Mechanical tools for site preparation in forest plantation: networks of field sites for evaluating and promoting innovative methods

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Mechanical site preparation (MSP) methods are widely used to facilitate or to allow forest plantation. With the restriction of the use of chemical herbicides around the world, MSP methods have received new attention.

Each planting operation presents specific characteristics which must be taken into account when selecting the MSP method to be implemented, among which: (1) site: soil conditions (structure, compaction, water content, presence of rocks and logging residue), vegetation (type, cover), topography (slope); (2) history: former land use, former stand type, recent disturbance; and (3) management objectives: planted tree species, maximum total cost, control of environmental impacts.

In many contexts, there is no MSP method that meets the existing constraints : for example, low density plantation in sites with rocky conditions, underplanting in case of shelterwood, plantation in dense fern or grass layers, sites with soils sensitive to compaction, sites where the total environmental impact must be controlled. New MSP tools have been developed to fulfil the needs that have recently appeared.

Two networks of experimental sites were installed in France (Fig. 1) to test tools recently developed to meet various existing constraints and fulfil management objectives. The sites were set-up to provide **technical and economical evaluations of the methods**, and are used as **demonstration sites** to **promote the methods to forests practitioners**. The networks are:

- ALTER (Alternative to herbicides): 8 sites across 4 regions, set up in 2011 and 2012.
  The objective is to estimate the effect of various MSP methods on seedling survival and growth, on vegetation dynamics and on environmental factors (soil structure, soil temperature, water availability).
- PILOTE (Pilot field sites): 7 sites across 6 regions, set up in 2013 and 2014.
  The objective is to estimate the effect of various MSP methods on seedling survival and growth and on vegetation dynamics and on soil structure, and to perform a cost analysis. The cost analysis includes for each MSP method: machine productivity per hour, direct implementation cost, and costs of all subsequent operations (mainly planting and release operations) required within 10 years after treatments to ensure full stocking.

Promotion of tested methods includes organisation of **training sessions** (students and professionals), **demonstration** days and **technical information exchange** days, publication of **technical reports**, **data sheets**, and **presentation videos**.

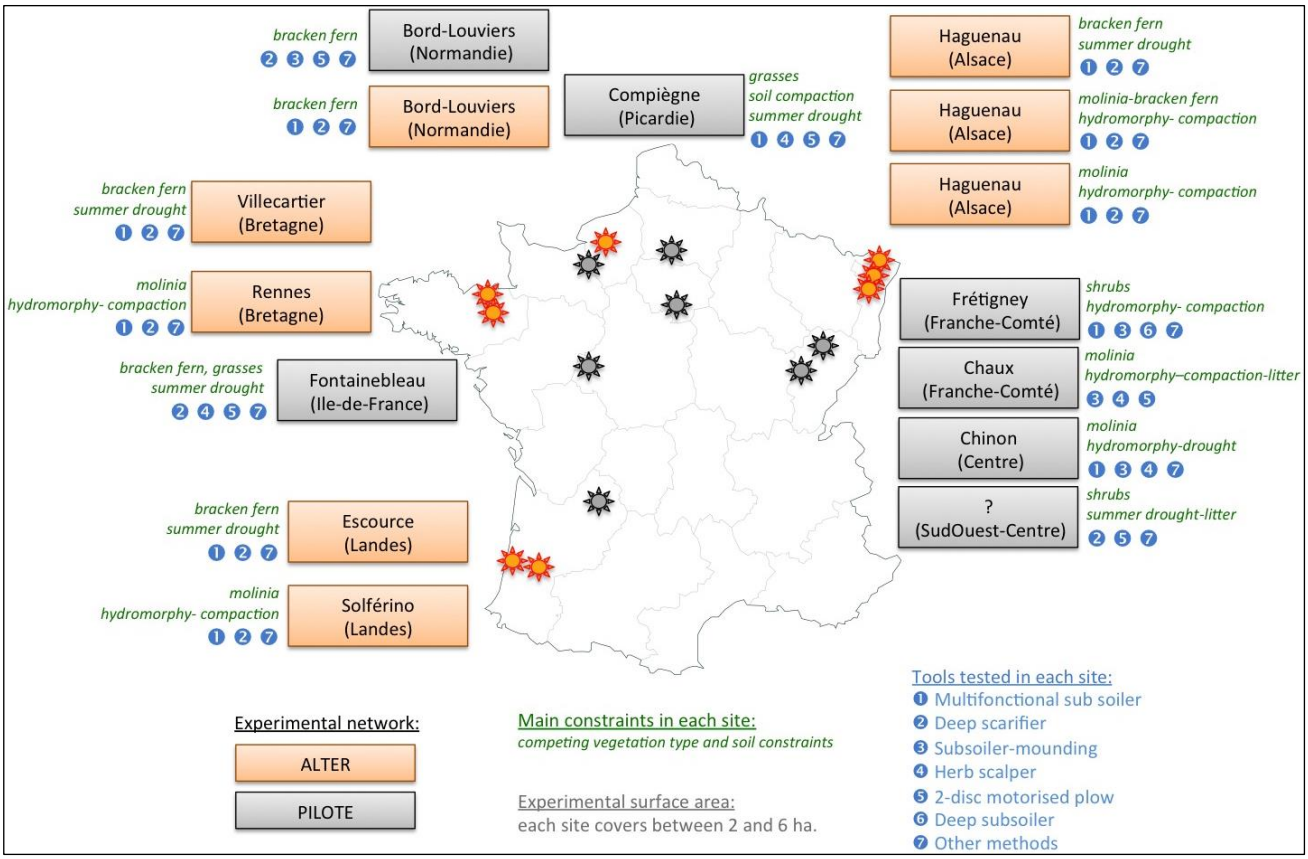

Fig.1 : ALTER and PILOTE experimental networks in France: location, main constraints and tools tested in each site.

In each site, a series of MSP tools were implemented and tested. The tools were chosen to meet the main constraints of each site. The following tools were tested:

1. A multifunction sub-soiler (Sous soleur multifonction®, Grenier-Franco, France) mounted on a mini excavator, which decompacts the soil down to 60 cm without reversing the soil horizons. An additional 20-cm mound may be created. The tool may also be used to remove the vegetation. The tool is used on sites with compacted or waterlogged soils.
2. A deep scarifier (Scarificateur Réversible®, Grenier-Franco) mounted on a mini excavator, which removes the vegetation, extracts the root systems and fractures the soil structure down to 60 cm. The tool is particularly adapted to sites where *Pteridium aquilinium* that has a deep root system, is competing with the young trees.
3. A sub-soiler-mounding (Culti 3B®, Grenier-Franco) pulled by a forest tractor, which fractures the soil structure down to 60 cm and creates a mound. The tool is used on sites with compacted or waterlogged soils.
4. A herb-scalper (Razherb®, Grenier-Franco) mounted on a mini excavator, which removes the above ground part and the first 5 cm of the root system of herbs. It is used in sites with dense herb coverage (e.g. *Molinia caerulea*).
5. A 2-disc motorised plough (Charrue bidisque motorisée®, Alliance Forêts Bois, France) pulled by a forest tractor, which removes the vegetation and plough the soil down to 35 cm. The tool is used on sites where shrubs are competing with the trees.
6. A deep sub-soiler (bident Maillard, France) mounted on an excavator (22t), which fractures the soil structure down to 80-100 cm. The tool is used on sites with strongly compacted soils.

Name	Tool	Site preparation

Multifunction sub-soiler Sous soleur multifonction®		
Deep scarifier Scarificateur Réversible®		
Sub-soiler-mounding Culti 3B®		
Herb-scalper Razherb®		
2-disc motorised plough Charrue bidisque motorisée®		
Deep sub-soiler Bident Maillard		

Table 1 : Main tools tested in the ALTER and PILOTE experimental networks.