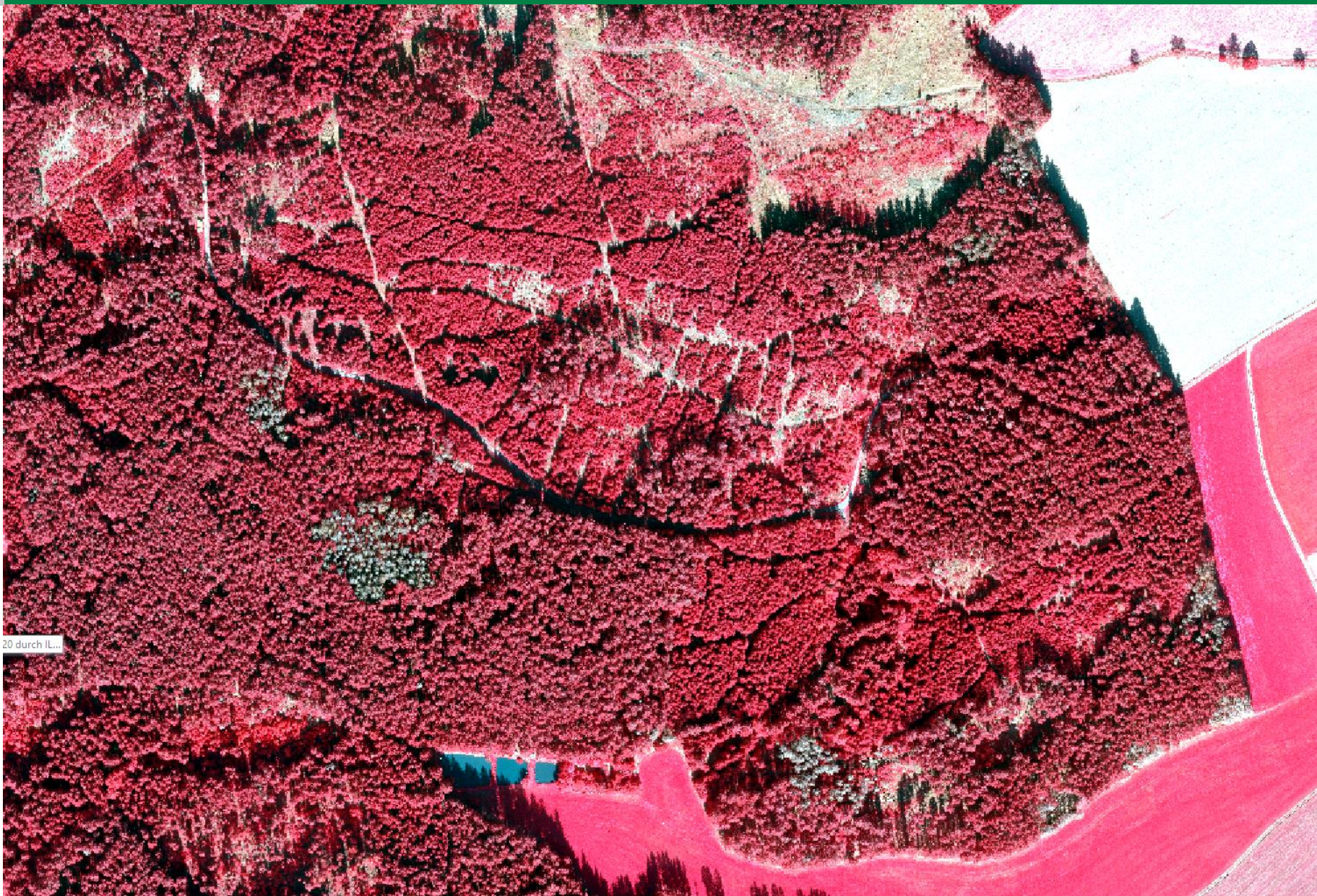
Practical application of the method in 2020
Application for a much larger AOI (sub-area of AELF Münchberg)



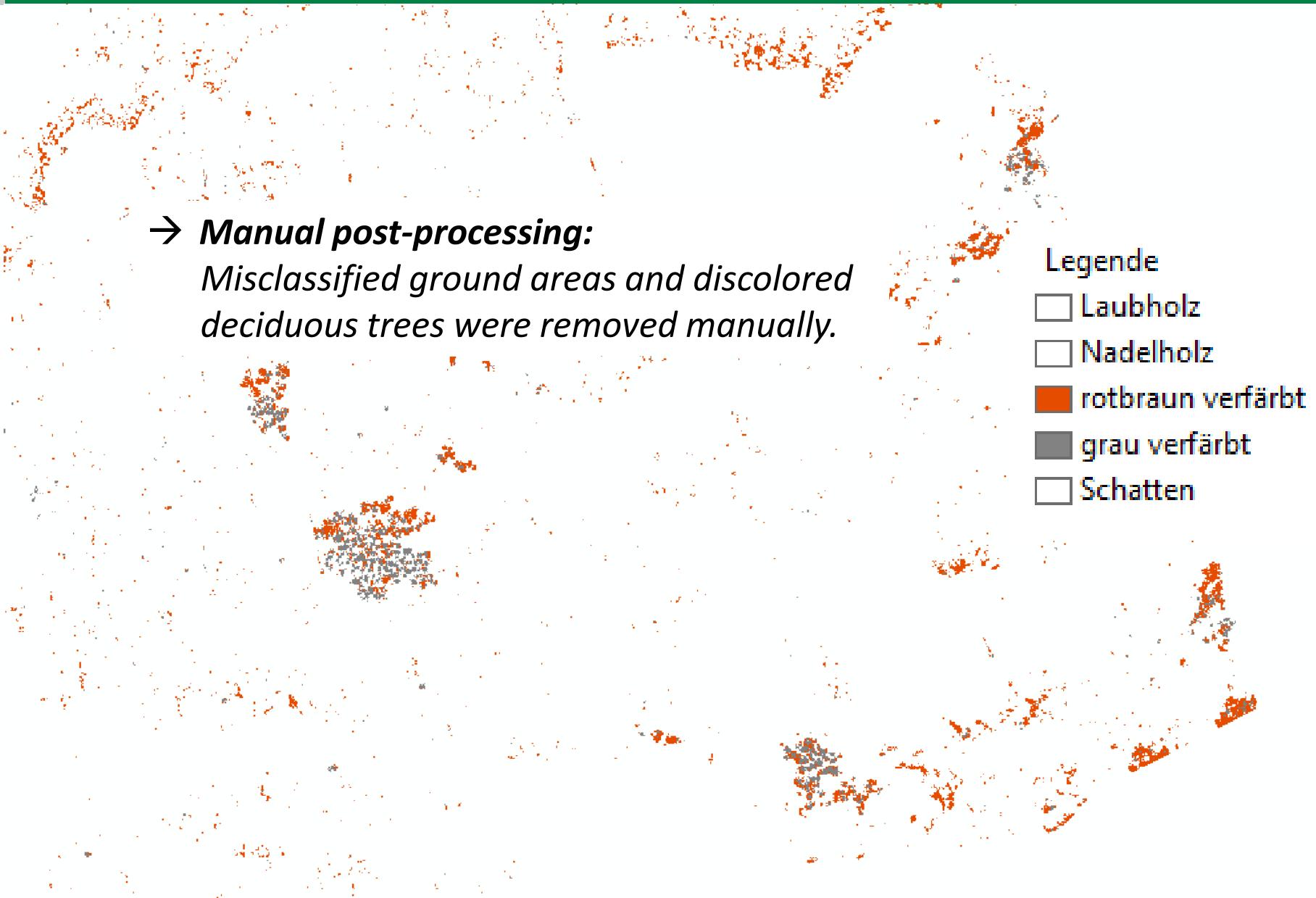
- Camera: DMC III
- True-Orthophotos
- GSD: 10 cm
- 4 spectral bands

Practical application of the method from ST331 – Application for a much larger AOI (sub-area of AELF Münchberg)



Practical application of the method from ST331 – Application in larger AOI (sub-area of AELF Münchberg)

→ ***Manual post-processing:***
Misclassified ground areas and discolored deciduous trees were removed manually.



Practical application of the method from ST331 – Application in larger AOI (sub-area of AELF Münchberg)

Feedback from forestry practice:

- Classification was useful ☺
- Several infested areas were identified in the image data that were not detected in the field ☺
- The data supply was not quick enough ☹

  here: flight campaign at the end of September, supply of the semi-automatic classification in January

→ Project FastOrtho to speed up the data supply,

- *Adjustment of the flight parameters*
- *Supply of image data, no supervised classification*

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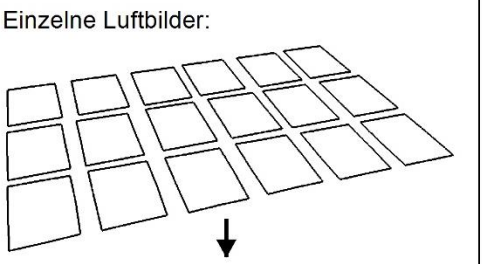
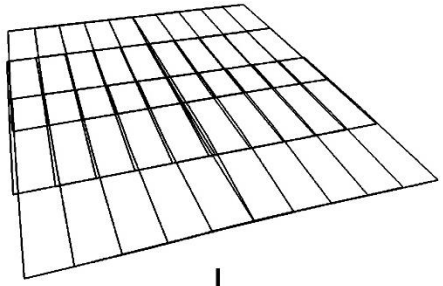
True-Orthophoto (overlap: 80% / 60%)

many images



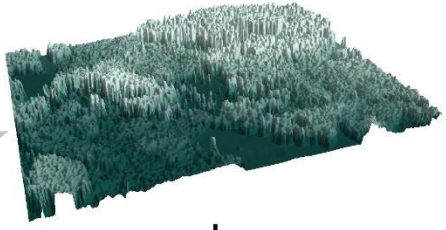
Erstellung Bildverband (orientierte Luftbilder mit hoher Längs- & Querüberlappung)

High accuracy requirements for the orientation of the images

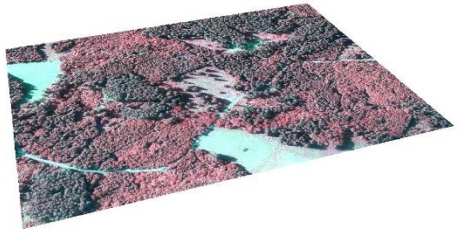


Entzerrung mit einem digitalen Oberflächenmodell

Orthorectification with DSM → needs to be computed from image data



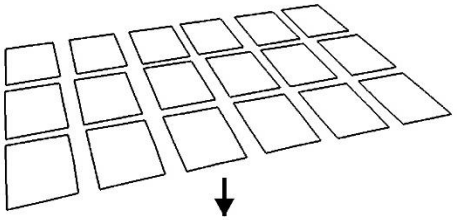
True-Orthophoto



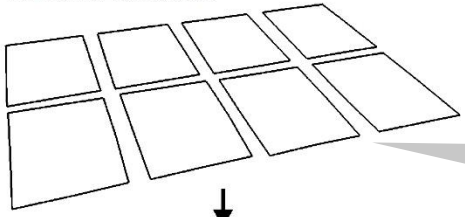
True-Orthophoto (overlap: 80% / 60%)

Fast-Orthophoto (overlap: 70% / 30%)

Einzelne Luftbilder:



many images

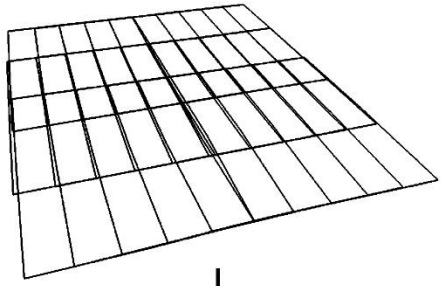


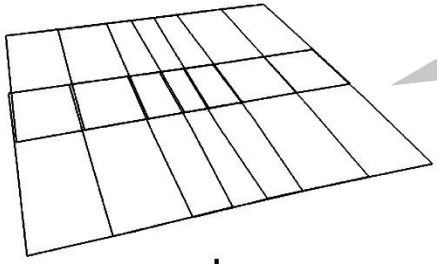
less images

Erstellung Bildverband (orientierte Luftbilder mit hoher Längs- & Querüberlappung)

Erstellung Bildverband (orientierte Luftbilder mit geringer Längs- & Querüberlappung)

High accuracy requirements for the orientation of the images



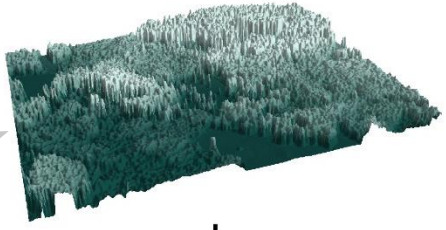


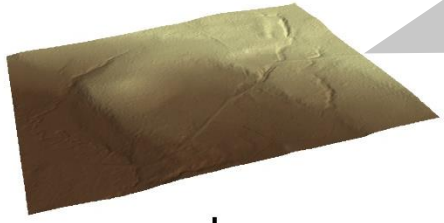
Less accurate orientation of the images

Entzerrung mit einem digitalen Oberflächenmodell

Entzerrung mit einem digitalen Geländemodell

Orthorectification with DSM → needs to be computed from image data

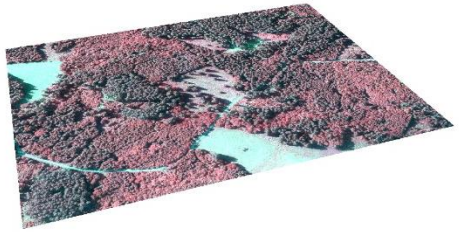


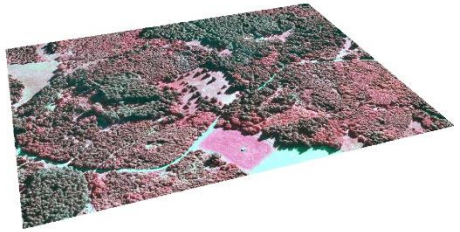


Orthorectification with ALS based DTM → available from Survey Administration

True-Orthophoto

Fast-Orthophoto

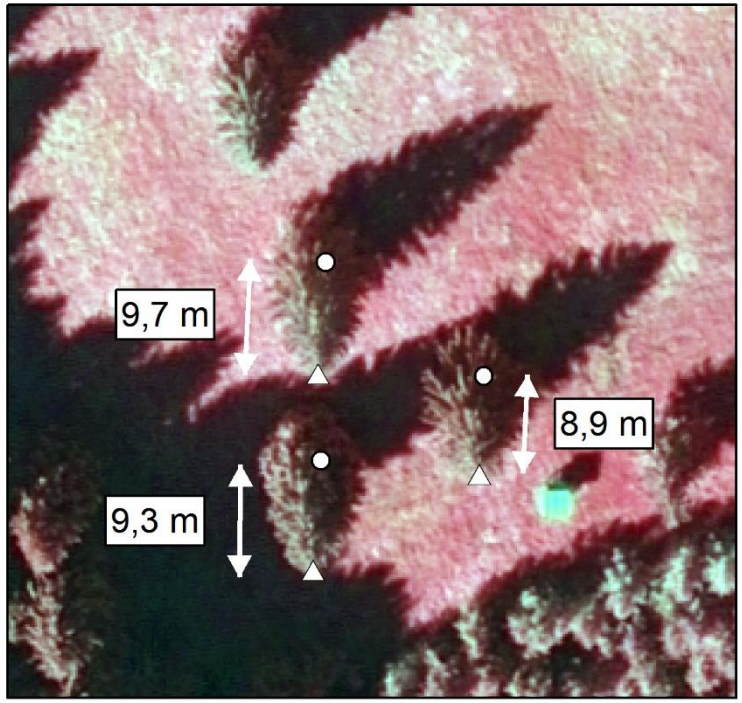




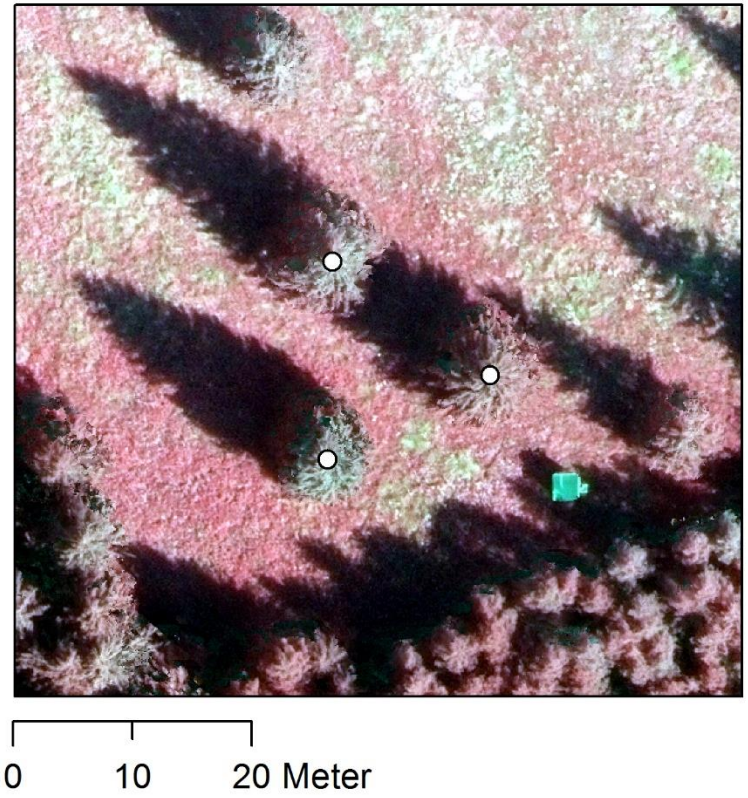
LWF

Fast-Orthophoto - inaccuracies in the tree positions

Fast-Orthophoto:

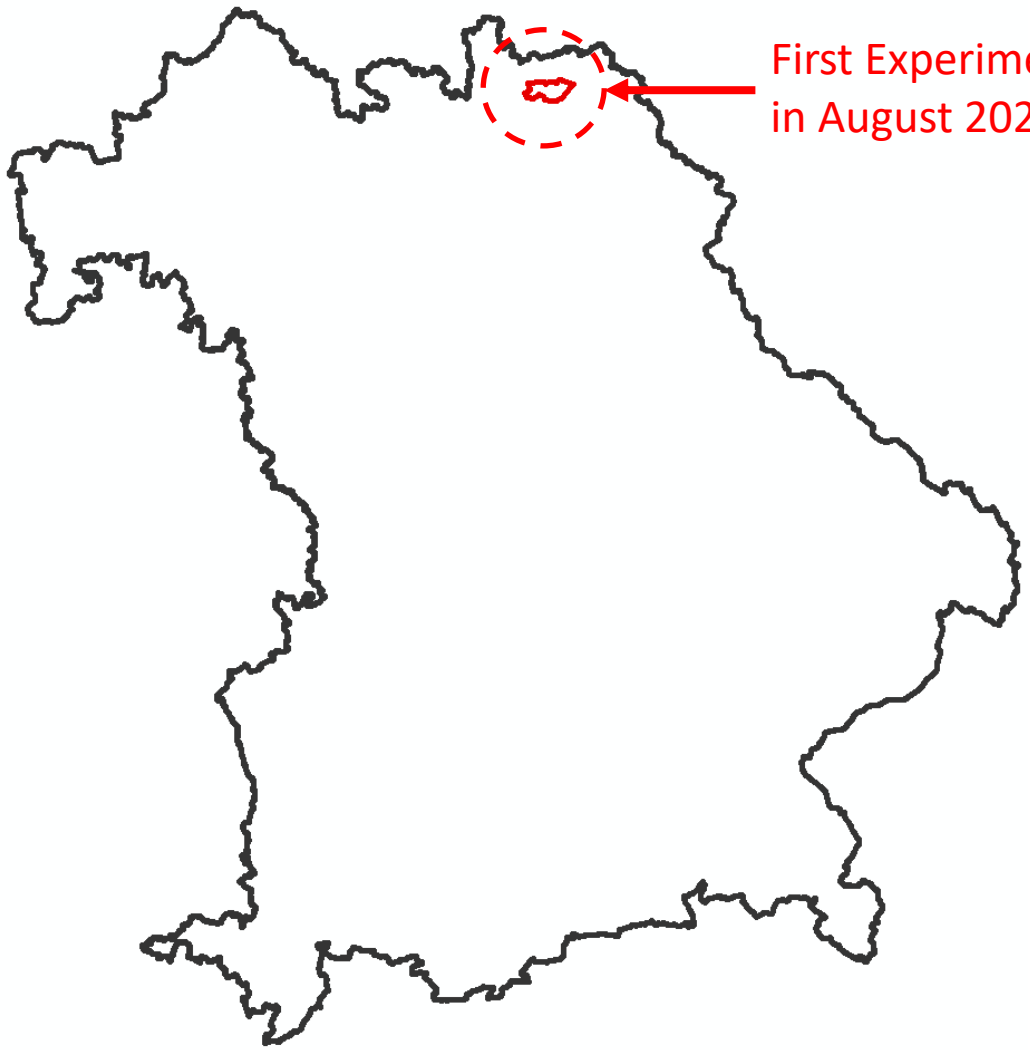


True-Orthophoto:



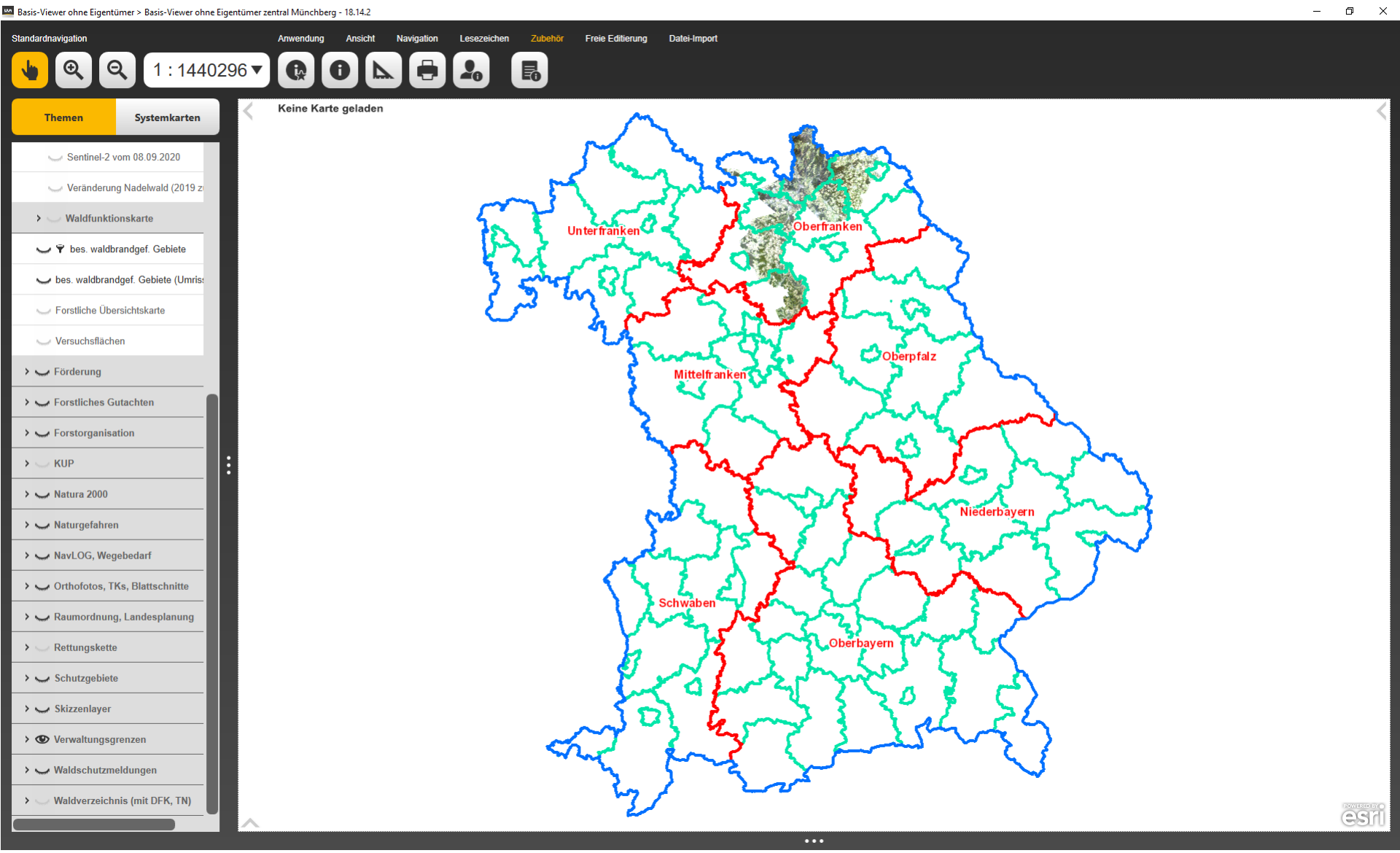
Kennzahl	Wert [m]
Min.	0,30
Max.	12,27
Mittelw.	2,48
Stand. Abw.	2,41

Fast-Orthophoto

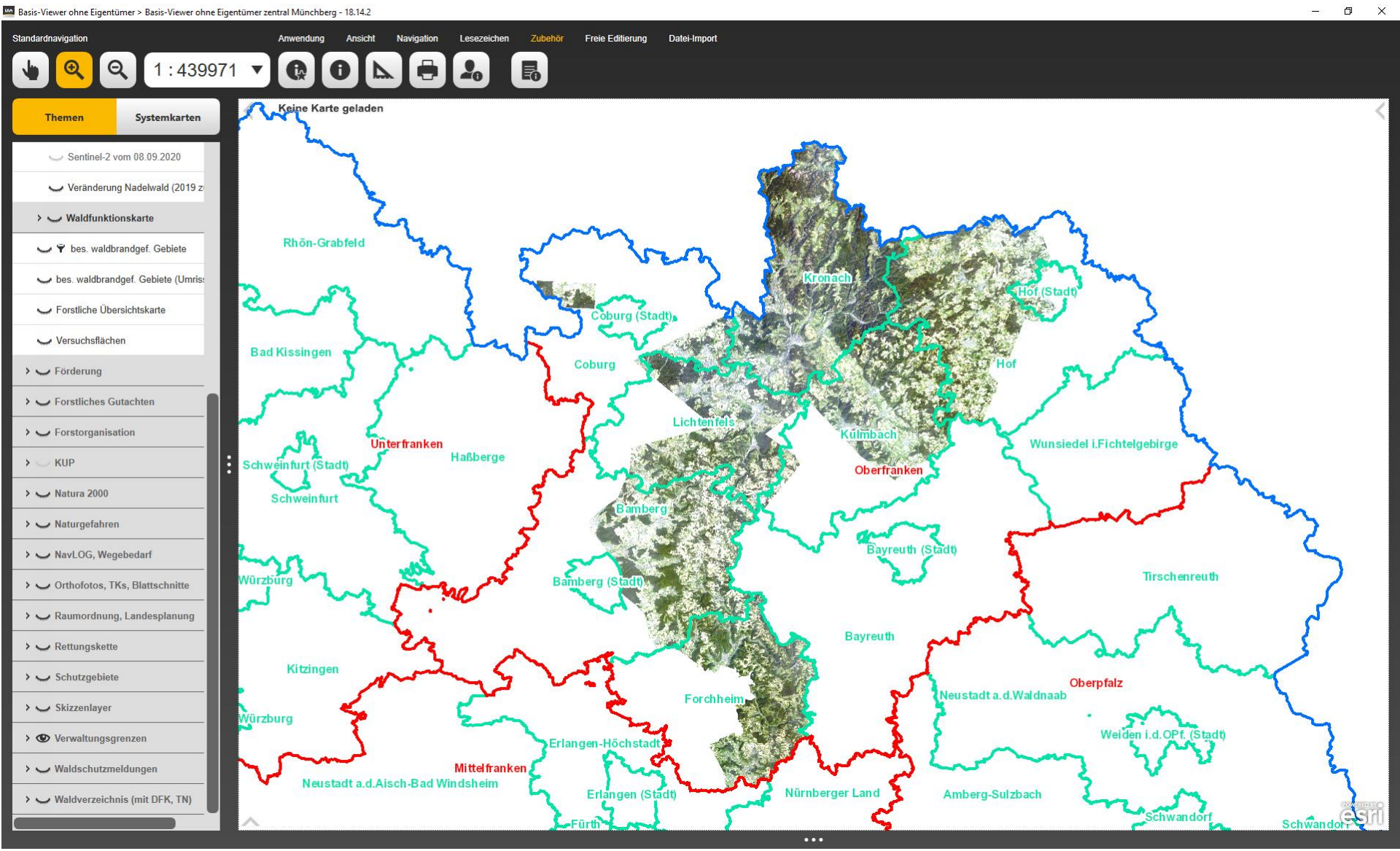


First Experimentation with Fast-Orthophotos in August 2021 in a test site with 85 km²

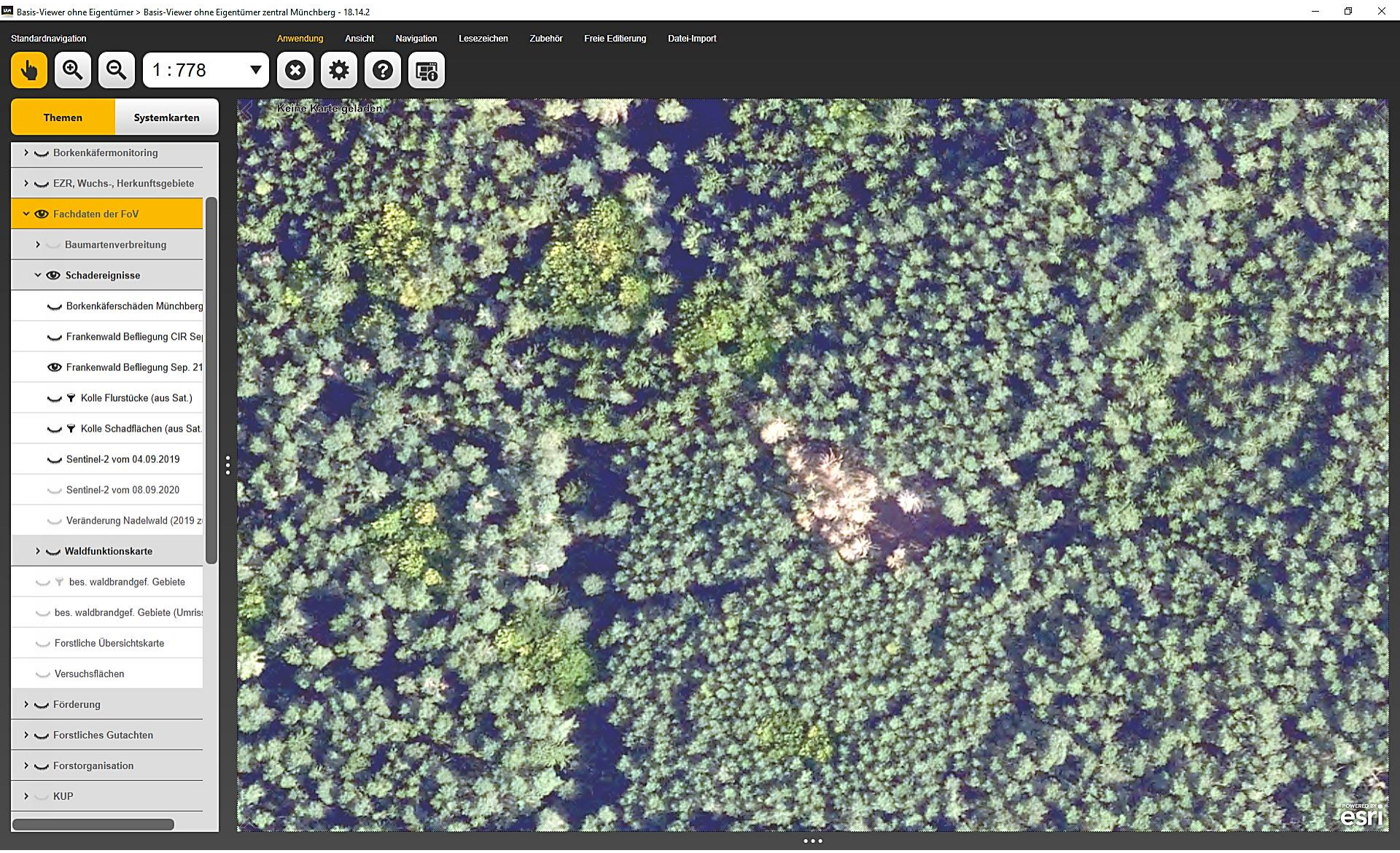
Flight camapaign 2021 (3.000 km²) on 08.09.2021, Fast-Orthophotos, data supply on 14.10.2021



Flight camapaign 2021 (3.000 km²) on 08.09.2021, Fast-Orthophotos, data supply on 14.10.2021

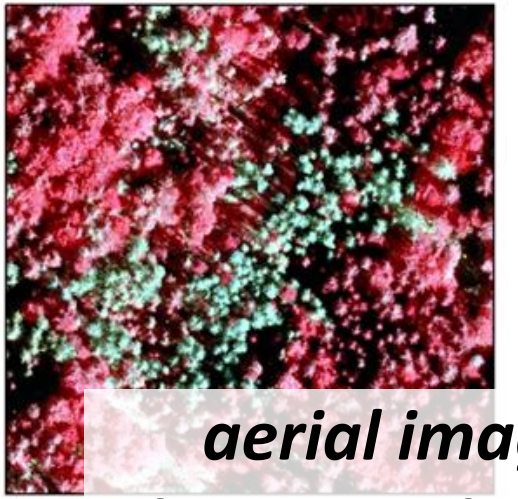


Flight camapaign 2021 (3.000 km²) on 08.09.2021, Fast-Orthophotos, data supply on 14.10.2021



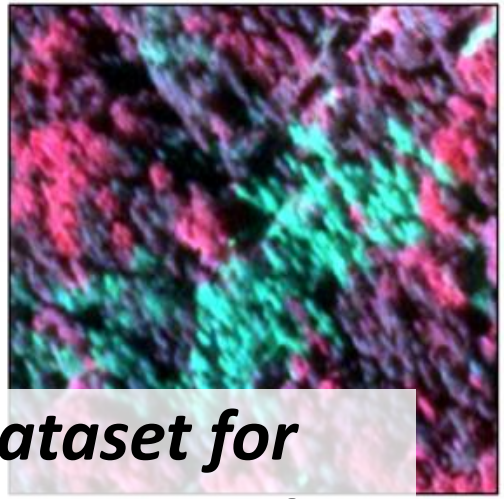
IpsSAT - Assessing optical satellite data for automated detection of bark beetle damage

Luftbild (0,20 m):



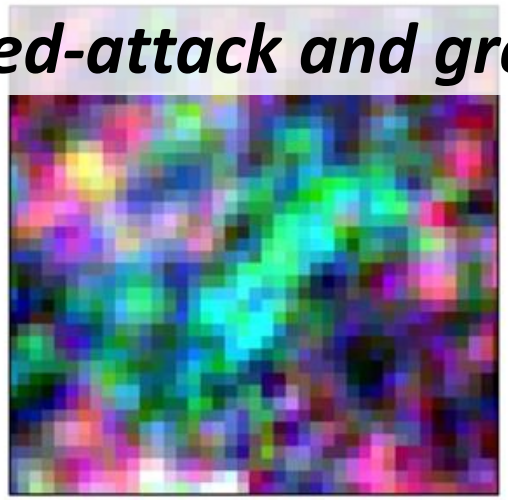
WorldView 3 (0,30 m):

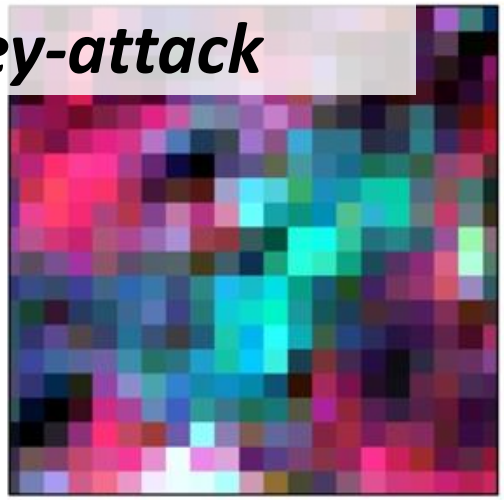
SkySAT (0,80 m):

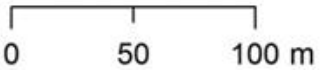


aerial imagery is the best dataset for detecting damaged and dead trees and to classify red-attack and grey-attack

Planet

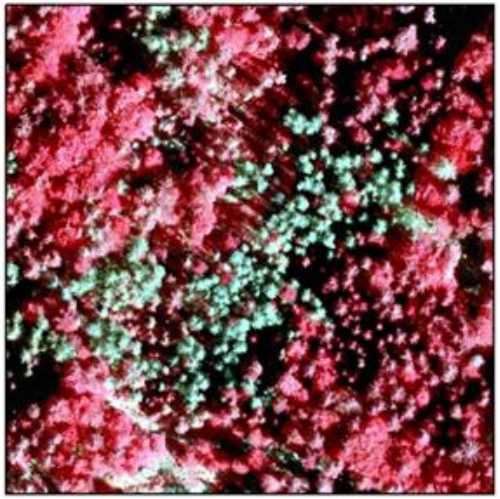




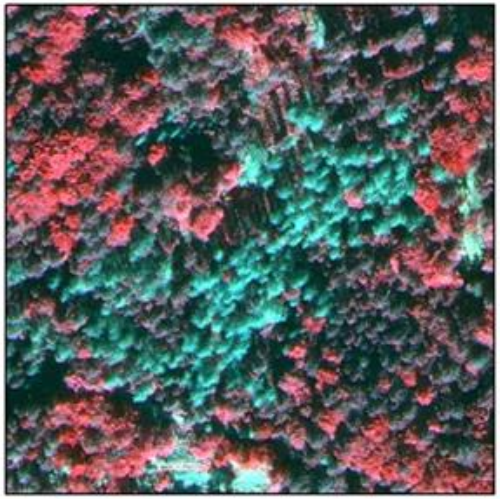


IpsSAT - Assessing optical satellite data for automated detection of bark beetle damage

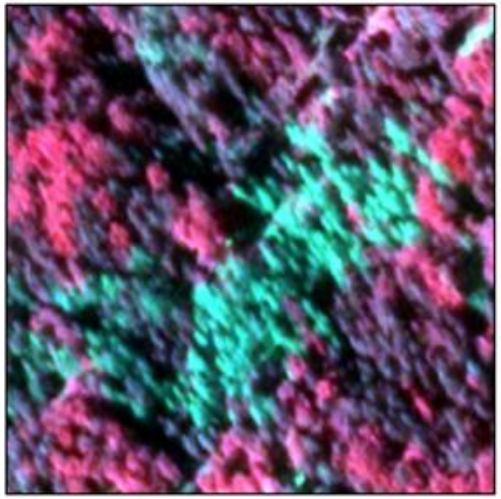
Luftbild (0,20 m):



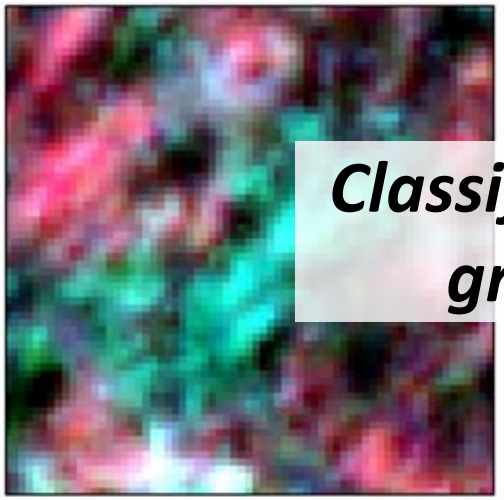
WorldView 3 (0,30 m):



SkySAT (0,80 m):



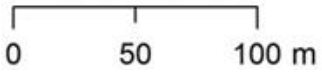
Planet Scope Dove (3,00 m):



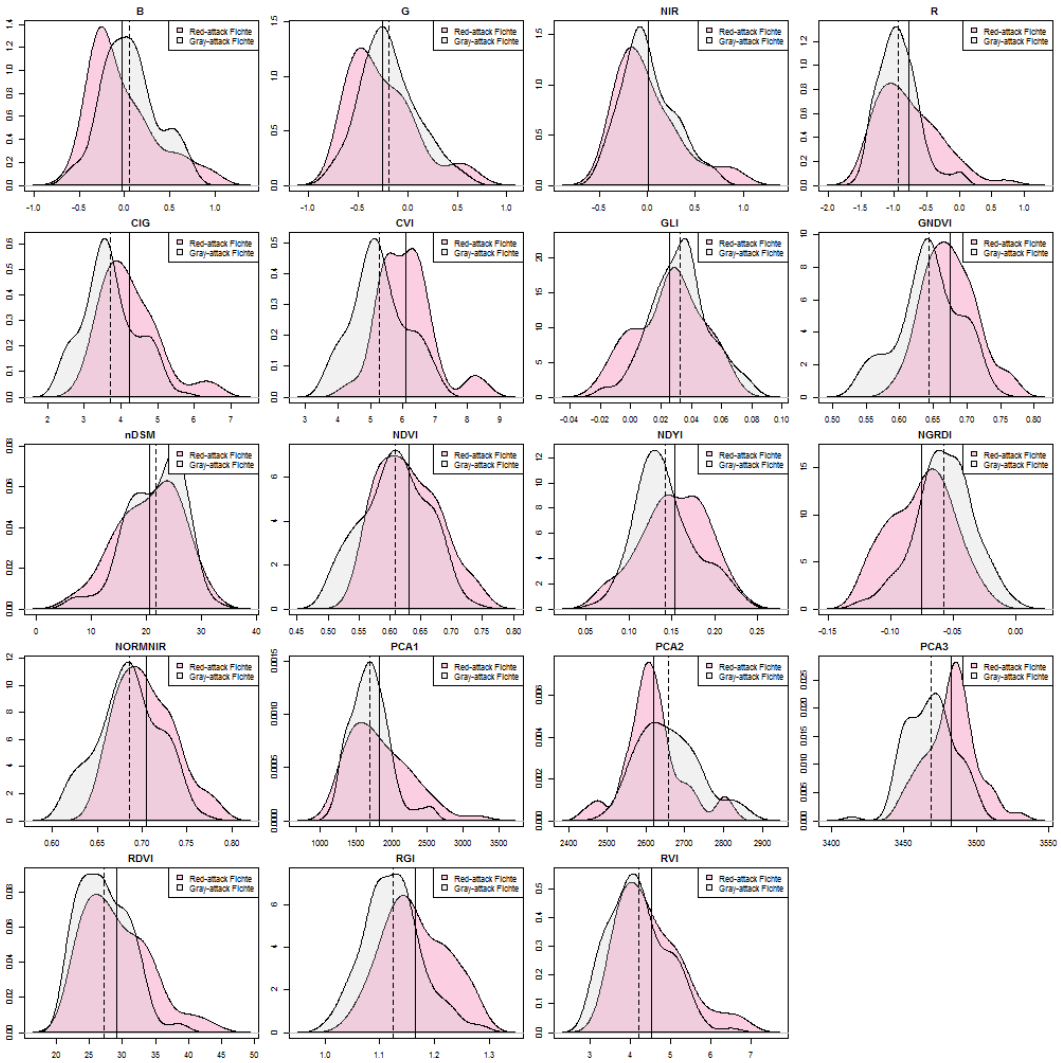
RapidEye (5,00 m):

Sentinel-2 (10,00 m):

Classification of red-attack and grey-attack not reliable

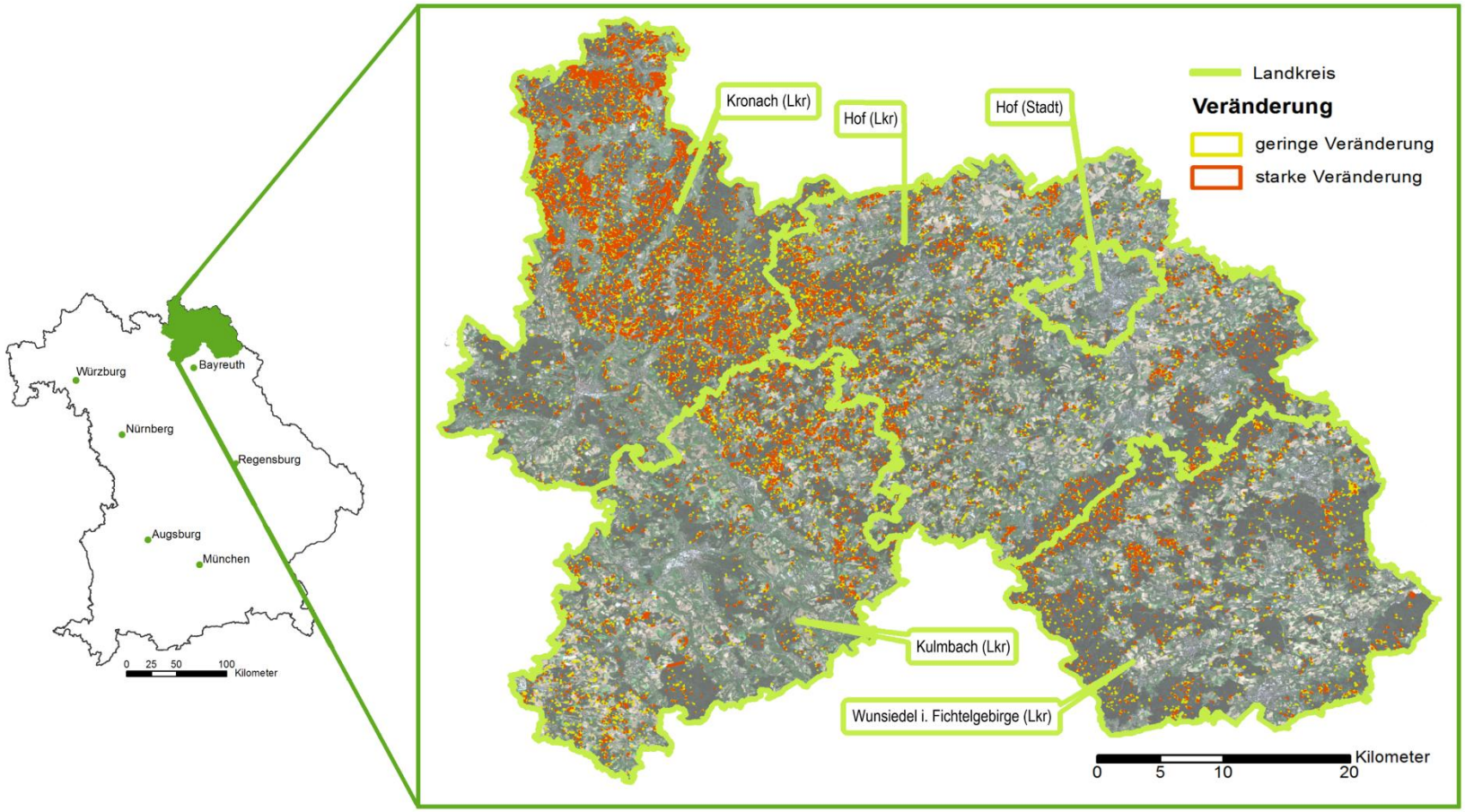


IpsSAT - Assessing optical satellite data for automated detection of bark beetle damage



Bildautor: Javier Gonzalez

Spectral changes in the vegetation from Sentinel-2 in the period September 2019 to September 2020



Einzmann K., Straub C., Seitz R. (2022): Dem Wald auf der Spur – mit den »Wächtern« aus dem All. LWF aktuell 132, S. 8-11.

https://www.waldwissen.net/de/waldwirtschaft/schadensmanagement/dem-wald-auf-der-spur-mit-den-waechtern-aus-dem-all

Outlook

- Further attempts to increase automation in the evaluation of the image data
- Deep Learning → challenge: huge amount of training data is needed

Thank you for your attention!

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