Advancing Remote Sensing Research: The Data Pool Initiative for the Bohemian Forest Ecosystem

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ABSTRACT

Forests worldwide represent hotspots of biological diversity, yet they are increasingly threatened by deforestation, overexploitation, and climate change. Effective forest conservation therefore requires comprehensive and continuous monitoring of changes in forest extent, structure, and species composition to improve our understanding of forest ecosystem dynamics and to support targeted management and conservation strategies. Traditionally, forest monitoring has relied on terrestrial inventories, which are highly time-consuming and costly. Recent advances in remote sensing technologies provide powerful alternatives and complementary approaches. Unmanned aerial vehicles (UAVs) enable the acquisition of high-resolution reference data, airborne platforms equipped with optical sensors or laser scanners support the assessment of disturbance events, and satellite-based optical and radar data allow frequent, spatially continuous observations with temporal resolutions of less than one week.

Remote sensing data thus offer an effective means for regular, large-scale monitoring of forest ecosystems and can serve as input for models that extrapolate point-based field measurements to broader spatial extents. Increasingly, remote-sensing-derived data products can replace parameters that previously required labour-intensive field measurements, provided the underlying models are well calibrated. This is particularly relevant in regions where regular and consistent field data collection is not feasible, underscoring the importance of coordinated remote sensing activities and structured knowledge exchange among researchers.

The Bohemian Forest Ecosystem is a low mountain range extending approximately 130 km in length and 60 km in width along the border between Bavaria (Germany), the Czech Republic, and Austria. Elevation ranges from 370 m a.s.l. in the valleys to 1,456 m a.s.l. along the mountain ridges. The climate is predominantly continental with maritime influence from the west, and annual precipitation ranges from 400 mm to 2,500 mm. Permanent snow cover persists for up to seven months at higher elevations (October–May) and up to five months in the valleys (November–April). The core of the ecosystem comprises two contiguous protected areas, the Bavarian Forest National Park (250 km^2) and the Šumava National Park (690 km^2), which are embedded within the Bavarian Forest Natural Park (3,007 km^2) and the Bohemian Forest Protected Landscape Area (1,000 km^2). While the national parks are largely forested, the surrounding landscape is characterized by a mosaic of smaller forests, meadows, arable land, and villages. Within the national parks, three major forest types exist: above 1100 m there are sub-alpine spruce forests with Norway spruce (Picea abies) and some Mountain ash (Sorbus aucuparia) (high altitude); on the slopes, between 600 and 1100 m, mountain mixed forests with Norway spruce, Silver fir (Abies alba), European beech (Fagus sylvatica), and Norway maple (Acer pseudoplatanus) are found (slopes); in wet depressions often experiencing cold air pockets in the valley bottoms, spruce forests with Norway spruce, Mountain ash, and birches (Betula pendula, Betula pubescens) occur(valley bottoms)

This area provides a perfect field of research for studying natural and near-natural ecosystems. The long-term and consistent environmental monitoring makes it an ideal study area for remote sensing research aimed at both improving understanding of long-term ecosystem dynamics, such as bark beetle outbreaks, and systematically evaluating the potential of different remote sensing approaches for diverse research

questions. To this end, the Data Pool Initiative for the Bohemian Forest Ecosystem was established in 2015 to coordinate remote sensing research activities within this transboundary ecosystem. Managed by the national park administrations, the initiative facilitates collaboration among international research institutions, supports external researchers conducting field campaigns, archives research outputs, and provides reference data for the calibration of remote-sensing-based models. In addition, an annual workshop fosters scientific exchange and supports the training of early-career researchers.

Overall, 9 partners signed the initial agreement, supporting the mutual goal of contributing to the data pool with remote sensing data and in-situ data, each with adequate metadata. The steadily increasing data pool provides input for a multitude of scientific questions concerning the two national parks. The main objectives of the data pool initiative are to store and provide large remote sensing datasets, to offer a testing environment for new sensor development, to serve as a laboratory for Essential Biodiversity Variables (EBVs), to facilitate collaborative research, and to provide information for national park management.

Over the last years, many airborne surveys have taken place using various remote sensing systems: LiDAR, digital imagery, hyperspectral reflective and thermal imagery, and SAR. In addition to the airborne campaigns, numerous intensive field activities were conducted. The overall suite of data is complemented by satellite data, such as SPOT-5, TerraSAR-X, ALOS, and, of course, the data products of the Sentinel satellite systems. Thematic research priorities within the data pool include biodiversity mapping, the development of habitat models for endangered species, monitoring of natural disturbances (e.g., windthrow and insect outbreaks), forest structure analysis, and automated individual tree detection.

Since its establishment, the initiative has produced a high volume of scientific output, including numerous peer-reviewed publications and academic theses, demonstrating the effectiveness of coordinated remote sensing research in advancing forest ecosystem science. Since 2015, 105 studies have been published in international peer-reviewed journals. A study by the German Aerospace Centre found that 34% of all forest remote sensing studies published in Germany between 2000 and 2020 focused on the Bavarian Forest National Park, placing it by a wide margin at the top nationwide. The authors attribute this success largely to the national park administration's international networking, which relies on the data pool for remote sensing research. Since its establishment in 2015, the data pool has supported and continues to support 14 doctoral theses, one habilitation, and numerous graduate theses. Owing to its success, the data pool now has grown to 18 research institutions as members, and the agreement was extended in 2025 for an additional 4 years, through the end of 2029.