Project *brief*

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Results of the Remote Sensing-Based National Forest Damage Assessment System (FNEWs)

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- **The methodological and technical development of remote sensing-based forest damage assessment using Sentinel-2 satellite data has been successfully completed.**
- **The FNEWs annual product provides highly accurate information on damaged forest areas at the study area level through maps and statistics.**
- **The FNEWs monthly product reports damaged areas every month.**
- **The main damage components are evaluated in terms of their economic impact on timber production in forestry.**

Introduction

In the FNEWs project, a national remote sensing-based system for detecting forest damage was successfully established. In close collaboration with the project consortium, which is firmly anchored in the fields of technology, remote sensing, economics, and forestry research with practical application, both the methodology and the technical infrastructure of the monitoring system were developed and built. As a result, a largely automated system is now available that identifies and designates forest areas that have died due to biotic and abiotic damage events.

FNEWs Annual Product

Various remote sensing products are created using the time series analysis model of Sentinel-2 data developed in the project. The annual product identifies damaged areas along with an area statistic for annual forest changes (Fig. 1). The reference date is August 31st each year. In this product, next to the damaged area, the date of the damage and the most likely cause of the damage are provided. The spatial resolution is 10x10 m² and the minimum mapping unit is 0.1 ha. The accuracy of the annual product is ≥ 95 %, indicating a high level of reliability and good usability of the data for forestry practice. Annual products were calculated for the study areas from 2018 to 2022 and are available online in the Thünen Atlas (Fig. 2).

FNEWs monthly product

The monthly product delineates damaged areas per month. It is a combined output generated from the continuous ongoing near real-time component of the monitoring system, wherein every recently acquired Sentinel-2 image undergoes assessment. In addition to the areas, the most probable cause of damage and the number of evaluated images per month are provided. The spatial resolution is 10x10 m², and the minimum mapping unit is 0.25 ha. The monthly products were computed for the study areas. Local product quality depends on the number of usable, cloud-free image pixels available in the current month. Under ideal conditions, similar accuracies to the annual product can be achieved. However, validation has shown that the monthly product often exhibits significantly lower accuracies than the annual product because an area may not be continuously observed within a month, resulting in damaged areas being missed. Furthermore, it was found that the accuracy of damage-cause detection is insufficient for both

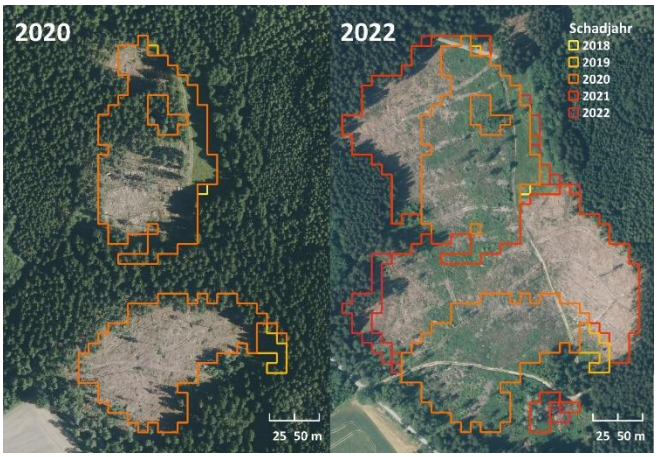

Figure 1: FNEWs annual product using the example of bark beetle damage with aerial images from 2020 (left) and 2022 (right) (©GeoSN).

products. Methodological advancements as well as further validation efforts are necessary.

Validation results

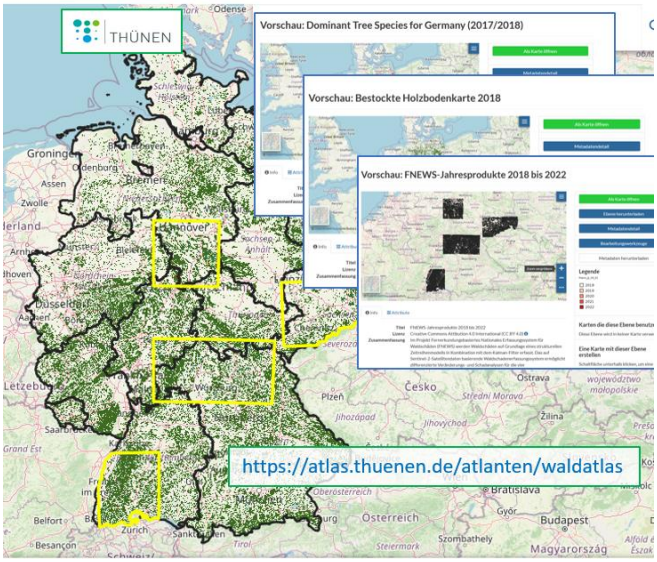

Figure 2: Selected project results are freely available as geodata in the Thünen Atlas.

For the validation of the described products, a concept was developed, a tool was created, comprehensive validation data was obtained, and the validation of the results was conducted. For the annual product, a total of 11,019 individual points were manually interpreted in the four study areas (SA). As an example, the validation data for Bavaria is presented in Fig. 3. The Bavarian State Institute of Forestry evaluated a total of 3,828 points in seven validation areas. Within the four SA, the annual product achieved an overall accuracy of 99.1±0.1 %. Damaged areas were detected with a user accuracy of 84.4±2.0 % and a producer accuracy of 85.1±3.4 %.

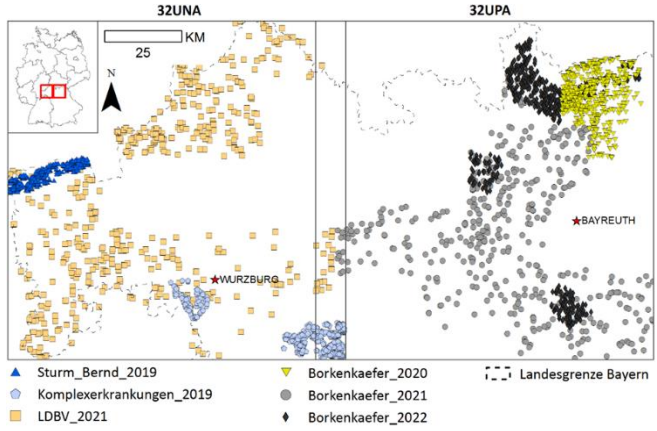

Figure 3: Overview map of the location and type of damage of the validation points in the Bavarian study area.

The evaluation assessed both, the accuracy of the annual product in mapping individual damaged areas and its reliability in depicting the overall extent of damage. For the forested area covered by the validation areas, the annual product indicates a damaged area of 27,582 ha during the observation period from August 2018 to August 2022. This corresponds to 2.86 % of the total forest area. Using the validation areas, the error-corrected actual extent of damage was estimated at 26,847±201 ha or 2.78±0.02 % of the total forest area. Overall, the actual extent of damage is thus slightly overestimated.

Economic evaluation

The project laid the groundwork for a continuous nationwide monitoring of the economic impacts of forest damage. Based on a comprehensive literature review, an assessment framework (Fig. 4, Fleckenstein et al.) was developed, encompassing the key components of damage. For most of these damage components, procedures were identified to economically assess the natural damage determined by the annual product. This enables a comparison of the economic impacts of forest damage across different reporting years.

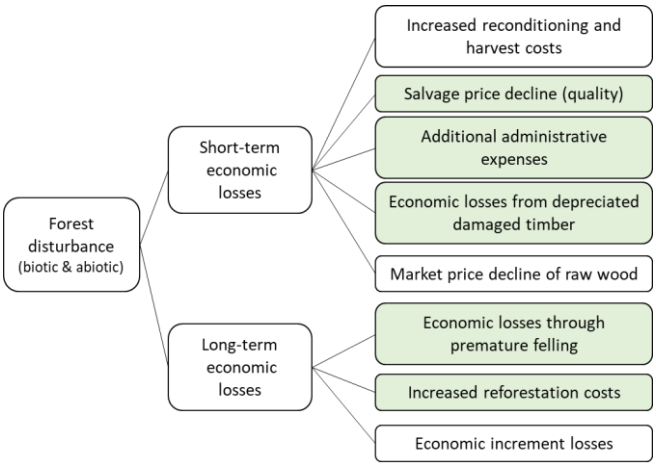

Figure 4: Assessment framework for the economic impact of forest damage on raw timber production in the forestry industry in Germany (green: assessable, white: currently non-assessable damage components).

Outlook

Due to the necessity of detecting and recording forest damage, as well as ongoing monitoring of such damage, the methodological and technical developments and project results are planned to be implemented into an operational monitoring system in the future. Thus, following the end of the project in December 2023, the transition from the project phase to the implementation phase will be carried out at the Thünen Institute of Forest Ecosystems. While the project focused on the study area level, the developed processes and algorithms from individual areas are now intended to be scaled up to cover the entire territory of Germany.

Further Information

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Projekt partners
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3 Swiss Federal Institute for Forest, Snow and Landscape Research
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6 Northwest German Forest Research Institute
7 Public Enterprise Sachsenforst
8 Thünen Institute of Forestry

Publications
Fleckenstein et al., 2023: Economic damage assessment of forest disturbances on forestry: State of knowledge and challenges for a continuous economic loss monitoring in Germany. Allg Forst Jagdzeitg 193(3-4):41-64, DOI:10.23765/afjz00092

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