

REGESOL: A DIAGNOSTIC TOOL FOR FOREST SOIL IMPROVEMENT BY LIMING

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As they are submitted to numerous stresses, forest ecosystems sometimes suffer from malfunctions which can finally lead to their decline. Various symptoms can be observed: leaf or needle yellowing, reduction of leaf production, drying of young shoots, etc. The possible causes are numerous and poor stand nutrition is one of them.

In the 1980s, the acid rain phenomenon and the risk of forest decline revived the problems of forest soil fertility. To understand the phenomenon and to rectify it, research scientists used old fertilization-improvement trials installed in the 1970s and new calcium and/or magnesium trials were set-up. Today, these trials form the liming-fertilization network. In parallel, to study the biogeochemical cycles and the mineral element inputs and outputs of forest ecosystems in depth, these experimental sites have been highly instrumented and monitored intensively and at present are integrated into SOERE F-ORE-T. The liming-fertilization network, linked with studies of biogeochemical cycles, has resulted in great improvements in our knowledge about the restoration of mineral fertility by liming in deteriorated forest ecosystems.

AIMS AND OPERATION OF REGESOL

The REGESOL software program is a tool to help with the estimation of nutrients necessary for many forest species (spruce, pine, Douglas fir, oak, beech, etc.) in different site conditions. It is a computerized tool to calculate the corrective requirements necessary for forest soil fertility based on the available stocks, biogeochemical cycles and on the nutrient input-output balances (Ca, Mg, P, K) in forest ecosystems. The inputs taken into account in the equation are atmospheric inputs and those derived from soil mineral weathering; the outputs are due to biomass exportation and losses in the drainage water (outside the root exploitation zone). The terms of the balance are estimated from spatialized data (e.g. atmospheric deposit maps from the Renecofor network) or extrapolated from data collected by the Forest Ecosystem Biogeochemistry (BEF) Unit over more than 20 years. The greatest uncertainties concern drainage losses, then atmospheric inputs and those derived from mineral weathering. Numerous research studies carried out in this field have aimed to clarify these fluxes, the processes in play and the control variables, in order to refine these estimations.

The principles of the way the software program functions are as follows:

Stage 1: REGESOL evaluates the nutrient stocks (Ca, Mg, K, P, etc.) available in the soils (a statistical extrapolation model makes it possible to evaluate soil nutrient stocks from 0-70 cm using an analysis of soil sampled from 0-15cm) and humus, as well as the nutrient fluxes entering, circulating and leaving the ecosystem, which could increase or decrease the stocks.

Stage 2: Then REGESOL compares the stocks with the quantitative nutritional norms established during 50 years of research by the BEF unit of INRA, Nancy. Using these norms it is possible to calculate the quantities necessary to restore a good nutrient cycle function in the forest ecosystem.

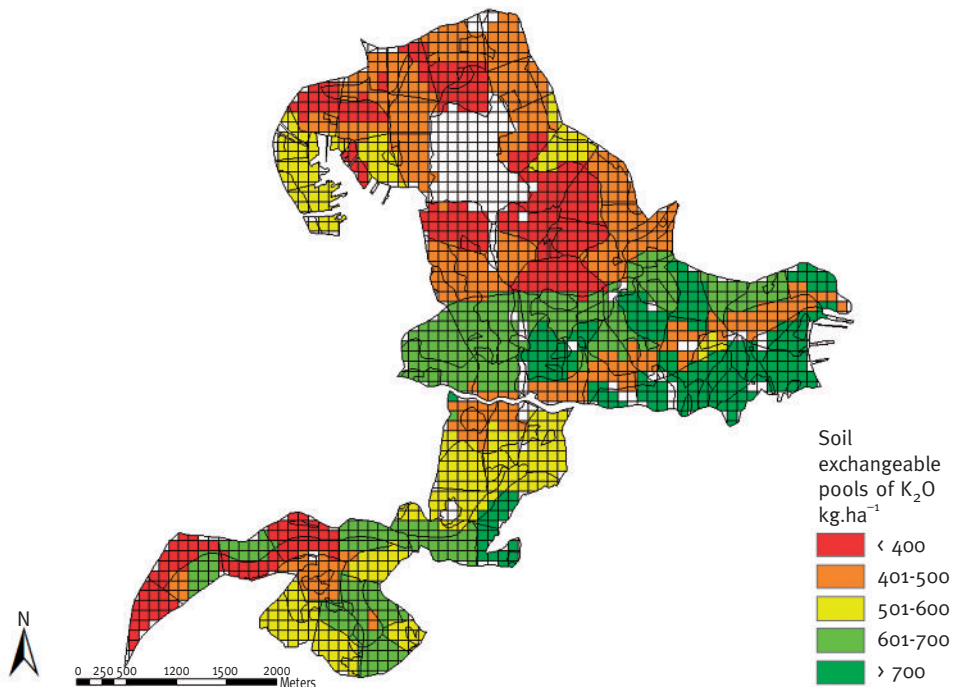
Stage 3: REGESOL produces a technical report consisting of fertility histograms of the soils before correction, an estimation of element requirements with the possibility of calculating the inputs in terms of products, either by plot or by spreading zone. Files permitting the production of maps showing stocks or requirements at the forest massif scale are also created.

FIELD OF EXPERTISE OF REGESOL AND CONDITIONS OF USE

The restoration of the mineral fertility of forest ecosystems shows long term benefits, not only at the plot scale with enhanced stand health, reduced production losses and the maintenance of recreation services, but also of its environment, due to improved surface water quality.

FIGURE 1

**EXAMPLE OF OUTPUT OF THE REGEFOR TOOL:
SPATIAL DISTRIBUTION OF SOIL-K AMOUNTS
IN THE RIBEAUVILLÉ STATE FOREST (VOSGES)**



The expert assessment provides managers with spatial soil analyses, tables and maps whose colour coding permits easy identification of zones deficient in the major mineral elements (Ca, Mg, K and P). The REGESOL outputs combined with a geographic information system (GIS) have proved to be a useful tool for forest managers.

At present this software program is not available to managers. The expert assessments of possible improvement requirements, which form part of the program, are carried out by the BEF unit.

PRESENT ACHIEVEMENTS AND FUTURE PROJECTS

Since 2010, more than 30000 hectares have been assessed by INRA, mainly in the Vosges massif. Once the diagnosis has been made, it is up to the forest managers and owners to decide their priorities and carry out the treatments following the recommendations given by INRA.

Improvement consists of spreading calcium and/or magnesium carbonate, sometimes with a complement of other elements like potassium or phosphorous, depending on the recommendations. The improvement operations, which cost about 500/ha and are carried out by specialist companies, follow a set of specifications and are monitored over time.

The expert assessments carried out by INRA have led to more than 4000 ha being treated by helicopter in the Vosges since 2008. Although concentrated in the Vosges at first, demands for expert assessment have spread to other regions, like the Massif Central, the Ardennes, Alsace and Brittany.

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