

**Host Laboratory**

UR 1138-Biogéochimie des Ecosystèmes Forestiers ; INRA Nancy; 54280 Champenoux, FRANCE

**Supervisors**

Legout Arnaud, CR INRA <a href="mailto:legout@nancy.inra.fr">legout@nancy.inra.fr</a> 03 83 39 73 36	Ranger Jacques, DR INRA <a href="mailto:ranger@nancy.inra.fr">ranger@nancy.inra.fr</a> 03 83 39 40 68
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**Chemical fertility of forest soils: concepts, influencing factors and the definition of reliable indicators.****The Problem**

Soil chemical fertility is a concept that it is essential to define correctly for forest soils whose behaviour is specific. They are generally chemically poor or even very poor soils, and are colonised by perennial plants adapted to their situation due to a group of processes described under the title of biogeochemical cycles of mineral elements (Ranger and Turpault, 1999). Following many research projects carried out on highly instrumented sites, it has been shown that the definition of soil fertility, inherited from an agronomic context and thus better adapted to rich or enriched environments, has limited relevance to forest soils. The agronomic fertility budgets only compensate for a deficit in the soil reservoir for a given crop. For example, the norms defined by Bonneau (1995) for forest soils are based on this concept. However, in practice very few or no stable forest soils contain the optimal reserves indicated by these norms, for example 800 kg.ha<sup>-1</sup> of Ca down to a depth 70 cm of soil (Salas Lopez, 2010).

The concept described above, mainly based on stocks of available nutrients, does not include the circulation of elements or the recycling specific to biogeochemical cycles. In fact, one must incorporate the lower activation threshold of the biological component of the cycles on the one hand and also the reserve of elements able to cover the agro-biogeochemical functioning of the soil by recycling. The new definition of chemical fertility proposed for forest soils can be divided into two components:

<b>Current chemical fertility of the soil</b>	<b>Long term chemical fertility</b>
<ul style="list-style-type: none"> <li>▪ A potential available reserve.</li> <li>▪ Active element fluxes in limited quantities derived from the soil, litter recycling, atmospheric inputs, transfers within the plant or even inputs by fertilisation in very parsimonious/poor systems. Soil properties capable of holding these elements (the state of exchange sites and active surfaces, i.e. permanent or variable charges).</li> </ul>	<ul style="list-style-type: none"> <li>▪ The capacity of the soil to maintain or even restore fertility in a given environmental or management context which reflects the environmental budgets.</li> <li>▪ This involves not only the flux of elements derived from the weathering of nutrient-bearing minerals when they are present, but also atmospheric inputs, whose exact role remains to be defined.</li> </ul>

The production potential defined above will be exploited as a result of constraints, which needs to be studied to understand the concept of chemical soil fertility correctly: limiting water contents (water table, dry seasons, excesses or deficits, etc.), real species requirements (as a function of their auto ecology, development speed and production) and their means of uptake (from retained water, deeper horizons, etc.) but also the colonisation of the soil which depends on physical constraints (compaction, hypoxia, waterlogging, etc.).

**Literature :**

Bonneau, M. (1995). Fertilisation des forêts dans les pays tempérés. Nancy, ENGREF, pp 367.

Ranger, J. and M. P. Turpault (1999). Input-output nutrient budgets as a diagnostic-tool for the sustainability of forest management. Forest Ecology and Management, 122: 7-16.

Salas Lopez, A. (2010). Conditioning factors in chemical fertility and nutrient cycles in nutrient-poor forest ecosystems under different climates. Internship report, Nancy, AgroParisTech-ENGREF: 72 p + annexes.

## Objectives and methods

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The candidate will be required to examine the present state of knowledge regarding the above mentioned propositions. The objective is to define reliable indicators which characterise the chemical fertility of the soils of the sites studied. These indicators (simple or compound, qualitative and/or quantitative) will make it possible to explore the existing links between the chemical fertility and element cycles. The candidate will use the numerous experimental sites participating in the study (*SOERE FORET* <http://www2.gip-ecofor.org/f-ore-t/> : Barbeau, Breuil, Fontblanche, Fougères, Hesse, Kondi in the Congo, Landes, Puechabon, Renecofor level III ; *Other Sites* : Aubure, Ardennes, Bonhomme, Gémaingoutte, Vauxrenard, Itatinga in Brazil).

To complete the project successfully, firstly a study and an analysis must be made to find out whether a multi-variate approach including the pedological factors and parameters can define chemical fertility, which is considered to be a potential to be exploited by plants. The combination of indicators generally considered to be process integrators which are sometimes taken into account in studies describing soil fertility (% base saturation, C/N ratio, pH, exchangeable, available and total elements, etc.) will be required to see whether these combinations are relevant to the definition of this potential fertility.

Then, the candidate will work on the possible expression of this potential relative to environmental limitations. To do this, additional factors which may influence the expression of the chemical fertility, will have to be analysed and integrated into the equation: water regimes and limitations, root prospection and access to nutrient reserves, and the real needs of different species. Some idea of temporal processes relative to each factor will also have to be integrated into the equation (wet or dry season, vegetative season, etc.).

At the end of this stage the « real » chemical fertility will have been defined, and the last stage will be to explore the relationship between chemical fertility and the input-output nutrient budgets. This will require the examination of the proportions of the different fluxes (weathering, restitution, mineralisation, internal transfers, and atmospheric inputs) to try to define categories of ecosystem function. The aim of this classification will be to demonstrate the differences in cycle function, with the preponderance of one component over another (the **BIO**geochemical versus the **bioGEO**chemical cycle), related to the real chemical fertility of the environment, as defined before.

Once this classification has been established, its reliability and general applicability will be tested within Renecofor network level III. This project is essential for our understanding of the function or dysfunction of forest ecosystems and will establish the conceptual bases for fully operational simulations in the future.

## Qualifications required

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- ❖ Academic qualification : PhD
- ❖ Experience required: the project essentially involves Biogeochemistry and Pedology, but a knowledge of Ecophysiology, Hydrology and many other subjects will be essential to carry out this study correctly and to understand the determining factors involved in the chemical fertility of soils. Statistical competence.
- ❖ Motivation and an ability to work in a team, both internally and with the different project participants.
- ❖ Ability to write and publish articles in French and English scientific journals.

## Additional information and application forms

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The contract is for 24 months (2012-2013). The gross monthly salary is 2650 €. The contract will be financed by the GIP-Ecofor and the FEDER.

A motivation letter and a CV should be sent by post and e-mail before **30th November, 2011**.

Send by e-mail to: [legout@nancy.inra.fr](mailto:legout@nancy.inra.fr), [ranger@nancy.inra.fr](mailto:ranger@nancy.inra.fr) and [st-andre@nancy.inra.fr](mailto:st-andre@nancy.inra.fr).

Send by post to: Ranger Jacques, Unité BEF, INRA, 54280 - Champenoux.