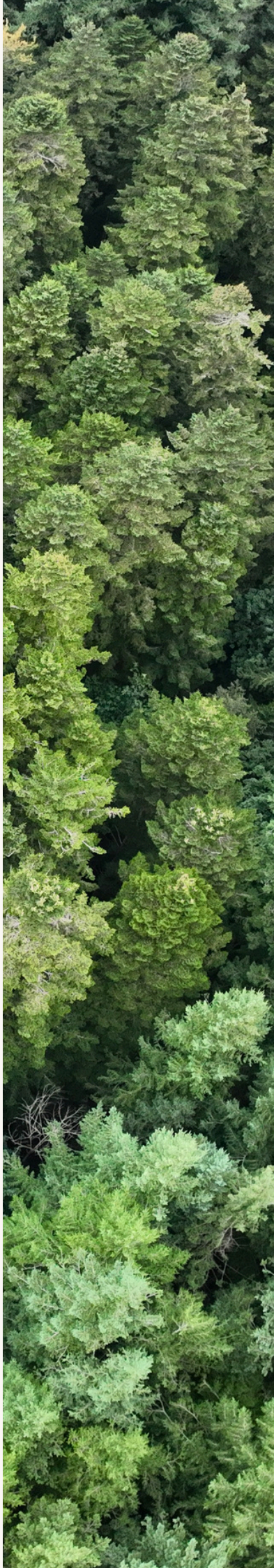
Early quality assessment of timber products

Joint Policy Brief

DIGIMEDFOR, *Digital tools and technology systems for the sustainable management of Mediterranean forest resources* - Deliverable D7.5.

SINTETIC, *Single item identification for forest production, protection and management* - Deliverable D6.11.



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Joint Policy Brief

Project Acronym: DIGIMEDFOR

Project name: Digital tools and technology systems for the sustainable management of Mediterranean forest resources

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Project Acronym: SINTETIC

Project name: Single item identification for forest production, protection and management

Project number: 101082051

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Introduction

Quality is crucial in any value chain and production processes. However, the definition as well as the parameters depicting quality vary according to a plethora of factors. They include **technical** aspects – how well the raw material meets the requirements for its intended use or final product – **technological** aspects – such as species, aesthetic qualities, physical and mechanical properties – and **economic** aspects – factors that impact on processing and product value throughout the manufacturing process. The industrial context is also crucial: for example, highly mechanized processing favors uniformity of characteristics to ensure consistent production and lower scale costs; however, this factor is less important for raw materials intended for more artisanal manufacturing as could be the case of solid-timber beams locally used for construction.

Consequently, quality assessment is not an absolute concept, making a unique quantification challenging and often time-consuming.

In this policy brief wood early quality assessment refers to the process of evaluating the characteristics and suitability of wood at an initial stage, before it is processed or used in manufacturing. This assessment primarily applies to standing trees and logs immediately after harvesting or at roadside before piling or loading for transportation.

For industrial applications, particularly in structural design where mechanical properties such as stiffness and strength define quality, a quality assessment that can relate to a grading system is essential. This evaluation can be made visually or mechanically and, once properly calibrated for the various species and origins, assigns an appropriate grade to each piece of timber based on its predicted mechanical strength.

While this approach is harmonized for sawn wood, applying it to standing trees or roundwood presents significant challenges. These include technical difficulties in accurately measuring key wood properties, as well as the added variability introduced by the chosen sawing pattern and potential unseen defects.

Another important consideration is the method of harvesting. Mechanized harvesting typically allows for easier collection and storage of valuable data during normal operations, whereas manual systems require extra time and effort to record any additional information. Combined with the inherent variability among trees of the same species, these challenges have prevented the uniform standardization of standing and round timber grading, revealing a critical gap in current industrial practices.

Technology context

Recent advancements in sensors technology, computational power, and analytical techniques disclose new possibilities to perform early assessment of timber quality directly in the forests.

Laser scanning and **photogrammetry** techniques are predominantly used for quantitative measurements of standing trees (such as diameter, height, volume). However, recent studies have extended their application to evaluating stem quality attributes. **Image analysis** is also highly promising, due to the rapid advancements in computational power and machine learning methods. These techniques primarily focus on external stem characteristics; by analysing the morphological characteristics of a stem, it is possible to estimate the potential quality of the wood. However, they do not provide information about internal properties.

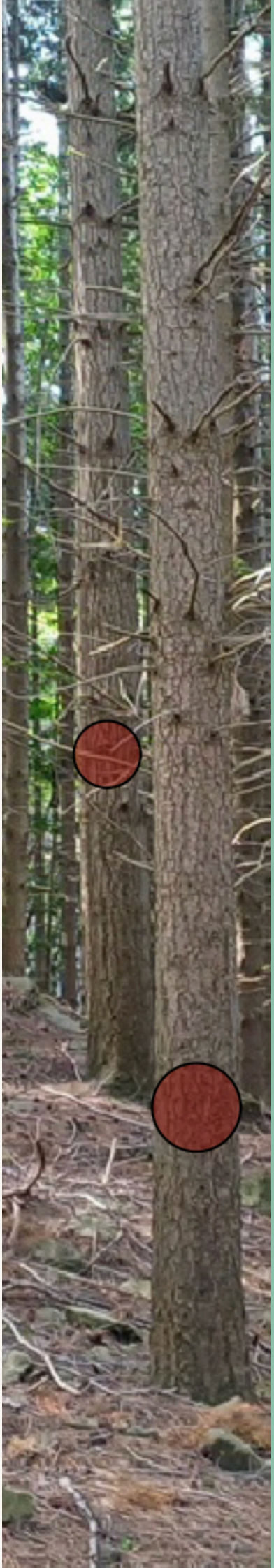
Standing tree stem assessment by image analysis

To assess the intrinsic characteristics of the wood, several methods have been developed, although each of them has their pros and cons. Various non-destructive testing (NDT) methods can be applied to standing trees: some devices estimate wood density by measuring the **resistance to drilling** encountered by a needle penetrating the trunk, others the depth of **needle penetration** under a known impact force, and others the force required for **screw extraction**. Though, these point-based methods provide localized data, which must be cautiously extrapolated to represent the entire tree.

Sonic techniques such as Time of Flight (TOF) and acoustic tomography detect internal defects by measuring how sound waves travel through the wood, either longitudinally along a part of the trunk or radially at a given height to reveal internal variations respectively. **Electrical resistance tomography** complements these methods by mapping moisture levels and decay zones at different heights based on conductivity. These techniques are influenced by density which is influenced by the moisture content and the measured values are obtained only between each probes, which must be also cautiously extrapolated to represent the entire tree Another type are specialized mechanical devices that have been developed to directly evaluate wood rigidity in standing trees using controlled bending tests, but some time is needed to set it up. Finally, some analysis can also be made by extracting larger-than-standard **core samples** to analyze a wider range of wood properties in detail. As most of these methods require lab processing, costs increase. On those samples different technologies can be applied to obtain information such as X-ray diffractometer, X-ray tomography or densitometry, NIR, hyperspectral images as well as Ultrasound's ToF.

Once the tree has been felled, additional techniques such as **resonance measurements** can be added to the list. These measurements analyze the natural frequencies of wood when the timber element vibrates freely after a percussion, these measurements are linked to the mechanical properties and internal defects of the timber, and thus, to the overall quality of the log. As for all the acoustic techniques, by combining mechanical wave velocity with wood density, the elasticity of the material can be determined.

However, despite the advancements in sensor technology, there is still a lack of harmonization in defining the concept of wood quality and identifying the key characteristics that best represent it in standing trees. Timber quality assessment at the early stages of the value chain is still **rarely performed.**



Wood quality evaluation process in the field

EU policy framework

The early quality assessment of timber could have an impact within the framework of several EU policies.

EU Forest Strategy

This is the primary framework for forest management in the European Union. It focuses on improving the quantity and quality of EU forests while ensuring their protection through sustainable exploitation. The strategy, among other things, promotes: sustainable forest management; efficient monitoring and data collection; a sustainable wood-based bioeconomy, where timber is used for long-lasting products; and the socio-economic functions of forests to ensure dynamic and thriving rural areas.

Forest Information System for Europe (FISE)

A platform that provides reliable data on European forests to support evidence-based policy-making and monitoring of sustainable forest management.

Common Agricultural Policy (CAP)

Provides funding and incentives for afforestation, agroforestry, and sustainable forest management which can enhance timber production. Promotes the use of wood for rural development and encourages innovative wood-based businesses.

EU Climate Law (Regulation EU 2021/1119) and LULUCF Regulation

Promotes the use of timber in construction as a means of long-term carbon storage. The two regulations highlight that not only do forests act as carbon sinks while trees are growing, but the wood products made from these trees can also play a role in mitigating climate change by storing carbon over time.

European Green Deal

Encourages the use of sustainably produced wood in various sectors as part of the transition to a circular and carbon-neutral economy.

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Potential benefits

The quality and quantity assessment performed early in the value chain provides several benefits. In the frame of the projects DIGIMEDFOR and SINTETIC, the following benefits had been discussed with professional stakeholders:

- **Enhanced use of resources;** by gaining a deeper understanding of a resource, it can be utilized more efficiently. This proactive approach contributes to sustainable forestry practices by promoting the efficient use of natural resources while ensuring high-quality end products.

- **Improved planning of silvicultural operations;** understanding the wood quality attributes of a forest resource enhances production efficiency and enables the prescription of suitable silvicultural practices to cultivate more valuable wood.

- **Higher yield of industrial process/manufacturing;** by selecting products based on quality early in the value chain, it is possible to supply industries with raw materials that better match processing requirements, improving production efficiency. Early identification of potential defects also allows manufacturers to optimize material use, lower CO_2 emissions, enhance product reliability, and reduce costs associated with rejected or defective wood.

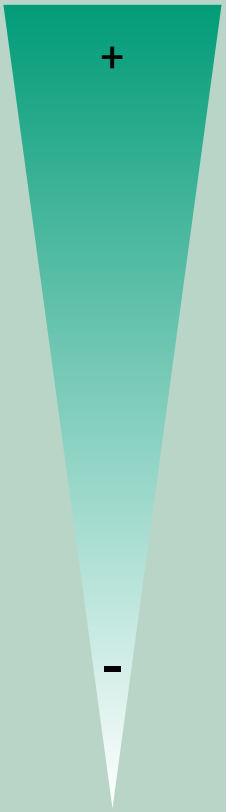
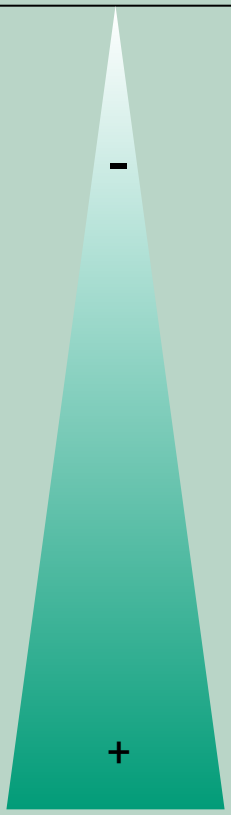
- **Optimized processing and production planning;** a comprehensive insight of the available material and its qualitative characteristics helps the timber industry in optimizing manufacturing planning and guiding investment decisions.

- **Lower costs of logistics and lower environmental impacts;** detailed knowledge of quality and quantity parameters of the timber assortments, and real-time share with digital tools with the value chain actors enables a significant improvement in logistics operations. The availability of this information in the decision process enables to transport to each end user just the needed raw material (in terms of quality and quantity). This avoids the current situation where undesired assortments are transported over large distances to a facility, which performs on site the selection of suitable quality, detouring the discarded material to other end users with additional transportation costs. Accordingly, GHG emissions related to transportation may be drastically reduced.

- **Promotion of local uses and value chains;** early quality assessment with digital technologies allows for an easier deployment of timber products in local and niche markets. As an example, this is the case of small companies performing both forest operations and provision of timber products (e.g., beams) to rural construction works.

- **Support the economy of rural areas;** up-to-date and easily accessible information on the qualitative and quantitative characteristics of forests can highlight their exploitation potential, supporting the development and maintenance of the local rural economy.

Early quality assessment can be performed on standing trees, in the stage of forest inventory, or on roundwood, during the harvesting and hauling operations which span from the felling site to mill gate.

Decision-making opportunities	Stage	Actions	Accuracy of measurement
	Forest inventory	Quality and quantity assessment of standing trees. To be confirmed measuring logs at roadside (harvest output) and with the sawmill measurements.	
	Harvest operations	Quality and quantity contrasted with the previous, further measurements during logistics (e.g., at the yard, but with same type of portable technologies) and the sawmill measurements	
	Sawmill processing	High precision and accuracy of measurement, used for invoicing and for process optimization. But the product had been already purchased and delivered	

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Understanding and harmonizing the definition of quality in early stage of the forest-wood chain

Understanding the concept of quality from the early stages of forest management is essential for applying appropriate silvicultural practices, optimizing production, and meeting specific market demands.

At the European level, harmonized standards exist for assessing the characteristics and defining the quality of wood products in the later stages of the supply chain. There are standards for visual grading of roundwood and sawn timber, but there is no common definition of criteria and characteristics to identify the quality of standing trees for timber production.

A framework defining a common understanding of quality is needed to secure the benefits brought by an early quality assessment. Beyond the difficulties due to the perception, evaluation and acceptance of quality which varies according to a plethora of factors - among them local market, end users, tree species and growing environment, technologies deployed, etc.

Moreover, harmonizing the data collected at forest inventory level, not only about quantity but also about quality open lots of possibilities to understand the factors influencing the growth of timber species and the production of quality timber.

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Participants during the field trip at the Annual Meeting in Barcelona, exploring local forest management practices on site.

The example of Digital data standards

The establishment of commonly accepted standards is crucial for the adoption of an innovation, independently by its technical maturity. In the forest value chain a relevant example can be posed by the decision, taken in 1986, to create a standard for communication between computers in forest machines. This initiative was promoted by the manufacturers of forest equipment, which envisaged the potential of digital technologies, but also the constraints posed by a fragmented sector. The development of this standard was commissioned to the Swedish research centre Skogforsk, leading to the creation of the Standard for Forest machine Data and Communication (StanForD). Presently, it is used in several countries and constitutes a global de-facto standard even though it has no official status.

The availability of a digital standard for trees and roundwood measurement, among other parameters, paved the way to several services. Besides reporting work time and following up silvicultural operations, StanForD data is used for business transactions. In this case digital data is directly transmitted by the forest machines reporting quantity and quality (assortments) of roundwood produced for invoicing timber at the sawmill and/or paying forest owner, simplifying all processes. A similar approach could be disclosed by the establishment of a standard for quality evaluation in the frame of an information and communication technology (ICT) infrastructure.

Participants during the field trip at the Annual Meeting in Barcelona, exploring local forest management practices on site.

Actions for promotion

Advocate for the development of a common framework for wood quality

Promote the creation of a standardized framework to define a common understanding of wood quality at the early stages of the value chain. Such a framework is essential to fully realize the advantages of early quality assessment and to support more efficient and sustainable forest management practices.

Harmonize data collection at the forest inventory level

Support efforts to harmonize the collection of forest inventory data, incorporating both quantitative and qualitative information. An integrated data approach will improve understanding of the factors influencing timber growth and quality. This, in turn, allows for more accurate forest health assessments, the identification of optimal silvicultural practices, and the development of long-term management strategies. By merging quality and quantity data, forest managers can better predict timber yield, enhance sustainability, and adapt practices to meet evolving market demands while maintaining ecological integrity.

Promote research to validate measurement systems

Encourage research initiatives aimed at proving the reliability and accuracy of early-stage wood measurement systems. Comparative studies contrasting field-based measurements with sawmill sensor data can demonstrate consistency and precision, providing a strong scientific basis for standardization and broader adoption across the sector.

Wood quality evaluation process in the field

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Logs at the yard

Educate and raise awareness

Educate forest professionals, policymakers, managers, and industry stakeholders on the benefits of early wood quality assessment. Raising awareness about the importance of collecting and utilizing qualitative data can drive the cultural and operational changes needed to integrate early assessment practices across the value chain.

Promote local labels for timber quality

Support the creation and dissemination of local or regional labels that highlight specific timber characteristics, including quality attributes. Easily identifiable and recognized quality labels will enhance market transparency, promote the value of differentiated wood products, and strengthen local and niche value chains.

Contribution of the projects DIGIMEDFOR and SINTETIC

Both the DIGIMEDFOR and SINTETIC projects are developing innovative tools to improve quality assessment, value analysis, and traceability throughout the forest-wood chain. DIGIMEDFOR focuses primarily on low-mechanization scenarios, both in harvesting and sawmilling operations, aiming to serve small-scale or less industrialized contexts. In contrast, SINTETIC is designed to address both low and high-mechanization value chains, making it suitable for a broader range of operational settings, including fully mechanized logging and industrial processing environments.

DIGIMEDFOR provided a literature review of technological advancements for assessing quality at early stages in standing trees. It is also developing a rapid, image-based tool that uses smartphone camera input to assign quality scores to tree stems within forest parcels. This tool also estimates potential assortments and integrates into a mobile app for forest inventory, linking quality evaluations with quantitative data collection.

Additionally, DIGIMEDFOR and SINTETIC are also measuring log quality using acoustic resonance-based measurements, storing this data in a traceability platform that links information related to the forest unit with data collected on the logs. The quality assessment is validated further through analysis of the resulting sawn timber, providing essential information to support the selection of the appropriate destination for the material.

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Inside the SINTETIC project a smartphone App for forest inventory as well as for timber measurement has been developed. This application can be deployed at two key stages of the forest value chain: during forest inventory for value assessment on standing trees, and during manual harvesting for measuring and quality classification of the produced logs. By using a smartphone, operators can easily and accurately collect field data, streamlining the assessment and documentation process.

The SINTETIC project aims at accurate stem value analysis and value recovery suggestions. Through both mechanical and manual harvesting, the system supports accurate stem value analysis and provides optimal bucking recommendations. These insights contribute to more efficient, quality-driven logistics and improved roundwood stock management, maximizing the value recovered from each tree increasing revenue and production of long-lasting timber products, featuring the highest CO_2 immobilization potential.

SINTETIC provides an entire value chain traceability system for forest products (mechanical and manual). This traceability system utilizes physical marking of individual logs and is supported by a simplified data platform. It enables effective stock management, accurate product invoicing, and highly reliable information of forest products with the EUDR. Additionally, it incorporates georeferencing to track the exact origin of each log, ensuring transparency and accountability throughout the supply chain.

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