Continous country-wide forest monitoring through remote sensing

- Example Germany -

Forests‘ Hidden Secrets
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Dr. Torsten Welle (Natural Forest Academy)
Dr. Jonas Franke (Remote Sensing Solutions)

Natural Forest Academy

rss remote sensing SOLUTIONS

Information demand

- There is a lack of open access and continuously updated information on forest characteristics at a national level in Germany and in Europe
- The strong impact of the drought years in 2018, 2019, and 2020 revealed the need for **full coverage** and **updated information** in support of national strategies for sustainable and climate change adapted forest management, forest protection and restoration
- The New EU Forest Strategy for 2030 makes a legislative proposal for a forest observation, reporting and monitoring framework
- Development of the „Forest Monitor Germany“ as a demonstrator on how beneficial open access Copernicus Earth Observation data are for a country wide forest monitoring
- Copernicus is the Earth observation component of the European Union’s Space program, looking at our planet and its environment to benefit all European citizens. It offers information services that draw from satellite Earth Observation and in-situ (non-space) data

Objectives: Forest monitor Germany

Provision of public spatial explicit information on the:

(1) distribution of dominant tree species

(2) anually assessment of the forest status and **detection of disturbed forest areas**

(3) active forest fire detection for decision making process

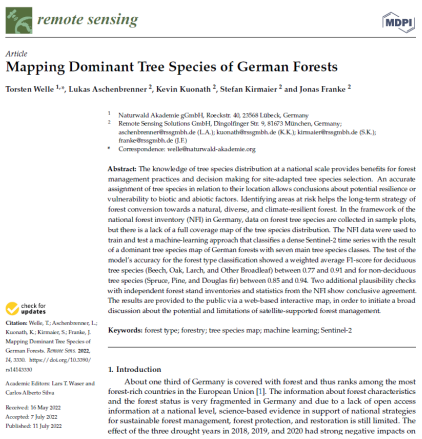
(4) OUTLOOK: further information layer


Tree species

Distribution of dominant tree species

What do we need?

- Ground truth data:
  - very important to develop remote sensing products
  - accurate geolocated information on existing tree species (available through: National Forest Inventories or national sample plot inventories)



remote sensing

MDPI

Article

Mapping Dominant Tree Species of German Forests

Torsten Welle [1,*], Lukas Aschenbrenner [2], Kevin Kuonath [2], Stefan Kirmaier [2] and Jonas Franke [2]

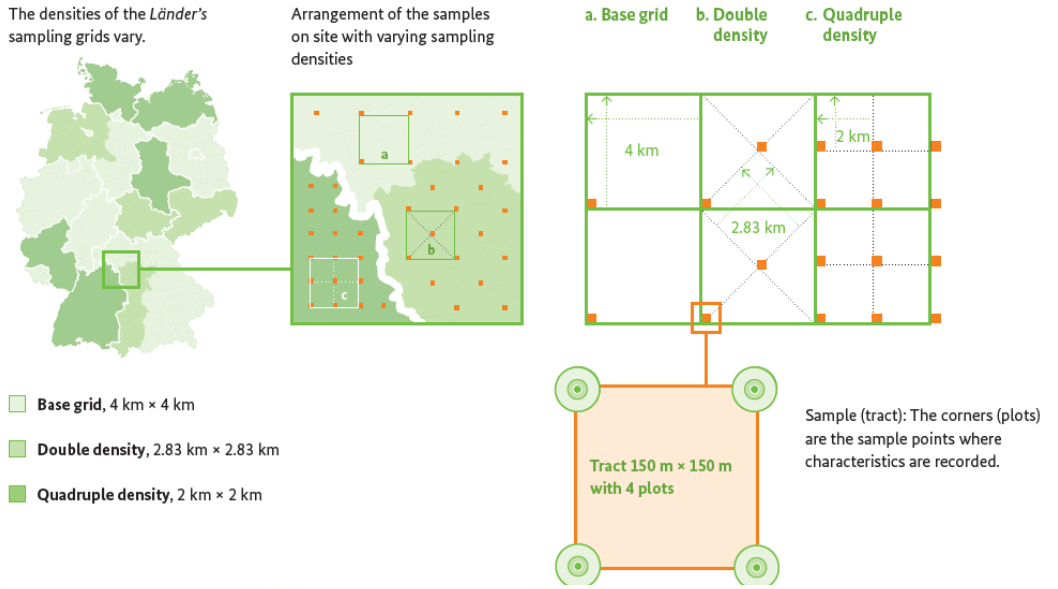
[1] Naturwald Akademie gGmbH, Roeckstr. 40, 23568 Lübeck, Germany
[2] Remote Sensing Solutions GmbH, Dingolfinger Str. 9, 81673 München, Germany; aschenbrenner@rssgmbh.de (L.A.); kuonath@rssgmbh.de (K.K.); kirmaier@rssgmbh.de (S.K.); franke@rssgmbh.de (J.F.)
* Correspondence: welle@naturwald-akademie.org

Abstract: The knowledge of tree species distribution at a national scale provides benefits for forest management practices and decision making for site-adapted tree species selection. An accurate assignment of tree species in relation to their location allows conclusions about potential resilience or vulnerability to biotic and abiotic factors. Identifying areas at risk helps the long-term strategy of forest conversion towards a natural, diverse, and climate-resilient forest. In the framework of the national forest inventory (NFI) in Germany, data on forest tree species are collected in sample plots, but there is a lack of a full coverage map of the tree species distribution. The NFI data were used to train and test a machine-learning approach that classifies a dense Sentinel-2 time series with the result of a dominant tree species map of German forests with seven main tree species classes. The test of the model's accuracy for the forest type classification showed a weighted average F1-score for deciduous tree species (Beech, Oak, Larch, and Other Broadleaf) between 0.77 and 0.91 and for non-deciduous tree species (Spruce, Pine, and Douglas fir) between 0.85 and 0.94. Two additional plausibility checks with independent forest stand inventories and statistics from the NFI show conclusive agreement. The results are provided to the public via a web-based interactive map, in order to initiate a broad discussion about the potential and limitations of satellite-supported forest management.

Keywords: forest type; forestry; tree species map; machine learning; Sentinel-2

1. Introduction

About one third of Germany is covered with forest and thus ranks among the most forest-rich countries in the European Union [1]. The information about forest characteristics and the forest status is very fragmented in Germany and due to a lack of open access information at a national level, science-based evidence in support of national strategies for sustainable forest management, forest protection, and restoration is still limited. The effect of the three drought years in 2018, 2019, and 2020 had strong negative impacts on



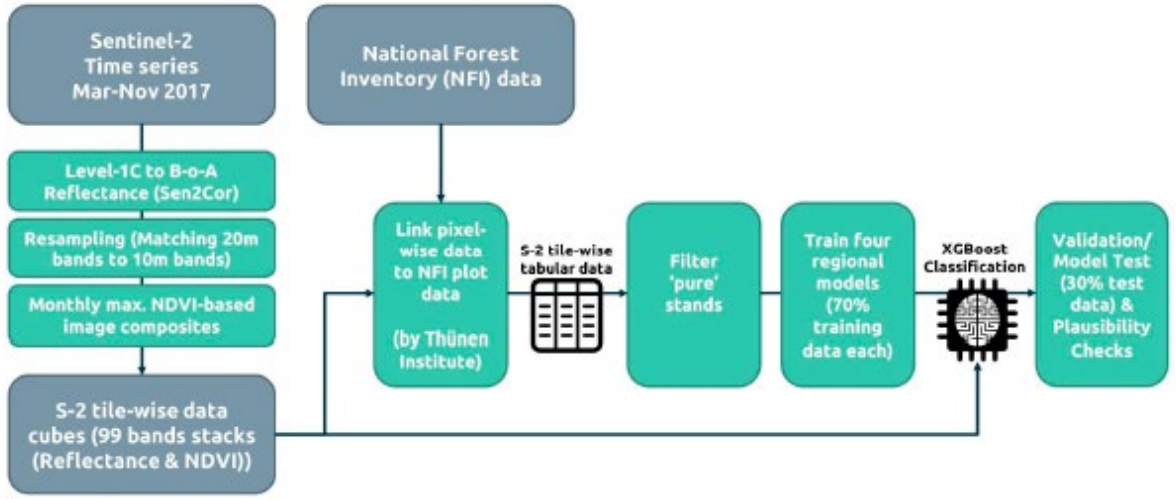
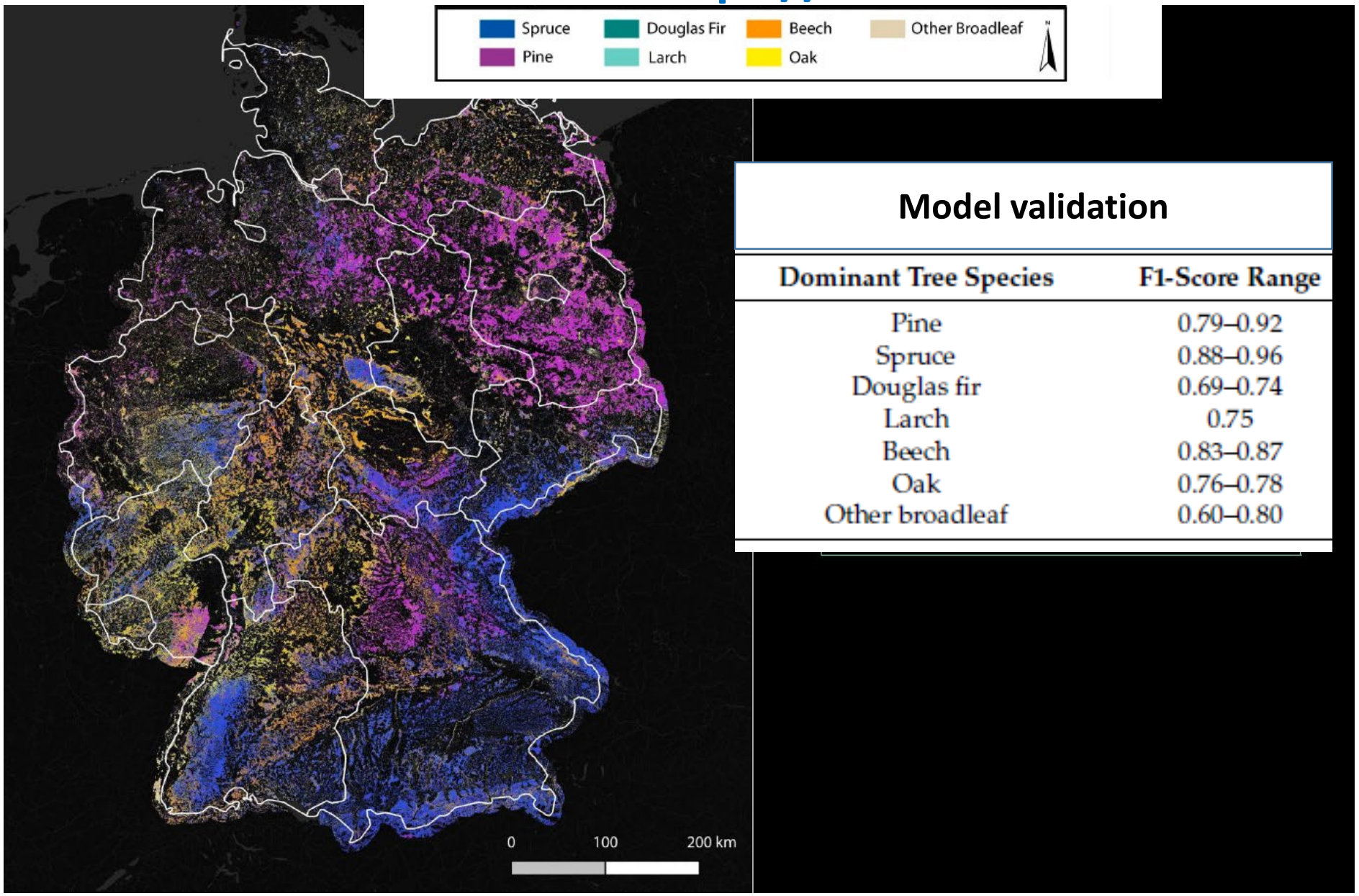


Figure 2. Schematic representation of the workflow.

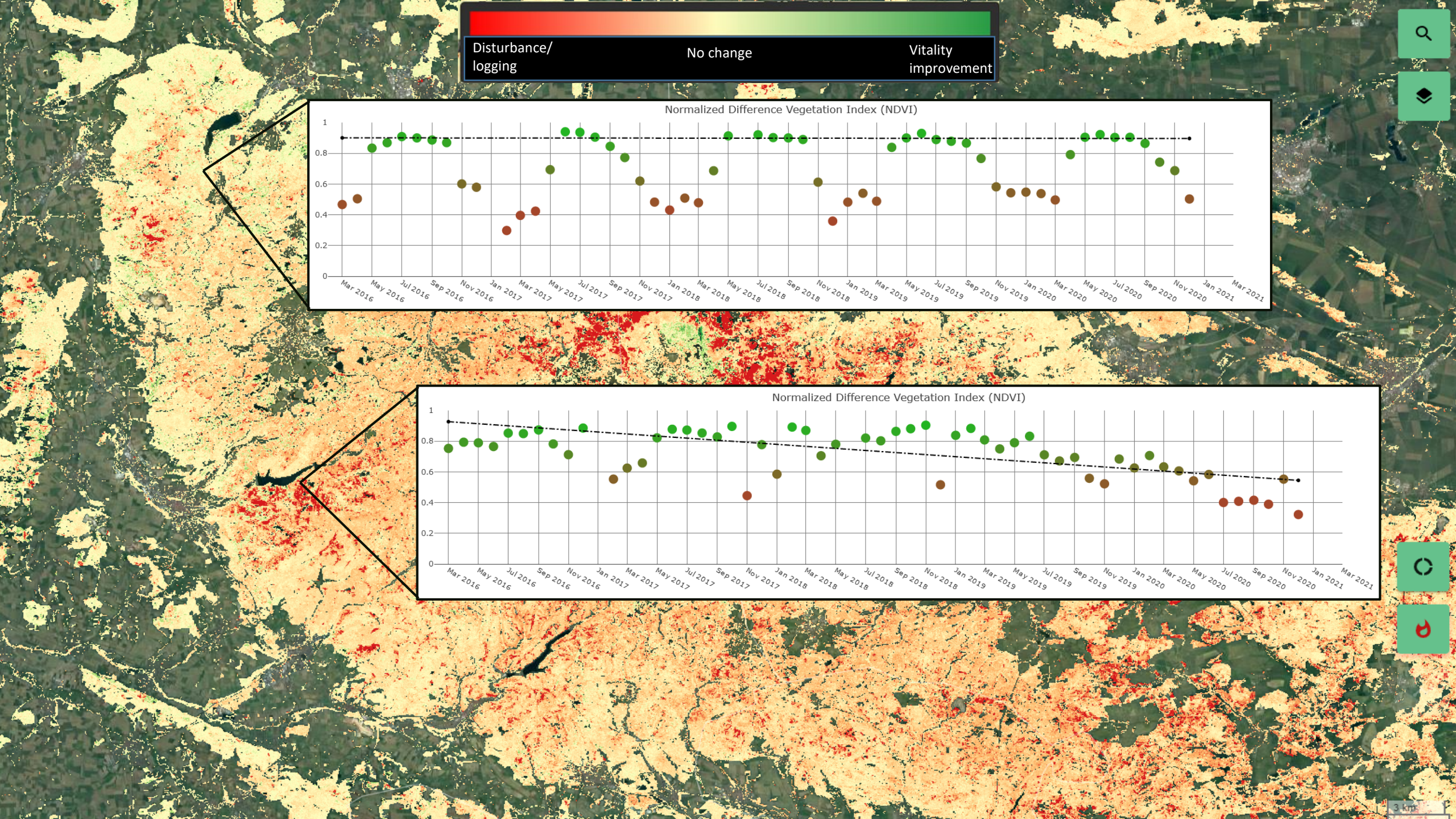
Distribution of dominant tree species https://waldmonitor-deutschland.de/



Model validation

Dominant Tree Species	F1-Score Range
Pine	0.79–0.92
Spruce	0.88–0.96
Douglas fir	0.69–0.74
Larch	0.75
Beech	0.83–0.87
Oak	0.76–0.78
Other broadleaf	0.60–0.80


Forest status


Disturbance/ logging
No change
Vitality improvement
Normalized Difference Vegetation Index (NDVI)
1
0.8
0.6
0.4
0.2
0
Mar 2016
May 2016
Jul 2016
Sep 2016
Nov 2016
Jan 2017
Mar 2017
May 2017
Jul 2017
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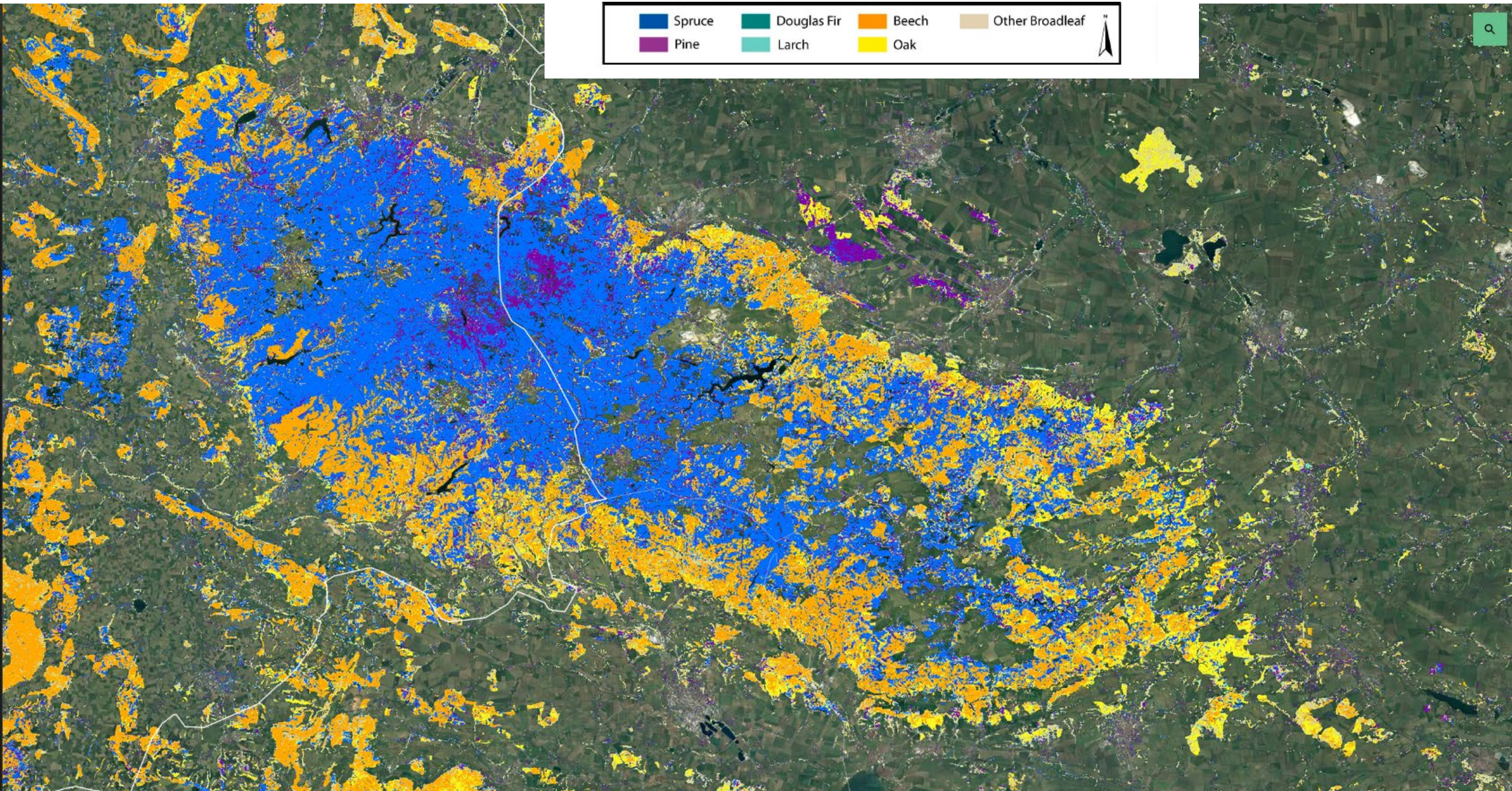
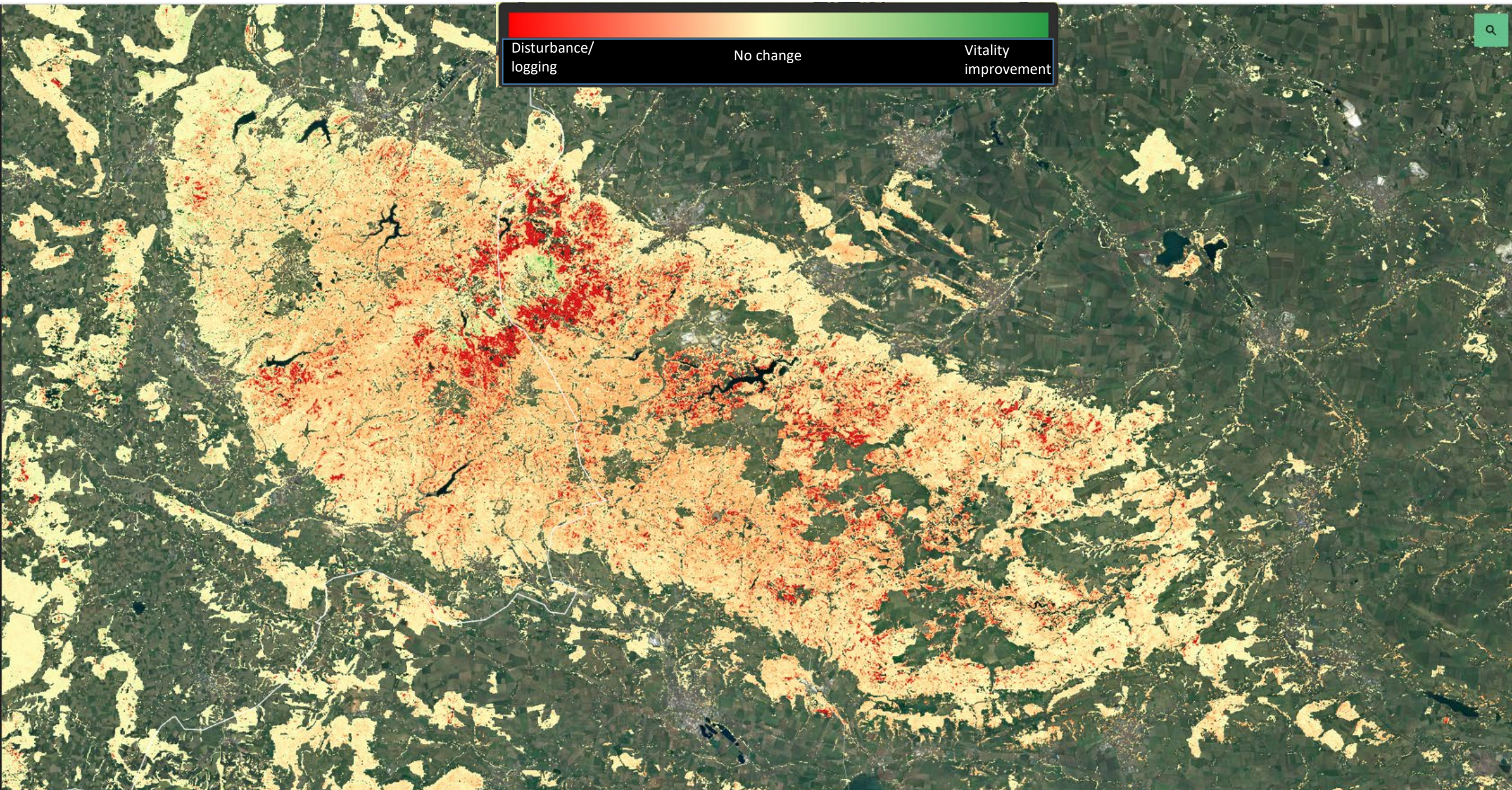
Mar 2021
3 km

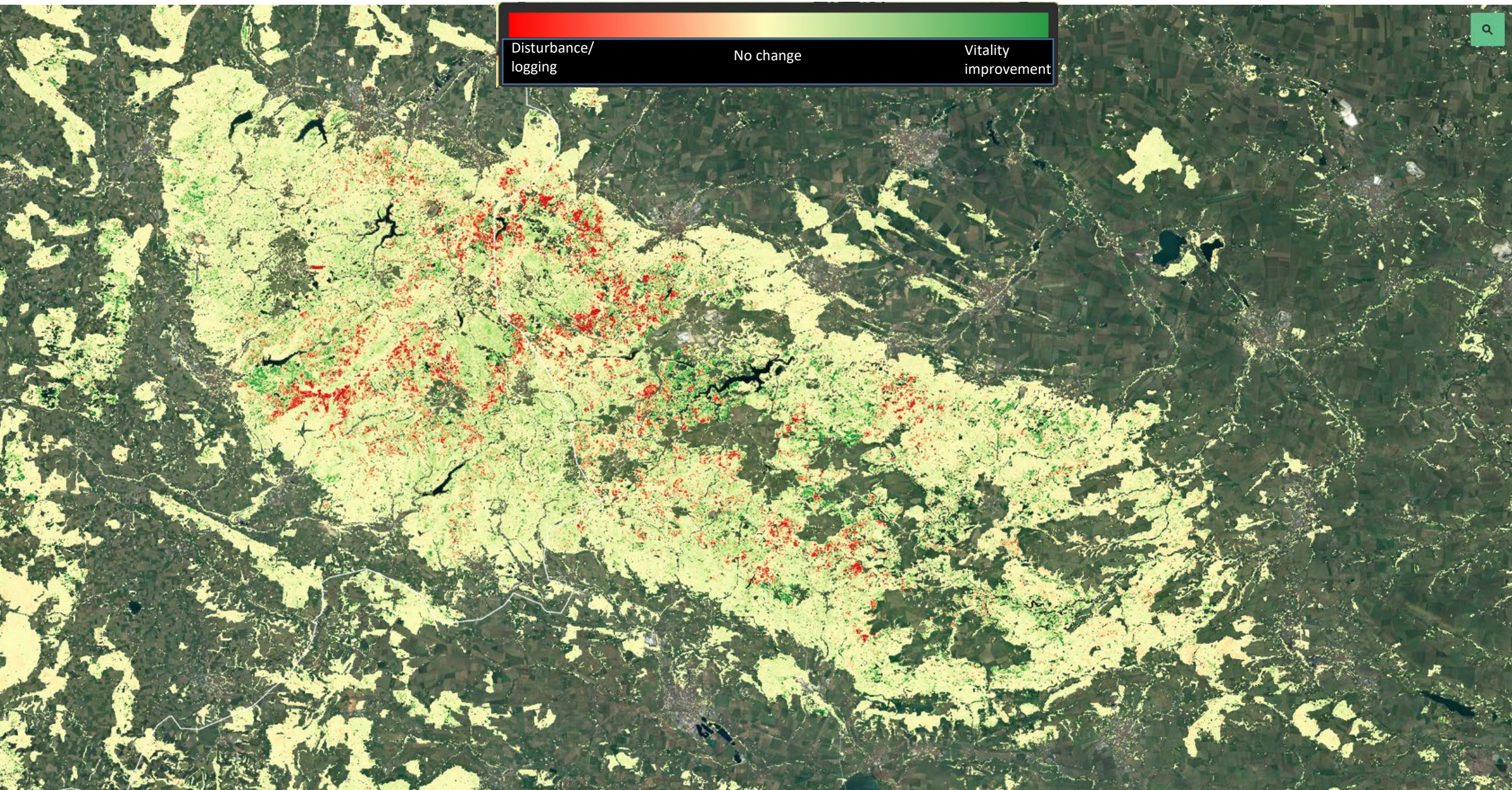
Example: Harz mountains (tree species)



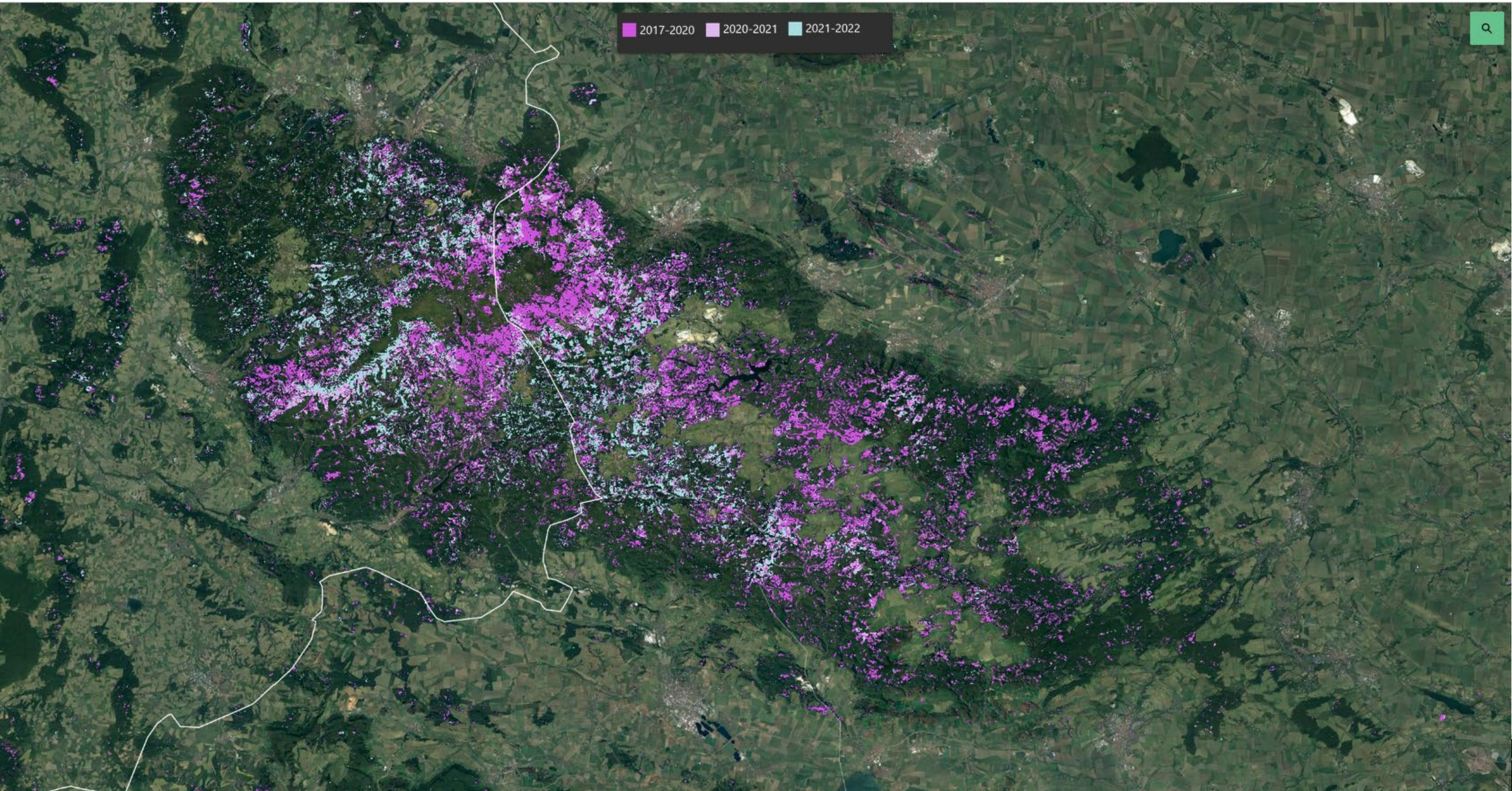
Example: Harz mountains (forest status 2017-2020)



Example: Harz mountains (forest status 2020-2021)

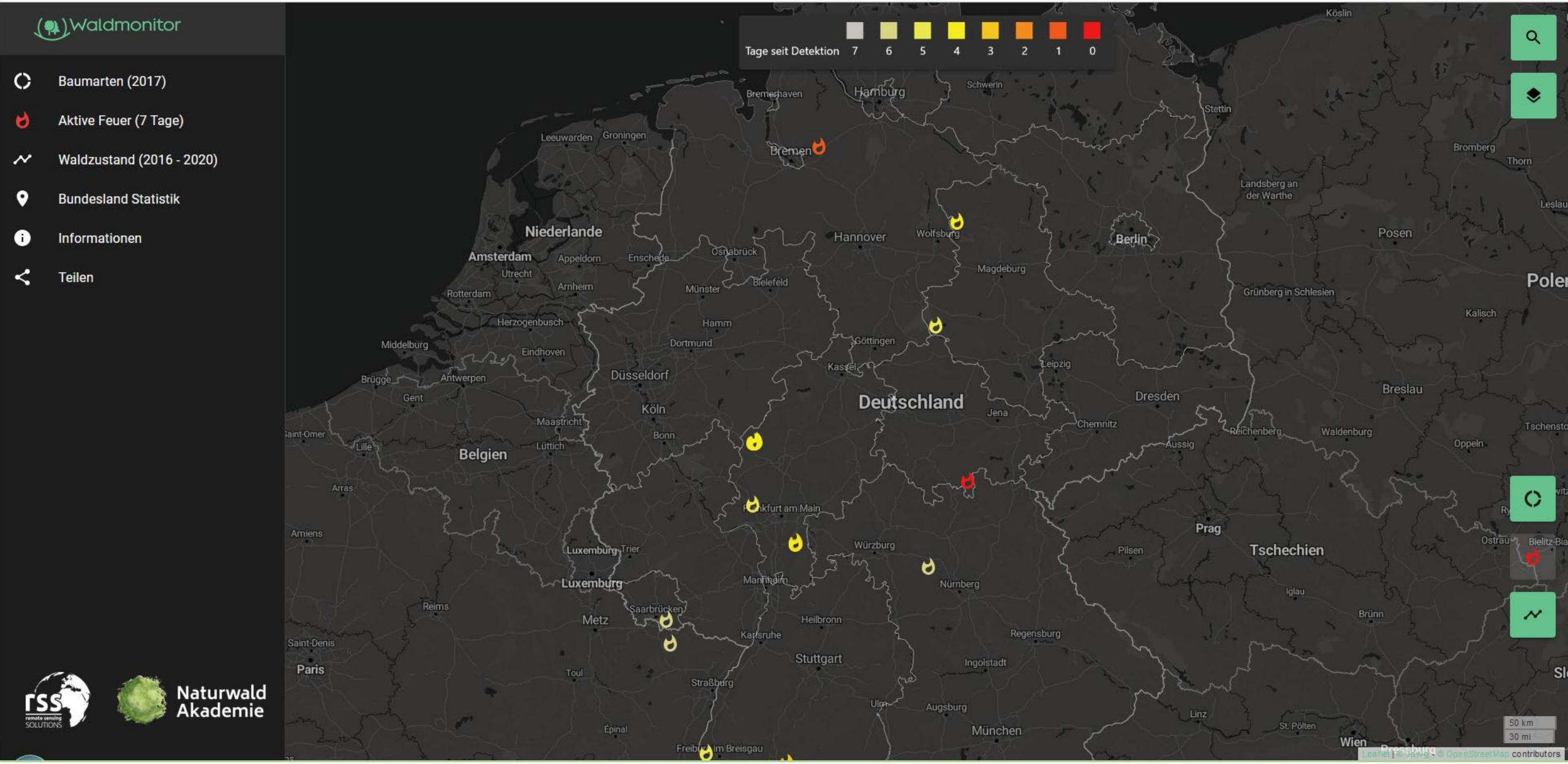


Example: Harz mountains (disturbed areas 2017-2022)

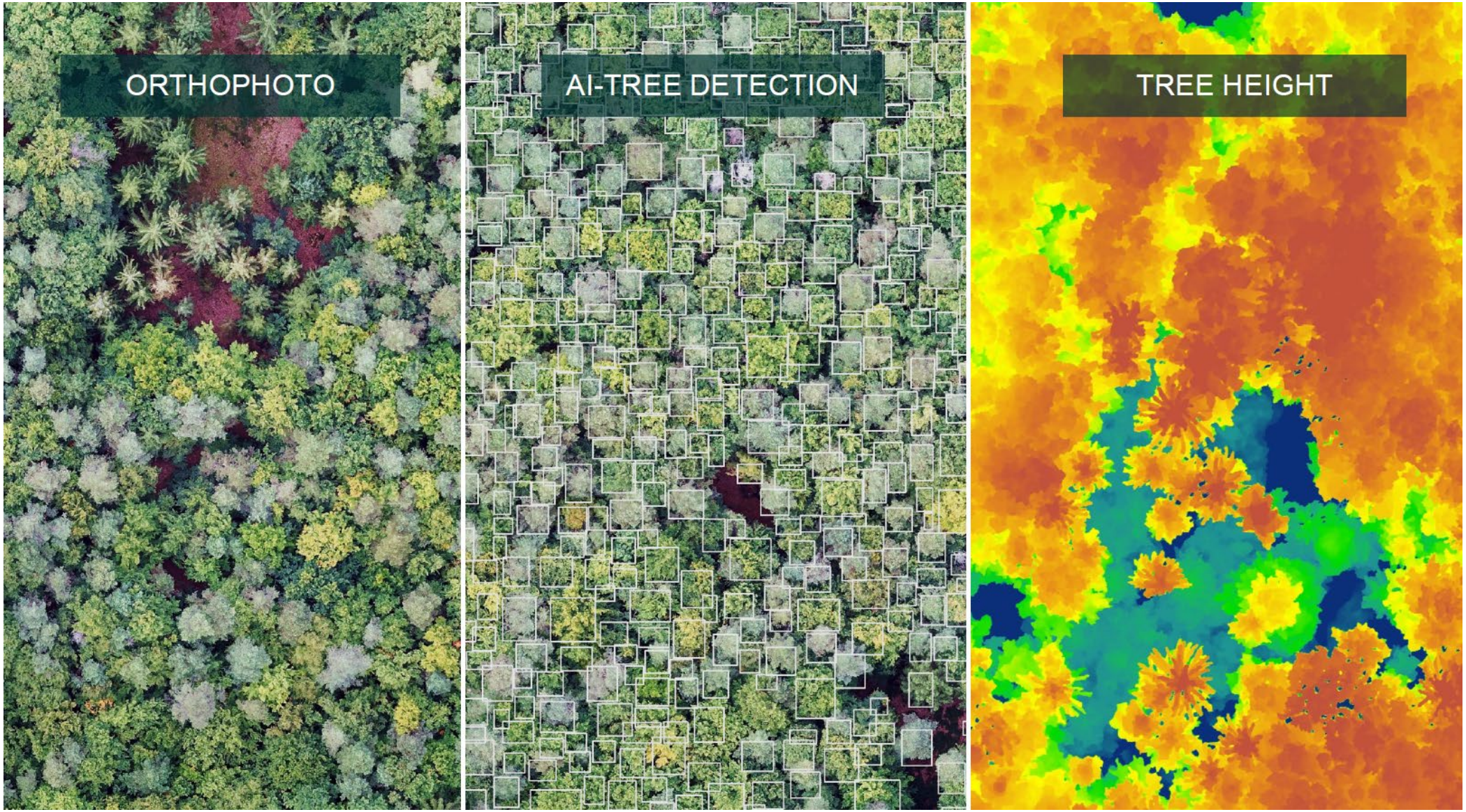


Active fire detection

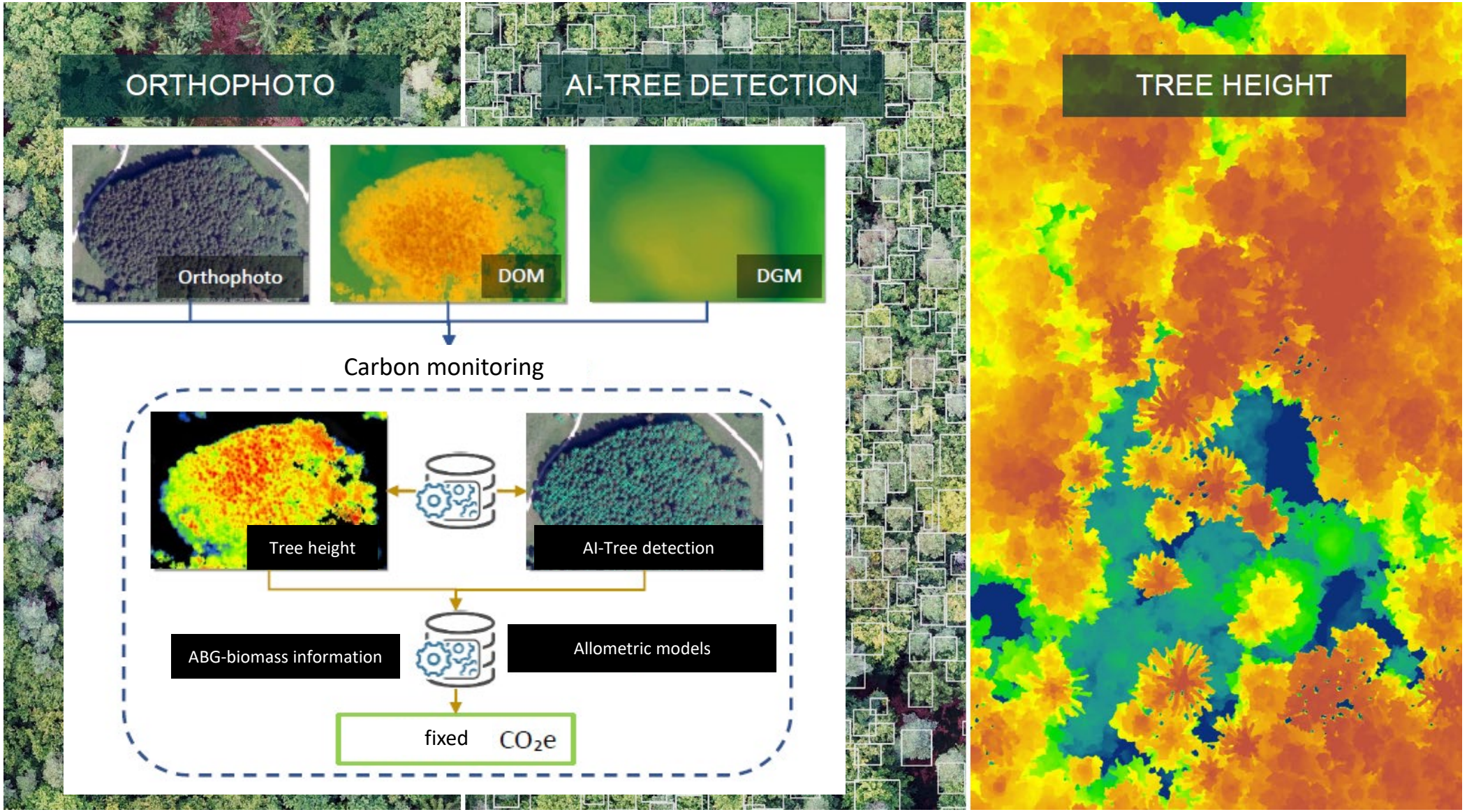
Active forest fire detection



Outlook



Outlook


ORTHOPHOTO
AI-TREE DETECTION
TREE HEIGHT
Orthophoto
DOM
DGM
Carbon monitoring
Tree height
AI-Tree detection
ABG-biomass information
Allometric models
fixed CO_2e

Conclusion

- Remote sensing does NOT replace work on the ground in the forests – it provides high temporal resolution and spatially comprehensive information
- Sentinel data (spatial resolution 10x10m) and EU open data policy show the potential and benefit for generating specific spatially explicit forest information at a national scale
- Detailed monitoring of changes in tree species composition and forest status on monthly/yearly basis is possible
- Additional data enables assessment of forest structure, carbon stock and forest height distribution
- The concept of the Forest Monitor Germany is transferable to other European Countries (cloud computation on EU-wide server structure, adapted national approaches)
- EU Copernicus program offers objective and comparable, multi-year, stable time series that can be used cost-efficiently to monitor European forest areas to support current EU forest policies

Thank you for your attention.

Contact information: welle@naturwald-akademie.org / franke@rssgmbh.de

Forest Monitor Germany: www.waldmonitor-deutschland.de