# 20-MONTH FIXED-TERM CONTRACT

## Modelling changes in biogeochemical cycling and the soil chemical fertility of forest ecosystems of the Renecofor network (ICP Forests Level II)

## Job description

### Context

Many forest ecosystems in metropolitan France are developed on acid and nutrient-poor soils. Elevated acidifying atmospheric deposition (S and N) during the second half of the XX$^{th}$ century considerably accelerated the acidification of soils and surface water causing in numerous cases the depletion of soil fertility and forest dieback. Since the 1980s, acidifying atmospheric deposition inputs have decreased (strong decrease of S inputs and to a lesser extent of N) but, in the same time, decreases in atmospheric inputs of nutrient cations (calcium, magnesium and potassium) have also been reported. It is thus important today to quantify the changes in soil chemical fertility in these forest ecosystems in response to this changing context and to determine the driving processes of these changes in order to ensure the sustainable management of forests.

### Objectives

The objective of this project is to analyze the processes and the different drivers of changes in soil chemical fertility of 9 forested sites in metropolitan France (see Methods section) in order to improve our understanding of their biogeochemical functioning. A very common approach for this is to calculate mass balances (difference between the input and output fluxes in a system) for the different nutrients to estimate the variations in plant-available pools in the soils. However, a previous study of these 9 selected sites revealed strong discrepancies between the input-output mass balances and the change in exchangeable cation pools measured between two soil sampling campaigns. To reach the objective of this research project will first require to identify the causes of these discrepancies. For this, the project will rely on a holistic approach by numerically modelling the biogeochemical cycling of the different nutrients and major elements (N, Ca, Mg, K, S, Al, Si, P, etc.) with the mechanistic biogeochemical model NutsFor developed by the BEF unit.

### Methods

RENECOFOR[1] is the French network of long-term monitoring of forest ecosystems and part of the Level II network of the European program ICP Forests. Its creation in 1992 by the French National Forestry Office (ONF) follows the commitment of the French Government to contribute to the international effort to monitor the impacts of atmospheric pollution on forests. The objective of this network is to detect changes in the functioning of forest ecosystems and understand the underlying reasons of these changes. It is composed of just over 100 permanent plots at which the different compartments of the forest are monitored: trees, soil, atmosphere, plant diversity, etc.

This project will mobilize the data from 8 level III plots of the RENECOFOR network (EPC08, EPC87, HET30, PS67A, SP38, SP57, CHS41, CPS77) and from the highly equipped experimental site of Breuil-Chenue[2]. These *in situ* plots are very well documented and environmental monitoring data has been collected over the past 20 to 25 years (atmospheric and soil solutions, litterfall, green leaf/needle chemistry, mineral soil and organic layer samples…). In addition to conventional approaches and tools, the biogeochemical model NutsFor[3] will be used in this project. This mechanistic model simulates the different main biogeochemical cycling processes in forest ecosystems (atmospheric deposition, organic matter decomposition, water and elemental transport in soils, surface exchange reactions

[1] http://www1.onf.fr/renecofor

[2] https://www.anaee-france.fr/service/experimentation-in-natura/foret/breuil/

[3] van der Heijden, G., S. Belyazid, E. Dambrine, J. Ranger and A. Legout (2017). "NutsFor a process-oriented model to simulate nutrient and isotope tracer cycling in forest ecosystems." Environmental Modelling & Software 95: 365-380.

between the liquid and solid phase of the soil, nutrient uptake by roots, mineral weathering, etc.) and enables to simulate the circulation of major nutrients and elements (N, S, P, Ca, Mg, K, Na, Cl, Al, etc.) between the different ecosystem compartments (atmosphere, mineral and organic phases of the soil, soil solution, aboveground biomass).

### Description of the different tasks

A recent study of the different selected sites estimated the different main biogeochemical fluxes: mineral weathering, atmospheric deposition, tree net uptake, leaching and litterfall.

(1) The first task is to re-analyze this dataset of biogeochemical fluxes and carry out new calculations and estimations when necessary. Observed temporal trends in the pools of exchangeable cations and the soil solution chemistry will be compared to the biogeochemical fluxes to assess the driving processes of these trends.

(2) The second task is to model the different nutrient pools and fluxes between the pools in these ecosystems. This modelling approach should enable to i) identify and test different hypotheses that may explain the discrepancies between mass balances and measured soil exchangeable pool changes (*e.g*. deep root uptake, contribution of coarse material (> 2mm) to mineral weathering, other pools of plant-available nutrients, etc.), ii) identify the fluxes and pools that are either poorly represented in the NutsFor model (and contribute to improving their representation in the model) and/or poorly understood or quantified by conventional soil fertility diagnostic methods (and propose different approaches to improve the quantification of these fluxes or pools) and finally iii) identify the different forest ecosystem biogeochemical functioning types as a function of the environmental parameters (climate, soil type, atmospheric deposition) to help forest management and policy to adapt silviculture and biomass harvest to the local context.

## Candidate profile

**Training:** PhD in soil sciences, biogeochemistry or geochemistry

**Skills and experience:** Biogeochemical cycles, soil science (experience in forest ecosystems is a plus), statistical analysis, report and scientific paper writing skills. This project aiming to use an existing computer model, skills and experience in the use and/or development of numerical models or computer programming is not necessary but may be considered a plus.

## Other information

**Contract:** 20-month long fixed-term contract, starting in September or October 2024. Funding: ONF (Convention de recherche ONF INRAE 2023-2026. Modélisation de l'évolution de l'équilibre biogéochimique des sols forestiers du réseau Renecofor).

**Gross Salary:** between 3135 and 3559€ per month, as imposed by the INRAE salary grid (dependent on past work experience).

**Laboratory:** UR 1138-Biogéochimie des Ecosystèmes Forestiers, INRAE Centre Grand-Est Nancy, 54280 Champenoux, France.

## Application

To apply for this position, send us before June 1st 2024 an application letter, your curriculum vitae, a list of your scientific publications and a copy of your diplomas to arnaud.legout@inrae.fr and gregory.van-der-heijden@inrae.fr

The supervising scientists for this position are:


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