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Comparing Tree Metrics Across different LiDAR Platforms in a Mature Beech Stand

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Forests are vital to sustaining ecosystems and supporting life on earth through their roles in carbon sequestration, biodiversity provision, and climate regulation. However, increasing pressures from climate change, biodiversity loss, and land-use change are transforming forest dynamics, making sustainable forest management and continuous monitoring more important than ever. Reliable, spatially explicit forest information is essential for effective management decisions, yet traditional field-based inventories are often labor intensive, costly, and time consuming.

As an emerging remote sensing technique for forestry, light detection and ranging (LiDAR) has already been explored and compared regarding its acquisition platforms in previous studies. However, a comprehensive comparative analysis systematically evaluating manned and unmanned airborne, terrestrial and mobile systems has so far been lacking. Consequently, this study addresses the challenge of improving efficiency, spatial coverage, and data quality in forest monitoring by evaluating how the four different LiDAR systems can complement conventional forest management planning. Sensor types, acquisition trajectories, and resulting point cloud characteristics are explored within a mature beech stand in the Spessart, Germany, to assess each platform's ability to derive key forest metrics, such as basal area, tree height or canopy closure, for forest management planning at both tree and stand level.

The findings demonstrate that no single LiDAR platform can comprehensively capture all evaluated forest information. Instead, the integration of complementary LiDAR systems, combined with carefully planned acquisition trajectories, provides the most effective approach for generating consistent, high-quality data to support modern, sustainable forest management planning. Such planning must be closely aligned with forest and terrain characteristics, ensuring that flight paths, point densities, and viewing geometries are

adapted to stand structure and topography. Additionally, acquisition parameters, particularly environmental conditions such as wind, must be carefully considered to guarantee the reliability and comparability of the resulting datasets. The contribution addresses multiple stakeholder groups, including forest managers, conservation agencies, and researchers seeking improved tools for forest assessment and monitoring. By identifying the strengths, limitations and optimal use contexts of each LiDAR platform, this case study provides assistance and serves as an additional tool for selecting the most appropriate LiDAR platform for specific forest monitoring objectives.