EFFORTE –

‘Efficient forestry by precision planning and management for sustainable environment and cost-competitive bio-based industry’

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 720712
Project duration: 1.9.2016–30.8.2019.
Coordinator: Natural Resources Institute Finland (Luke).

Deliverable 4.4 Report on validation of operator tutorials and efficient information transfer between actions in the forestry process.		
Work Package 4 - Validation and analyses of expected impacts		
Task 4.4 Validation of operator tutorials for efficient and gentle soil preparation and other actions in the silvicultural chain and evaluate the potential in efficient information transfer between actions in the forestry process.		
Due date	30.04.2019	
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Date of publication	24.06.2019	
Dissemination level		
PU	Public	
PP	Restricted to other program participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	
Nature of the Deliverable		
R	Report	
P	Prototype	
D	Demonstrator	
O	Other	

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1. Introduction

1.1. EFFORTE project objectives

The Efforte project is built on the idea that forests and forestry provide a great potential to meet challenges of tomorrow by providing the Bio-based industry with efficiently processed raw material resulting in low carbon footprint.
To realize this and systematically replace fossil fuels and other non-renewable raw materials it is of great importance to find novel technologies and methods to improve and guarantee sustainability within the forestry.

The project is built on three different areas of development

- Trafficability (Better knowledge on soil properties, in particular soil mechanics)
- Efficiency in sustainable forest management and silviculture (development and utilization of novel technology, planning and decision tools)
- Precision forestry (in mapping, characterizing, planning and operations by using information from different sources such as terrain maps and models, harvester data models for predicting detailed yield and operational cost and additional information from earlier silvicultural and harvesting operations)

1.2. Background

In modern society, large amounts of digital information are generated, often called Big Data. By utilizing Big Data, efficiency, productivity and sustainability of processes and operations can be developed and improved. This, of course also applies to forestry. In a sustainable forestry it is crucial to avoid negative impact on the environment as much as it is possible and at the same time maximize forest production and the value growth of the forest. In this matter knowledge and information plays an important role, as example terrain, climate, geology and water flows are important information in any forest activity as well as knowledge of human impacts such as cultural heritages, recreation, roads and power lines, buildings etc.
In presence remote sensing, digital maps, planning and standardized instructions are used as valuable sources of nformation. In addition to this there is a great potential in merging different data into tutorials and decision tools and thereby increase the importance of the information as well as facilitate understanding of the information. More and better information gives opportunity to describe specific conditions in each spot and thereby improve forest production as well as decrease negative impact on the environment.

1.3. Objectives

This task in the EFFORTE project describes how different operator tutorials and tools built on BigData models that have been tested and validated fits into the process of forestry and silviculture. As example this includes:

- Decision tools for site preparation built on terrain- and DTW models
- Tools for precision forestry and timing in young stand management
- The use of DTW-maps as an information layer to avoid damages to wet areas and water
- The use of DTW- maps to facilitate selection of land or trees that should be excluded from forestry as nature conservation
- Operator recommendations concerning soil and water protection

The aim of this task is to illustrate how different operator tutorials and operator support tools tested within the EFFORTE facilitate forest activities. And in addition, how they improve results both concerning production and environmental considerations and contribute to better information and dialogue between different actors within the forestry.

2. Materials and Methods

The idea of our work in EFFORTE is to support and improve the forestry process as well as the information flow with new and developed tools and tutorials. It is important to note that some of the tools were not developed within EFFORTE, but the operational use of the tool has been validated and improved within the project. Following chapter is a synthesis of how different tools and tutorials facilitate the different phases of the process.

3. Results

The forestry is represented of many different actors and activities. There are also a lot of environmental conditions to be considered, figure 1. Everything in this system creates and generates data which all together forms Big Data in forestry. This data is used all the time in forestry, but mostly separately when it is created and within a single activity. There is thus a great potential in combining data into tools, tutorials and information flows to improve the precision and sustainability of forestry. This is a part of the main object of the EFFORTE project and in this report, we want to show how tutorials, tools and information created from Big Data fits into the forestry process and thereby improves management and information chains.

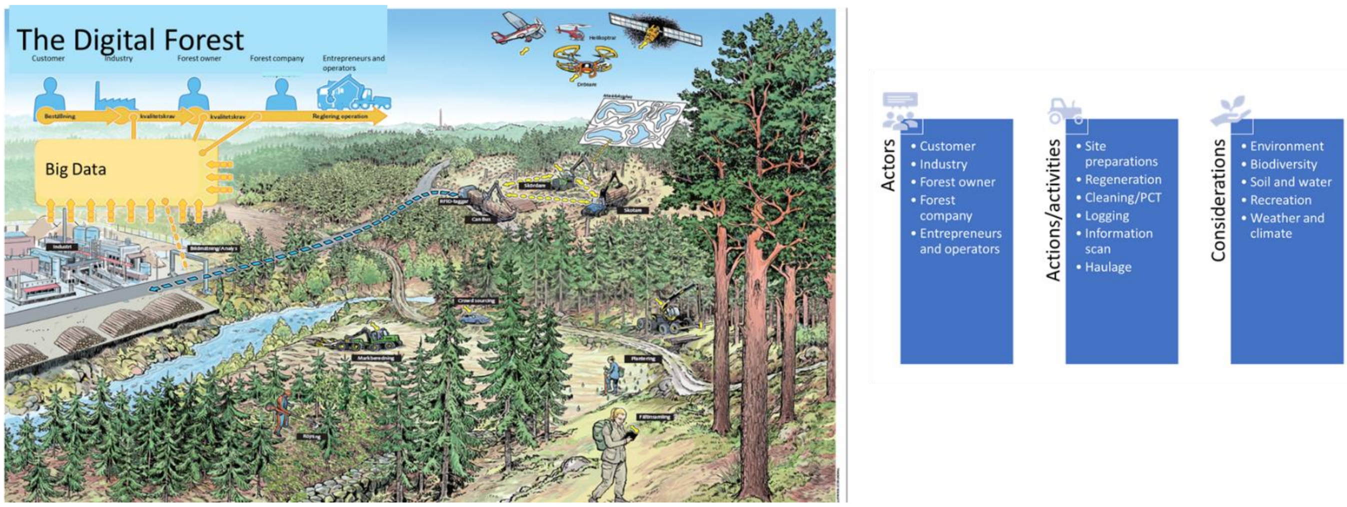


Figure 1. Forestry is a complex system with many actors, activities and environmental considerations. Everything in the system creates data-Big Data in the digital forest

3.1. Forestry process

A rotation period of a forest stand in a production forest could look differently in different countries or at different forest owners depending of what outcome you want from the forest. Mostly thus, this process consists of **reforestation** of a clear-cut area followed by different **thinning** activities and after 50-150 years the treatment area is **final felled.** figure 2.

Each activity consists of an individual process of planning, preparations, operations and follow-up after the operation, figure 2

Examples of the individual process in logging operation:
Planning (6-9 month before):

- Examination of maps and estimation of risk distribution
- Dialogue with forest owner to seal a good contract

Preparations (a few weeks before):

- Planning on-site (extraction-trails, nature conservation, protection of water, landings etc.)
- Instructions to entrepreneurs and operators

During the operation

- Weather surveillance
- Alert procedure and continuous dialogue
- Fall-back positions depending on weather conditions etc.

Follow-up after haulage

- Extraction-trail restauration (if necessary)
- Dialogue

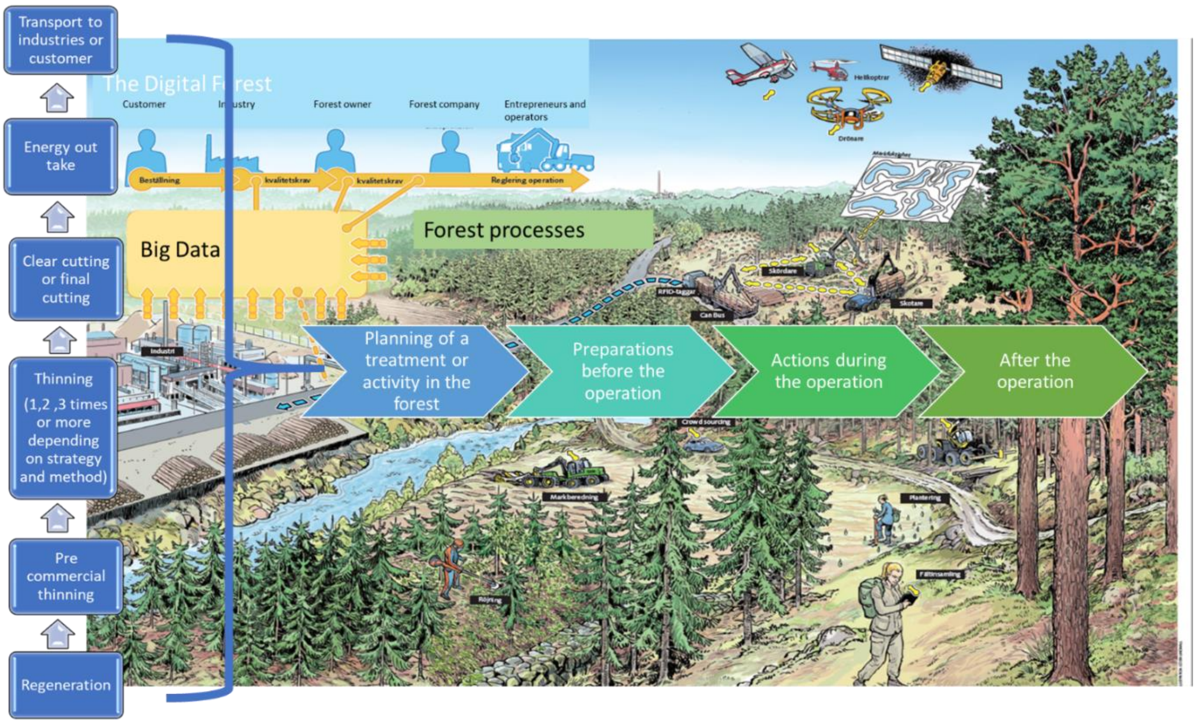


Figure 2. Schematic picture of the forestry process where each action has an individual process of preplanning, agreements, planning on-site, environmental considerations and follow-ups

3.2. Regeneration phase

Site preparation tool

Maps and models of terrain and soil wetness should be considered as tools and those have a great potential as a base map in soil preparation. Depth to water maps (DTW maps) are useful when selecting soil preparation method and they also help to decide how to carry out the operation in the field, figure 3. In addition, DTW maps and models are used to identify wet areas and to adjust water protection zones according local circumstances to control environmental risks and hazards.

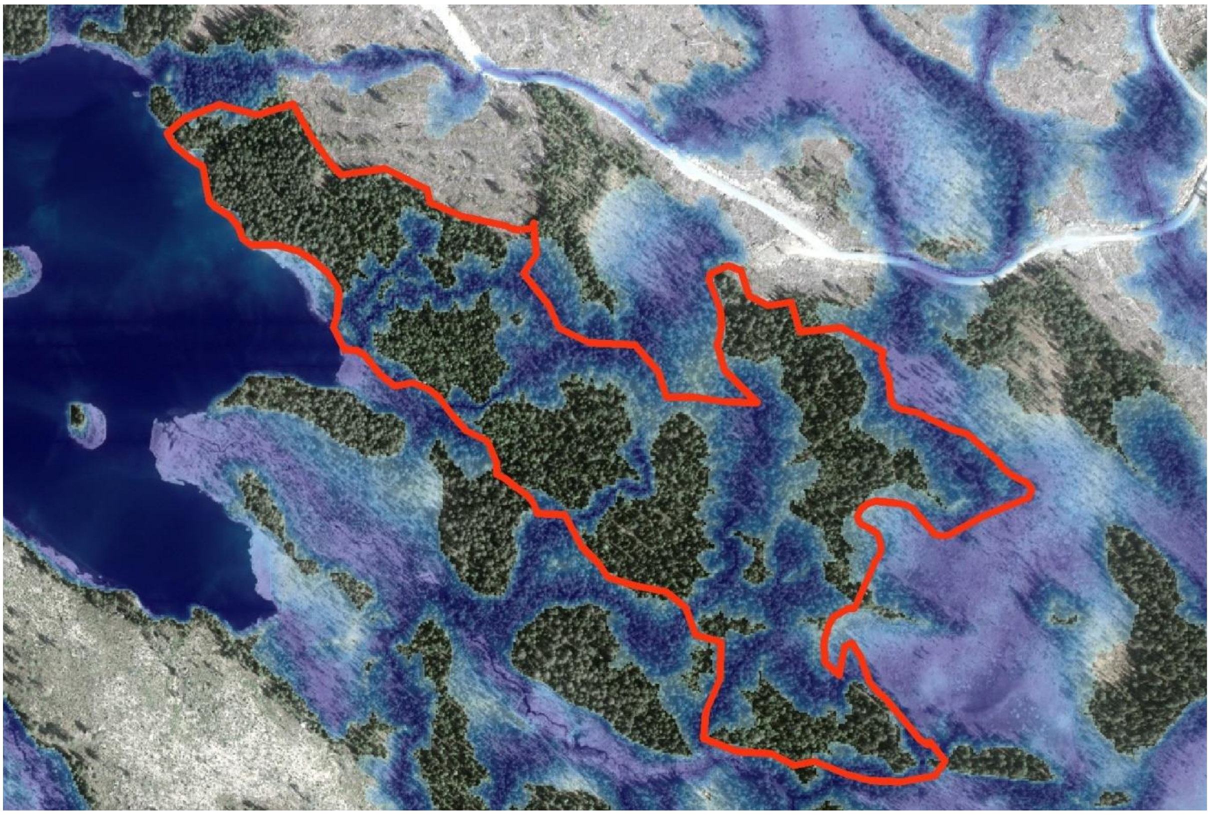


Figure 3. The DTW map is basically a model that uses The Digital Elevation Model (DEM) from LIDAR to illustrate areas where the distance to soil water is less than 1 m (the darker blue the shorter distance from water to surface). Blue areas (wet areas) indicates where the conditions might result in "no go "areas concerning soil preparation.

A combination of DEM (digital elevation model) and DTW maps have been tested as a decision tool for site preparation in a study on 21 sites in the northern part of Sweden. The aim of the study was to evaluate whether a slope index (extracted from the DEM) and a DTW- map can improve productivity and results of scarification, figure 4.

The results show that the slope index helps to stabilize the number of planting points per scarified meter, regardless of the slope on the site. Without the slope index, there was a greater variation in the number of planting points on the site, depending on the proportion of sloping sections. On sites with a high proportion of sloping ground, the decision-support tool also helps to ensure more planting points per meter of driving distance, although this does marginally increase the unproductive driving distance.

The results also show that the slope index is associated with the proportion of unproductive driving distance, and this association is strengthened if the distance-to-water map and the slope index are combined.

The results are thought to be applicable on current slope maps if these maps have the same limit values for slopes as the slope index in the study and have a wide color scale.

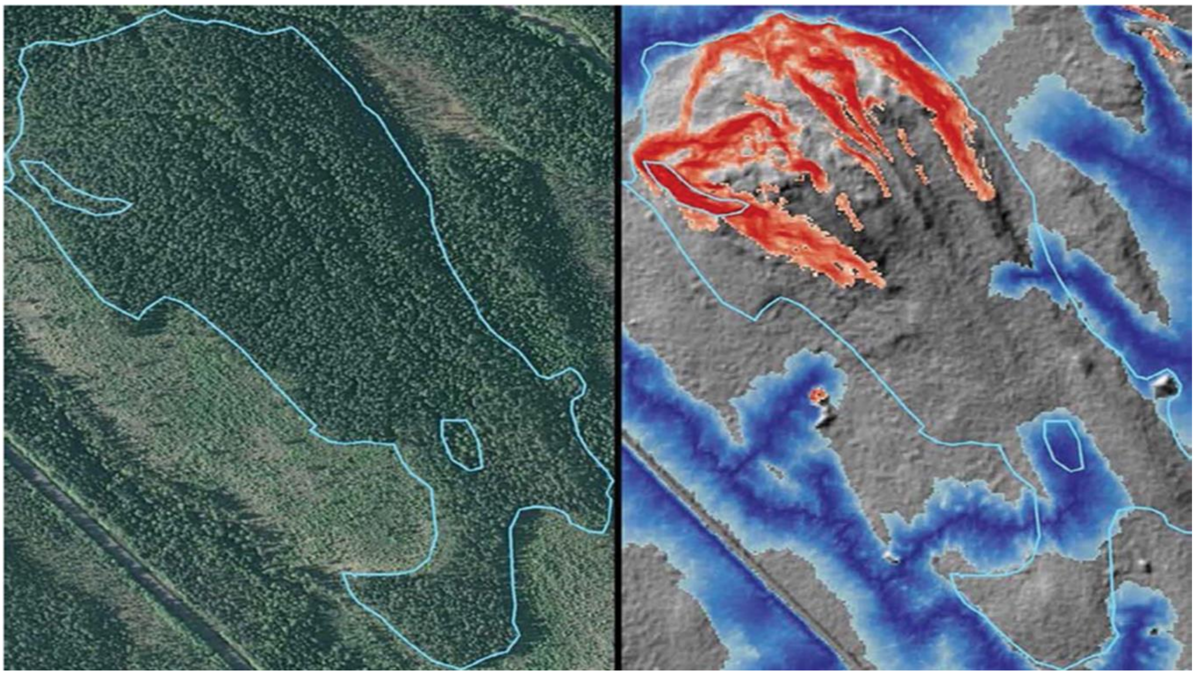


Figure 4. A slope index (red) and DTW (blue) was combined in a planning tool for scarification.

Plant ordering tool

In the regeneration phase, big data from geo- based information and harvester data etc. facilitates silviculture and management with high precision. This has been tested in a “plant order tool” where we have combined updated SI and root rot index from harvester data together with geo-data from maps and models, figure 5. Based on this data we were able to create subareas with more precise descriptions of site conditions (e.g SI, occurrence of root rot, soil wetness, terrain etc). This tool will be valuable and facilitates decisions about the best selection of tree species, type of seedling, quantity of seedlings per area etc. (the full report will be published as an appendix)

Figure 5. Sub areas in a clear-cut site based on three growth indexes from harvester data

Tree species selection tool

In addition, a similar method for selection of tree species in planting was developed and tested in six case stands in Finland. It was based on information collected in final felling. The local growth potential estimation was based on the age (from forest data) and size (from HPR-data) of dominant trees in previous stand. First this local growth potential was calculated for 16x16 meters pixels and these pixels were then combined to larger micro compartments (minimum 0.25ha). The tree species selection for a micro compartment was based on certain threshold values in growth potential. In this case study the tested threshold values (estimated with Motti-simulator) for changing planting tree species from pine to spruce were 6, 7 or 8 m3/ha/year, figure 6

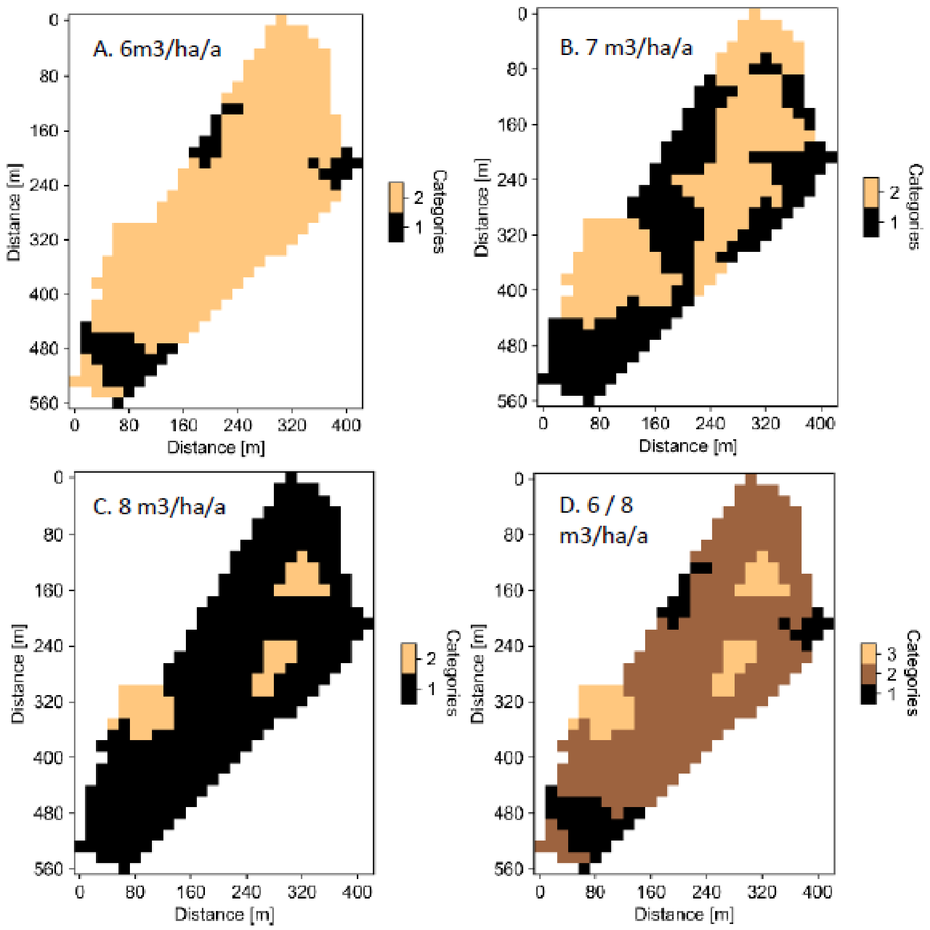


Figure 6. Visualization of micro compartments in study stand 49 categorized with single threshold values of 6 (A), 7 (B) and 8 m3/ha/a (C); and double threshold values of 6 and 8 m3/ha/a (D). A-C: Category 1= pine, 2= spruce, D: 1= pine, 2= pine or spruce and 3= spruce (from deliverable 2.6).

According to the test in this case study the tree species selection method worked quite well and the formation of micro compartments was also feasible in practice. Also the variation between different micro compartment solutions in net present values for next stand rotation (simulated with Motti-simulator) was quite small but logical.

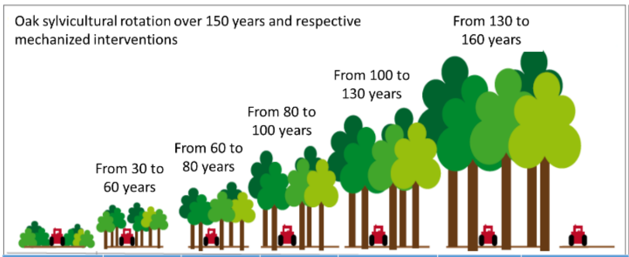
3.3. Thinning phase

Operators recommendation (tutorial for practitioners and operators)

When planning and undertaking logging operations in the plains, French forest companies are often confronted with multiple challenges related to soil bearing capacity and respective sensitiveness towards compaction and rutting. Risk mitigation measures are already in place both in the forest management plan and the pre-harvest planning but some knowledge gaps still hinder efficiency.

French mineral soils make it a hard job because forest soils are heterogeneous, and sensitive situations are numerous with high proportions of silt and clay, and frequent hydromorphy.

Complex phenomena are at play below the surface (spatial and vertical heterogeneity, rockiness, abundant root systems from the perennial forest stand…), and traffic by forest machines is frequent, whereas soil recovery is limited at best between operations (7-10 years, Figure 7).



Nb of interventions	3	3	2	3	2	1 Final felling
Volume harvested per ha and intervention	25 – 47 m3/ha	40 – 45 m3/ha	34 – 41 m3/ha	39 – 45 m3/ha	45 – 51 m3/ha	430 – 460 m3/ha

Figure 7: Frequent forest machine interventions over the 150years rotation in oak dominated forest in French plains

In the Northern half of the country, many companies are confronted to sensitive soils in a consistent share of their working areas. Weather conditions strongly influence logging operations as trafficability-ban can last for months and situations requiring extra-cautiousness can frequently apply half of the year.

In such cases, soil-risk mitigation requires strong engagement from both forest managers and logging operators, from early and macro planning to the final site evaluation after haulage. The need for knowledge-based and open dialog is present every step of the way, in addition to the operational tool the forest manager or the logging company might be using.

Hence, capacity building for practitioners to organize multi-site and seasonal distribution of mechanized logging operations is one of the EFFORTE objectives. Operators tutorial are being designed for that purpose with the French partners, based on the lessons learnt from the on-going research in WP1.

Five workshops were organized with the French partners to test different capacity building modalities:

- Internal workshop within CBB (Chateauroux, April 2018)
- Internal workshop with 2 teams of the cooperative F&BE (Epinal, Nov. 2018)
- Workshop with ONF (one local team), SEFE and two of their usual logging sub-contractors (Colombey, Feb. 2019)
- Internal workshop with two local teams within ONF (Alençon, March 2019)
- Workshop with ONF (one local team), two logging companies and a delegation from a different region (Chatillon, April 2019)

Two major types of adaptations were implemented by FCBA as operators' tutorials were tested with the participants:

- Tutorial contents and respective steering methods were adjusted to take into account how receptive the target population had been during the previous workshops;
- Emphasis on the different modules was tuned to the actual status quo in the area and within the community for which the workshop was held.

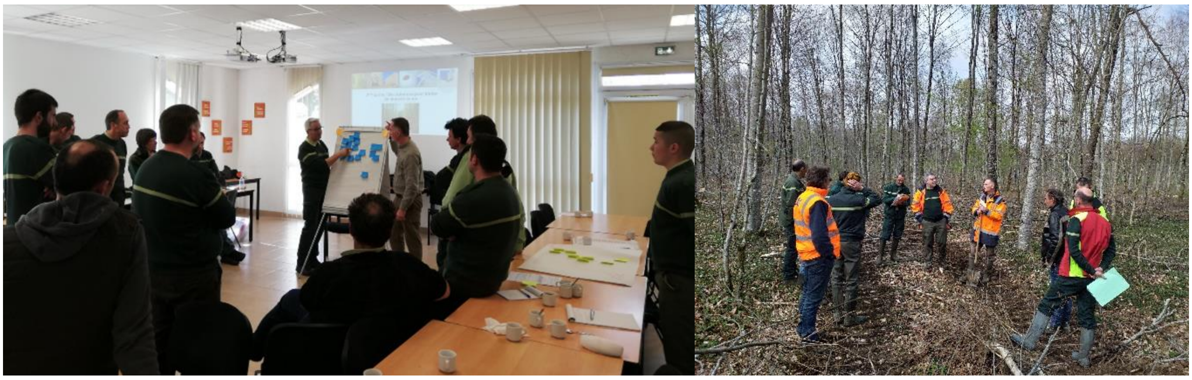


Figure 8: Capacity building was organized as a combination of participative workshops, indoor presentations and field demonstration

Validation of the operator tutorial can only be completed when the national recommendations from the WP1 research is finalized. However, feedback from the upper-mentioned workshops already confirms the relevance or such tutorials. Within the participating companies, the word of mouth and internal communication already resulted in three local demands for similar capacity building activities and dialog facilitation.

3.4. Final felling phase

Digital map layers used as a tool to avoid negative impact on soil and water and as a planning tool to improve efficiency within operational forestry

Maps and models of terrain and soil wetness had already before the start of EFFORTE been implemented in operational forestry. Digital maps describing terrain and soil wetness (DTM, DTW) are frequently used in planning of different activities and as a layer in most forest machines. When defining borders of a logging area those maps facilitates estimations of risks for windfall and other hazards in border stands as well as when locating retention trees on places favorable for biodiversity and wood production.

Logging operations was the first activity where DTW maps were used as a mapping tool, and as mentioned it was implemented in the forestry before EFFORTE started. During the EFFORTE project it has thus been evaluated and developed concerning interpretation, application and spread of information (see also deliverable 4.5). This has been made through feedback and dialogue in a number of seminars, workshops and educations as well as discussions with practitioners.

Figure 9. Seminars, workshops and educations and benchmarking with practitioners to improve use and information in digital maps and models.

The DTW map has additionally shown to be valuable concerning how to plan retention areas and buffer/riparian zones along wet areas and water. This has been evaluated in a tool, “Envi tool” (full report in a technical report and also summarized in D4.6).

4. Conclusions

Tools summarized in this report has showed to be valuable in operational forestry. They lead to improved environmental care and increased productivity e.g. less negative impact of soil and water, working towards precision forestry and facilitated selection of retention trees, areas and riparian/buffer zones along wet areas and water.