Silvicultural itineraries and sustainability of soils

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Report of the workshop 1

Guy Landmann – Laurent Augusto – Anne-Sophie Cabral – Laurent Saint-André

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INTRODUCTION

This workshop was chaired by Guy Landmann (ECOFOR) and Laurent Augusto (INRA), and Anne-Sophie Cabral (ECOFOR) acted as secretary. The workshop was attended by about thirty people, mainly from research institutes and regional management and consultancy organizations.

This was the first of the four workshops. The other workshops considered the role of the forestry industry (workshop 2), actions to compensate for the export of nutrients and remedy degradation (workshop 3) and exploiting soil data (workshop 4).

It considered i) harvesting practices leading to the significant export of nutrients, ii) the impacts of such exports on the soil and forest ecosystem, iii) the development of indicators for the impact of exporting nutrients and iv) changes in practices for harvesting wood for fuel.

HARVEST TREATMENTS LEADING TO STRONG EXPORT OF NUTRIENTS

Laurent Augusto (INRA) presented the current state of knowledge on the relationship between forest management policies and the maintenance of soil fertility based on the results of the RESOBIO(1) project (Landmann & Nivet, 2014) which studied the management of harvesting residues and the preservation of soils and biodiversity. Laurent Saint-André (INRA) gave a special presentation on the management of forests in tropical regions.

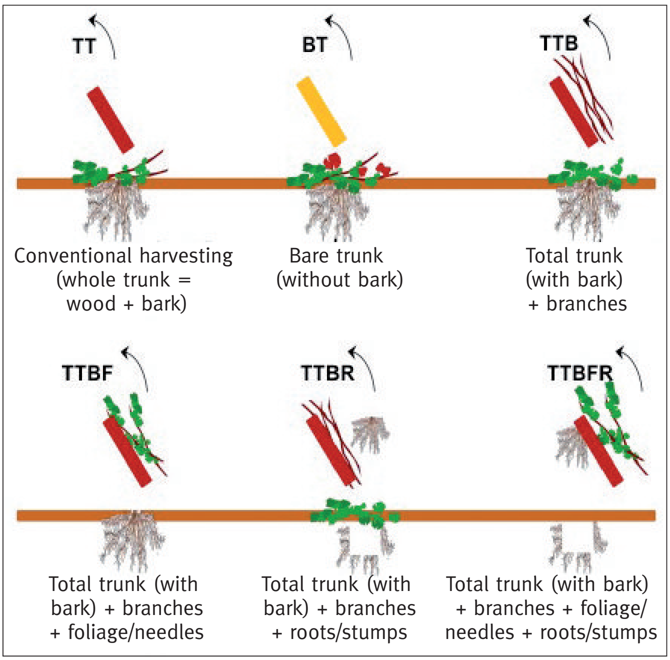
There is extensive scientific literature in this field world-wide, which has been built up over many decades. 254 publications were reviewed by Achat (2014) to identify the harvesting methods that removed the greatest amount of nutrients and could consequently be most damaging to soils and forest ecosystems. The studies taken into account were those which made it possible to compare conventional treatment with other itineraries on the same site, including more intensive biomass harvesting.

(1) http://www.gip-ecofor.org/?q=node/900.

To assess this large amount of disparate information, Achat (2014) carried out a *meta-analysis* which combines the results of various independent studies, reported in various publications, relating to a common statistical measure. This approach has both strengths and weaknesses. Its main strength is to identify patterns within highly variable data that would not show up in a conventional literature search. Although carrying out a meta-analysis requires specialist training, it has become popular above all because of the increasing availability of data sets in the literature.

Six different harvest treatments used in the experiments were identified (figure 1).

FIGURE 1 **HARVEST TREATMENTS COVERED IN THE META-ANALYSIS** (Achat, 2014)



TT: conventional harvesting exporting the total trunk (wood and bark)

BT: traditional harvesting in coniferous forests exporting the bare trunk with the bark being removed manually on felling

TTB: harvesting the total trunk (for construction wood); the large branches (for the wood industry, logs or chips) and the small branches (chipboard, and, in the past, faggots for domestic use)

TTBF: harvesting the total trunk, branches and foliage

TTBR: harvesting the total trunk, branches and roots (stumps and part of the root system), but not the foliage (TTBR)

TTBFR: "total" harvest (total trunk, branches, foliage and roots)

The most striking result was the contrast between the relatively small increase in the quantity of *biomass* exported when changing from conventional practices to highly intensive practices on the one hand and the relatively high increase in *nutrients exported* on the other. Exporting branches, foliage and stumps had a detrimental effect. Foliage was responsible for the greatest increase in *nutrients exported* despite the low biomass of this compartment.

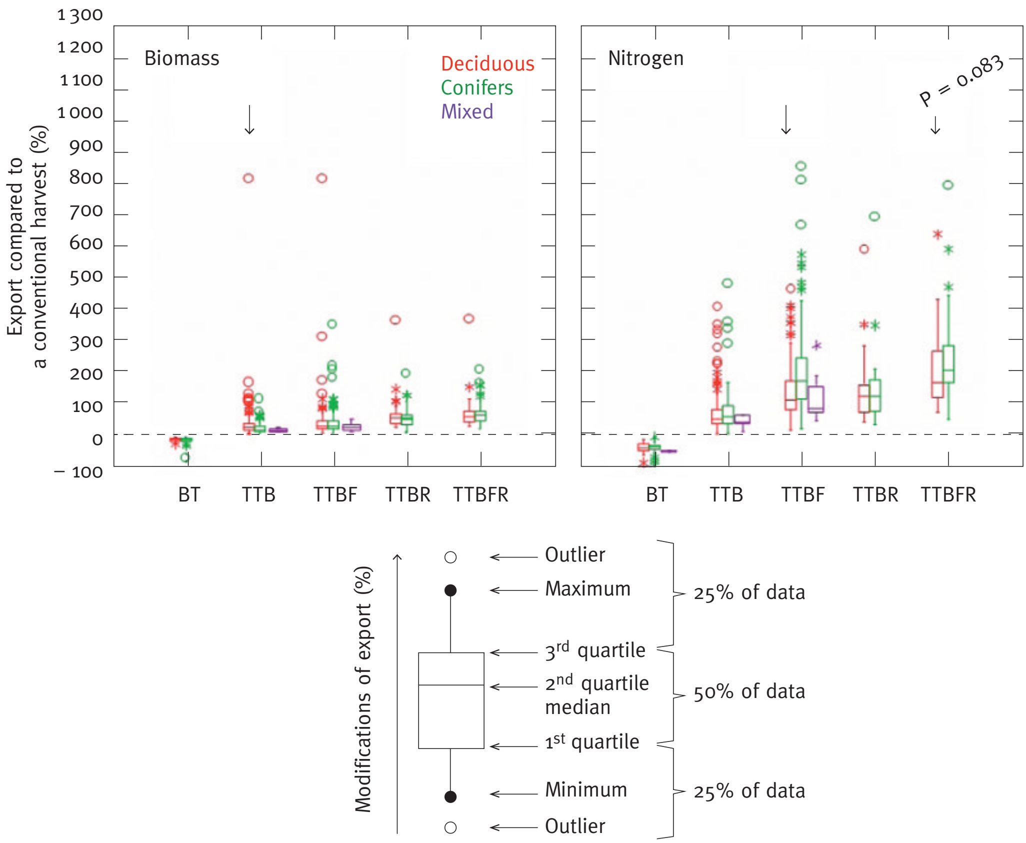
After the type of compartment exported, it was the *size of the tree compartment exported* which had the next greatest influence on the quantity of nutrients exported, small compartments (such as twigs and rootlets) having a greater concentration of nutrients than larger compartments (such as branches and structural roots). These two effects were more pronounced that the effect of different species of tree but there were differences between deciduous trees and conifers (in particular spruce, firs and Douglas fir) where harvesting exported more nutrients than for deciduous trees as shown in figure 2 (p. 135).

The question of *harvest rates* (i.e. the difference between theoretical (100% of a compartment) harvest and observed harvest), particularly for the smaller compartments, was raised: does this wastage reduce the impacts correspondingly? In fact, the wastage was generally of the order of 40%,

FIGURE 2

EXPORT OF BIOMASS (LEFT) AND NITROGEN (RIGHT) FOR VARIOUS HARVEST TREATMENTS COMPARED WITH CONVENTIONAL TOTAL TRUNK HARVESTING

(see figure 1 for a definition of the methods)



but this varied depending on the compartment, the species and the harvesting technique. This was taken into account (on the basis of a synthesis of the available results) in the impact evaluation (see below). However, there was still insufficient information for the most important cases and this affected the quality of the impact assessments for the various types of harvesting.

THE IMPACTS OF INCREASED EXPORT OF NUTRIENTS

Compared with the data on export of nutrients, there was little experimental data for the effect of exporting nutrients on the following rotation and published results rarely covered periods of more than 10 years (Achat, 2014). The limited data available makes it very difficult to draw conclusions on certain types of impact.

Although the stocks of nutrients in the soil were clearly affected, on average, there was little effect on the nutritional status of the trees, even though there were some proven cases of nutritional stress. Tree growth dropped slightly but significantly (on average around 3-7% in height and diameter) especially when foliage was exported. The current state of knowledge could not as yet allow us to identify the most sensitive ecosystems.

The interpretation of the moderate drop in growth was discussed. It was considered that it was probably the cumulative effect of successive harvests, and that account should be taken of the different types of effect, some being more marked than the effect on tree growth, in particular the change in microbial communities and biological activity of the soil as well as a decrease in organic matter, and thus in carbon. Here again, the effects were always more marked when tree foliage was exported.

Report on experiments in industrial plantations in tropical regions

Laurent Saint-André (INRA) described the case of tropical industrial plantations, in an experimental network set up by CIFOR[(2)], as an extreme example of the relationship between intensive harvesting and drop in productivity. In these experiments, stands of fast-growing trees were subjected to very different treatments, including removing the whole tree (including harvesting residues and foliage) and laying bare the soil (removing all the litter) which corresponded to a practice that was still current in certain tropical ecosystems (as was the removal of litter in temperate forests in the past).

In soils that were deep and well supplied with water, although poor in nutrients, growth was strong (the rotations were usually less than 10 years and growth could exceed 40 m^3/ha/year as in Brazil) and the final effects could be rapid and very pronounced, making these experiments particularly interesting for study and modeling. After the first rotation, production dropped significantly for these ecosystems, which was consistent with the fact that they functioned almost exclusively in a biological loop (the soil reserves were very low). The results for the second rotation were less clear and had not yet been assessed by the CIFOR network.

A new generation of trials in France

A set of trials (MOS for Soil Organic Matter) is being set up to provide data for temperate regions to complement those in Scandinavia, North America and the tropics. the experiments include an extreme treatment (harvesting residues and litter, leaving the soil bare every year) and a treatment whereby ash was returned to the forest (when the harvesting residues were exported as well as logs, envisaged for the increase in demand for wood for fuel – see workshop 3).

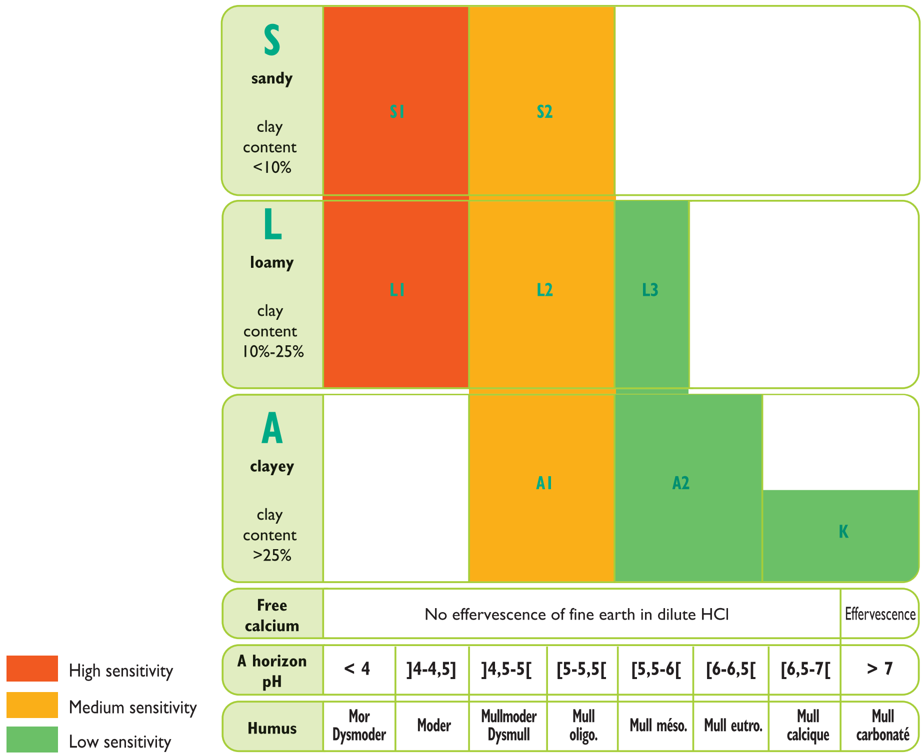
DEVELOPING INDICATORS FOR THE IMPACT OF EXPORTING NUTRIENTS

With the development of intensive biomass harvesting, there is an urgent demand by foresters for reliable indicators for an *in situ* assessment of the *risks* associated with of exporting nutrients. The presentations given to the workshop and the discussion that followed confirmed that research in this field was very active but that there were still no methods giving sufficiently reliable results based on parameters that were easy to establish.

For the moment, the only indicator available for forest managers in the field was based on a simple analysis of soil quality which combined the soil texture and the pH of the A horizon deduced from the type of humus (ADEME guide: Cacot *et al.*, 2006).

(2) Center for International Forestry Research ‹http://www.cifor.org/›.

FIGURE 3 **KEY FOR DETERMINING THE SENSITIVITY OF SOILS TO EXPORT OF RESIDUES BASED ON THE TEXTURE AND TYPE OF HUMUS**
(ADEME guide: Cacot *et al.*, 2006)



On the basis of soil inventory data (16 x 16 km Network of Forest Health Departement and RENECOFOR), Pousse (2014) considered other indicators of forest soil sensitivity. It was not possible to define variables and thresholds that provided better discrimination of the sensitivity of soils to the export of residues than those proposed in the ADEME guide (2006). In particular, contrary to a hypothesis commonly put forward, the base saturation did not prove any more appropriate than the pH in this context. The results of this study could, however, be used to improve the sensitivity table proposed in the guide (figure 3) based on the relationship between soil pH on the one hand and humus type, soil texture and climate on the other.

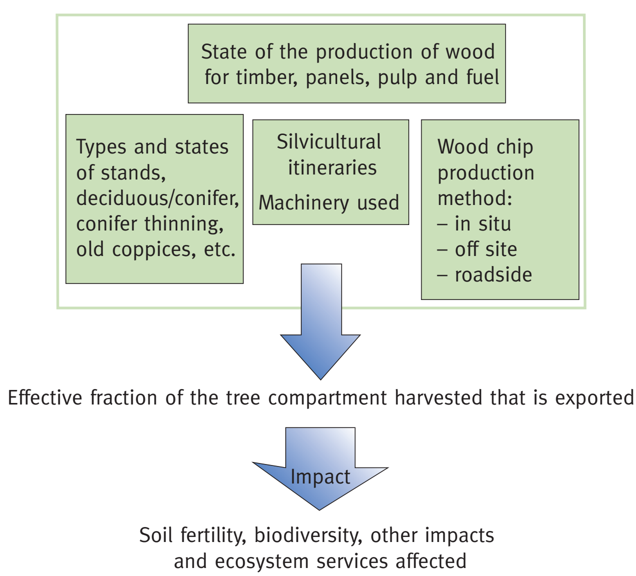
Going beyond the data relating solely to the soil (pH, humus type, etc), a different approach might be to consider the relevance of the relationship between the quantity of nutrients removed by harvesting and the quantity remaining (stock) in the soil. This was the approach followed by Laurent Saint-André in his studies in tropical regions: he was looking in particular at load indices, the “load” being the ratio between the quantity removed by harvesting and the quantity remaining in the soil which could be used to model the impact on growth during the following rotation. During the 1990s, this type of approach produced useful results for boreal forests (nitrogen-based indicators) and in tropical regions (eucalyptus, CIFOR trials during the 1990s). This type of approach was not new but was becoming more generalized with an increase the number of sites throughout the world (from boreal to tropical regions).

Other approaches are currently being explored: for example analyzing the flows of nutrients (input flows from atmospheric deposits and degradation of minerals and output flows by drainage and export of biomass). This study, presented by Emmanuel Cacot at this workshop, is the subject of a written report on the tools developed for forest soil management (see Cacot *et al.*, this volume). It gave rise to many questions on setting the parameters for the model used (for example the drainage flow, which was considered to be very difficult to calibrate), how to make it useful for forest owners, how to make it more generally applicable, etc. Emmanuel Cacot admitted that there was still a lot of evaluation work to be done, in particular assessing its limitations (such as the uncertainties in the biogeochemical flow measurements). Its state of maturity also needed to be better defined. As the model had only been calibrated in two small regions (Orléans and Vercors), it needed to be parameterized using data for the other areas where it will be used (types of soil, biomass and nutrients, rainfall and evapotranspiration, atmospheric deposits, etc). Finally, it was clear that in its present form it was of greater use for forest managers than for forest owners.

THE NATURE OF AND CHANGES IN PRACTICES FOR HARVESTING WOOD FOR FUEL

The state of knowledge presented above did not answer the question of whether the most detrimental methods of harvesting wood (in particular felling whole trees) were currently practiced in France and, more generally; what were the most commonly used methods of harvesting wood for fuel. For the moment, there was no objective answer to these simple questions as there were no statistics on harvesting wood for fuel. The information provided by the RESOBIO project (Landmann *et al.*, 2014) was based on the opinion of experts who were deeply involved in the production of wood chips (Union de la Coopération Forestière Française, ONF-Energie, Fédération Nationale Entrepreneurs des Territoires, Institut Technologique Forêt Cellulose Bois-construction Ameublement).

Figure 4 **POTENTIAL EFFECTS OF HARVESTING WOOD FOR FUEL: RELATIONSHIPS WITH FOREST MANAGEMENT, ECOLOGICAL CONDITIONS AND SOCIOECONOMIC ENVIRONMENT**



These experts agreed that a major part of wood chips came from thinning conifers (the more so because the chipboard industry which was a major consumer was in difficulties), a practice which had only a limited impact on the nutrient balance if the tree tops were left in place (which was not always the case). Wood chips also came from harvesting whole trunks from old coppices, a practice which was more detrimental (the foliage was not exported, but could, possibly, be piled up at the edge of plots, in areas for storing or producing chipboard). Those taking part in the workshop said that Limousin and Rhône-Alpes were regions where these practices would increase. Finally, and paradoxically, collecting harvesting residues during final felling, which was usually considered to be the main source of small wood, was a less common practice as it was less profitable.

The change in practices is explained by the rapid development of forestry machinery.

These considerations led to considering the export of biomass and its possible impacts in a wider technical and socioeconomic context (figure 4, p. 138).

CONCLUSION

The presentation on the state of knowledge was of great interest to participants and aroused lively discussion. However, it was clear that some people were unconvinced and worried as there was still insufficient information about the situation in the field and it was difficult to formulate recommendations for forest managers.

In reality, it was not possible to quantify the level of risk for a given situation with certitude and we were forced to be content with general recommendations with, at best, certain assessments provided by simple tools (ADEME guide: Cacot *et al.*, 2006).

The need for the best possible information, but above all for recommendations and decision-making tools, became a leitmotiv throughout the workshop. "*Even if they leave much to be desired*", was the comment that was heard again and again during the workshop. This need was particularly obvious in a situation which was changing rapidly, whether for forestry management and harvesting practices or for the volume of wood chips produced. Another requirement that was expressed was for better coordination between those involved in forestry and a demand for the harmonization of protocols to ensure that the data in the databases was coherent (see workshop 4).

The reality would, therefore, be different in the future. Those involved in promoting the use of wood for fuel were demanding change, ADEME, in particular, was supporting research and development activities. The workshop ended with an unusual final discussion, as those involved in research and development were invited to comment on the probable time it would take to resolve the main problems remaining: 2 years, 5 years, 10 years? As is usual there was a difference of opinion about the timescale, the scientists considering that progress would take place over the medium to long term. Some considered that the state of knowledge could advance rapidly by adopting indicators such as load indices, limiting the scope to that which was possible and applicable in the field using rapid in situ measurements while others considered that it would take longer, as progress would rely on the collection of data from the networks that were only just being set up. It was, therefore, decided symbolically to "meet again in 2, 4 and 6 years to review the situation".

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