

Introduction

Conversion of coniferous to broadleaved forests is generally assumed to improve soil quality (pH and nutrient status), to modify soil physico-chemical characteristics, nutrient cycling, microbial biomass and/or activity. However, impacts of forest conversion on soil are not 'universal': they depend on site characteristics and on ecological or eco-physiological characteristics of tree species.

Our measurements were performed at a site converted to a mixed stand after 2 spruce generations. We assessed, 12 years after plantation, the effects of spruce (no conversion scenario) and broadleaved species (conversion scenario) on pH, microbial biomass, basal respiration and potential nitrification in the organic soil layers. Broadleaved species contrasted in terms of ecological characteristics (pioneer species versus main tree species) and physiological characteristics (N_2 fixing tree species (alder) versus no N_2 fixing species). All these species were growing on the same site, sharing identical initial soil conditions and history: potential effects can thus be imputed to tree species only.

We hypothesised that:

- broadleaves can improve soil quality and modify some soil microbial activities as compared to spruce;
- differences between broadleaves are contrasted:
 - below secondary broadleaved species (pioneer species) as compared to main tree species
 - below species with a particular eco-physiological (N_2 fixing species) trait

Site characteristics and history

After 2 spruce generations, the catchment 'Robinette' (east Belgium, 50°33'N, 6°04'E), was partially clear-cut in 1996. Since 1998, this catchment is experiencing an 'extensive' afforestation with a mixture of main and secondary tree species, adapted to specific site conditions. Broadleaved species were planted in four 2-ha fenced plots (species planted in rows spaced by 2.5 m).

Pluviosity: 1300mm/an

Mean annual temperature: 7°C

Soil: acid brown soil with moder to dysmoder humus type



Fig. 1. Fenced plot with broadleaved species (La Robinette)

Methods

Studied species: alder (*Alnus glutinosa*), birch (*Betula pendula*), oak (*Quercus robur*), beech (*Fagus sylvatica*), willow (*Salix caprea*), rowan (*Sorbus aucuparia*), spruce (*Picea abies*).

Sampling design:

- sampling in October 2009,
- 1 composite sample from 5 soil cores (83mm Ø; Of+Oh) taken around each selected tree (broadleaves) or in each subplot (spruce)

→ **broadleaves:** 6 trees /species from a 2-ha fenced plot (Fig. 1)

→ **spruce:** 6 subplots of young spruce across the catchment (same age as broadleaves)

Laboratory analyses: measured on sieved (4 mm) soil: pH (H_2O and KCl), water and organic matter content (weight loss at 105 and 450°C), microbial C and N (C_{mic} and N_{mic} : $CHCl_3$ fumigation/ K_2SO_4 extraction), basal respiration (CO_2 emission during a 180' incubation), net nitrogen mineralisation (net NO_3^- and NH_4^+ production during 28d incubation), potential nitrification (shaken soil slurry)

Statistics: one-way Anova (SAS)

Results

Soil acidity

	pH H_2O	pH KCl
beech	3.5 a	3.0 ab
spruce	3.5 ab	2.9 a
oak	3.6 abc	2.9 a
alder	3.6 abc	3.1 bc
willow	3.8 bc	3.2 c
rowan	3.9 c	3.1 bc
birch	3.9 c	3.1 bc

• pH H_2O : higher pH below birch, rowan, willow than below spruce and beech

• pH KCl: higher value below secondary species than below spruce and oak

Table 1. Mean (n=6) pH measured in H_2O and KCl of organic layer below different tree species. Means with different letters indicate significant differences ($p < 0.05$).

Microbial biomass (C_{mic}) and microbial quotient (Q_{mic})

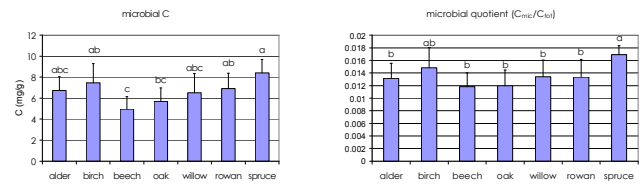


Fig. 2. Microbial C (mg C/g) and microbial quotient (mg C_{mic} /g C_{tot}) below different tree species. Mean + 1 standard error, n=6. Means with different letters indicate significant differences ($p < 0.05$).

Higher C_{mic} under birch could be due to the better quality of the litter and/or to the better growth development of this secondary species (data not shown)
Higher Q_{mic} below spruce indicates a better adequacy of microorganisms to substrate without conversion

Basal respiration and metabolic quotient (qCO_2)

The metabolic quotient ($qCO_2 = \text{basal respiration}/C_{mic}$) is inversely related to substrate use efficiency

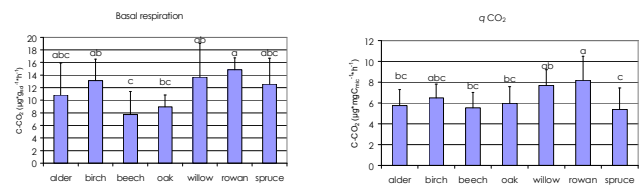


Fig. 3. Basal respiration ($\mu\text{g C-CO}_2 \text{ g}_{soil}^{-1} \text{ h}^{-1}$) and microbial quotient (qCO_2) ($\mu\text{g C-CO}_2 \text{ mg C}_{mic}^{-1} \text{ h}^{-1}$) below different tree species. Mean + 1 standard error, n=6. Means with different letters indicate significant differences ($p < 0.05$).

Higher basal respiration below willow, rowan, birch versus beech, oak could be due to the better litter quality of secondary species

Higher metabolic quotient (qCO_2) below rowan and willow and lower qCO_2 below spruce (no 'conversion') are consistent with:

- higher substrate use efficiency without conversion
- younger microbial communities, higher turnover rate and/or higher carbon availability under rowan and willow

Microbial C/N

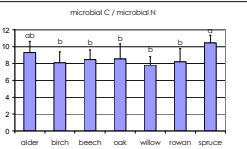


Fig. 4. Ratio between microbial C and microbial N below different tree species. Mean + 1 standard error, n=6. Means with different letters indicate significant differences ($p < 0.05$).

Lower C_{mic}/N_{mic} below broadleaves versus spruce points to a modification of the microbial community structure towards a lower fungal biomass below broadleaves

Potential nitrification

The potential nitrification is related to the population size of nitrifying bacteria at the time of sampling

Higher nitrification below alder could be due to ammonia enrichment in soil through symbiotic N_2 fixation

Lower nitrification below spruce might be related to the higher stand density or specific inhibition below spruce

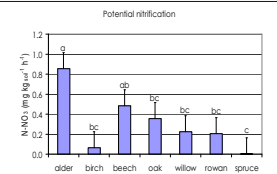


Fig. 5. Potential nitrification ($\text{mg N-NO}_3 \text{ kg}_{soil}^{-1} \text{ h}^{-1}$) below different tree species. Mean + 1 standard error, n=6. Means with different letters indicate significant differences ($p < 0.05$).

Conclusions

12 years after conversion, tree species had a significant impact on soil pH and on microbial activities in the organic layer :

- ✓ **broadleaves (conversion) versus spruce (no conversion scenario) :** broadleaves induced higher soil pH, lower metabolic quotient and a lower C_{mic}/N_{mic} ratio, indicating changes in soil quality, substrate use efficiency and microbial community structure (a possible shift towards a lower fungal biomass below broadleaves)
- ✓ **secondary broadleaved versus main tree species:** secondary broadleaves (birch, willow, rowan) increased soil pH and basal respiration, probably related to the better litter quality and/or growth development of these pioneer species
- ✓ **ecophysiological traits (N_2 fixation)** can change microbial activities in the soil, as illustrated by the higher potential nitrification under alder

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