# Biological nitrogen fixation (BNF) and nitrogen mineralization in forest soils under elevated $CO_2$

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## Context

**N cycle processes : key elements to predict soil C sequestration:**

- Tree has higher demand for available N under $eCO_2$
- Trees will allocate more organic C belowground to support microbes for mineralizing soil organic N and to fix atmospheric N where possible.
- Microbial metabolic N demands may increase like trees under $eCO_2$
- Progressive N limitation expected if no other N sources secured by trees [1]

- BNF is the main pathway for N increment in natural ecosystems
- N mineralization under elevated $CO_2$ is expected to increase as a result of microbial activity stimulation

**Scientific questions :**

- Will BNF and organic N mineralization compensate the higher demand for available nitrogen by trees under elevated $CO_2$?
- How will enhanced carbon allocation belowground by trees and subsequent microbial activity affect the emission of $N_2O$ and $N_2$ gases under $eCO_2$ ?

**Free living N fixers in forests: understudied organisms:**

- Where? In Soil, Leaf litter, mosses, lichens and (canopy leaves ?)

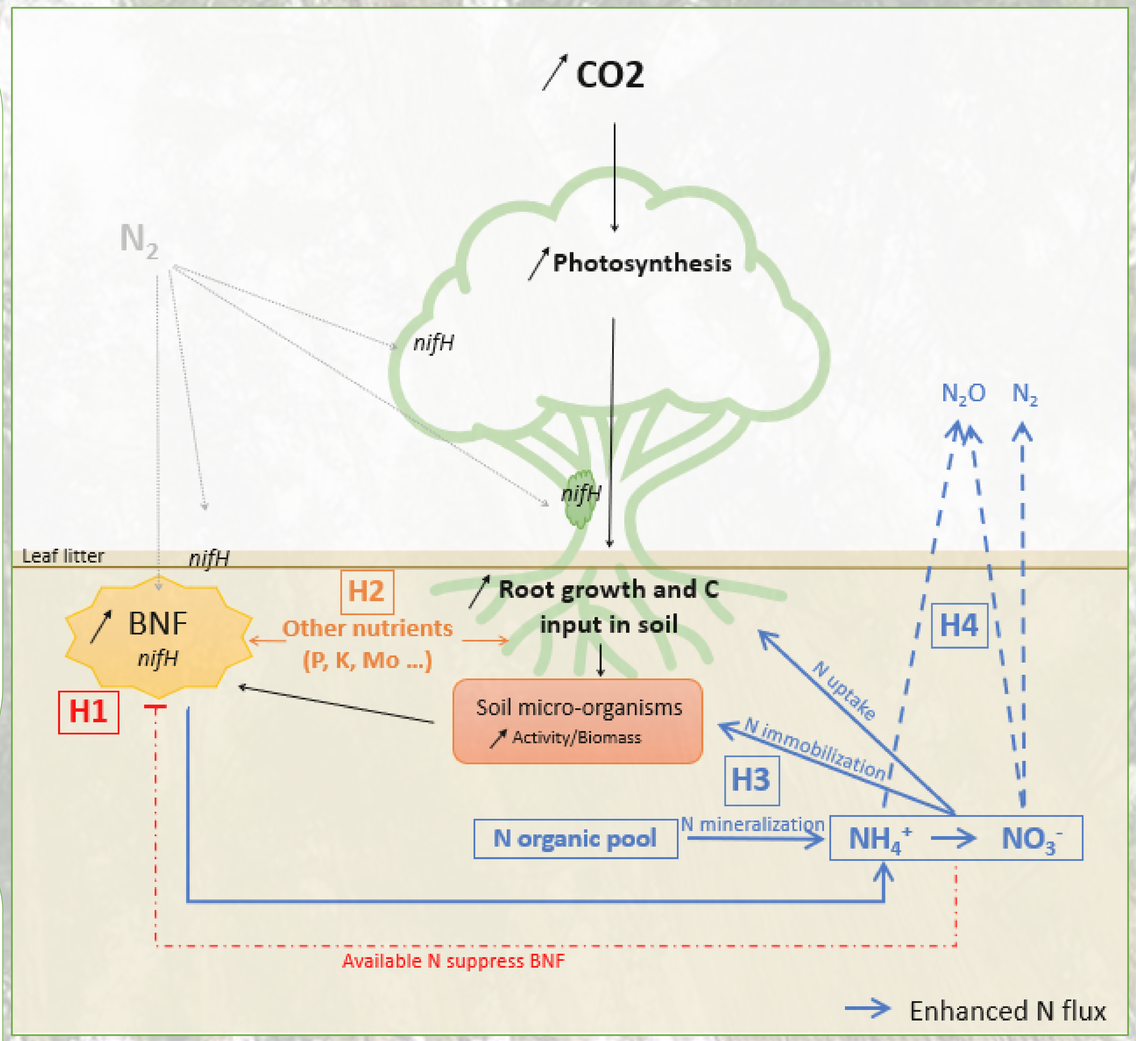
Regulation ?

- Downregulated by N availability
- Upregulated by P, K, Mo, Fe, V, Zn availability
- Upregulated by humidity, temperature and light [2]

**N mineralization (ammonification, nitrification & immobilization)**

- Mineralization will increase with immobilization (relative rates critical to predict N availability)
- Enhanced mineralization will increase $N_2O$ & $N_2$ emissions.

## Interactions and hypotheses




**Hypotheses :**

- **H1** N depletion and C input in soil enhance BNF under elevated $CO_2$
- **H2** BNF enhancement is downregulated by nutrient limitations (Mo, P, Fe, etc.)
- **H3** Elevated $CO_2$ upregulate mineralization
- **H4** Elevated $CO_2$ upregulate $N_2O$ and $N_2$ emission

## Material & Methods

**Experiments :**

- BNF activity under elevated $CO_2$ at BIFOR FACE in UK and EucFACE in Australia
- BNF activity under N&P fertilization (QUINTUS plots)
- N mineralization and N emission under elevated $CO_2$ (BIFOR FACE)

**Methods: $^{15}N$ isotopic assimilation and pool dilution**

- $^{15}N$ assimilation method : determine the amount of N fixed
- $^{15}N$ pool dilution method : determine N cycle rate processes (mineralization, immobilization, nitrification and N emission)

**Metagenomic method for BNF :**

Analysis of nifH gene expression

## Expected outcomes

- Better understanding of BNF (rate, control and localization)
- Understand direct and indirect effects of $CO_2$ on BNF and on N mineralization
- Better prediction of tree growth and C sequestration under climate change

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[1] Van Groenigen, K.-J., de Graaff, M.-A., Six, J., Harris, D., Kuikman, P., van Kessel, C., 2006. The Impact of Elevated Atmospheric [CO2] on Soil C and N Dynamics: A Meta-Analysis.
[2] Reed, S.C., Cleveland, C.C., Townsend, A.R., 2011. Functional Ecology of Free-Living Nitrogen Fixation: A Contemporary Perspective

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