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Key words: forested soils, fertility, experimental leaching, Sr isotopes, numerical modelling

Highlights:

- Exchangeable Ca might be only partly available for tree nutrition
- Low Ca release might be due to strong bindings with clay and organic matter
- Sr isotopic composition of leaching solutions helps understanding the Ca reactivity
- Atmospheric deposition and efficient biological cycling sustain tree nutrition

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Abstract

The global demand for wood is growing and the sustainability of forests has become an increasingly important issue. The first metre of soil represents the reserve of nutrients cations (K, Ca, Mg) for trees. The depletion of these elements in the soil gradually leads to a decrease in soil fertility, which can have a strong impact on the development and health of forests.

The aim of this study was to better understand the source and dynamics of nutrients in forested soils from a base poor environment by combining mineralogic, chemical, isotopic and numerical tools through an experimental approach. We designed batch experiments to follow the leaching of soils from two experimental plots (under spruce and under beech from the Strengbach catchment, Vosges Mountain, NE France). The studied elements show highly contrasting behaviours. Mg release results from a mixing between cationic exchange, mineral dissolution (mainly smectite) and organic matter mineralization. The dynamics of K are underestimated by modelling, which may be attributed either to an unknown source of K or to an overestimation of the secondary phase precipitation. The Sr isotopic approach, used as a proxy to identify the sources of Ca, shows that the exchangeable complex supplies nutrients first and rapidly to the solution, followed by the clay compartment and at the very end, the bulk soils. Na is mainly controlled by albite dissolution.

The release of Ca is significantly lower than that of other cations as Mg or K. Our results suggest that the exchangeable Ca, estimated through classical extractions, is only partly available for plants, due to strong chemical binding with organic matter and/or the occurrence of Ca-chemical bridges between clay and organic matter. Sustainable management should thus consider that exchangeable Ca, conventionally determined, does not necessarily provide an accurate picture of the real availability of Ca and therefore of the fertility of soils, with a risk of overestimation of nutrient reservoir for trees. Calcium tree nutrition at these sites has to rely on the long term on atmospheric deposition and an efficient recycling through biological cycling. This is also true for the other nutrient cations, but to a lesser extent since soil intrinsic fluxes (i.e., weathering, mineralisation of OM...) are not null and may thus supply the exchangeable pools and participate substantially to tree nutrition. Harvesting and biomass exportation could rapidly impact the biological cycle and threaten the sustainability of these ecosystems, similar to changing tree species that may influence the nature of the litter, its turnover and the input of nutrients to the soil.

Key words: forested soils, fertility, experimental leaching, Sr isotopes, numerical modelling

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1. Introduction

Increased human activities (both industrial and transport) has led to the emission of atmospheric pollutants such as SO_2 and NO_x, which were maximal in Europe during the 1970s (Klimont et al., 2013). The transformation of these contaminants in the atmosphere generated atmospheric acid deposits that are able to modify and impact, sometimes strongly, natural ecosystems, through soil and stream water acidification (Probst et al., 1999; Lucas et al., 2011; Tian and Niu, 2015), reduction of stream (Guerold et al., 2000) or soil (Wei et al., 2017) biodiversity, and damage to vegetation (Cape, 1993) such as forest decline (Reichle, 1981; Paces, 1985; Schulze, 1989; Probst, Fritz, and Stille, 1992; Dambrine et al., 2000; Poszwa et al., 2000; Thimonier, Dupouey, and Le Tacon, 2000; van der Heijden et al., 2011; Cohen et al., 2016; Legout et al., 2020).

Although soil acidification is a natural process that plays a key role in pedogenesis and the supply of nutrients for plants, an excessive input of protons can significantly modify the soil equilibrium between microorganisms, weathering, and exchangeable phases, and therefore impact vegetation in forest ecosystems (Rodhe et al., 1995; Calace et al., 2001; Bolan, Adriano, and Curtin, 2003; Qiu et al., 2015). Proton input may be balanced by cationic exchange and/or weathering of soil minerals (Ulrich, 1986; Li et al., 2018), but strong soil acidification can result in the loss of nutrient cations and soil desaturation with the dominance of H^+ and Al^{3+} on the cationic exchangeable capacity (CEC), making nutrient cations less available for plants. The decrease of the bioavailability of these essential cations may result in plant chlorosis, leaf and needle yellowing and/or loss (Mehne-Jakobs, 1995; DeHayes et al., 1999; Siefermann-Harms et al., 2004), and may ultimately lead to forest decline (Durka et al., 1994; Likens, Driscoll and Buso, 1996; De Vries et al., 2014).

The global emission of acid rain precursors, especially SO_2, has declined since the 1980s, resulting in a decrease in the acidity of atmospheric deposits recorded in many places around

the world (Smith, Pitchera, and Wigley, 2001; Khokhar et al., 2005; Kopáček and Veselý, 2005; Lu et al., 2010; Klimont, Smith, and Cofala, 2013; Sudalma, Purwanto, and Santoso, 2015; Pierret et al., 2018; 2019). Despite this decline, numerous forest ecosystems show very little sign of recovery (Stoddard et al., 1999; Sverdrup et al., 2006; Jonard et al., 2012), especially in the Vosges Mountain (northeast France) mainly due to base poor bedrock and chemically poor soils (Landmann, 1995; van der Heijden et al., 2011; Legout et al., 2020). Acidification may also be reinforced by other pressures such as forest management, especially through the choice of tree species and the exportation of biomass (Augusto, Bonnaud, and Ranger, 1998; Augusto et al., 2002; Berger, Köllensperger, and Wimmer, 2004; Legout et al., 2016), which may jeopardize the recovery of these forest ecosystems.

In soil, Ca, Mg, and K are present in different forms with different levels of bioavailability: entrapped within organic matter (available through mineralization), within primary and secondary minerals (available through weathering) or adsorbed on the cationic exchangeable capacity (available by ionic exchange). The true bioavailability of Mg and Ca for plants is difficult to define, measure and accurately assess and is still not clearly understood (Jandl, Alewell, and Prietzel, 2004; Jonard et al., 2009; van der Heijden et al., 2011; Hansson et al., 2020). Usually, the chemical fertility of forested soil is investigated from the determination of the global CEC and its composition in Mg, Ca, K and Na. However, atmospheric deposits and weathering of soil minerals have to be considered because they are the main sources of nutrient cations in forest ecosystems, and the recycling by plants also plays an important role in maintaining and optimizing these nutrients in the soil-plant system (Cole, 1986; van der Heijden et al., 2013; Dessert et al., 2020; Turpault, Calvaruso, and Dincher, 2019). However, in chemically poor soils widely affected by strong past acidification, we may question the remaining capacity of soils to supply nutrient cations for plant growth, especially through the weathering of soil minerals. Numerous environmental and societal issues including

development of sustainable forestry, the use of wood as a renewable energy or as a way to store CO_2 depend on forest healthiness, practices and management (Chum and Overend, 2001; Viana et al., 2010; Ellabban, Abu-Rub, and Blaabjerg, 2014; Pang et al., 2019). Currently, we need to provide a better characterization of the actual availability of nutrient cations in soils, their origins and their dynamics to provide forest managers and policy makers with the most accurate picture of the potential of forest ecosystems and associated threats.

The main objectives of this study were to evaluate the potential contribution of this chemically poor soil to tree nutrition through the supply of nutrient cations in the mid- to long-term. For this purpose, Here, we developed a new approach based on laboratory experiments to study the interactions between water and natural acidic soils from a well-monitored field site characterized by low pools of nutrient cations (Strengbach catchment, Vosges Mountains, France). We designed batch experiments with soil samples from two plots characterized by different soil and vegetation types.

2. Site descriptions

To better understand the relationship between forest decline and acid rain, several investigations have been conducted since the 1980s in the Strengbach catchment (Dambrine, Le Goaster, and Ranger, 1991; Probst, Fritz, and Stille, 1992; Probst et al., 1992; 1999; Pierret et al., 2018).

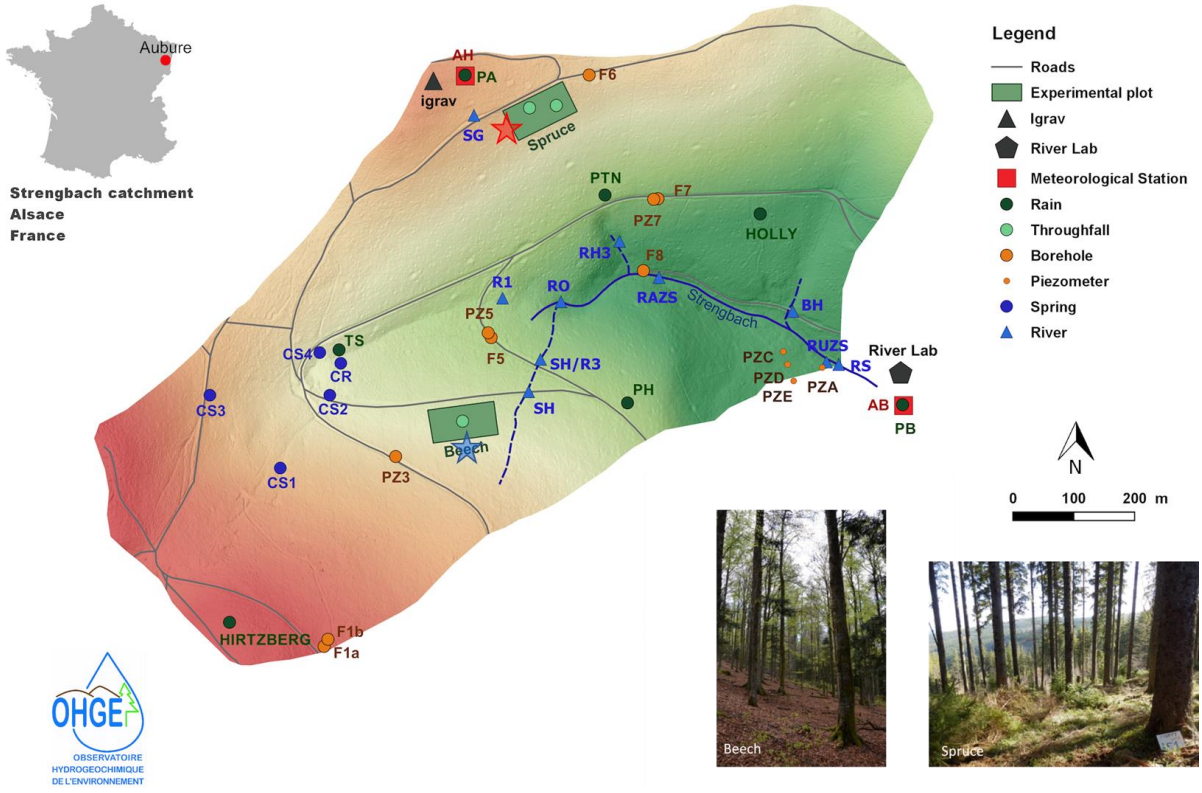


Fig. 1: Strengbach catchment map with different equipment and monitoring stations (see legend). The red star corresponds to the soil pit at the SP site (SP: Spruce plot), and the blue star corresponds to the soil pit at the BP site (BP: beech plot).

Located in the Vosges Mountains (Northeast of France), the Strengbach catchment covers an area of 80 ha with altitudes ranging from 883 to 1146 m. Since 1986, the catchment has been highly equipped allowing a continuous monitoring of meteorological, geochemical and hydrological data.

Today, the Strengbach catchment is monitored by OHGE (Observatoire hydrogéochimique de l'environnement, http://ohge.unistra.fr) and is involved in the French critical zone observatories network OZCAR (http://www.ozcar-ri.org) (Gaillardet et al., 2018).

Approximately 90% of the catchment is covered by commercially managed forest, principally dominated by conifers (80%, *Piceas Abies L.*) and beeches (20%, *Fagus Sylvatica*). Plantations

are between 70 and 175 years old (Pierret et al., 2018). The stands are managed by the National Forestry Office and are exploited for the municipality of Aubure. Wood represents a significant economic resource for the municipality and the health of the forests is therefore a major issue in mountain areas. The climate type is oceanic mountainous. The annual temperature is 6 °C and the mean annual precipitation and discharge are 1370 mm and 760 mm respectively for the period 1986-2015 (Pierret et al., 2018). Due to a north exposition, the southeast side is colder, more humid and rainier than the south-exposed northwest side (Pierret et al., 2018).

The main bedrock of the catchment is a Hercynian base-poor granite (cordieritic granite) with low Ca and Mg contents (Bonhomme, 1967). The granite on the northern slope is more hydrothermally altered than that on the southern slope (El Gh'Mari, 1995). Hydrothermal events caused the alteration and transformation of albite, K-feldspar and muscovite into fine-grained illite and quartz; biotite and albite disappeared to a large extent (Pierret et al., 2014). The soils range from ochreous podzolic to brown acidic soils and are approximately 1 metre thick (Lefèvre, 1988). The brown acidic soils are mainly located in the northern part of the catchment whereas the podzolic soils are mainly in the southern part. The soils of the Strengbach catchment are acidic, with pH ranging from 3.4 at the top of the profiles to 4.9 at 1-metre depth. The humus is generally moder or mor.

Two experimental forested plots were deeply monitored to investigate the atmosphere/soil/plant interactions by regular monitoring and sampling of throughfalls, soil solutions, soils, litters or plants (Pierret et al. 2019). Each parcel is representative of the two main ecosystems: one under spruce on brown acidic soil and on the northern slope (SP site), and the second one under beech on ochreous soils and on the southern slope (BP site; cf. Fig. 1). The soils sampled and studied in the present work came from these two plots.

The long-term monitoring of the Strengbach catchment showed the following trends:

- There was a significant decrease in the concentrations of H^+, SO_4^{2-}, Cl^-, and Ca^{2+} in precipitation and throughfalls. These decreases are linked to the decrease in anthropic SO_2 emissions, and of particles from industrial processes (Pierret et al. 2019).
- A continuous decrease in Ca and Mg in soil solution since 1986 under spruces and beeches is probably due to modification of cation exchange processes (Prunier et al., 2015; Schmitt et al., 2017; Dambrine et al., 1998; Beaulieu et al., 2020)
- Ca and Mg deficiencies in the needles of spruce are attributed to the low contents in the soils, with a 30% needle loss and needle yellowing (Dambrine et al., 1991; Landmann, 1995).

3. Methods and analytical procedures

3.1. Sample collection

Two soil profiles were collected in April 2017: one at the SP site (under spruce), and one at the BP site (under beech; Fig. 1). In the field, we dug pits with a surface of about 1 x 2 m with a mechanical shovel. For each horizon we evaluated the proportions of coarse elements and roots. The profiles were divided into the following horizons: 00-05 cm; 05-10 cm; 10-20 cm; 20-40 cm; 40-60 cm and 60-80 cm. The surface differentiation (0-20 cm) is finer because of the higher contents of organic matter and clays which are important and dynamic reservoirs of nutrients. Under 20 cm depth, we studied layers of 20 cm thickness. The soil samples were sequentially sieved (4 cm and 4 mm) in the field. For each soil layer, approximately 1 kg of the fraction between 4 mm and 4 cm was collected and 2 kg for the fraction lower than 4 mm from a big box that has been carefully homogenized. For each horizon, the roots were also separated and

178 weighed. We work with the fine soil i.e. the fraction < 2mm, as it is classically the case in
179 pedology.
180
181 ### 3.2. Litter analyses
182 Two different levels of humus were collected:
183 - OL, anything that falls to the ground and is still almost intact
184 - OH-OF, characterized by an absence of any recognizable plant structure.

185 The litter was then several times washed and rinsed with ultrapure water to remove impurities
186 and small rock fragments (the heavier soil particles settle to the bottom and can be separated
187 from the litter). The chemical concentrations in litter were determined by alkaline fusion with
188 LiB_2O_4. The solution obtained was analysed by ICP-OES (ICP-OES 6500 radial ThermoFisher)
189 for major elements with an accuracy of ± 2% and by ICP-MS (X7 ThermoFisher) for trace
190 elements with an uncertainty of 10 %. The accuracy was controlled using a spinach Standard
191 Reference Material® 1570a (Carignan et al., 2001).

192 ### 3.3. Soil analyses
193 Each soil sample was dried at 50°C and all the analyses were performed with the fine soil
194 fraction (<2 mm). In the laboratory we carefully homogenized this initial fraction, then we
195 carefully divided it into sub-samples with a sample splitter until we obtained the mass necessary
196 for our experiments. We thus obtained several aliquots of the same initial homogeneous soil
197 that we used for the different analyses and for the 3 experiments.
198 This methodology allows us to work in a repeatable way. The pH_{water} was determined according
199 to the standard NF ISO 10390. The composition of the exchangeable phase (Al, Fe, Na, Mg,
200 Ca, K and H) and the CEC were determined following cobaltihexamine extraction, with an
201 uncertainty of 10%, according to the standard NF X 31-130 and described by Ciesielski et al.
202 (1997a; 1997b).

Clay (grain size < 2µm), fine silt (2 – 20 µm), coarse silt (20-50 µm), fine sand (50-200 µm) and coarse sand (200-2000 µm) size fractions were determined according to the standard NF X 31-107. All these analyses were performed at INRA LAS (Arras, France).

The mineralogical composition of the soil samples was determined by X-ray diffraction (XRD) using a Bruker AXS D5000 X-ray diffractometer at LHYGES (Strasbourg, France). The clay fraction was extracted by sedimentation, using the Stokes law, according to Robert and Tessier (1974). To remove organic matter, a pretreatment with hydrogen peroxide was realized for the soil sample with high OM contents (all samples above 20 cm depth). Four different treatments allow the identification of the different clay minerals: air drying without treatment; drying at 490°C for 4 hours; 24 h under an ethylene glycol saturated atmosphere; and 24 h under a hydrazine monohydrate saturated atmosphere (Larque and Weber, 1978; Thiry et al., 2013).

The chemical composition of bulk soils and clay fractions were determined by alkaline fusion with LiB_2O_4 following the protocol described in Carignan et al. (2001). The major and trace elements were analysed at the CRPG, Nancy, France, using the same methods as described in the previous section for litter. The uncertainties are 2% for major elements and 10% for Sr concentrations.

3.4. Leaching experimental set up

To avoid contamination by materials, all the laboratory equipment used was washed beforehand with the following protocol: 24 h 10%-HCl bath, double rinsing, two sequential 24 h water baths and double rinsing. Ultrapure water (resistivity < 18 MΩ · cm) was used for this purpose. Discontinuous batch experiments between soils and acidic solutions were conducted. For each experiment, after a homogeneous splitting, 5 g of soil from the 6 horizons of the two soil profiles (SP and BP) was put into a 50 mL conical centrifuge tube (Falcon™) with 40 mL of ultrapure hydrochloric acid at pH 3.5. The pH of the solution was chosen to mimic the pH of the superficial soil solution (Pierret et al. 2019). After a variable time of experimentation ΔT during

which the reactors were continuously stirred, each tube was centrifuged at 4700 rpm for 40 min, allowing the soil to flocculate at the bottom of the cone. Then, the supernatant was recovered for chemical and isotopic analyses. The reactors were then refilled with 40 mL of fresh solution, thus the soils are resuspended in the solution, for an additional step of solution-soil interactions. Eleven successive steps were conducted over 150 days in total, according to an increasing period of reaction (Table 1). At the final step of the experiments, the soils were dried and fully characterized for comparison with the initial soils. Each experiment was run in triplicate, representing 36 tubes at each time step.

Number of step	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**
Name of the step (Nb of days)	**$D_{0.6}$**	**D_1**	**D_3**	**D_5**	**D_8**	**D_{12}**	**D_{18}**	**D_{28}**	**D_{48}**	**D_{96}**	**D_{152}**
Δt	14 h	10 h	2 d	2d	3 d	4 d	6 d	10 d	20 d	48 d	56 d
Duration	14 h	1 d	3 d	5 d	8 d	12 d	18 d	28 d	48 d	96 d	152 d

Table 1: Time between each step (between T_i and T_{i-1}) and total duration (D_d; d corresponding to the number of days) for each iteration of the batch experiments. In the figure the times will be represented with in index the total number of days of corresponding experiment.

3.5. Solution analyses

The pH of the solution was measured using a pHM210 meterLab pH-meter (Radiometer Analytical) fitted with a Mettler HA406-DXKS8 electrod. The precision of the pH-meter was ± 0.02. The conductivity of the solution was measured using a CDM210 MeterLab (analytical radiometer) with a CDC 745-9 conductivity cell with a precision of 0.1 µS/cm.

The concentration of major elements was determined by ICP-AES (Thermo Scientific iCAP 6000 SERIES – Thermo Fisher Scientific©) with an uncertainty of ±2%. Trace elements were

analysed using ICP-MS (Thermo Fisher X Serie II – Thermo Fisher Scientific©) with indium as an internal standard and with ± 10% uncertainties.

3.6. Sr isotopes

Sr does not play a major role in plant nutrition, unlike Ca (Capo, Stewart, and Cahdwick, 1998). However, Sr is often considered as a calcium analogue because of its similar chemical structure (similar ionic charge, radius, electron configuration, etc...). Thus, the combination of $^{87}Sr/^{86}Sr$ and Ca/Sr ratios can be used to characterize the different Ca pools in ecosystems as atmospheric deposits, soil solutions, litter, soil minerals, exchangeable fractions (Miller, Blum, and Friedland, 1993; Bailey et al., 1996; Blum et al., 2002; Kennedy, Hedin, and Derry, 2002; Bullen and Bailey, 2005; Pett-Ridge, Derry, and Barrows, 2009; Meek et al., 2016), and then to discuss the signature of experimental solutions.

Solid samples (bulk soil and clays) were digested using a mix of HCl, HNO_3 and HF. Litter samples were digested by microwaves with HNO_3/H_2O_2.

The experimental solutions and the exchangeable fractions were first evaporated and then dissolved in two steps, with a mix of HCl/HNO_3 and then with HF.

The purification of Sr was performed with 0.05 N HNO_3 on an Eichrom Sr spec resin, 50-10 mesh using the protocol established by Horwitz, Dietz, and Fisher (1991) and Philip, Chiarizia, and Dietz (1992). The yield of this purification step was between 88 and 92%. Isotopic ratios were determined by MC-ICP-MS (Thermo Finnigan Neptune) at LHyGeS, France (Pierret et al., 2014; Prunier et al., 2015; Brazier, 2018). The repeatability of the Sr isotopic analyses was tested by regular measurements of standard NBS 987 (prepared following the methods used for the samples). The resulting mean value of NBS 987 $^{87}Sr/^{86}Sr$ was 0.710256 ± 0.00003 (n = 62).

3.7. Numerical modeling of the reactivity of soil samples

- Description:

The WITCH code is a geochemical box model that can be used to calculate the evolution of the soil solution composition as a function of time in a given soil profile (Goddéris et al., 2006, 2010; Beaulieu et al., 2012). Here, the code was used as a tool to single out the sources of the release of several key elements over the course of the experiments. The code accounts for dissolution/precipitation processes and the exchange fluxes with the exchange complex surface. The mass balance is solved in each box at each time step and for each chemical species as follows:

$$\frac{d(z.\theta.C_i)}{dt} = F_{in} + F_{out} + \sum_{j=1}^{n_m} F_{diss,i}^{j} - \sum_{j=1}^{n_m} F_{prec,i}^{j} \pm F_{exch} \quad (1)$$

where C, z and θ are the concentration of chemical species *i*, the thickness and the water content in the considered soil box, respectively. The F_{in} and F_{out} parameters represent the input and output fluxes of chemical species estimated from vertical drainage. F_{diss} and F_{prec} are the fluxes resulting from dissolution and precipitation processes of minerals *j* in the considered box, calculated using kinetic rate laws derived from laboratory experiments, and based on the transition state theory. The cation flux exchange (F_{exch}) between the soil solution and the clay-humic complex is calculated according to the Fick's second law of diffusion (Sverdrup et al., 1995) and could be either negative or positive. The values of selectivity coefficients associated with the reactions of cation adsorption have been previously calibrated on the measured soil solutions of the Strengbach catchment and fixed at $10^{-2.7}$ for Ca^{2+} and 10^{-3} for Mg^{2+}, K^{+}, and Al^{3+} (Beaulieu et al., 2020). These values are of the same magnitude as the values estimated in other studies (Ludwig et al., 1999; Cosby et al., 2001; Zetterberg et al., 2014). The selectivity coefficient is described as:

$$k_{H/BC} = \frac{H_{surf} \cdot E_{BC}}{BC_{surf}^{1/n} \cdot E_H} \quad (2)$$

where E_{BC} and E_H are the fractions of sites on the exchange complex occupied by a given cation BC (Ca^{2+}, Mg^{2+}, Al^{3+}, or K^{+}) and by H^{+} respectively, BC_{surf} is the concentration of BC at the

exchange surface (with *n* the cation charge), and H_{surf} is the concentration of H^+ at the exchange surface.

Two simulations were performed with soil samples from each site (HP and VP) with the WITCH code in order to simulate the evolution of the soil solution in two soil layers: 0-5 cm depth and 40-60 cm depth. The results of these simulations were then compared with the results obtained from batch experiments for the same depths.

- Model inputs and outputs:

The parameters required for the simulations were chosen to be as close as possible to the mineralogical, physical and chemical features of the reacted powders and the experimental set-up. We used the mineralogical composition of the two soil layers (0-5 cm and 40-60 cm depths) estimated from XRD (see #3.3). The measurements of exchangeable cation contents (see #3.3) were used to set the initial fraction of the CEC sites occupied by each cation for each soil layer. The initial water content of each soil layer was set at its maximum (θ_{sat}), corresponding to solids fully immersed in aqueous solution. Last, the specific surface area of minerals was fixed to 10 m^2/g for secondary phases and to 0.1 m^2/g for the primary phases (Hayes et al., 2020).

At the end of the simulation, the WITCH code allows to estimate the evolution of the concentration of each cation in the solution of the considered box, the fluxes resulting from the exchange between the solution and the clay-humic complex, the solution saturation index with respect to each mineral and the fluxes resulting from mineral dissolution/precipitation.

4. Results

4.1. Soil analyses

4.1.1. Litters

For the two sites, the chemical concentrations were higher in the OF-OH layers than in the OL layer, except for Ca (Table 2). The litters of the beech plot BP were enriched in Si, Al, Na and K as opposed to Ca compared to the spruce plot SP (Table 2).

	Si	Al	Mg	Ca	Na	K	Sr	$^{87}Sr/^{86}Sr$	err (2σ)
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g		
BP OL	12200	1231	549	3945	356	2515	11	0.753399	0.000003
BP OF-OH	55672	8402	772	2409	2411	7164	19	0.729347	0.000004
SP OL	11312	773	549	5618	<d.l.	1212	11	0.730029	0.000003
SP OF-OH	15800	2006	537	3473	215	2133	12	0.724282	0.000003

Table 2: Composition of the two litter layers for spruce (SP) and beech (BP) plots in µg/g. OL corresponds to the horizon of recognizable remains, and OF-OH contains degraded materials and humic components.

4.1.2. Characteristics of the soils and exchangeable phase

The soils are mainly sandy, with an average of 65% for the sandy fraction, except for the 00-05 cm horizon, which had lower values (45% on average) at both sites. Clay proportions decreased with depth from 30% to 9% under BP, and from 30% to 16% under SP. The soils under spruces had higher clay contents than those under beeches, especially below 20 cm depth (Table 3). For both sites, the pH_{H20} increases with depth, from 3.52 (respectively, 3.85) at the surface to 4.59 (respectively, 4.33) for the deepest horizon on BP (respectively, SP). SP soils are more acidic than BP soils below 5 cm depth (Table 3).

The surface horizon is significantly more concentrated in organic matter due to the decomposition of litter with almost 23% of C at 00-05 cm. C decreases with depth and reaches 1.6% and 0.6% in BP and SP deepest horizons, respectively. Below 10 cm depth, the BP soils have higher OM contents than those of the SP site (Table 3).

	Depth	C	pH_{H2O}	Clay	Silt	Sand	CEC	Ca_{exch}	Mg_{exch}	K_{exch}	Na_{exch}	Al_{exch}	H_{exch}	CEC	Ca_{exch}	Mg_{exch}	K_{exch}	Na_{exch}	Al_{exch}	H_{exch}
	cm	%		%	%	%	cmol/kg							cmol/kg						
	Initial values													After experimentation						
Beech Plot	0-5	22.9	3.52	29.9	25.1	45	16.1	3.09	0.86	0.73	0.07	5.62	5.87	14.00	2.22	0.51	0.25	0.05	5,00	4.3
(BP)	5-10	4.2	3.56	16.8	22.7	60.5	8.49	0.31	0.16	0.19	0.03	6.21	2.24	7.15	0.18	0.09	0.34	0.1	5.04	0.96
	10-20	4.4	3.69	15	19.7	65.3	7.64	0.1	0.08	0.12	0.02	7.04	1.1	6.93	0.08	0.07	0.28	0.08	5.71	0.36
	20-40	2.6	4.12	15.5	20.5	64	8.35	0.07	0.04	0.09	0.03	8.93	<0.05	5.44	0.04	0.04	0.25	0.06	4.77	<0.05
	40-60	2.3	4.45	13.8	23.1	63.1	4.09	0.05	0.02	0.05	0.03	4.7	<0.05	3.04	0.03	0.02	0.17	0.04	2.83	<0.05
	60-80	1.6	4.59	8.6	26.7	64.7	2.41	0.03	0.01	0.03	0.02	2.68	<0.05	<1.5	0.03	0.02	0.16	0.04	1.72	<0.05
Spruce Plot	0-5	22.8	3.85	30.4	20.9	48.7	17.9	3.31	1.05	0.77	0.11	5.52	4.88	16.1	2.84	0.9	0.36	0.03	6.36	4.32
(SP)	5-10	8.1	3.54	18.9	17.3	63.8	9.97	0.69	0.25	0.22	0.03	6.53	2.89	10.8	0.56	0.28	0.45	0.04	7.31	1.62
	10-20	2.2	3.79	15.2	13.4	71.4	8.85	0.2	0.09	0.11	0.04	7.66	0.79	8.04	0.09	0.16	0.49	0.04	6.34	0.13
	20-40	1.3	4.04	19.5	19	61.5	8.8	0.16	0.05	0.1	0.02	8.93	0.21	8.86	0.07	0.12	0.49	0.03	7.47	<0.05
	40-60	0.8	4.17	17.8	16.5	65.7	7.99	0.09	0.03	0.1	0.02	8.61	0.27	7.81	0.04	0.13	0.52	0.03	6.71	<0.05
	60-80	0.6	4.33	16	16.1	67.9	7.13	0.07	0.03	0.1	0.02	7.81	0.13	6.93	0.05	0.18	0.64	0.04	5.75	<0.05

Table 3: Soil description (particles smaller than 2 mm diameter) from the beech and spruce plots at the Strengbach catchment. CEC: Cation Exchange Capacity, determined with cobaltihexamine. Data from the initial soils before leaching and after the end of the experimentation.

CEC ranges from 16.1 to 2.4 and from 17.9 to 7.1 $cmol^{+}\cdot kg^{-1}$ with increasing depth, for soils from the BP and SP sites, respectively (Table 1). The CEC corresponds mainly to the total exchangeable sites in the clay humic complex and is related to the clay and OM concentrations. As OM and clays, the CEC decreases with depth in both profiles, with higher values in SP soils. These greater values are consistent with the higher clay contents in the SP than in the BP plots (Table 3).

The CEC determined with cobaltihexamine was lower than the sum of the measured exchangeable cation concentrations, except at 00-05 cm for the SP soil (Fig. 2; Table 3). The difference between the CEC and the sum of exchangeable cations is on average 12% on both sites, which may correspond to the uncertainty of the analyses (about 10%, see 3.3).

The chemical composition of the exchangeable pool presents similar evolution with depth for both soil profiles, but with higher Ca, Mg, K, Mn and H concentrations in SP soils, having also higher CEC than that in the BP soils (Fig. 2).

The exchangeable pool of the top 5 cm of soil strongly differs from the other layers, with higher Ca, Mg, K, Mn and H concentrations. Conversely, the Al and H concentrations are similar, each corresponding to approximatively one-third of the CEC (Fig. 2). The 5-10 cm depth layers have intermediate chemical concentrations of Ca, Mg, K or protons. Below 10 cm depth, Al strongly dominates the exchangeable chemistry, representing more than 90% of the total pool (Fig. 2) and Ca, Mg, K and Na become minor elements.

The CEC and the concentration of exchangeable cations were also determined in the soil after the experiment (Table 3). Above 5 cm depth, Na, Mg in some cases and mainly K enriched the exchangeable fraction underlining changes in the nature of the exchangeable reservoir (Fig. 2; Table 3).

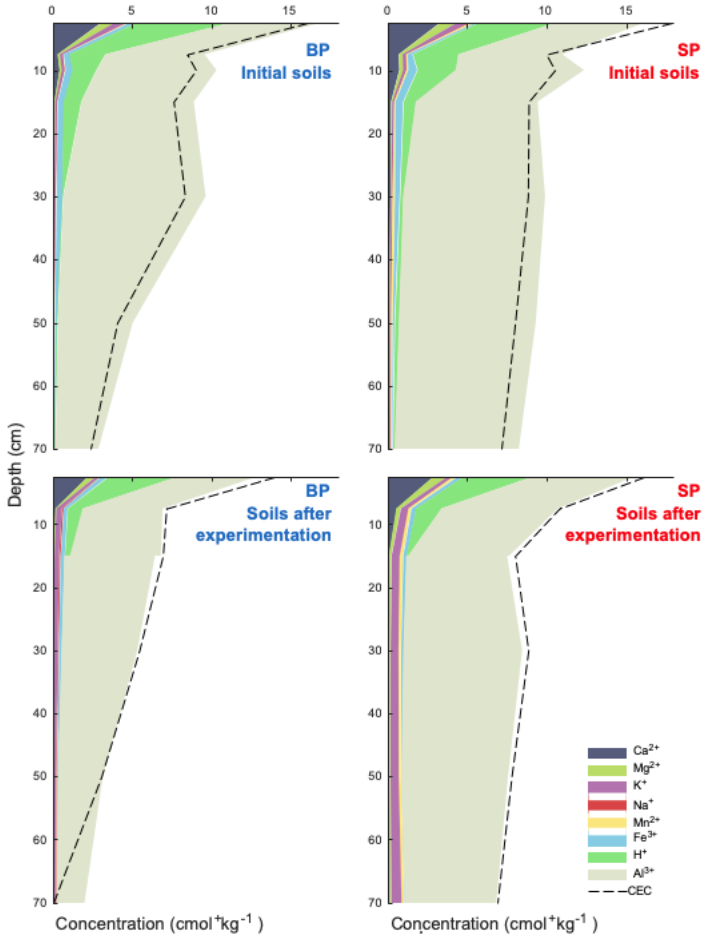


Fig. 2: Composition of the exchangeable phase for both BP (under beech) and SP (under spruce) soils at various depths, in initial soils and in soils after experimentation. Compositions were determined by cobaltihexamine extraction protocol.

4.1.3. Mineral and chemical composition of bulk soil and clay

The soils are composed mainly of a mix of organic matter, clays (kaolinite, illite, vermiculite and smectite) and primary minerals (muscovite, biotite, K-feldspar, albite and quartz). Since the proportions of organic matter and clays in each soil sample were already determined (cf. 3.3), the proportion of primary minerals was simply deduced from the residual phase and quantified by XRD (cf. 3.3).

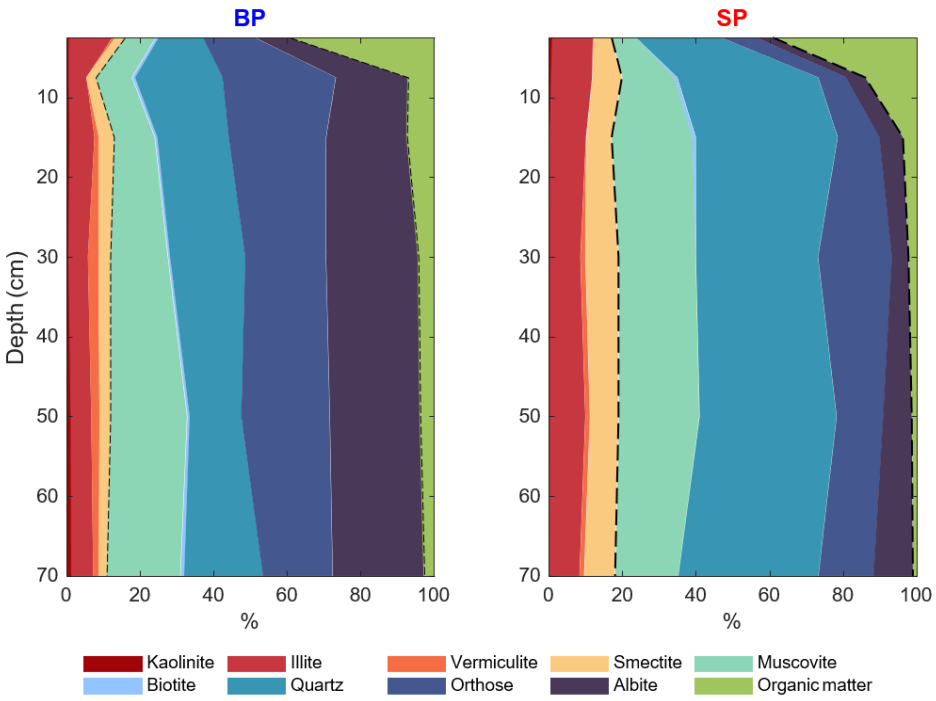


Fig. 3: Mineral composition in % of the soils from BP (left) and SP (right) profiles. Reddish parts correspond to clays, blueish parts correspond to primary minerals and greenish parts to organic matter (data in appendix A - supplementary material).

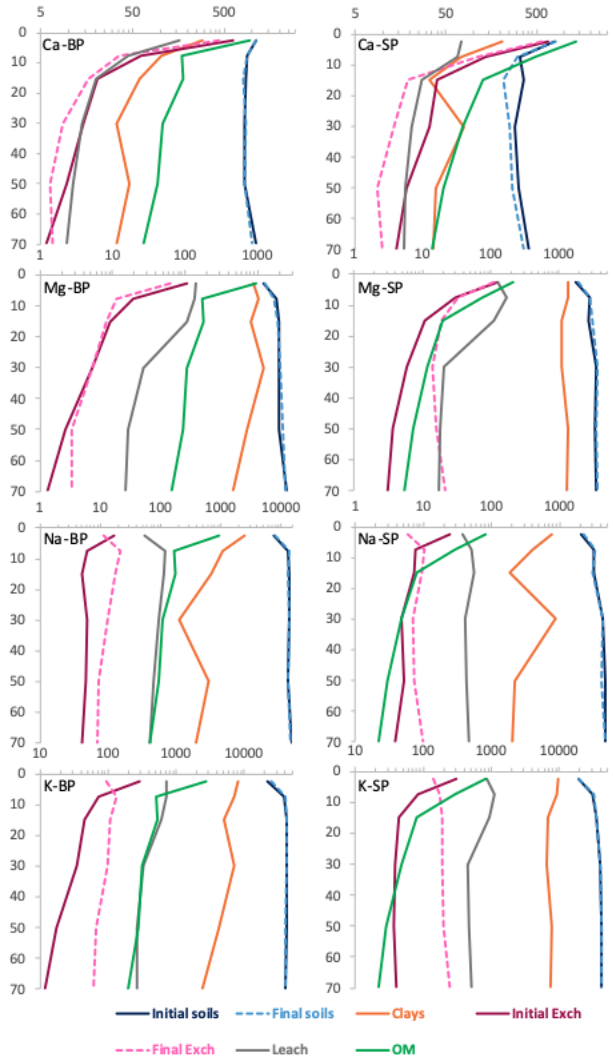
For both sites, organic matter dominates the soil composition at the surface (40% for the 0-5 cm depth sample). Below 10 cm, the mineralogical composition remains rather stable along the soil profile. The proportions of kaolinite and biotite are very low for both sites. BP has a higher level of organic matter, K-feldspar and albite than SP. The soils from the SP site are characterized by higher clay contents in general, as well as higher quartz, illite and smectite contents than the BP site, especially in the 5-10 cm range (Fig. 3).

	Depth	*Si*	*Al*	*Na*	*K*	*Mg*	*Ca*	*Sr*	$^{87}Sr/^{86}Sr$	err (2σ)
	cm	*mg/g*	*mg/g*	*mg/g*	*mg/g*	*mg/g*	*mg/g*	µg/g		
Bulk soil										
Beech Plot	0-5	167.48	21.76	7.40	21.87	1.22	1.13	31.34	0.789114	0.000014
(BP)	5-10	290.94	36.94	13.23	39.32	1.79	0.89	45.51	0.806601	0.000016
	10-20	297.9	39.13	13.52	41.91	1.99	0.86	46.70	0.809622	0.000012
	20-40	303.32	40.62	13.79	41.73	1.97	0.84	48.29	0.806266	0.000012
	40-60	303.65	40.63	13.13	41.7	1.97	0.82	43.67	0.811786	0.00001
	60-80	295.84	44.96	14.83	40.62	2.54	1.11	43.12	0.809955	0.000026
Spruce Plot	0-5	182.3	20.09	2.10	18.90	1.78	0.79	35.40	0.757335	0.000014
(SP)	5-10	292.95	33.35	3.23	31.36	2.80	0.33	53.87	0.764484	0.000012
	10-20	332.91	33.93	3.26	34.40	2.75	0.36	51.24	0.764455	0.00001
	20-40	310.43	43.29	4.40	40.00	3.53	0.29	76.23	0.764404	0.000014
	40-60	314.68	43.31	4.61	41.80	3.42	0.32	72.43	0.768632	0.000016
	60-80	315.43	44.02	4.73	42.54	3.49	0.41	73.80	0.768716	0.000012
Clays										
Beech Plot	0-5	188.53	73.65	8.29	27.52	2.90	0.96	52.50	0.771566	0.000004
(BP)	5-10	241.73	135.13	6.44	42.12	6.15	0.61	42.65	0.83199	0.000003
	10-20	190.77	115.65	4.55	33.57	5.40	0.39	28.38	0.845975	0.000004
	20-40	207.95	139.78	1.33	45.37	7.83	0.07	32.20	0.848006	0.000006
	40-60	177.89	124.7	4.47	30.52	5.27	0.34	28.52	0.8329	0.000004
	60-80	167.53	128.25	4.38	27.62	5.33	0.39	26.04	0.825962	0.000004
Spruce Plot	0-5	171.55	85.19	2.48	31.62	4.46	0.69	72.17	0.751935	0.000004
(SP)	5-10	228.57	133.1	2.11	48.87	7.24	0.39	67.07	0.745304	0.000007
	10-20	198.52	128.35	1.25	44.55	7.24	0.07	32.99	0.836336	0.000003
	20-40	192.59	123.8	4.44	33.67	5.72	0.40	30.27	0.84285	0.000003
	40-60	204.07	136.65	1.22	44.03	7.74	0.07	29.34	0.857096	0.000003
	60-80	208.74	140.79	1.24	45.43	7.98	0.23	30.24	0.862445	0.000003

Table 5: Chemical and Sr isotopic composition of bulk soils and clays from the beech and spruce plots at the Strengbach catchment.

The chemical compositions in both plots were dominated by Si with overall values of 300 and 200 mg/g for soils and clays respectively, except at the top profile characterised by the lowest values (Table 5). Bulk soil geochemical compositions vary little along the profile for each of the two sites, while those of the clays are more heterogeneous. Calcium is the least concentrated nutrient in bulk soils and clays. On the other hand, Ca is the only element with a higher surface

401 content in both profiles, with concentrations ranging from about 1 $mg \cdot g^{-1}$ in uppermost horizons
402 to 0.3 and 0.07 $mg \cdot g^{-1}$ in deeper compartments, for bulk soils and clays respectively. Except for
403 Ca, the uppermost horizon generally has the lowest concentrations, due to the high content of
404 organic matter.
405 In addition, significant chemical variations were observed between the two sites, especially for
406 bulk soils (Table 5). The sodium concentrations in BP bulk soils (≈12 $mg \cdot g^{-1}$ on average) are
407 strongly higher those in SP soils (3.7 $mg \cdot g^{-1}$ on average), consistent with the highest albite
408 content in BP profiles (Table 4, 5; Fig. 3). In contrast, Mg concentration was the highest in SP
409 soils (Table 5). In detail, the samples from the BP site exhibit slightly but significantly higher
410 Ca and K and lower Al and Sr contents in bulk soils than those from the SP site.
411 The proportions of the different reservoirs (organic matter, exchangeable phases, clays,
412 minerals) in the soil are represented on the same figure by element (Fig. 4), to compare the
413 contributions of the different soil constituents. Each reservoir is thus related to its proportion in
414 the bulk soil, and each elemental concentration expressed is normalized to one gram of soil
415 (Fig. 4, Appendix A-Supplementary material). The initial and final (after experiment)
416 concentrations of bulk soils and exchangeable pool are also represented in the same Figure, as
417 well as, the total cumulative concentrations of the experimental leachate solution (sum of the
418 quantities of each element leachate during the 11 steps of the experiment). The chemical
419 concentration of organic matter has been approximated from the proportion of organic matter
420 in the soils and the chemical composition of the degraded litter (OF-OH layer; Table 2) for each
421 type of soil profile (BP or SP). No significant variations (p value > 0.05) were observed between
422 the initial and final concentrations in bulk soils, which was confirmed by the two very similar
423 blue curves in Fig. 4.
424



425

426 Fig. 4: Variation versus depth of chemical compositions (expressed in µg/g of soil) for initial
427 and final (after experimentation) bulk soils, compare with the contribution of different
428 reservoirs as clay minerals, initial and final exchangeable pool, organic matter as total
429 cumulated experimental leachate calculated for 1 g of soil (see text; Appendix A-
430 Supplementary material) for two sites: BP-Beech Plot and SP-Spruce Plot.

431

432 ## 4.2 Results of the leaching experiments

433 ### 4.2.1 Chemistry of experimental solutions

434 #### 4.2.1.1. Reproducibility of triplicates

435 The concentrations were monitored in each experiment run in triplicate (see 3.4). A standard
436 deviation was then estimated for all parameters at each step between the three results (Appendix
437 B. Supplementary material). Overall, the standard deviations calculated on the chemical
438 concentrations reveal good reproducibility.
439 The standard deviation varies with time and type of element. For example, calcium and sodium
440 have a low standard deviation of 5% on average while Si, Al and Mg have a standard deviation
441 of 10.4, 13.5 and 15.5% on average. Then the discussion will be based on the average values of
442 the three triplicates.
443
444 4.2.1.2. Temporal variation of concentration
445 The chemical concentrations were determined at 11 time steps during about 5 months of the
446 experiment (152 days; Table 1). The temporal variations show different patterns, depending on
447 the elements, site or depth (Fig. 5), which are:
448 - Sharp decreases in concentration during the first steps followed by a regular increase
449 (e.g., Na in all cases and pH between 10 and 20 cm depth).
450 - Global increases in concentrations with different slopes (e.g., K in SP and BP profiles
451 below 20 cm depth).
452 - Sharp decreases in concentration at the beginning of the experiment, followed by an
453 increase prior to levelling off to a plateau value (e.g., Ca below 10 cm depth in BP
454 profile) or a decrease to lower values (Ca below 10 cm depth in SP profile).
455 - Sharp decreases, followed by a scattered increase for about 960h (40 days) (Mg, K
456 above 20 cm depth, pH in uppermost soils).

457 The main differences observed between the two profiles are as follows:
458 - Significantly higher Na and lower K concentrations in experiments conducted with BP
459 samples compared to experiments conducted with SP samples from all depths;

- Higher Mg, pH and lower Ca in experiments conducted with SP samples from uppermost soils and vice versa for samples from deeper levels.

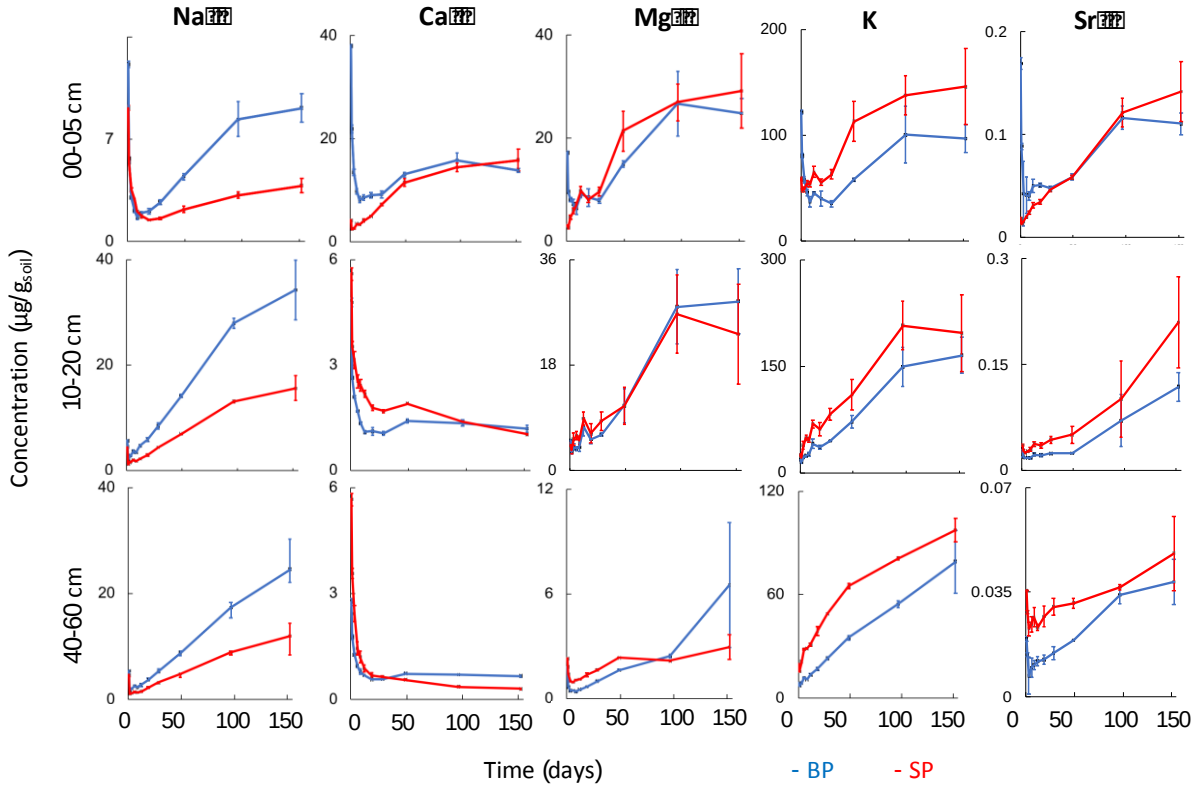


Fig. 5: Na, Ca, Mg, K and Sr concentrations leached over time for experiments conducted with soils from three representative different depths (0-5; 10-20 cm; 40-60 cm). Concentrations are expressed in µg of element per g of soil. The concentrations for the BP and SP profiles are in blue and red, respectively. The symbols represent the average concentrations from triplicate measurements and the vertical bars indicate the standard deviation.

4.2.2. Sr isotopes

The bulk soils, as well as the litter samples from the BP sites have higher Sr isotopic ratios than those from the SP soils (Tables 2, 5, Fig. 6). The clays below 10 cm depth represent the most radiogenic materials with $^{87}Sr/^{86}Sr$ ranging from 0.82 to 0.86 (Fig. 6). The lowest Sr isotopic

ratios were measured in the topsoil exchangeable pool and in litter (Appendix A-supplementary material; Fig. 6).

In general, the Sr isotopic ratios of bulk soils, clays and exchangeable pools increase with depth in the SP profile and exhibit a maximum between 15 and 40 cm depth in the BP profile (Fig. 6).

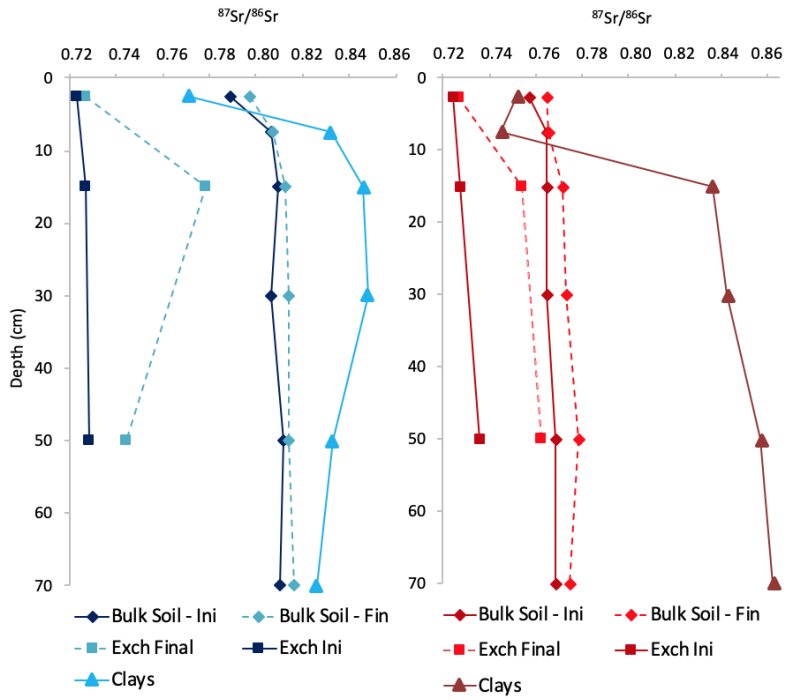


Fig. 6: Evolution versus depth of the isotopic ratio $^{87}Sr/^{86}Sr$ of the clays, the bulk soils and the exchangeable fraction (Exch.) before (init) and after leaching (final) in the BP profile (left) and the SP profile (right).

For both bulk soils and the exchangeable pool, the isotopic signatures obtained after experimentation are shifted towards higher values than the initial materials (Fig. 6), underlining the preferential leaching of Sr with lower $^{87}Sr/^{86}Sr$ during experiments.

Four output solutions from the experiments were selected to study the evolution of isotopic release over time: at $D_{0.6}$ (14 h), D_3 (3 days), D_{28} (28 d) and D_{152} (152 d) (Table 1). These times are representative of the global dynamic, with two early times ($D_{0.6}$ = 14 hours and D_3 = 2 days)

when the variations of concentration are the most important (Fig. 5) one intermediate and one final time.

For each selected depth, the temporal evolutions of the experimental output solutions systematically show the lowest Sr isotopic composition at $D_{0.6}$, a significant increase to D_3 and then to D_{28} for both profiles. Between D_{28} and D_{152}, the values decrease or remain similar (Fig. 7)

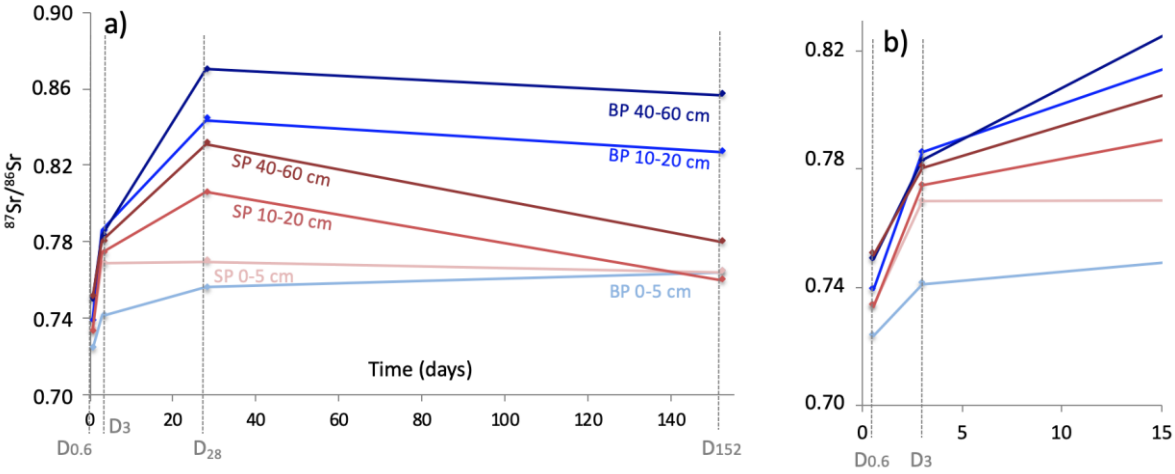


Fig. 7: Variation of the $^{87}Sr/^{86}Sr$ isotopic ratios versus time for experimental BP and SP leached solutions a) at 4 steps $D_{0.6}$ (14 h), D_3 (3 days), D_{28} (28 d) and D_{152} (152 d) and b) with a zoom for the first 15 days, for 3 different soil horizons (0-5 cm; 10-20 cm and 40-60 cm).

5. Discussion

5.1. Strontium isotope variations to trace the origin of calcium

The Sr isotopic compositions allow tracing the origin of elements because of the lack of isotopic fractionation during water/mineral interactions and biogeochemical reactions. It has been

507 frequently used to study the dynamics of Ca in atmosphere/soil/water/vegetation systems
508 (Graustein, 1989; Capo, Stewart, and Chadwick, 1998; Probst et al., 2000; Aubert et al., 2002;
509 Poszwa et al., 2004; Bélanger et al., 2012; Gangloff et al., 2014; Bedel et al., 2016; Blotevogel
510 et al., 2019; Novak et al., 2020).

511 5.1.1. Characterization of the different end-members:

512 Characterization of the different sources of Sr in the soils is essential to discuss the signature of
513 the leachates and their evolution during the experiments. This explains why we separately
514 analysed the exchangeable fractions, clays, soils and litters, in the present study.

515 Previous studies focused on tree samples from the two plots of the same catchment showed
516 $^{87}Sr/^{86}Sr$ ratios ranging from 0.72433 to 0.72577 at the BP site and from 0.71653 to 0.72349 at
517 the SP site for leaves and litters (Prunier, 2008; Prunier et al., 2015). With this data set and
518 those from the present study, we can define a mean biological end-member with $^{87}Sr/^{86}Sr$ ratios
519 of 0.7268 and 0.7230 for BP and SP, respectively. Based on the same studies, the mean Ca/Sr
520 ratios of tree samples (leaves and litters) were 418 and 447 for BP and SP, respectively. The
521 biological end-members shown in Fig. 8 correspond to these averages.

522 The atmospheric end-members have been determined from throughfalls sampled at both sites
523 and correspond to $^{87}Sr/^{86}Sr$ = 0.71327 (respectively 0.71664) and Ca/Sr = 438 (respectively
524 402) for SP and BP (Prunier et al., 2015; Pierret et al., 2019).

525 The Sr from exchangeable fraction showed low $^{87}Sr/^{86}Sr$ ratios (from 0.723 to 0.736; Table 3),
526 which may be attributed to mixing between organic matter and atmospheric inputs. This
527 assumption is supported by the work of Van der Heijden et al. (2014), who showed that
528 atmospheric inputs represent a major source of Ca and Mg in exchangeable and total pools of
529 base-poor soils and that the litter layer played an essential role in the retention of throughfall
530 Mg and Ca. In addition, Bedel et al., (2016) indicated that the Sr isotopic compositions of

exchangeable soil are controlled by the mixing of litter Sr and throughfalls Sr in two acidic soils, in superficial and deep horizons (down to 1 metre depth).

The more radiogenic materials are the clays and the primary minerals of granite. However, the $^{87}Sr/^{86}Sr$ ratios of clays show contrasting values (Table 5; Fig. 7; 8) with low ratios in the superficial horizons. The clay content is at a maximum in topsoil (about 30% in the 0-5 cm samples), and decreases with depth to 9% and 16% in BP and SP profiles, respectively (Table 3). Clay minerals can have two origins: either primary (i.e., from bedrock) or pedogenetic (i.e., resulting from the soil formation). We can hypothesize that the proportion of pedogenetic clays increases at the superficial oldest soils, in agreement with the measured increase in clay proportion. The precipitation of secondary phases occurred from solutions containing atmospheric and biological Sr, resulting in a less radiogenic signature. Conversely, clays from bedrock, coming from the weathering/hydrolysis of primary minerals preserved their initial Sr isotopic composition. Thus, the evolution of the clay Sr isotopic signature along both weathering profiles (Fig. 10) is the result of variable proportions of radiogenic primary clays and less radiogenic pedogenetic clays. Kaolinite, for example, results from the hydrolysis of K-feldspar and its proportion within the clay fraction increases with depth in BP profile. Illite can precipitate from solution (Godderis et al., 2006; 2009; Beaulieu et al., 2020), and its highest proportion was recorded in the uppermost soil (about 70% in 0-5 cm depth soils).

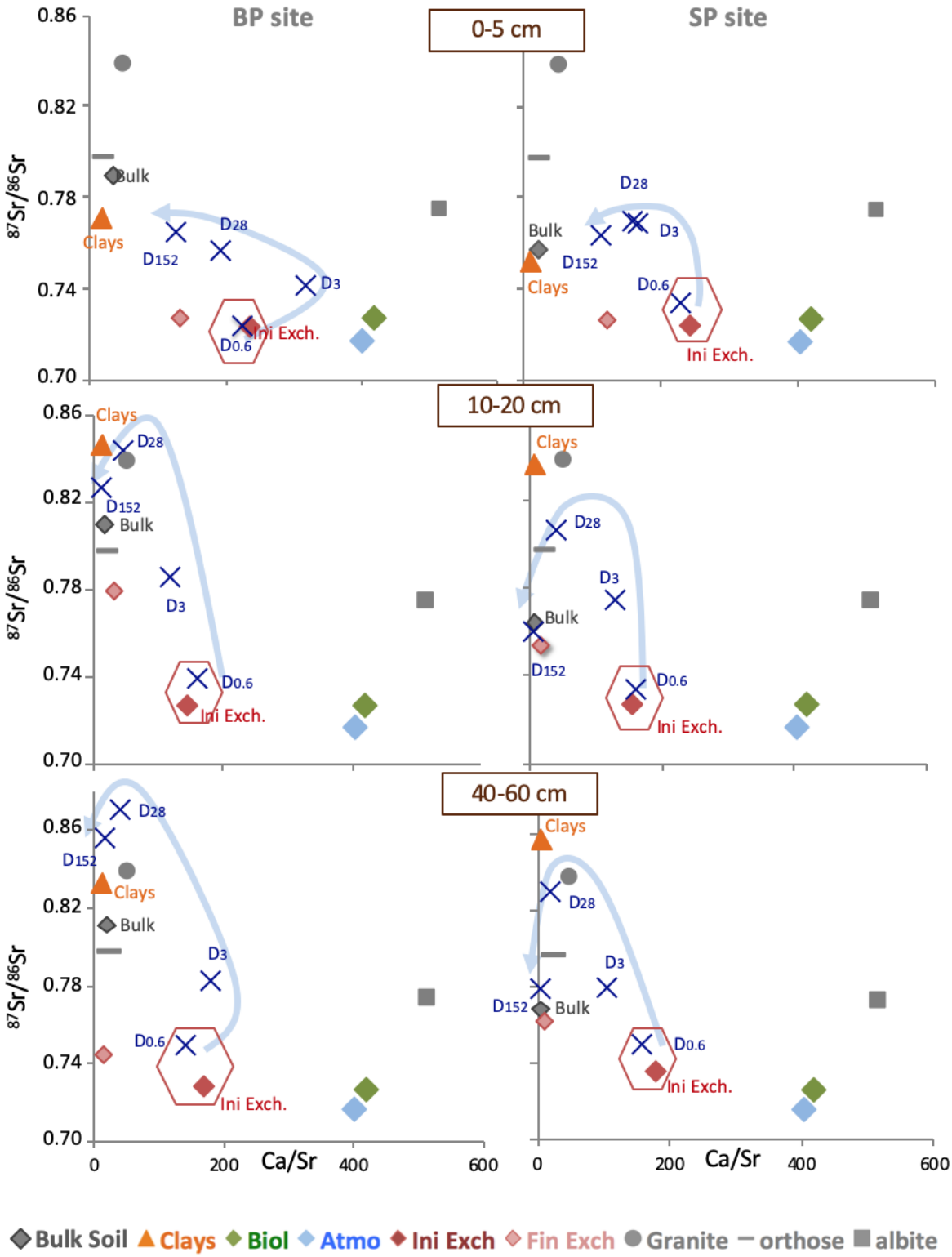


Fig. 8: $^{87}Sr/^{86}Sr$ isotopic ratio versus Ca/Sr ratios (mass ratio) for the different end-members (defined in text), and the exchangeable fraction in initial and final soils. The leached solutions obtained during the experiment at four different time steps $D_{0.6}$ (14 h-0.6d), D_3 (3 days), D_{28} (28 d) and D_{152} (152 d) (see Table 1) are represented by the dark blue cross and for soils at three

555 representative horizons (0-5 cm; 10-20 and 40-60 cm). The signatures of bulk soil and clay are
556 specific for each corresponding depth. Granite and primary mineral signatures are from Aubert
557 et al., (2002). BP (under beech) and SP (under spruce) represent the two studied plots.
558
559 The contrasting Sr isotopic signatures between soils from the two plots (more radiogenic for
560 BP site; Fig. 6) have already been observed (Aubert et al, 2002; Pierret et al., 2014; Prunier et
561 al., 2015) and can be explained by the contrasting bedrocks, the northern slope being
562 characterized by strongly hydrothermally altered granite.
563
564 5.1.2. Evolution of Sr isotopic signature during the experiments
565 The temporal Sr isotopic evolutions of leachate during the experiments are shown in Fig. 7,
566 with the different potential end-members. For the six studied samples of the SP and BP sites,
567 the composition of the $D_{0.6}$ leachate is very close to the initial exchangeable pool in terms of Sr
568 isotopic composition as well as Ca/Sr ratios (Fig. 8). It can therefore be deduced that the Ca or
569 Sr released at the beginning of the experimentation results mainly from the exchangeable stock,
570 even at deep horizons where the CEC is the lowest and the proportion of exchangeable Ca or
571 Sr in the bulk soils is weak (less than 0.2% for the Sr; Table 3, 5). Thus, the exchangeable
572 compartment is very quickly mobilized while other sources are still negligible.
573 At D_3 (3 days) the $^{87}Sr/^{86}Sr$ ratios of each leached solution increase and deviate from the initial
574 exchangeable pool, suggesting an additional leaching of elements from other sources, such as
575 clays (Fig. 8).
576 The contribution of clay end-members (each having their specific signature, extracted from
577 each studied soil) to the solution composition increases at D_{28} (Fig. 8), suggesting that the
578 weathering of clay minerals represents an important source of Sr during the experiments for all
579 studied soils. At D_{152} (152 days), the Sr concentrations reach their highest values (Fig. 5) and

580 the isotopic composition is close or tends towards that of the bulk soils or a mixture of clays
581 and bulk soils (Fig. 8). In summary, the results show that the first mobilized reservoir is the
582 exchangeable pool, followed by the clay compartment and at the very end, the bulk soils, which
583 can control the Sr isotopic signature especially in deep horizons of the spruce plot.
584 In addition, the exchangeable pool Sr signature is more radiogenic at the end of the experiment
585 compared to the beginning, with lower Ca/Sr ratios than in the initial sample (Table 3; Fig. 6,
586 8). Thus, in addition to chemical changes in the exchangeable fraction, the sources from which
587 they originate also change during the experiments: the initial poorly radiogenic Sr derived from
588 biological materials and atmospheric inputs is partly replaced by more radiogenic Sr coming
589 from mineral dissolution, released in solution during the experiments. In addition, the Ca/Sr
590 ratios of the exchangeable pool at the end of the experiment are very close to those of final
591 leaching solution (D_{152} ; Fig. 8) for each depth and profile. We suggest that in the final
592 experimental steps, a chemical equilibrium occurs between the experimental solution and the
593 exchangeable pool. The lower Sr isotopic composition of the exchangeable fraction compared
594 to the final experimental solution (D_{152}) in some case, may be explained by the fact that part of
595 the initial Sr remains in the final exchangeable pool.
596 To conclude, time-resolved analyses of Sr isotopic ratios revealed that the exchangeable
597 complex supplies Sr (and therefore, supposedly, Ca) first and rapidly. Then the contribution of
598 mineral dissolution, especially clays, increases. The Ca content of the exchange complex
599 decreases during experiment, while its radiogenic Sr signature increases.

5.2. Reservoirs of nutrient cations in the soil profiles

5.2.1. Initial reservoirs of nutrient cations in soils

Plot	Depth	Ca		Mg		Na		K	
-	*cm*	kg · ha^{-1}	*%*	kg · ha^{-1}	*%*	kg · ha^{-1}	*%*	kg · ha^{-1}	*%*
Beech Plot (BP)	00-05	199	*54.8*	34	*8.6*	5	*0.2*	92	*1.3*
	05-10	20	*7.0*	6	*1.1*	2	*0.1*	23	*0.2*
	10-20	13	*2.4*	6	*0.5*	3	*0.04*	30	*0.1*
	20-40	22	*1.7*	8	*0.3*	9	*0.04*	53	*0.1*
	40-60	12	*1.2*	3	*0.1*	7	*0.04*	22	*0.04*
	60-80	6	*0.5*	1	*0.1*	6	*0.03*	13	*0.03*
	Total	*272*		*58*		*32*		*233*	
Spruce Plot (SP)	00-05	142	*83.6*	27	*7.2*	5	*1.2*	65	*1.6*
	05-10	30	*42.2*	6	*1.1*	2	*0.2*	18	*0.3*
	10-20	17	*11.0*	5	*0.4*	3	*0.2*	19	*0.1*
	20-40	39	*11.5*	7	*0.2*	6	*0.1*	46	*0.1*
	40-60	24	*5.7*	5	*0.1*	7	*0.1*	49	*0.1*
	60-80	15	*3.4*	3	*0.1*	4	*0.1*	41	*0.1*
	Total	*267*		*53*		*27*		*238*	

Table 6: Evaluation of the stock of exchangeable cation per soil layer (expressed in kg/hectare) and proportion of exchangeable pool in the bulk soils for Ca, Mg, Na, and K (expressed in %). The total corresponds to the sum over the whole soil profile.

The total pools of nutrients in bulk soil provide important information regarding the long-term fertility of ecosystems because they could be released by weathering over time (Schlesinger, 1997; Ghiel and von Wiren, 2014; Legout et al, 2020). Our results suggest that Ca is the most limiting nutrient cation among K, Mg or Na, in the Strengbach soils in terms of total stock (especially at the SP site with only 1.6 t of Ca in the whole profile until 80 cm depth; Appendix C. Supplementary material) and a large proportion of Ca is in exchangeable form, especially in the topsoil of the two sites (Table 6). The proportion of Na, K and Mg in an exchangeable form is also the highest in the 0-5 cm layer, which may be attributed to the highest CEC (Table 3) and to biological cycling (Jabbagy and Jackson, 2001).

5.2.2. Evolution of the nutrient cation reservoirs during the experiment

The composition of the exchangeable phase varied with time during the experiment (Table 3). The soil CEC decreased during the leaching experiment and the variations were more important with samples from the BP site (- 9 to -35%) than from the SP site (1 to -10%), especially below 20 cm depth (Table 3). These changes may be partly explained by the mineralization of organic matter and by the weathering and/or the interlayer aluminization of clay minerals (Mareschal et al, 2009) during the 5 months of the experiment.

The 0-5 cm depth layers are characterized by a general loss of all elements in parallel to a decrease of CEC indicating that there is no recharge of the exchangeable phase, with a net loss of nutrients over time.

Regarding deeper soil layers, the composition of the CEC also varies during the leaching experiment with an enrichment in Mg, K and Na (up to 570%, 530% and 260% of the initial value respectively; Table 5), and a depletion of Ca (-20 to -60% of the initial values) over time. Thus, part of the Mg, K and Na released in solution during the experiments by exchange, mineral dissolution or organic matter mineralization contribute to the supply of the exchangeable pools, which are considered as available for plants (van der Heijden et al, 2018). Conversely, the exchangeable phase was significantly and systematically depleted in calcium at the end of the experiment (Table 5; Fig. 4), highlighting the fact that the bioavailable Ca reserve in soils decreased with time.

5.3. Dynamics/mobilization of elements and processes

5.3.1. Model calibration and hypotheses used in the simulations

Several hypotheses have been tested in order to represent the experimental conditions and to determine the optimal set of parameters to simulate the evolution of the measured concentrations of all major cations in the leachate (Table 6). The simulations with the final

parameter set are thought to reflect for the actual processes that control the evolution of the concentrations of major elements, and to single out processes that cannot be captured by the simulations because such processes are not included in the model.

In the figures we have chosen to represent two horizons. These two depths represent two characteristic horizons of superior scientific interest.

0-5 cm corresponds to the level richest in organic matter, where recycling and litter is most important.

40-60 cm corresponds to the level of maximum root density, therefore where the root uptake is the most important.

Initial settings	***Results***	***Final settings***
Smectites represented only by Ca-Montmorillonite alone	Underestimation of Mg concentration in the solution	Smectites represented by Ca-Montmorillonite and Mg-Montmorillonite
Initial conditions of model fixed to zero for cation concentrations and fraction of occupied sites by the cations on exchange complex surface	Underestimation of cation concentrations and Si concentration in the solution	Initial conditions of model fixed to zero for cation concentrations and fraction of occupied sites by the cations on exchange complex surface fixed with experiment
Specific surface of albite fixed to 0.1 m^2/g, as a primary mineral	Underestimation of Na concentration in the solution	Specific surface of albite fixed to 10 m^2/g, as a secondary mineral, according to XRD
No exchange between the solution and exchange complex surface	Ca and K concentrations largely underestimated in the solution	Exchange between the solution and exchange complex surface allowed
No precipitation of secondary phases	Underestimation of Ca and Si concentrations in the solution, equilibrium solution/minerals modified	Precipitation of secondary phases allowed

Table 7: Tested hypotheses for model parametrization.

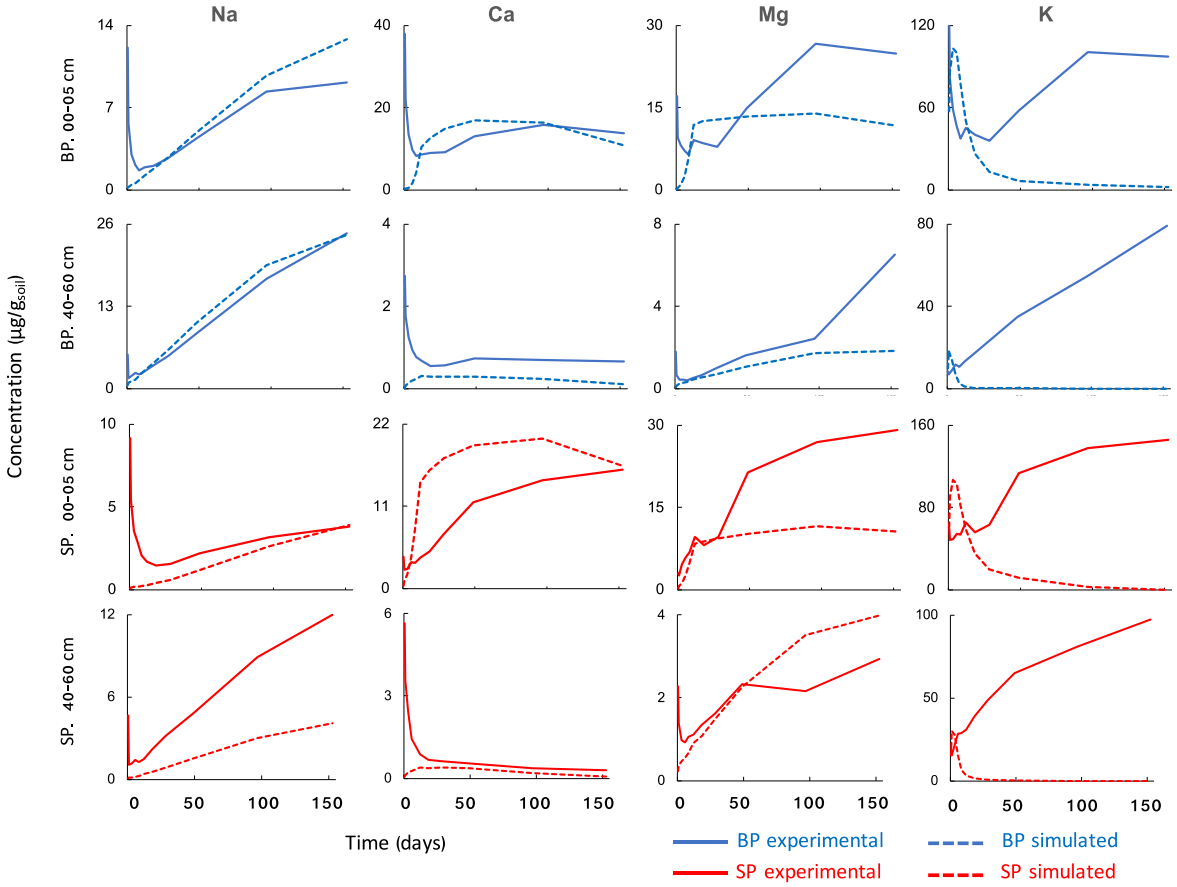


Fig. 9: Simulated and experimental concentrations for the leaching solutions at two different depths (0-5 cm and 40-60 cm) and for the two profiles (BP in blue and SP in red) for Na, Ca, Mg and K.

5.3.2. Magnesium and Potassium

The amounts of K and Mg leached during the experiments rapidly exceeded the initial amount of exchangeable K and Mg (after 2 to 5 days, except for Mg in the topsoil). These elements behave quite similarly, and our results suggest that the exchangeable pool is not the sole source of K and Mg in the system. Several Mg-bearing minerals are present in the soils of the Strengbach catchment (smectite, biotite, vermiculite and illite), which is also the case for potassium (orthoclase, muscovite, biotite and smectite). However, other reservoirs such as

organic matter could have also contributed to the release of K and Mg during the experiment, especially for the topsoil horizons, which were enriched in organic matter.

The WITCH code was thus used to investigate the sources of Mg and K found in the leachate. In the model, these elements can be released through exchange and/or dissolution of K/Mg bearing minerals. Sensitivity tests were performed until the WITCH code enabled satisfactory reproduction of the dynamics of Mg contents in the leachate below 10 cm depth at both sites (Table 7; Fig. 9). Good agreement between the simulated and observed Mg contents was reached when the dissolution of smectite (and to a lesser extent, illite and vermiculite) was considered. These phases supply the exchangeable pools and the leachate with Mg over time. In these horizons, the model also enables to reproduce the differences between sites in terms of Mg contents in the leachate; these differences are attributed to the higher smectite contents at the SP site compared to the BP site (Fig. 5), which confirms that smectite is the main source of Mg in these soil layers. This weathering flux of Mg compensates for the desaturation of the CEC over time in these soil horizons, which is not the case in the 0-10 cm soil layer at the beginning of the experiment. The initial CEC and Mg contents were higher in the topsoil than in the rest of the soil profile at both sites, which may partly explain why the simulated Mg weathering flux was lower than the Mg desaturation flux. Discrepancies between the modeled and experimental Mg contents in the leachate were also observed in the topsoil. We hypothesize that the mineralization of organic matter in the topsoil (not taken into account in the model) may contribute to the supply of the CEC and the leachate over time, which may explain the lower simulated Mg contents compared to the experimental ones.

Conversely, the model does not correctly reproduce the dynamics of K contents in the leachate: the experimental K contents in the leachate become rapidly much higher than the simulated contents, and our results suggest that several fluxes/processes are not correctly reproduced by the model. The main input flux of K simulated by the model is the desaturation of the CEC,

occurring at the beginning of the experiment, while the simulated weathering flux is particularly low throughout the experiment. We hypothesize that either:

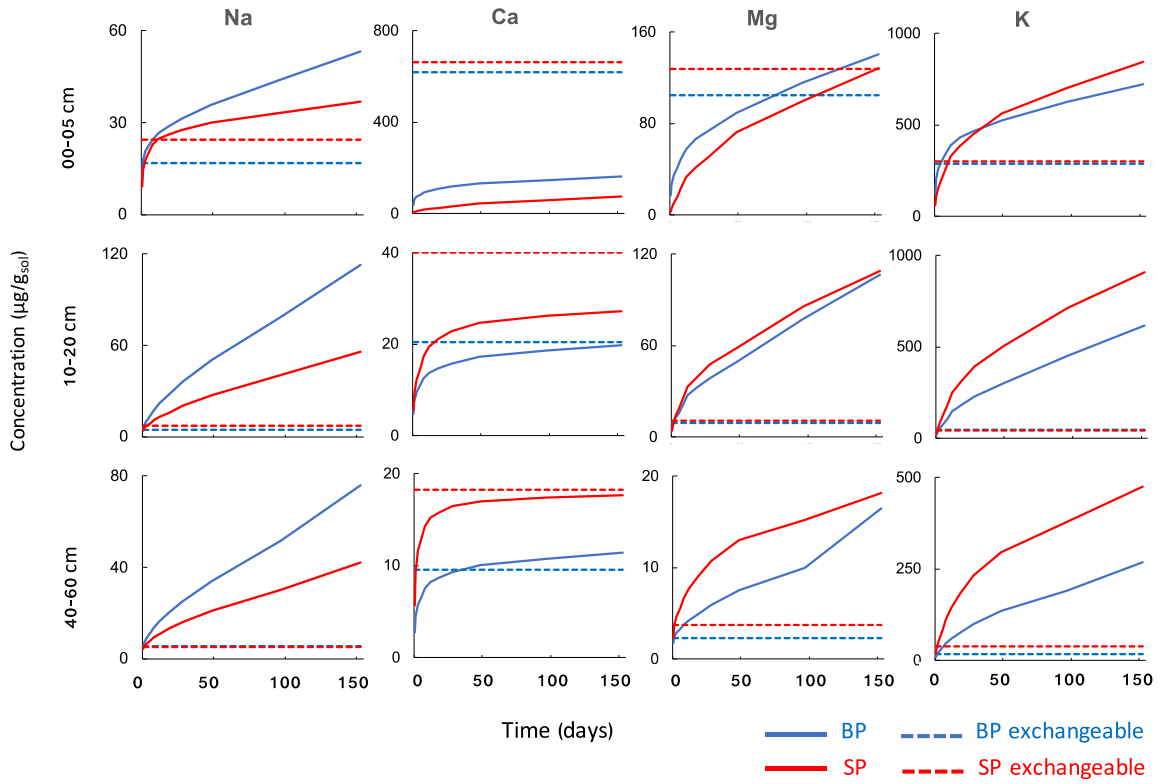
(i) The dissolution rate constant and/or the solubility of K-bearing secondary minerals implemented in the WITCH database is/are underestimated. However, this is unlikely because laboratory-derived parameters used in reactive transport models such as WITCH generally overestimate the actual release rates of elements (White and Brantley, 2003; Goddéris et al., 2006; Daval et al., 2011; Wild et al., 2016; Wild et al., 2019);

(ii) The model overestimates the precipitation of K-bearing minerals, which is thermodynamically controlled (i.e., instantaneous as soon as the solution is supersaturated);

(iii) Another source releases K, but is not considered in the model. Organic matter can release K through mineralization, but it is unlikely that this process occurs in the deepest soil layers, which are poor in organic matter.

In the end, it is more likely that another source of K, such as interlayer K, was released during the experiment, as suggested by several authors (Rahmatullah and Mengel, 2000; Falk Øgaard and Krogstad, 2005). In addition, several studies have shown the role played by plant roots in releasing interlayer K in soils (Barré et al., 2007; Vetterlein et al., 2013; Khormali et al., 2015; Paola et al., 2016). Note that the code is not designed to simulate such a process, which could explain why the simulations fail to reproduce the dynamics of K release over the course of the experiments.

5.3.3. Calcium



713

714 Fig. 10: Cumulative concentrations of Na, Ca, Mg and K from the leached solution at three
715 representative different depths over the 152 days of experimentation (in µg normalized to 1g of
716 bulk soil). Blue and red lines represent the BP and SP profiles, respectively. The dashed lines
717 represent the exchangeable pool in the soils (in µg for 1g of soil). Each concentration is
718 normalized to 1 g of soil.

719 Unlike other elements, the cumulative concentration of Ca remains below the amount of
720 exchangeable Ca (Ca-exch), even at the end of the experiments, down to 60 cm depth (Fig. 10).
721 Below 60 cm depth, the initial stock of exchangeable calcium is reached after 8/12 days (for
722 BP and SP sites, respectively), whereas for K, Na or Mg, the same threshold is exceeded after
723 a few hours (Fig. 10).
724 More precisely, over the entire duration of the experiments (152 days), the total amount of
725 calcium released from the 0-5 cm depth soil was four to ten times lower than the exchangeable
726 calcium (for SP and BP sites respectively; Fig. 10), while Ca-exch was the most important

727 exchangeable cation in the uppermost horizons (Table 6). Several hypotheses to explain the
728 incomplete mobilization of the exchangeable Ca during leaching experiments are discussed
729 below.
730 A hypothesis could be that the amount of exchangeable calcium is too high to be exchanged or
731 leached during the experiment by the available protons. The total amount of protons available
732 in solution during the whole experiment (11 steps) corresponds to 1.4 10^{-4} mol (HCl solution at
733 pH=3.5). By considering the sum of cations (Na, K, Mg and Ca), the values obtained are
734 between 0.05 and 0.6 10^{-4} mol+ in soils below 5 cm depth, underlining the fact that protons are
735 not limiting. Thus, the low Ca release observed during the experiments cannot be explained by
736 a proton-limiting effect.
737 Numerical simulations of experimental Ca release run with WITCH were realized with different
738 scenarios by changing the values of selectivity coefficients associated with the cation adsorption
739 parameter, which represents the exchange between the Ca present on the humic-clay complex
740 and protons in the solution (Fig. 11). These selectivity coefficients are derived from the Gapon
741 convention, and their values are often adjusted to calibrate the models. Regardless of run, the
742 model is not able to simulate the experimental pattern, implying that the release of Ca in solution
743 is controlled not only by simple cationic exchange coupled with dissolution. The model
744 systematically overestimates the Ca released from cation exchange (Fig. 11). The exchangeable
745 Ca might behave differently from other cations such as Mg or K, because of different bonds or
746 exchange sites. Calcium is stabilized in the clay-humic complex via two main mechanisms,
747 involving either weak or strong bonds (Sutton and Sposito, 2006; Kalinichev and Kirkpatrick,
748 2007; Bogatko et al., 2013; Rowley, Grand, and Verrecchia, 2018):
749 1) Inner-sphere complex formation with direct ionic bonds between Ca (having higher affinity
750 than Mg, K or Na) and organic matter (Iskrenova-Tchoukova et al., 2010);(André and

751 Pijarowski, 1977; Baes and Bloom, 1988; Curtin, Selles, and Steppuhn, 1998);(Sentenac and
752 Grignon, 1981).
753 2) Outer-sphere complex. Calcium specifically forms a bridge via weak interactions between
754 the different molecules of organic matter and clays, which is well documented (Edwards and
755 Bremner, 1967, Oades, 1988, Clough and Skjemastad, 2000; Feng et al., 2005; Von Lützow et
756 al., 2006; Sutton and Sposito, 2006; Iskrenova-Tchoukova et al., 2010).
757 For all these reasons, Ca-exch is probably less accessible and less mobile during experimental
758 leaching than Na-, K- or Mg-exch because of stronger chemical binding and Ca-chemical
759 bridges occurring among the clay-humic complex.
760 In a practical way, our study highlights that the amount of calcium released in solution during
761 the acid leaching experiment is much lower than the existing exchangeable pool in soil, unlike
762 other cations such as K or Mg. Therefore, we hypothesize that the amount of calcium actually
763 available for plants does not correspond to the amount of Ca-exch determined by classical
764 extraction protocols. Our experiments suggest that the fertility of soils may be overestimated
765 for Ca when considering classical exchangeable Ca.
766 In addition, both BP and SP soil profiles exhibit different behaviors. In the uppermost soil (0-
767 5cm depth), the Ca, but also Mg and K release in solution during experimentation was higher
768 in BP, whereas the Ca, Mg- and K-exch was lower than in SP soil (Fig. 2; 5). This can be due
769 to higher organic matter content in BP, and probably to different reactivities between the two
770 litter types. The biodegradability of decomposed beech litter is significantly higher than that of
771 spruce litter (43% versus 31% after 42 days of incubation; Don and Kalbitz, 2005). This can
772 explain why the quantity of cations released during the experiments was the highest in BP (0-5
773 cm) soil (Fig. 5). Thus, the type of tree and thus of litter can play an important role in the cycling
774 of nutrients and in particular Ca in forest ecosystems, especially in environments with acidic
775 and base-poor soils.

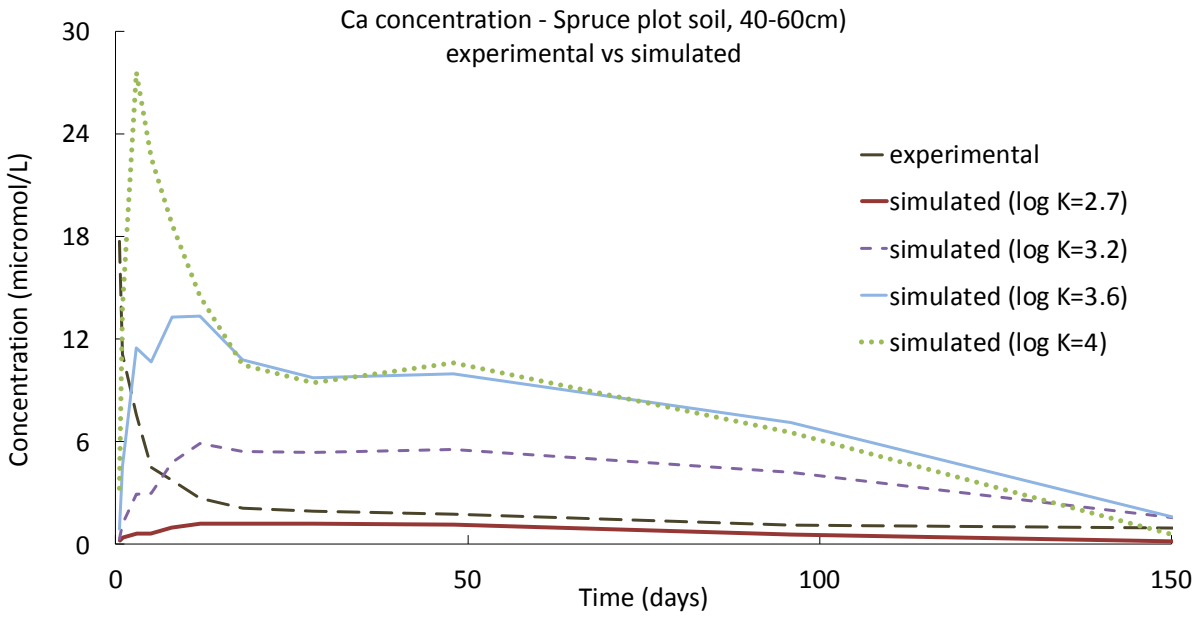


Fig. 11: Evolution of experimental Ca concentrations (leached solution) versus time, compared to simulations run with various values of Ca constants of exchange ($10^{-2.7}$, $10^{-3.2}$, $10^{-3.6}$, 10^{-4}) on SP plot at 40-60 cm. The Ca concentration in the solution increases with the decreasing exchange constant. The calculated concentrations with exchange constants of $10^{-3.2}$, $10^{-3.6}$ and 10^{-4} are largely overestimated over time, despite a fast increase at the beginning of the simulation, as in the experimental conditions. This illustration corresponds to the 40-60 cm depth horizon from the spruce plot (SP).

5.3.4. Sodium

The experiments reveal that the amount of Na leached during the experiment rapidly exceeds the initial amount of exchangeable Na, suggesting the contribution of a other source. The exchangeable Na is low, 10 to 100 times lower than Ca, Mg and K, and it represents less than 0.1% of the total Na in bulk soils, for both profiles. Thus, the main source of sodium in the soils is albite ($NaAlSi_3O_8$), which represents on average 27% of the crystalline phases at the HP site and 10% at the SP site (Fig. 3, Sup mat.). The differences may be explained by the geological history of the catchment: strongly hydrothermalized granite on the northern slope (SP

localisation) having depleted in albite compared to the non-hydrothermalized granite (BP localisation) found on the other slope (El Gh'mari, 1995 ; Fichter et al., 1998a).

The WITCH code enables satisfactory reproduction of the dynamics revealed experimentally for Na contents in the leachate over time for samples from both sites (Fig. 9). In the simulation, the contribution of exchangeable Na is negligible and the dissolved Na is mainly due to albite dissolution. Moreover, the release rate of Na from albite is not influenced by secondary processes such as precipitation or complexation with organic matter (Chou and Wollast, 1985; Knauss and Wolery, 1986; Chen and Brantley, 1997). Thus, a simple description of albite hydrolysis remains sufficient to account for the release rate of Na, and the differences between SP and BP soil experiments related to the albite content in soils.

As mentioned above, the specific surface area of albite was increased by two orders of magnitude compared to other primary minerals (from 0.1 m^2/g to 10 m^2/g). This adjustment complies with the surface area estimated from SEM observations and is consistent with the fact that albite in the soils was already partially weathered resulting in a higher specific surface area compared to pristine albite. Discrepancies between modelled and experimental concentrations were observed at the beginning of the experiment, and we hypothesize that this may be due to sodium from interstitial soil water or from the rapid dissolution of a labile Na-source such as salts (not taken into account in the model).

Although sodium is not one of the major nutrients for plants (Marschner, 1995), our results demonstrate that it may be used as a proxy for the weathering rates of primary minerals, as suggested by several authors (e.g., Sverdrup and Warfvinge, 1993).

5.4. Implications for tree nutrition and forest management

Plant-available pools are assumed to be stored in the soil as exchangeable cations adsorbed on the cationic exchange complex (van der Heijden et al, 2018). Although the pools of

exchangeable sodium, calcium, magnesium and potassium are low at the Strengbach, our results show that soil intrinsic fluxes of Na, Mg and K (i.e., weathering, mineralisation of OM...) may supply the exchangeable pools and could thus participate substantially to tree nutrition. Our results suggest that the situation is more critical for Ca for two major reasons: i) although reserves are still available in soils (total soil pools 1589 $kg.ha^{-1}$ and 4720 $kg.ha^{-1}$ for the SP and BP sites, respectively), soil intrinsic flux that may supply the pools of exchangeable Ca over time appears very weak and ii) exchangeable pools of Ca seem only partially available for plants (see section 5.3.4).

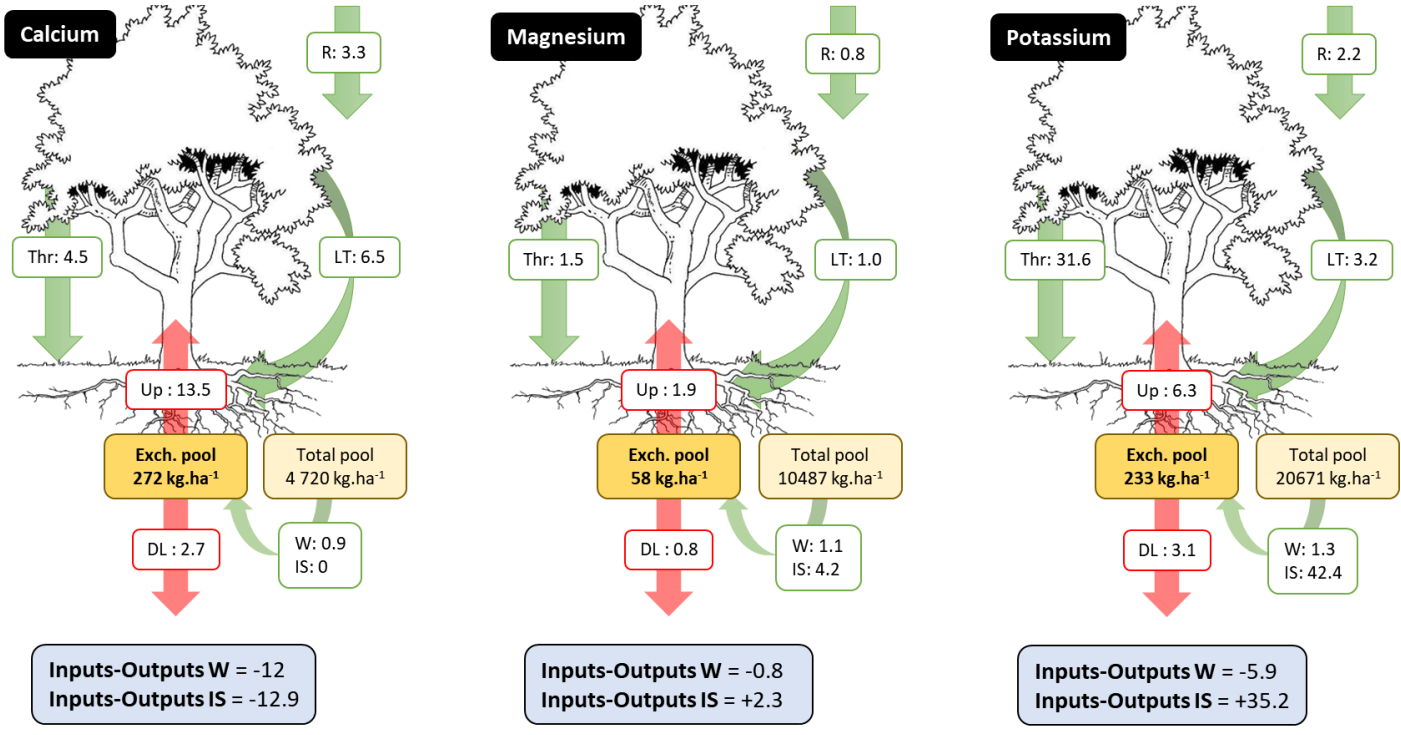


Fig. 12: Fluxes and input-output budgets (in $kg.ha^{-1}.yr^{-1}$) for calcium, magnesium and potassium at the BP site. IS is the intrinsic flux from soil estimated from our leaching experiments (corrected for the value of the initial exchangeable pool). W is the weathering flux, R is the atmospheric wet deposition, Up is the net uptake flux by roots and DL is the deep leaching (see Beaulieu et al. 2020). See additional explanation in text and Appendix D. Supplementary material, with the same diagram for the SP site.

The results of the leaching experiments were extrapolated to the plot scale according to the calculation detailed in Appendix D (Supplementary material), the flux of nutrients (Ca, Mg, K) intrinsic to the 0-80 cm soil profile (IS) was thus calculated for the BP and SP sites on an annual basis (Fig. 12 and Appendix E. Supplementary material). Input-output budgets were then computed (Ranger and Turpault, 1999) at both sites according to two scenarios (Fig. 12 and Appendix E. Supplementary material):

- Input-Output **W** = R + W – Up – DL
- Input-Output **IS** = R + IS – Up – DL

where R is the wet atmospheric deposition flux ($kg.ha^{-1}.yr^{-1}$), W the weathering flux ($kg.ha^{-}.yr^{-1}$), IS is the intrinsic flux of nutrients from the soil estimated from the leaching experiments ($kg.ha^{-}.yr^{-1}$), Up is the net uptake flux by trees ($kg.ha^{-1}.yr^{-1}$) and DL is the drainage losses at the bottom of the soil profile ($kg.ha^{-1}.yr^{-1}$). R, W, Up and DL fluxes are presented in Beaulieu et al. (2020). The W flux was estimated using a model only considering the release of nutrients from primary mineral dissolution, while the IS flux corresponds to the combination of several nutrient sources in soils (weathering of soil minerals, contribution of non-crystalline secondary minerals, mineralization of organic matter, etc.), corrected for the value of the initial exchangeable available. The conditions during the leaching experiment (pH=3.5, permanent water saturation) were more drastic/aggressive than those in the field, and the actual in situ flux that may supply the pools of exchangeable nutrients is probably lower than the IS flux estimated from the ex situ leaching experiments. Nevertheless, we may hypothesize that this in situ flux lies between the W flux and the IS flux for Ca, Mg and K.

Unsurprisingly, the IS flux is null for Ca at the two sites (Fig. 12 and Appendix E. Supplementary material) because the quantities of calcium released during the leaching experiment for the entire soil profile are lower than the initial quantity of Ca adsorbed on the

CEC, leading to negative input-output budgets for Ca regardless of the scenarios (Input-Output **W** and Input-Output **IS**). For Mg and K, the IS flux is higher than the W flux and the input-outputs budgets are negative when computing the budget with the W fluxes (input-output **W**), while they are almost balanced for Mg and largely positive for K when computing the budget with the IS fluxes (Fig. 12 and Appendix E. Supplementary material).

These results and the relatively high contents of exchangeable Ca in the topsoil at the two sites suggest that tree nutrition for Ca is mainly based on deposition and biological cycling in the Strengbach catchment. This is also true for Mg and K but to a lesser extent since the soil seems to still have the capacity to supply the exchangeable pools and balance the input-output budgets. In base-poor forest ecosystems, atmospheric deposits are a significant source of K, Mg or Ca (Clergue, 2015; Cole, 1986; van der Heijden et al., 2013; Pierret et al., 2019; Turpault, Calvaruso, and Dincher, 2019), and the biological cycling of nutrients (root uptake, litterfall, decomposition) plays an essential role in maintaining nutrients within the plant-soil system (Ranger et Turpault, 1999, Legout et al., 2020). Disturbances of biological cycling through harvesting and biomass exportation at the Strengbach catchment may thus rapidly threaten the sustainability of these ecosystems (Legout et al., 2020) and forest management has to consider this weakness by limiting biomass exportation and avoiding slash removal, unless a nutrient compensation is planned (i.e., liming, fertilization). A recent study also showed that the atmospheric inputs of calcium were reduced by 40% under spruces (from 15 to 9 $kg \cdot ha^{-1}\ yr^{-1}$) and by 70% under beeches (from 6 to 2 $kg \cdot ha^{-1} yr^{-1}$) over the period 1986-2012 at the Strenghbach, which constitutes an additional pressure on these ecosystems and questions their sustainability (Pierret et al., 2019).

6. Conclusion

The objective of this study was to characterize the sources of nutrient cations (Na, K, Mg and Ca) in the soils of the Strengbach and to assess the potential contribution of these chemically poor soils to tree nutrition. We designed laboratory batch experiments and performed acid leaching to mimic the processes taking place in nature, but simplified, enabling a fine control of key parameters (type of acid, pH, time, etc.). Combining mineralogical, chemical and isotopic analyses with modelling approaches allowed for different test scenarios to assess the capacity of these soils to release nutrient cations over time.

The results showed contrasting patterns for Na, K, Mg and Ca. The release of Mg in solution results from a mixing between cationic exchange, mineral dissolution (mainly smectite) and organic matter mineralization (especially in topsoils). The release of K in solution is high and systematically underestimated in our numerical simulations: this result may be attributed either to an unknown source of K (e.g., organic matter, unknown mineral phases or more likely interlayer K) or to an overestimation of the simulated precipitation rate of K-bearing secondary phases. The release of Na in solution is mainly controlled by albite dissolution, with differences between the two sites related to the contrasting geological history of the parent materials. The Sr isotopic approach, used as a proxy to identify the sources of Ca, show that the exchangeable complex supplies nutrients first and rapidly to the solution, followed by the clay compartment and at the very end, the bulk soils, which can control the Sr isotopic signature especially in deep horizons of the spruce plot. However, the release of Ca in solution during the experiment is quite low compared to the Na, Mg and K and results almost exclusively from the progressive desaturation of the CEC. Interestingly, our results also suggest that the exchangeable Ca in soils of the Strengbach catchment is only partially available for plants, due to strong chemical binding with organic matter and/or the occurrence of Ca-chemical bridges between clay and organic matter.

In a practical way, this study shows that soil intrinsic fluxes of Na, Mg and K (i.e., weathering, mineralisation of OM etc.) in the Strengbach catchment may replenish the soil exchangeable pools and could thus contribute to tree nutrition in the mid- to the long-term. For Ca, soil intrinsic flux seems nonexistent or extremely low, and tree nutrition must rely on the current bioavailable pool in the short term, and on atmospheric deposition and biological cycling in the long term. This is also true for the other nutrient cations, but to a lesser extent since soil intrinsic fluxes are not null and may thus significantly contribute to tree nutrition. In the topsoil, the exchangeable reservoir contains the largest proportion of total Ca illustrating the low content of Ca in these soils and the important role of biological cycling and organic matter for this nutrient.

Sustainable management should consider the fact that exchangeable Ca, conventionally determined, does not necessarily provide an accurate picture of the real availability of Ca and therefore of the fertility of soils, with a risk of overestimation of nutrient reservoirs for trees. These results are particularly important in soils with naturally low Ca content. In these ecosystems, efficient recycling through biological cycling is of paramount importance to maintain nutrients within the plant-soil system. Harvesting and biomass exportation may rapidly impact the biological cycle and threaten the sustainability of these ecosystems, similar to changing tree species that may influence the nature of the litter, its turnover and the input of nutrients to the soil.

Appendix A. Supplementary material: Mineral and chemical composition of soils.

	Depth	Kaolinite	Illite	Vermiculite	Smectite	Muscovite	Biotite	Quartz	Orthose	Albite	OM
	cm	%	%	%	%	%	%	%	%	%	%
Beech Plot	0-5	1.4	22.0	1.3	5.2	5.7	0.6	8.3	9.6	6.5	39.4
(BP)	5-10	1.5	10.0	0.0	5.3	8.8	0.8	21.3	27.6	17.5	7.2
	10-20	1.1	7.8	1.3	4.8	10.8	0.7	18.9	25.8	21.4	7.5
	20-40	0.8	6.8	3.7	4.2	15.0	0.6	19.6	21.0	24.0	4.4
	40-60	1.4	6.4	2.5	3.5	20.4	0.6	13.8	23.5	24.0	3.9
	60-80	1.1	4.6	1.2	1.7	20.5	1.1	22.1	19.4	25.5	2.8
Spruce Plot	0-5	1.5	20.1	0.4	8.5	4.7	0.0	16.0	6.6	3.3	39.1
(SP)	5-10	0.5	10.7	0.0	7.7	14.4	0.8	38.9	7.7	5.3	14.0
	10-20	0.2	8.9	0.0	6.1	22.6	0.8	39.4	11.6	6.6	3.7
	20-40	0.2	8.6	1.3	9.3	20.9	0.0	32.9	20.0	4.5	2.2
	40-60	0.2	9.2	1.1	7.3	22.3	0.0	37.8	12.9	7.9	1.3
	60-80	0.1	7.3	1.1	7.5	17.6	0.0	39.0	15.4	11.0	1.0

Mineral composition of soils from beech and spruce plots, calculated from XRD analyses on bulk soils and clays, and from organic matter content.

	Depth	Si	Al	Na	K	Mg	Ca	Sr	$^{87}Sr/^{86}Sr$	err (2σ)
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g		
Bulk soil	***initial***									
Beech Plot	0-5	167484.2	21760.4	7403.8	21874.5	1218.1	1129.2	31.3	0.789114	0.000014
(BP)	5-10	290935.4	36936.8	13234.8	39324.3	1791.0	886.2	45.5	0.806601	0.000016
	10-20	297900.2	39125.3	13516.7	41906.0	1990.0	857.6	46.7	0.809622	0.000012
	20-40	303322.6	40615.2	13791.2	41731.7	1971.9	836.2	48.3	0.806266	0.000012
	40-60	303649.8	40628.4	13131.0	41698.5	1965.9	821.9	43.7	0.811786	0.00001
	60-80	295843.5	44960.4	14829.8	40619.3	2538.8	1114.9	43.1	0.809955	0.000026
Spruce Plot	0-5	182302.0	20087.9	2099.5	18902.5	1779.0	793.3	35.4	0.757335	0.000014
(SP)	5-10	292945.4	33353.8	3227.1	31363.1	2804.1	328.8	53.9	0.764484	0.000012
	10-20	332911.6	33925.4	3256.8	34401.5	2749.9	364.5	51.2	0.764455	0.00001
	20-40	310427.7	43293.2	4399.2	39996.7	3533.8	285.9	76.2	0.764404	0.000014
	40-60	314681.4	43306.4	4614.4	41798.1	3419.2	321.6	72.4	0.768632	0.000016
	60-80	315429.3	44015.7	4725.7	42537.0	3485.6	414.5	73.8	0.768716	0.000012
Clays										
Beech Plot	0-5	56465,0	11010.9	2477.7	8228.3	867.3	286.4	15.7	0.771566	0.000004
(BP)	5-10	40678.6	11351.4	1081.8	7076.5	1032.4	103.3	7.2	0.83199	0.000003
	10-20	28663.5	8674.4	682.1	5035.7	809.6	59,0	4.3	0.845975	0.000004
	20-40	32285.2	10833.9	205.8	7032,0	1213.3	33.2	5,0	0.848006	0.000006
	40-60	24590,0	8604.9	617.3	4211.3	727.3	46.4	3.9	0.8329	0.000004
	60-80	14431.8	5515,0	376.4	2375.2	457.9	33.2	2.2	0.825962	0.000004
Spruce Plot	0-5	52236.7	12950.4	753.3	9612.6	1354.8	210.7	21.9	0.751935	0.000004
(SP)	5-10	43272.1	12578.7	399.6	9236.6	1367.7	72.9	12.7	0.745304	0.000007
	10-20	30225.1	9755.4	189.4	6771,0	1100.9	32.6	5,0	0.836336	0.000003
	20-40	37618,0	12071.4	866.5	6565.8	1116,0	78,0	5.9	0.84285	0.000003
	40-60	36385.3	12162.2	216.6	7837.6	1378.3	38.2	5.2	0.857096	0.000003
	60-80	33453.8	11263.9	198.2	7269.5	1277.5	36.6	4.8	0.862445	0.000003
Exch Initial		*Si*	*Al*	*Na*	*K*	*Mg*	*Ca*	*Sr*	*87Sr/86Sr*	err (2σ)
Beech Plot	0-5	12.4	505.45	16.81	286.59	104.88	619.21	2.64	0.723266	0.000004
(BP)	5-10	6.6	558.52	6.16	73.11	19.57	62.12	0.29	nd	nd
	10-20	5.4	633.17	4.9	46.14	9.31	20.44	0.14	0.726888	0.000003
	20-40	14,00	803.15	6.16	34.41	5.27	14.35	0.09	nd	nd
	40-60	17.8	422.71	5.77	17.83	2.27	9.56	0.06	0.728579	0.000002
	60-80	25,00	241.04	5.03	12.04	1.26	5.77	0.08	nd	nd
Spruce Plot	0-5	13.6	496.46	24.6	301.45	127.6	663.29	2.74	0.724128	0.0000069
(SP)	5-10	7.6	587.3	7.77	84.84	30.26	138.67	0.57	nd	nd
	10-20	2.8	688.93	7.26	44.18	10.89	40.08	0.26	0.72737087	0.00002
	20-40	8.4	803.15	4.69	38.2	6.03	32.86	0.12	nd	nd
	40-60	9.2	774.37	5.13	37.42	3.71	18.22	0.1	0.736045	0.00002
	60-80	10.2	702.42	3.91	39.49	3.17	14.11	0.09	nd	nd
Exch Final										
Beech Plot	0-5	5.82	449.69	11.36	95.79	62.46	444.87	3.35	0.726558	0.00002
(BP)	5-10	3.98	453.29	22,00	130.98	11.39	35.27	0.77		
	10-20	4.66	513.55	17.86	108.3	8.12	16.63	0.56	0.778818	0.00004
	20-40	5.98	429.01	13.27	98.53	5.27	8.82	0.49		
	40-60	9.38	254.53	9.26	66.47	2.78	6.39	0.43	0.7446	0.00002
	60-80	11.18	154.69	9.08	60.6	2.78	6.67	0.35		
Spruce Plot	0-5	6.36	572.01	5.89	141.54	109.62	569.11	4.71	0.726483	0.000003
(SP)	5-10	4.58	657.45	10.12	176.72	33.66	112.22	1.62		
	10-20	4.54	570.21	9.47	191.58	19.32	18.64	1.16	0.753777	0.00002
	20-40	6.6	671.84	6.87	190.41	14.22	13.15	0.79		
	40-60	8.56	603.49	7.22	201.36	16.28	8.62	0.84	0.762804	0.00004
	60-80	10.3	517.15	9.68	248.27	21.27	10.04	0.97		
Bulk soil	***Final***									
Beech Plot	0-5	180619.3	23888.0	7774.7	25078.9	1266.4	1107.8	29.6	0.797721	0.000012
(BP)	5-10	301873.5	36952.7	13442.5	40652.5	1670.4	886.2	42.8	0.807514	0.000012
	10-20	305379.3	38934.8	13049.4	41308.3	1917.7	814.8	44,0	0.812608	0.000008
	20-40	309679.8	41276.7	13405.5	41789.8	2086.5	850.5	44.8	0.81377	0.000014
	40-60	302855.1	41917.1	12849.1	40445.0	2195.1	829.0	41.6	0.814216	0.000008
	60-80	300424.4	43817.2	14221.5	40395.2	2382.0	1000.6	42.7	0.816388	0.000012
Spruce Plot	0-5	190716.0	21850.4	2255.3	19575.0	1917.7	807.6	33.6	0.764611	0.000038
(SP)	5-10	290234.2	34195.3	3368.1	32093.6	2846.4	307.3	54.6	0.765714	0.00001
	10-20	323375.8	35931.3	3115.8	35098.8	3015.2	214.4	51.5	0.771332	0.000004
	20-40	303883.5	44148.0	4236.0	40420.1	3678.6	250.1	65,0	0.772802	0.00001
	40-60	308651.4	43703.4	4109.9	41922.6	3576.0	271.6	59.1	0.778583	0.000026
	60-80	307295.8	44457.6	4658.9	42296.2	3612.2	364.5	66.8	0.774415	0.00001
Cumul Leach										
Beech Plot	0-5	2734.9	1318.61	53.42	721.6	139.91	161.08	0.8	0.764283	0.00002
(BP)	5-10	3802.07	1882.27	118.32	727.25	133.31	45.38	0.48	nd	nd
	10-20	3097.11	1571.13	112.29	612.38	105.63	19.75	0.37	0.826984	0.00004
	20-40	970.15	431.98	91.77	326.99	26.18	14.26	0.23	nd	nd
	40-60	582.85	315.81	75.95	267.1	16.38	11.41	0.19	0.85638	0.00003
	60-80	491.69	305.42	66.36	268.29	15.22	9.46	0.21	nd	nd
Spruce Plot	0-5	3393.17	1647.26	36.92	843.55	128.01	74.26	0.52	0.763848	0.00004
(SP)	5-10	4627.06	2444.36	50.04	1099.15	167.92	66.02	0.68	nd	nd
	10-20	3406.41	1640.92	56.59	918.21	110.49	27.02	0.62	0.760167	0.00002
	20-40	769.93	184.3	41.67	441.7	20.91	20.75	0.34	nd	nd
	40-60	749.09	148.82	41.95	475.91	18.21	17.63	0.34	0.779635	0.00004
	60-80	796.28	146.34	46.77	509.44	17.74	17.33	0.36	nd	nd
Organic matter										
Beech Plot	0-5	21673.19	3270.9	938.6	2789.02	300.5	937.63	7.51		
(BP)	5-10	3975.0	599.9	172.15	511.52	55.11	171.97	1.38		
	10-20	4164.28	628.47	180.34	535.88	57.74	180.16	1.44		
	20-40	2460.71	371.37	106.57	316.66	34.12	106.46	0.85		
	40-60	2176.78	328.52	94.27	280.12	30.18	94.17	0.75		
	60-80	1514.28	228.53	65.58	194.87	21.0	65.51	0.52		
Spruce Plot	0-5	6123.89	777.49	83.37	826.94	208.02	1346.29	3.57		
(SP)	5-10	2175.59	276.21	29.62	293.78	73.9	478.29	1.27		
	10-20	590.9	75.02	8.04	79.79	20.07	129.91	0.34		
	20-40	349.17	44.33	4.75	47.15	11.86	76.76	0.2		
	40-60	214.87	27.28	2.93	29.02	7.3	47.24	0.13		
	60-80	161.15	20.46	2.19	21.76	5.47	35.43	0.09		

943

944 Chemical compositions (expressed in µg/g of soil) for initial and final (after experimentation)
945 bulk soils, compared with the contribution of different reservoirs as clay minerals, initial and
946 final exchangeable pool, organic matter as total cumulated experimental leachate calculated for
947 1 g of soil.
948
949 **Appendix B. Supplementary material. Composition of leaching solutions**
950
951 Mean chemical composition and standard deviation (SD) from the three triplicates of the
952 leaching solution at the eleven time-step of each experiment (see Table 1). Chemical
953 compositions are expressed in µg/g of soil. *Data are provided as the excel file containing all*
954 *tables, the table is too big to be copy directly in this document.*
955
956 **Appendix C. Supplementary material.** Stock of Ca, Mg, Na and K

Plot	Depth	Ca	Mg	Na	K	Plot	Depth	Ca	Mg	Na	K
-	*cm*	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}	-	*cm*	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}
Bulk soils						**Clays**					
Beech Plot	00-05	362	391	2375	7017	Beech Plot	00-05	92	278	795	2640
(BP)	05-10	284	575	4246	12615	(BP)	05-10	33	331	347	2270
	10-20	550	1277	8672	26886		10-20	38	519	438	3231
	20-40	1285	3029	21187	64112		20-40	51	1864	316	10803
	40-60	1013	2423	16183	51389		40-60	57	896	761	5190
	60-80	1226	2793	16313	44682		60-80	37	504	414	2613
Spruce Plot	00-05	170	381	450	4050	Spruce Plot	00-05	45	290	161	2059
(SP)	05-10	70	601	691	6719	(SP)	05-10	16	293	86	1979
	10-20	156	1178	1395	14740		10-20	14	472	81	2901
	20-40	341	4220	5253	47760		20-40	93	1333	1035	7840
	40-60	423	4494	6065	54937		40-60	50	1812	285	10301
	60-80	429	3604	4886	43982		60-80	38	1321	205	7516
Ini Exch						**OM**					
Beech Plot	00-05	199	34	5	92	Beech Plot	00-05	614	88	32	288
(BP)	05-10	20	6	2	23	(BP)	05-10	112	16	6	53
	10-20	13	6	3	30		10-20	234	34	12	110
	20-40	22	8	9	53		20-40	328	47	17	154
	40-60	12	3	7	22		40-60	233	34	12	110
	60-80	6	1	6	13		60-80	150	21	8	70
Spruce Plot	00-05	142	27	5	65	Spruce Plot	00-05	1422	37	8	117
(SP)	05-10	30	6	2	18	(SP)	05-10	509	13	3	42
	10-20	17	5	3	19		10-20	269	7	2	22
	20-40	39	7	6	46		20-40	446	12	2	37
	40-60	24	5	7	49		40-60	290	7	2	24
	60-80	15	3	4	41		60-80	176	5	1	14
Final Exch											
Beech Plot	00-05	143	20	4	32						
(BP)	05-10	12	3	7	41						
	10-20	10	5	12	70						
	20-40	13	8	18	147						
	40-60	7	3	9	75						
	60-80	6	2	12	69						
Spruce Plot	00-05	122	23	1	30						
(SP)	05-10	24	7	3	37						
	10-20	8	9	3	85						
	20-40	17	17	9	225						
	40-60	11	22	11	255						
	60-80	11	18	8	262						

Evaluation of the stock of Ca, Mg, Na and K in bulk soil, and in the different reservoirs: initial and final exchangeable cations, clays, and organic matter in each soil layer (expressed in kg/hectare). This calculation considers the proportion of these different reservoirs inside the bulk soils.

Appendix D. Supplementary material: Evaluation and calculation of stocks available and leaching flux in Strengbach soils. *Fluxes and input-output budgets*

- Calculation of the total stock and the exchangeable stock expressed in kg/ha:

Element inventories are evaluated in the total soil and in the exchangeable phase based on the concentrations previously measured for each horizon studied. These inventories are expressed in $kg \cdot ha^{-1}$.

The leaching experiments were carried out with the fraction of the soil f< 2 mm, thus this fraction is used for the calculations:

$$m_{total\ horizon} \times f_{<2mm} = m_{f<2mm} \quad (6\text{-}1)$$

Each horizon has a defined surface area S of 2 m² and a thickness e (5,10 or 20 cm), which give the mass per unit of volume:

$$\rho_{f<2mm} = \frac{m_{f<2mm}}{V_{horizon}} = \frac{m_{f<2mm}}{S \times e} \quad (6\text{-}2)$$

This density is then used to determine the stocks available on a full hectare (10,000 m²). A horizon with a thickness *e* and with a surface area of 1 ha is considered. The stock for each chemical element i (expressed in $kg \cdot ha^{-1}$) was calculated with the elemental concentration Ci.

$$Stocki_{f<2mm} = Ci_{f<2mm} \times 10000 \times e \times \rho_{f<2mm} \quad (6\text{-}3)$$

The stocks were calculated for the bulk soil and for the exchangeable pool from the concentration in bulk soil and exchangeable fraction respectively.

This calculation is performed for each element and for each horizon of the two plots. To simplify certain calculations, the total stock in the entire profile is also used, which is expressed as the sum of the stocks of each horizon:

$$Stock_{total} = \sum Stock_i \quad (6\text{-}4)$$

- Calculation of total leached concentration expressed in kg/ha:

The same equation is used to calculate the total amount *A* of element leached during the experiment for one ha:

$$A_{leaching}(kg \cdot ha^{-1}) = C_{cumulative\ leaching}(kg \cdot kg_{soil}^{-1}) \times 10000 \times e \times \rho_{f<2mm} \quad (6\text{-}5)$$

With $C_{cumulative\ leaching}$ the cumulative concentration leached during the 11 steps of the 152 days of experimentation.

- Calculation of the leaching flux:

The leaching flux is calculated from the results of the leaching experiments, for each plot. The leaching experiments were carried out with 5 grams of soil. The time of experiment should be converted in corresponding in-situ field time in order to evaluate the leaching flux for each element in $kg \cdot ha^{-1}\ yr^{-1}$. The idea is to convert the water/material ratio in quantity or duration of rainfall in the site. The mean annual rainfall at the Strengbach catchment is 1400 mm (Pierret et al., 2018). The interception by vegetation is on average 300 mm/yr (Pierret et al., 2019). Thus the annual water flow infiltrating the soil is 1100 mm (1100 $L \cdot m^{-2}$ per year).

During the experiments, a $V_{experimental}$ volume of 440 mL of solution and a $m_{experimental}$ mass of 5 g were used. Thus, for a pit of mass m, the amount of rainfall, noted $V_{equivalent}$ required to leach in the same proportions is:

$$V_{equivalent}(L \cdot m^{-2}) = m_{f<2mm}(kg) \times \frac{V_{experimental}\ (L)}{m_{experimental}(kg)} \times \frac{1}{S(m^2)} \quad (6\text{-}6)$$

The equivalent time ($t_{equivalent}$ in year) corresponding to the experimental condition i.e. 152 days (Table 1) is then:

$$t_{equivalent} = \frac{V_{equivalent}}{V_{rain}} \qquad (6\text{-}7)$$

1005

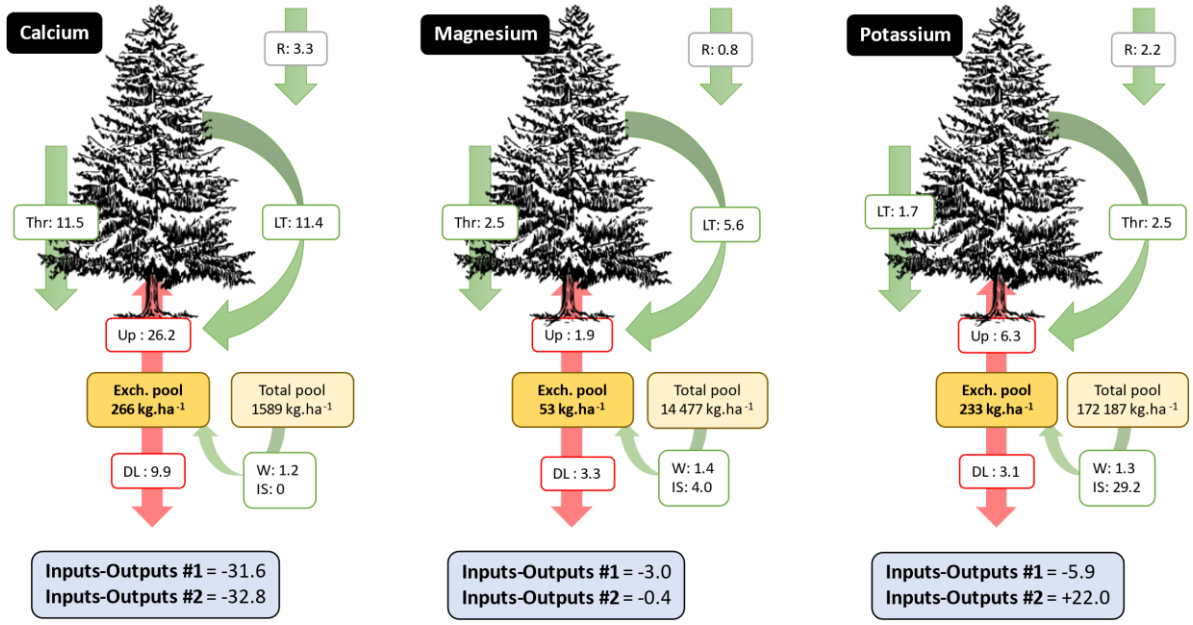
1006 The result obtained give 42 years of rain for experiment with soils from the beech plot and 35
1007 years with soils from the spruce plot. This equivalent time allows to calculate the equivalent
1008 annual leaching flow according to:

$$flux_{leaching}(kg \cdot ha^{-1} \cdot yr^{-1}) = IS = \frac{A_{leaching} - Stock_{exchangeable}}{t_{leaching}} \qquad (6\text{-}8)$$

1009

1010 If the leaching flux is lower than the initial exchangeable pool, then IS is equal to 0 (see figures)

1011



1012

1013 Fluxes and input-output budgets (in $kg.ha^{-1}.yr^{-1}$) for calcium, magnesium and potassium at the
1014 SP site. IS is intrinsic flux from soil estimated from our leaching experiments (corrected for the
1015 value of the initial exchangeable pool). W is the weathering flux, R is the atmospheric wet
1016 deposition, Up is the net uptake flux by roots and DL is the deep leaching (see Beaulieu et al.
1017 2020).

1018

CRediT author statement

Matthias Oursin: Methodology, validation, Investigation, Formal analysis, writing – original draft. **Marie-Claire Pierret**: Conceptualization, validation, Methodology, Investigation, visualization, Project administration, writing – review & editing, Supervision, Funding acquisition, Resources. **Emilie Beaulieu**: Software, Formal analysis, Data curation, Methodology, Writing – review & editing, Supervision. **Damien Daval**: Formal analysis, Methodology, software, Writing – review & editing. **Arnaud Legout:** Conceptualization, Methodology, Writing – review & editing, Supervision, Formal analysis, Resources, Supervision.

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This is an EOST - ITES contribution.

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Figure

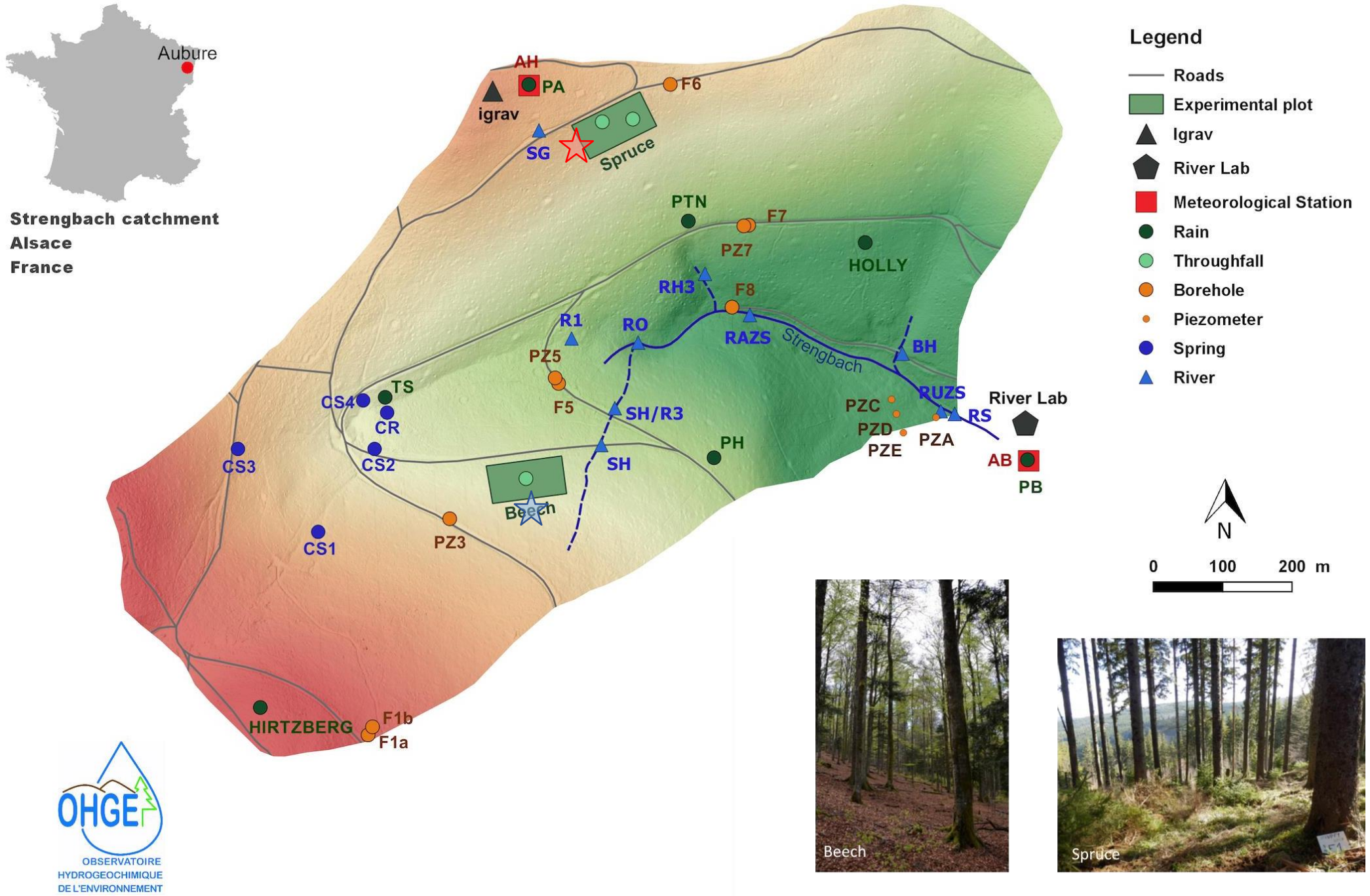


Fig. 1: Strengbach catchment map with different equipment and monitoring stations (see legend). The red star corresponds to the soil pit at the SP site (SP: Spruce plot), and the blue star corresponds to the soil pit at the BP site (BP: beech plot).

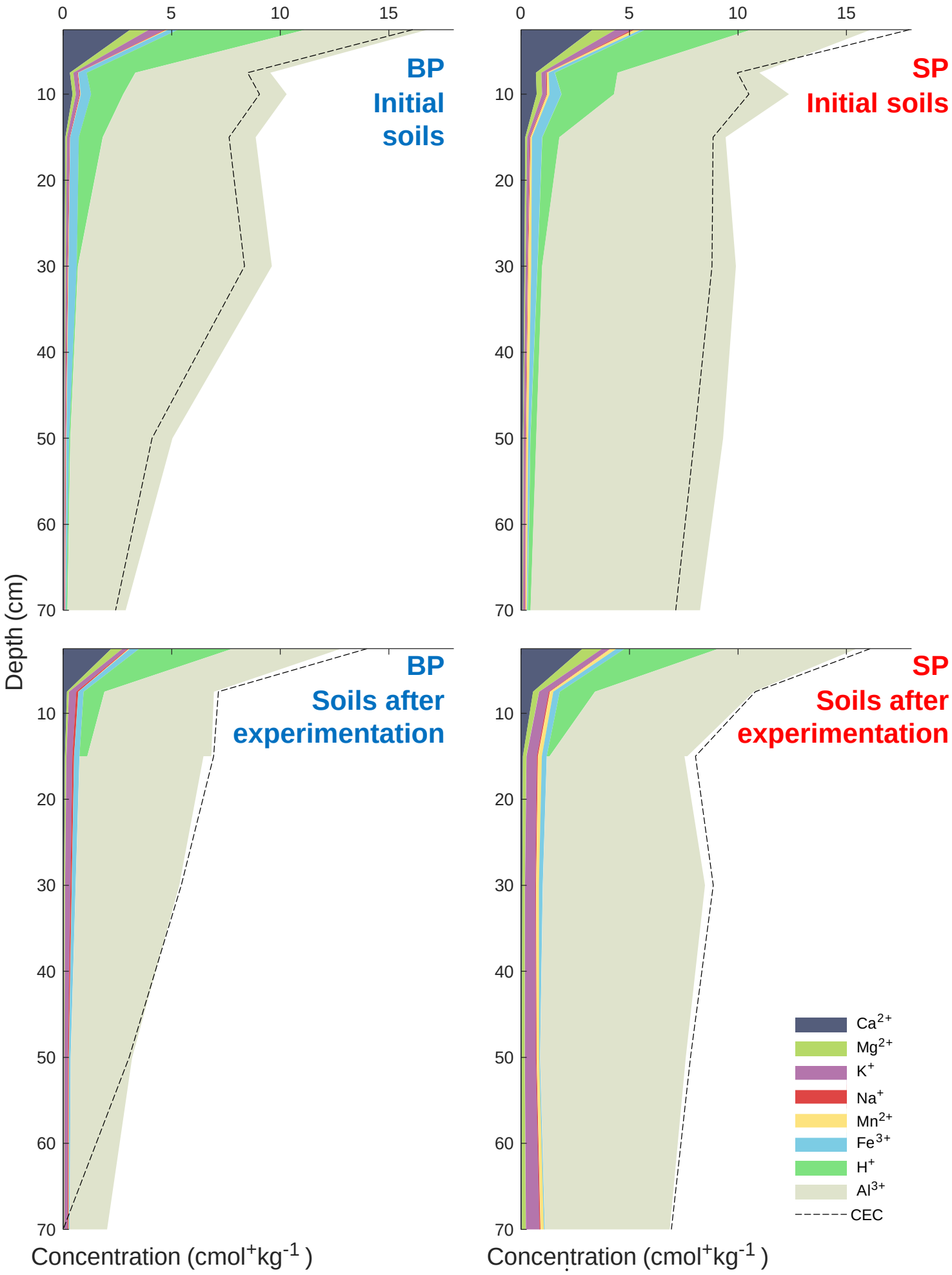


Fig. 2: Composition of the exchangeable phase for both BP (under beech) and SP (under spruce) soils at various depths, in initial soils and in soils after experimentation. Compositions were determined by cobaltihexamine extraction protocol.

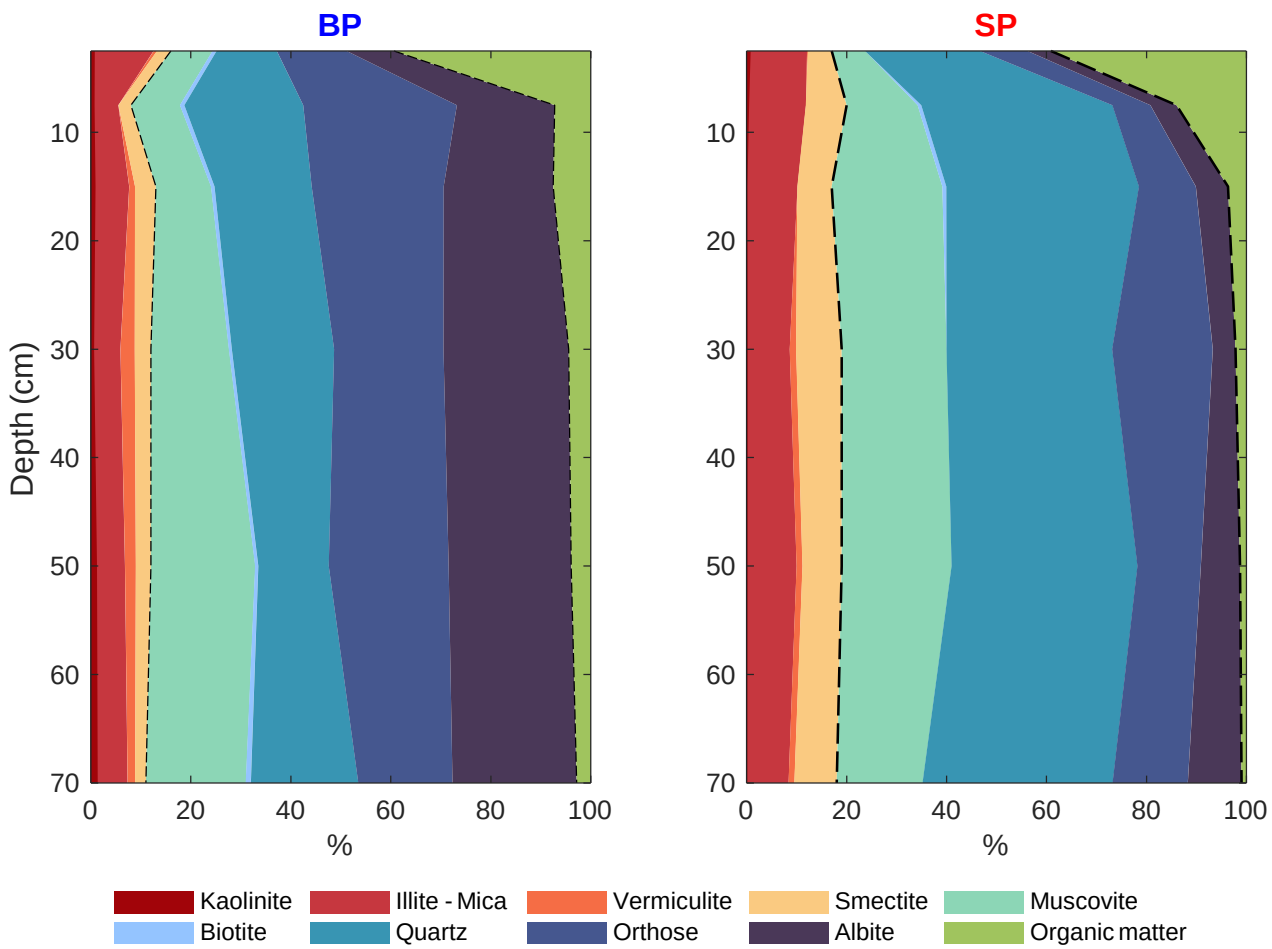


Fig. 3: Mineral composition in % of the soils from BP (left) and SP (right) profiles. Reddish parts correspond to clays, blueish parts correspond to primary minerals and greenish parts to organic matter (data in appendix A - supplementary material).

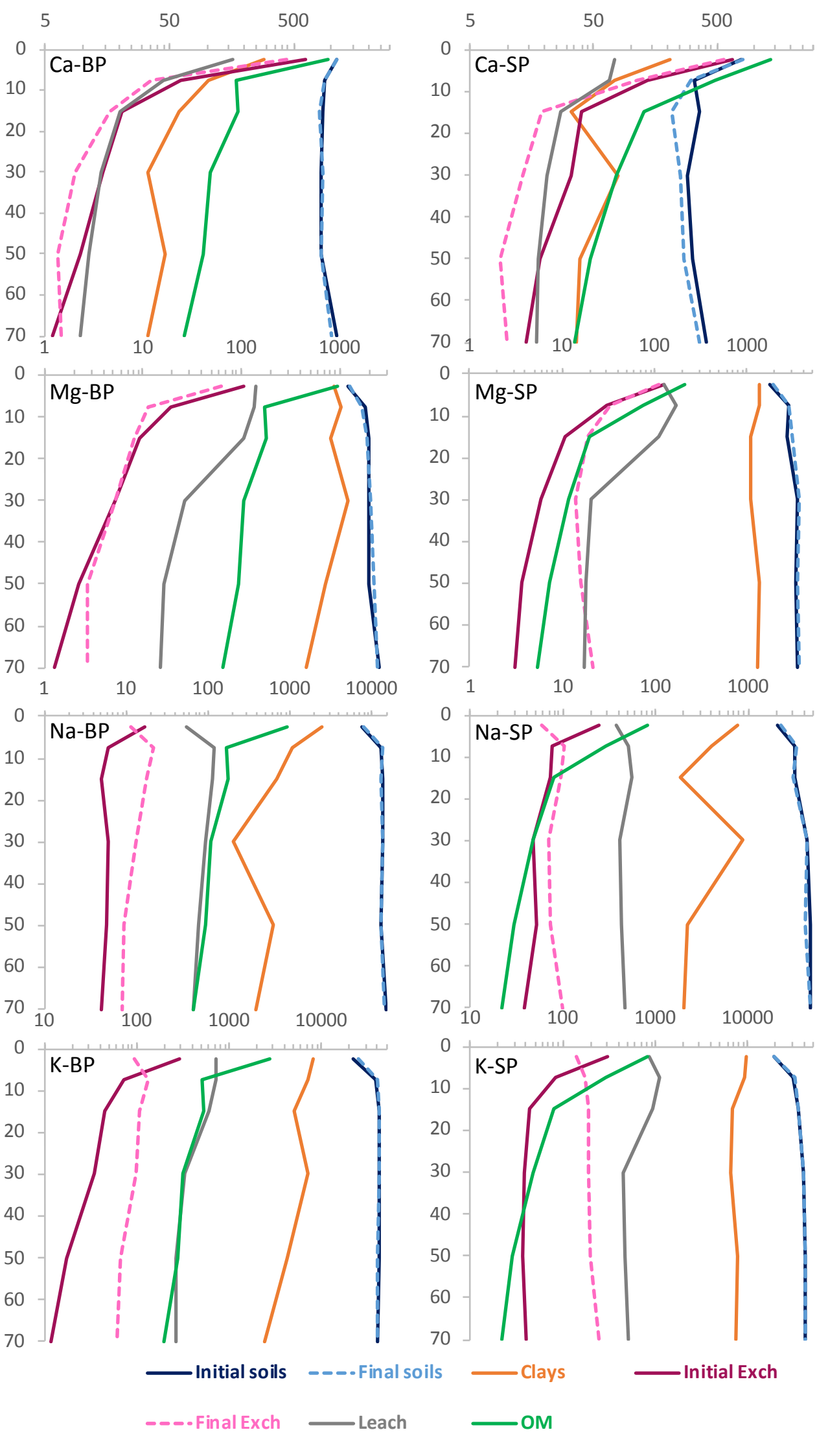


Fig. 4: Variation versus depth of chemical compositions (expressed in µg/g of soil) for initial and final (after experimentation) bulk soils, compare with the contribution of different reservoirs as clay minerals, initial and final exchangeable pool, organic matter as total cumulated experimental leachate calculated for 1 g of soil (see text; Appendix A-Supplementary material) for two sites: BP-Beech Plot and SP-Spruce Plot.

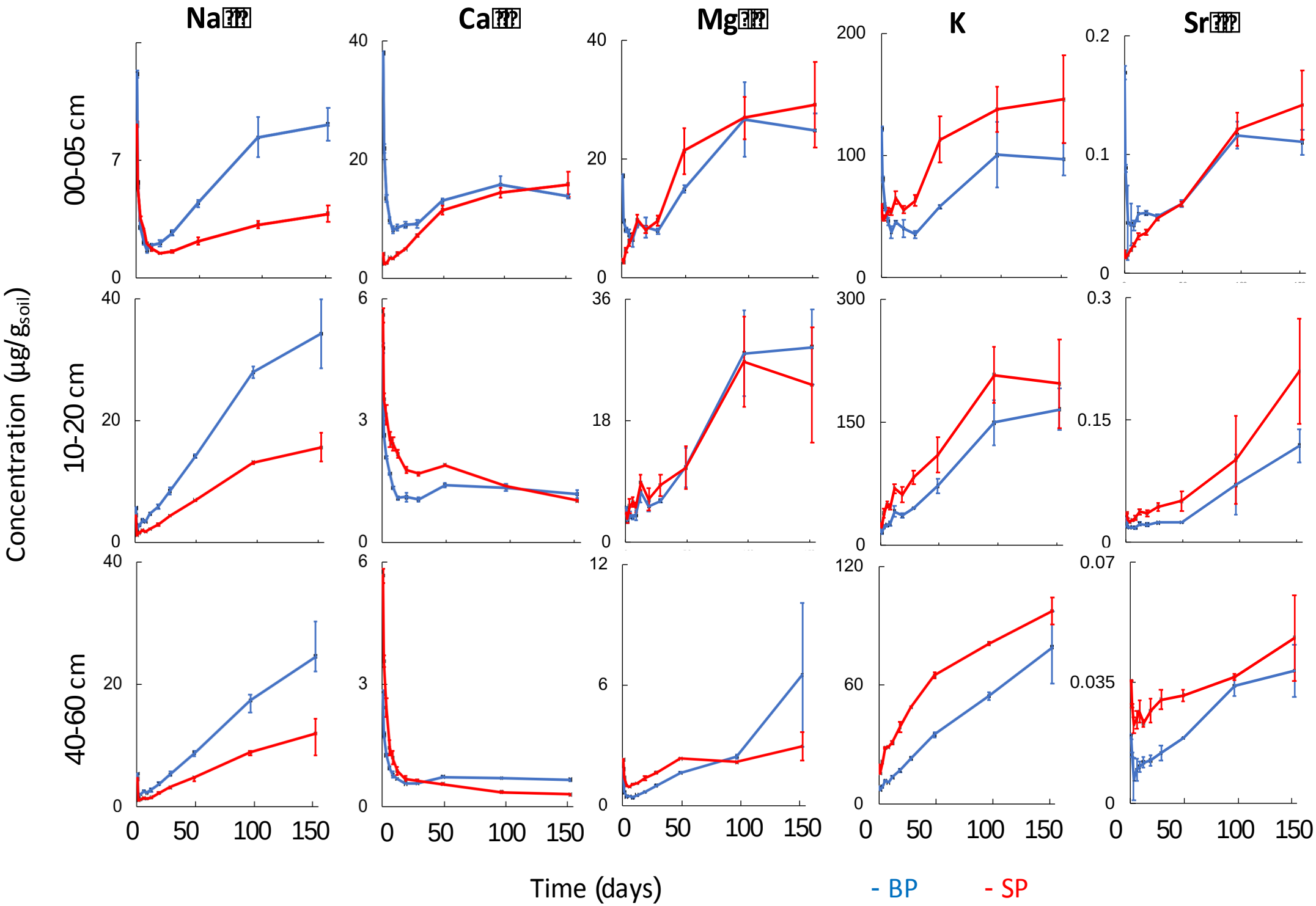


Fig. 5: Na, Ca, Mg, K and Sr concentrations leached over time for experiments conducted with soils from three different depths (00:05; 10-20 cm; 40-60 cm). Concentrations are expressed in µg of element per g of soil. The concentrations for the BP and SP profiles are in blue and red, respectively. The symbols represent the average concentrations from triplicate measurements and the vertical bars indicate the standard deviation.

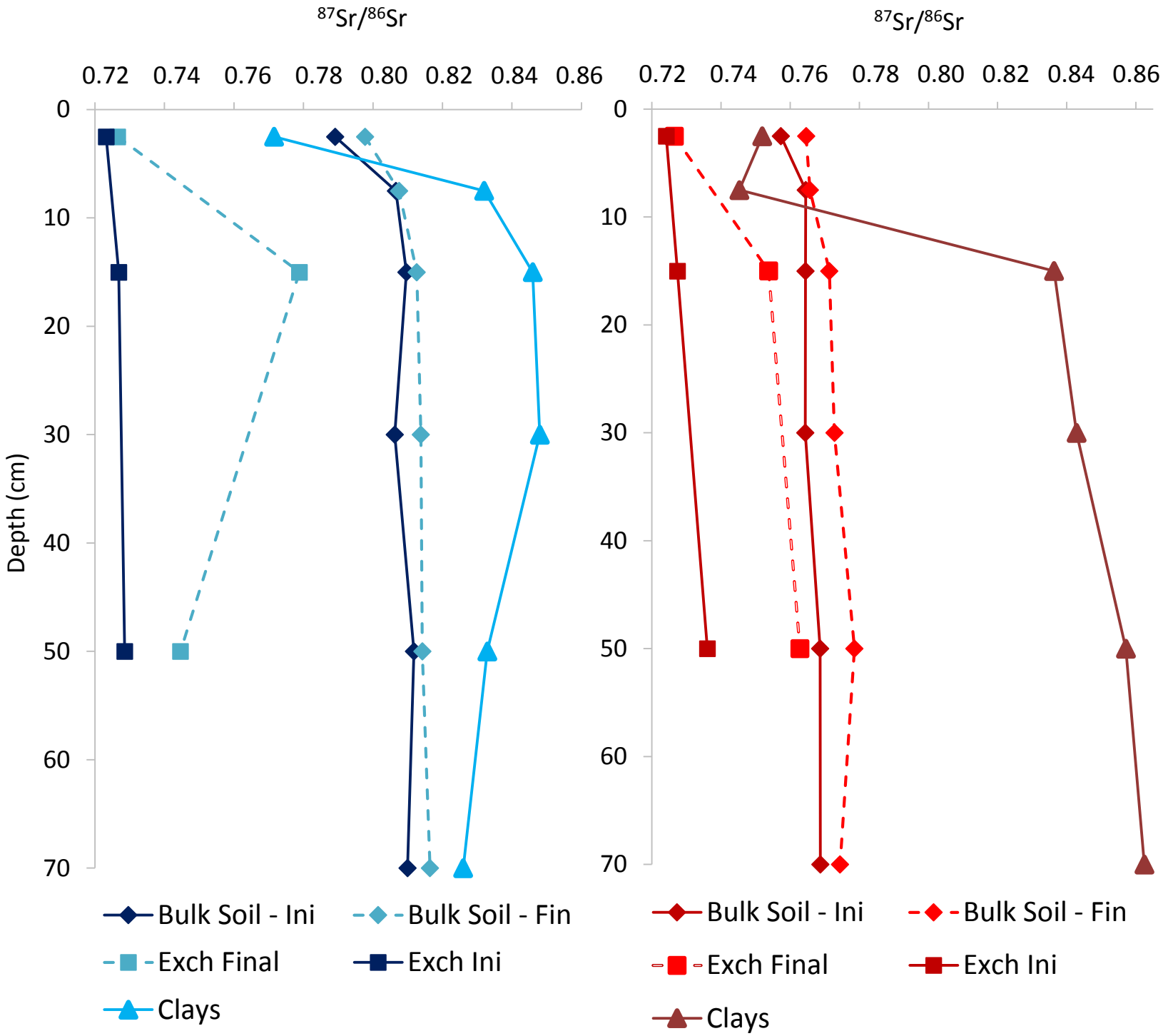


Fig. 6: Evolution versus depth of the isotopic ratio $^{87}Sr/^{86}Sr$ of the clays, the bulk soils and the exchangeable fraction (Exch.) before (Ini) and after leaching (Final) in the BP profile (left) and the SP profile (right).

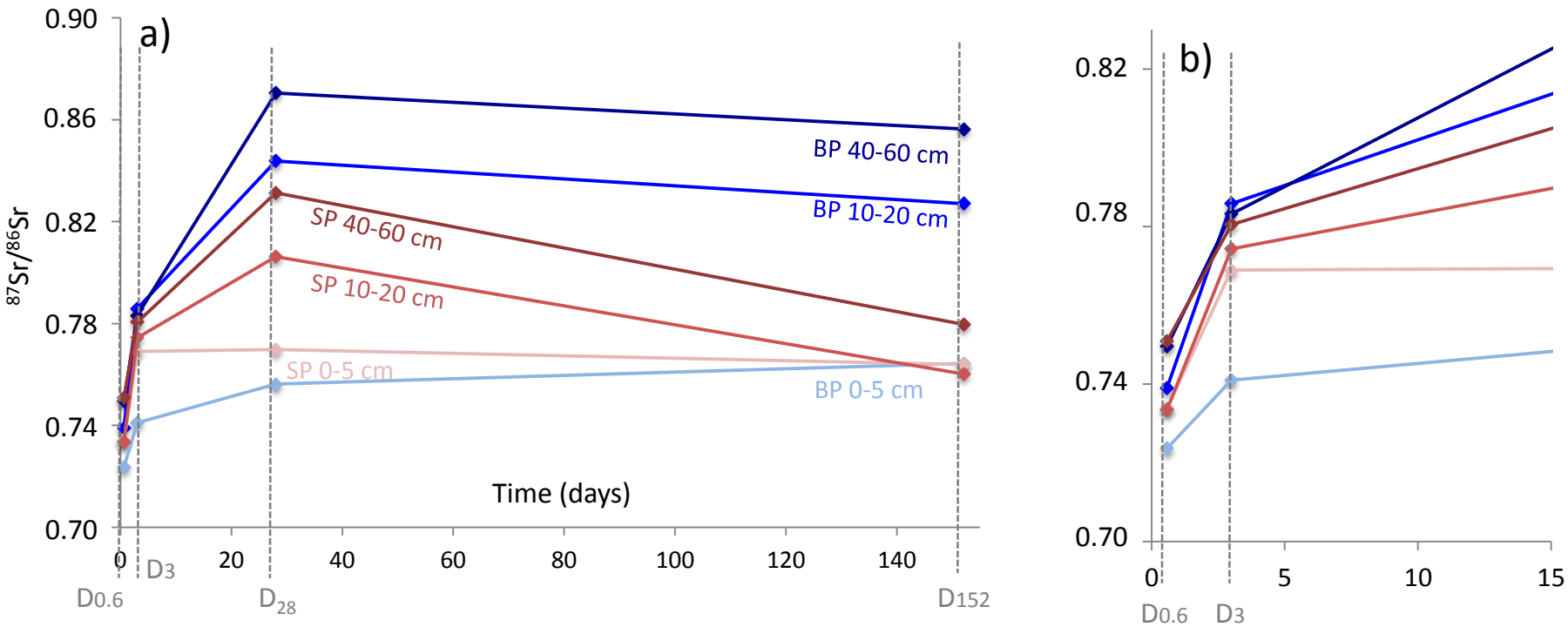


Fig. 7: Variation of the $^{87}Sr/^{86}Sr$ isotopic ratios versus time for experimental BP and SP leached solutions a) at 4 steps $D_{0.6}$ (14 h), D_3 (3 days), D_{28} (28 d) and D_{152} (152 d) and b) with a zoom for the first 15 days, for 3 different soil horizons (0-5 cm; 10-20 cm and 40-60 cm)

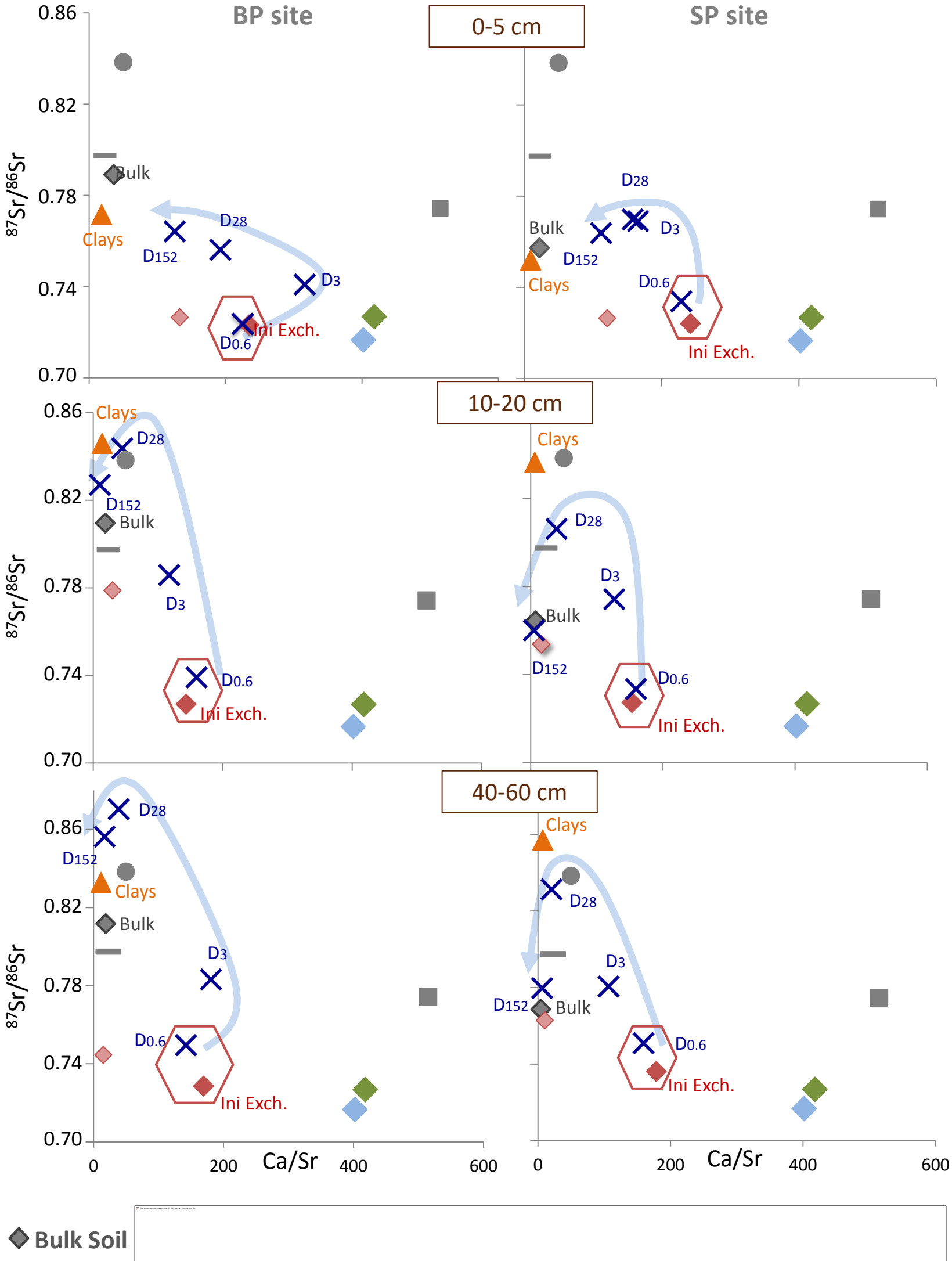


Fig. 8: $^{87}Sr/^{86}Sr$ isotopic ratio versus Ca/Sr ratios (mass ratio) for the different end-members (defined in text), and the exchangeable fraction in initial and final soils. The leached solutions obtained during the experiment at four different time steps $D_{0.6}$ (14 h-0.6d), D_3 (3 days), D_{28} (28 d) and D_{152} (152 d) (see Table 1) are represented by the dark blue cross and for soils at three representative horizons (0-5 cm; 10-20 and 40-60 cm). The signatures of bulk soil and clay are specific for each corresponding depth. Granite and primary mineral signatures are from Aubert et al., (2002). BP (under beech) and SP (under spruce) represent the two studied plots.

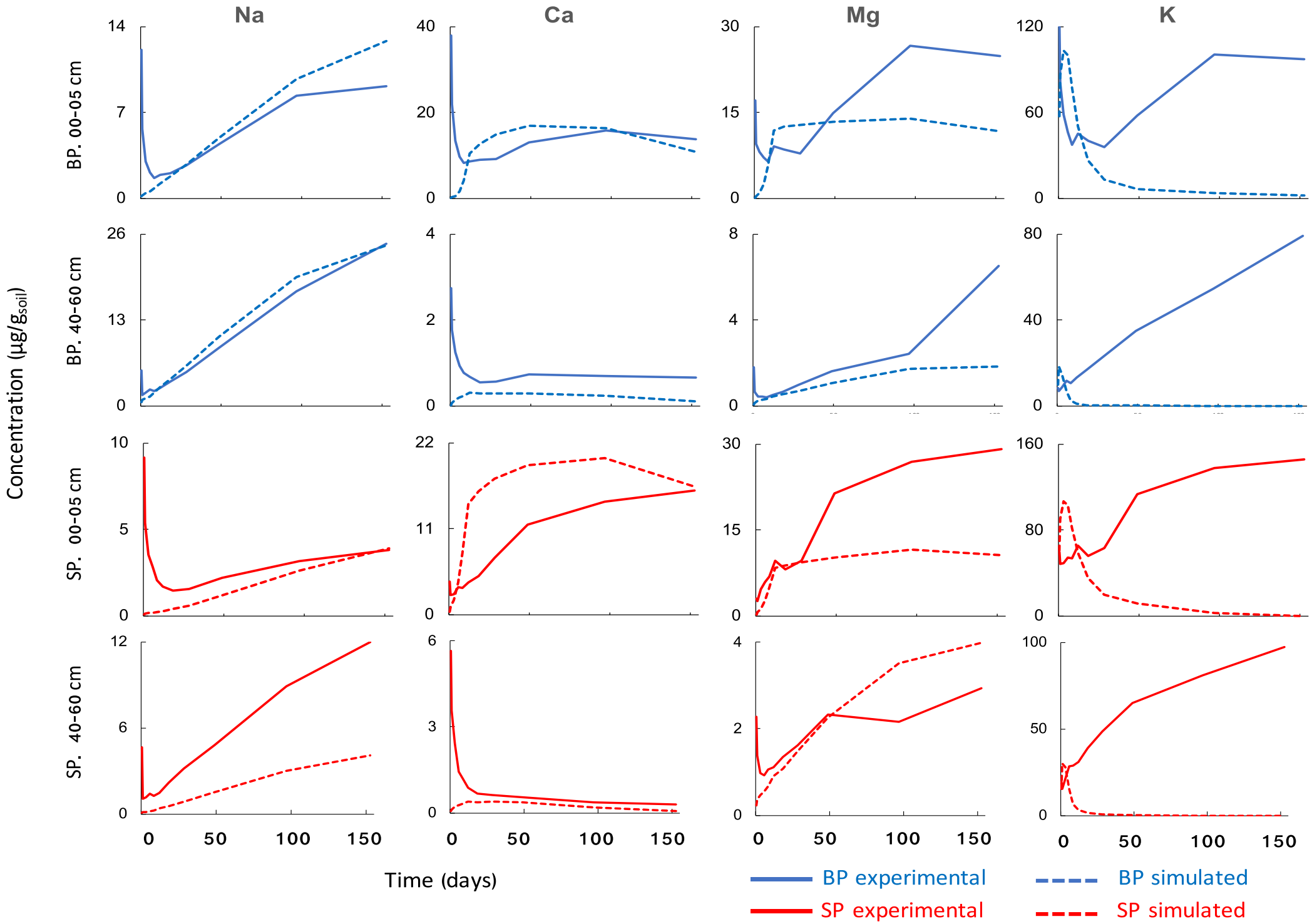


Fig. 9: Simulated and experimental concentrations for two different depths (00-05 cm & 40-60 cm) and for the two profiles (BP in blue and SP in red) for Na, Ca, Mg and K.

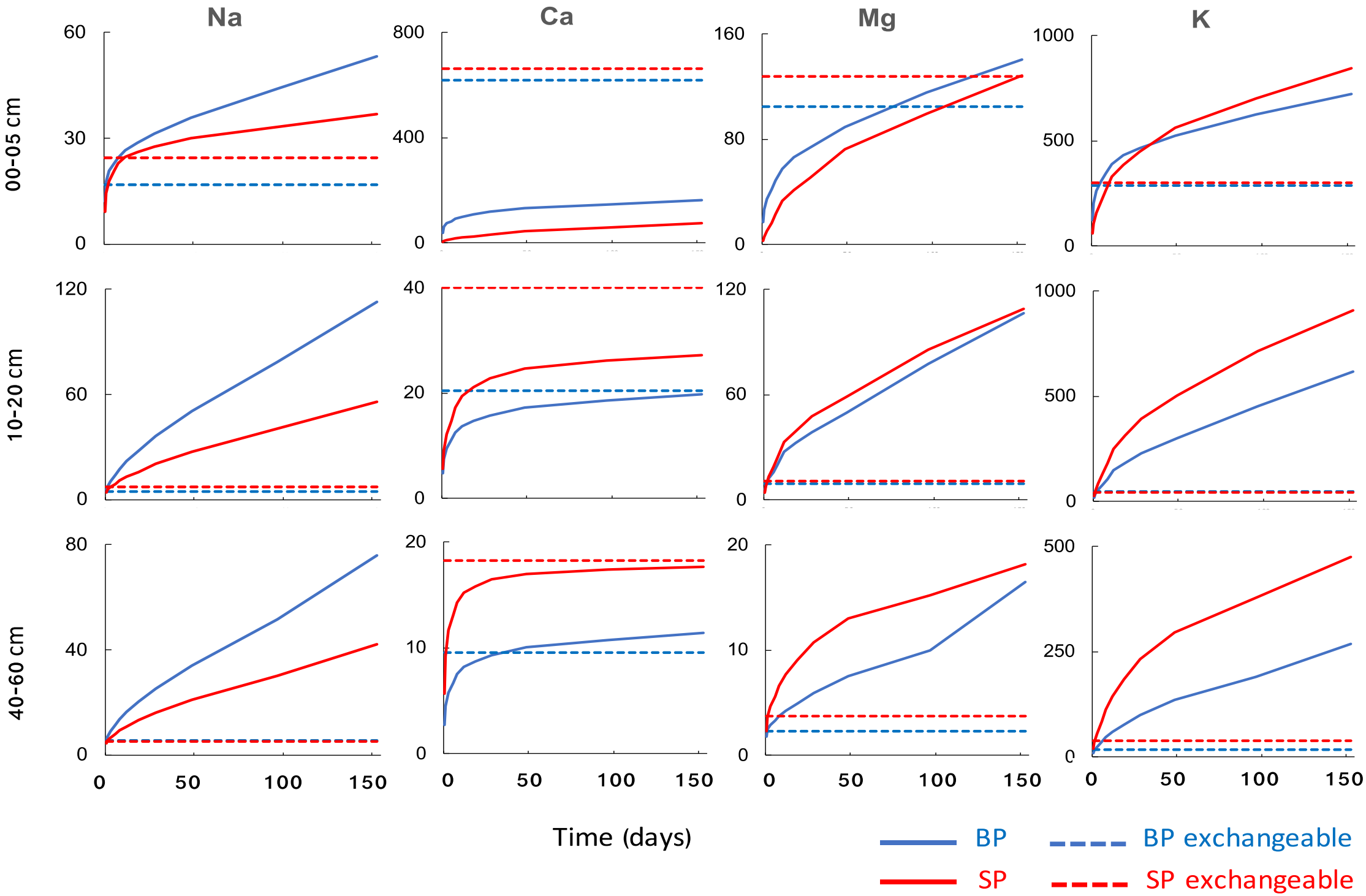


Fig. 10: Cumulative concentrations of Na, Ca, Mg and K from the leached solution over the 152 days of experimentation (in mg normalized to 1g of bulk soil). Blue and red lines represent the BP and SP profiles, respectively. The dashed lines represent the exchangeable pool in the soils (in mg for 1g of soil). Each concentration is normalized to 1 g of soil.

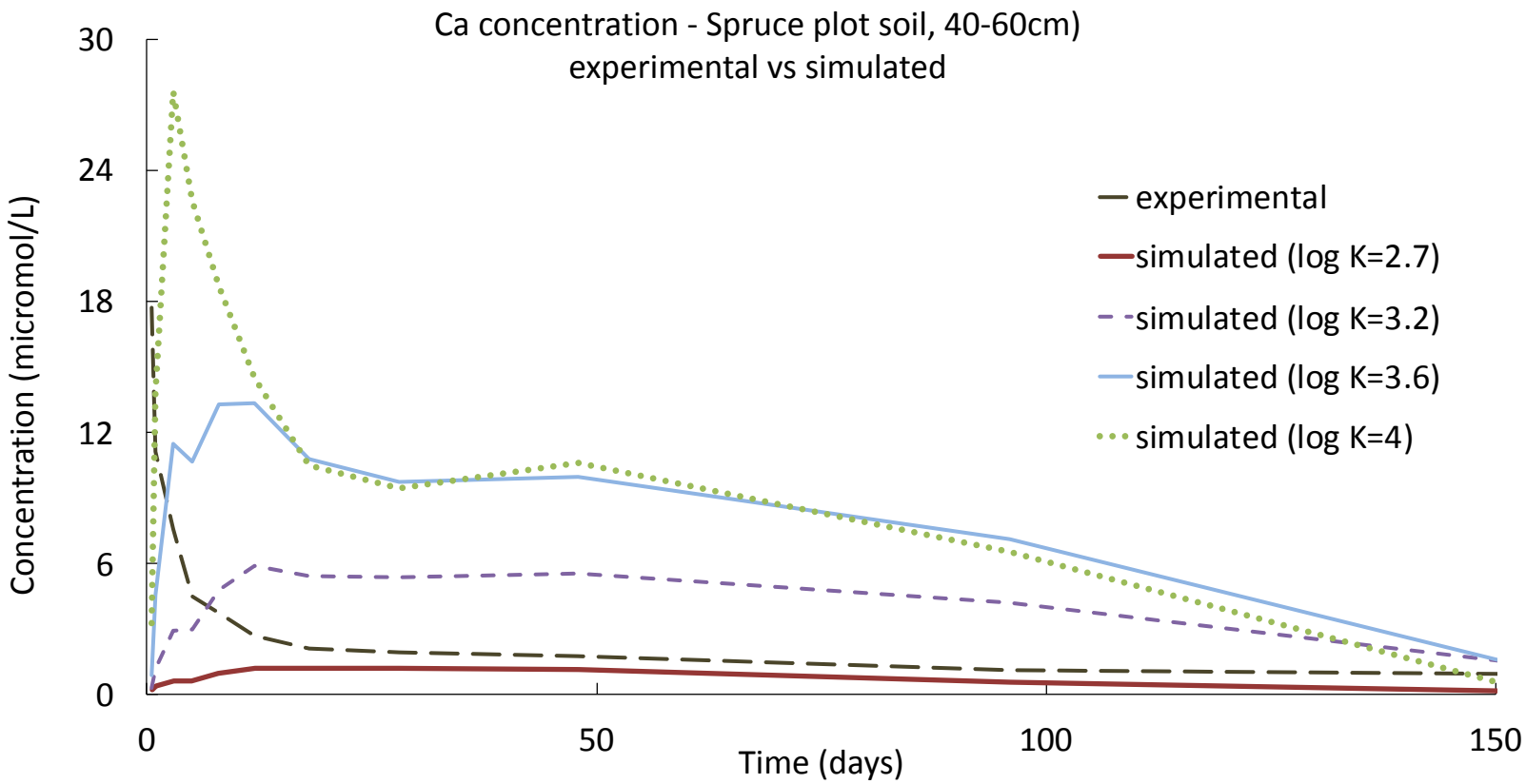


Fig. 11: Evolution of experimental Ca concentrations (leached solution) versus time, compared to simulations run with various values of Ca constants of exchange ($10^{-2.7}$, $10^{-3.2}$, $10^{-3.6}$, 10^{-4}) on SP plot at 40-60 cm. The Ca concentration in the solution increases with the decreasing exchange constant. The calculated concentrations with exchange constants of $10^{-3.2}$, $10^{-3.6}$ and 10^{-4} are largely overestimated over time, despite a fast increase at the beginning of the simulation, as in the experimental conditions. This illustration corresponds to the 40-60 cm depth horizon from the spruce plot (SP).

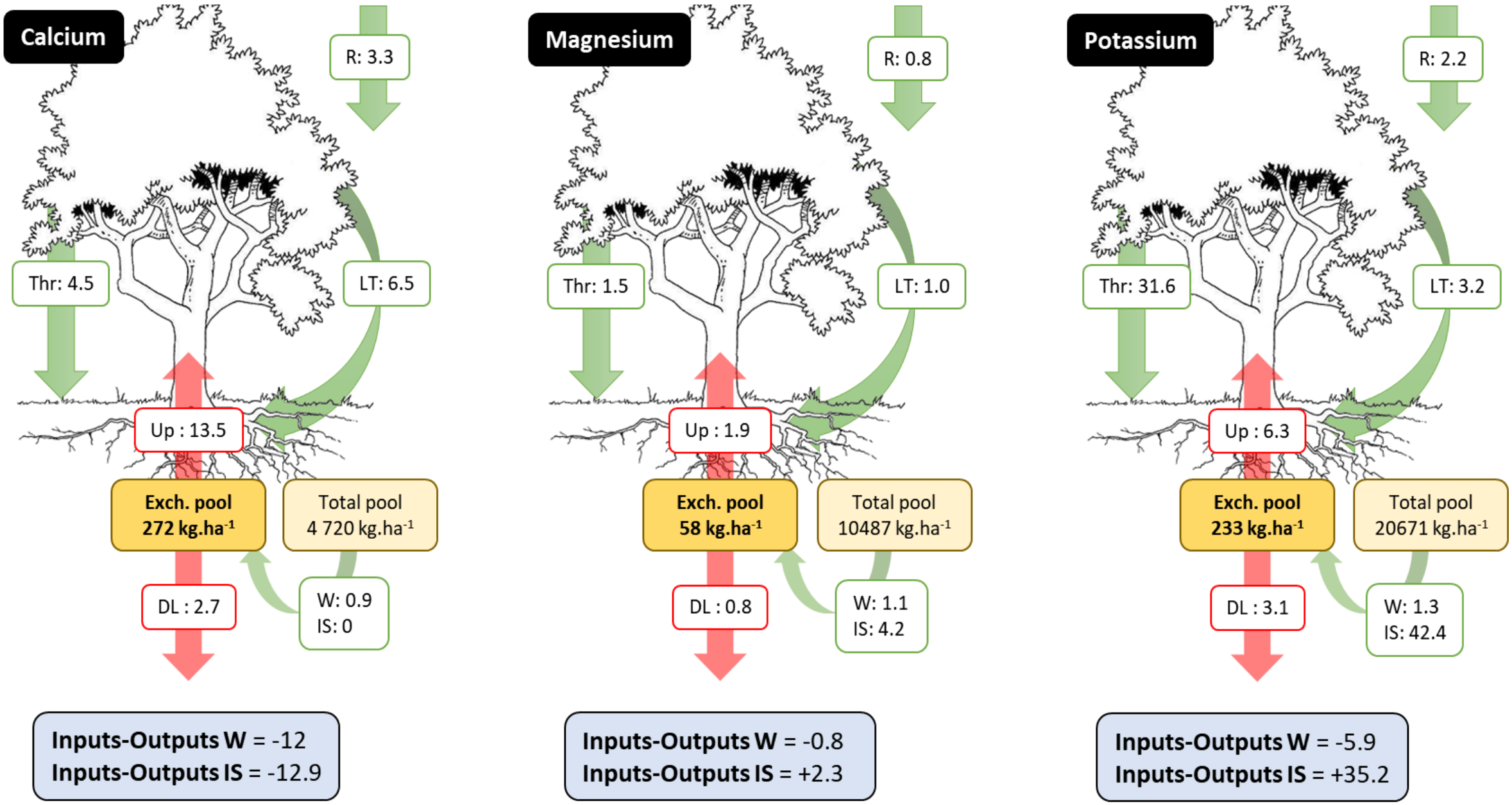
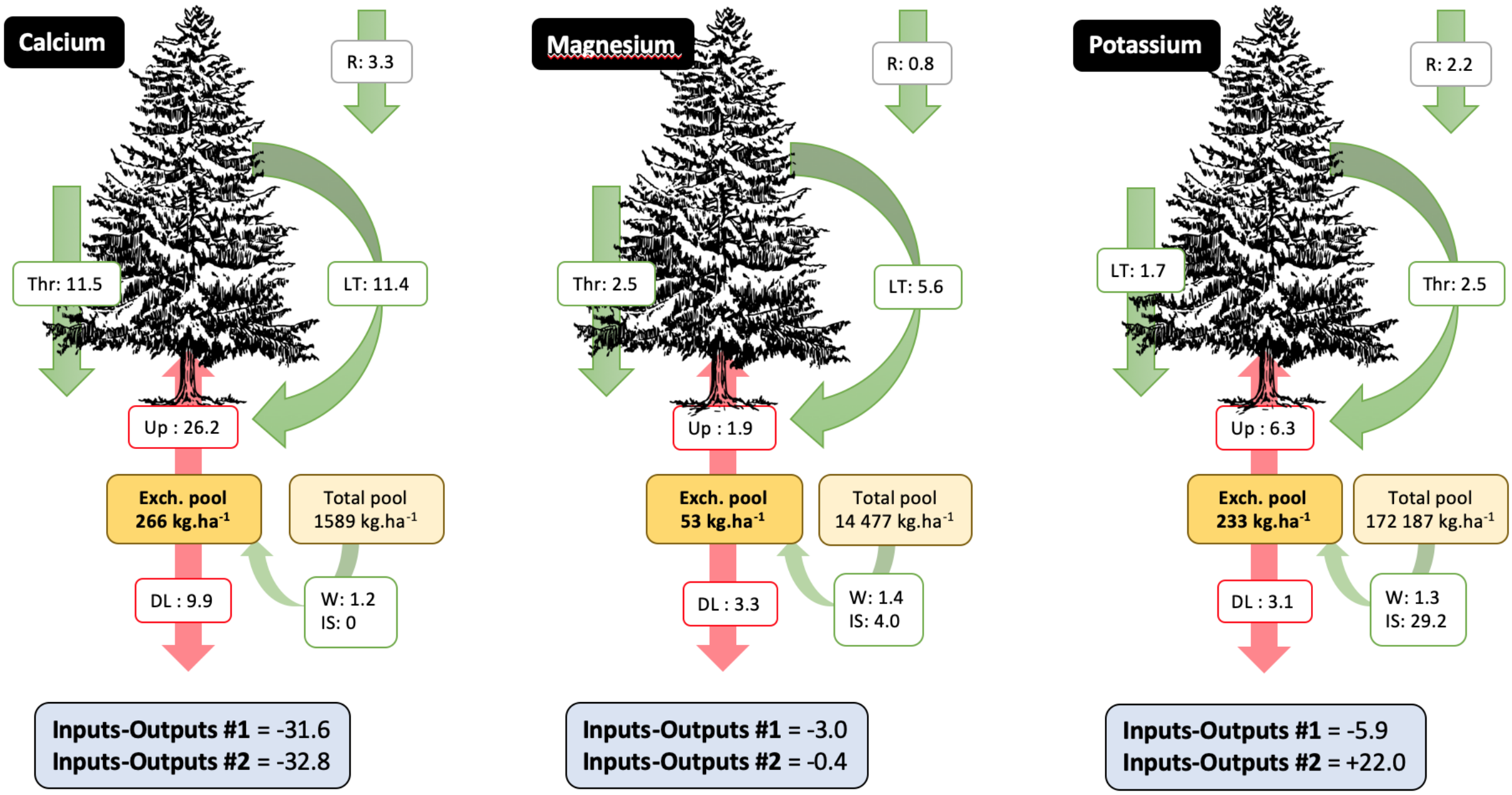


Fig. 12: Fluxes and input-output budgets (in $kg.ha^{-1}.yr^{-1}$) for calcium, magnesium and potassium at the BP site. IS is the intrinsic flux from soil estimated from our leaching experiments (corrected for the value of the initial exchangeable pool). W is the weathering flux, R is the atmospheric wet deposition, Up is the net uptake flux by roots and DL is the deep leaching (see Beaulieu et al. 2020). See additional explanation in text and Appendix D. Supplementary material, with the same diagram for the SP site.



Appendix E. Supplementary material: Fluxes and input-output budgets (in $kg.ha^{-1}.yr^{-1}$) for calcium, magnesium and potassium at the SP site. IS is the input from soil estimated from our leaching experiments (corrected for the value of the initial exchangeable pool). W is the weathering flux, R is the atmospheric wet deposition, Up is the net uptake flux by roots and DL is the deep leaching (see Beaulieu et al. 2020).

Name of step	T1	T2	T3	T4	T5	T6	T7
Δt	14 h	10 h	2 d	2d	3 d	4 d	6 d
Duration	14 h	1 d	3 d	5 d	8 d	12 d	18 d

Table 1

Table 1: Time between each step (between Ti and Ti-1) and total duration for each iteration of t

T8	T9	T10	T11
10 d	20 d	48 d	56 d
28 d	48 d	96 d	152 d

:he batch experiments

	Si	Al	Mg	Ca
	µg/g	µg/g	µg/g	µg/g
BP OL	12200	1231	549	3945
BP OF-OH	55672	8402	772	2409
SP OL	11312	773	549	5618
SP OF-OH	15800	2006	537	3473

Table 2: Composition of the two litter layers for spruce (SP) and beech (BP) pl
remains, and OF-OH contains degraded materials and humic components.

Na	K	Sr	$^{87}Sr/^{86}Sr$	err (2σ)
µg/g	µg/g	µg/g		
356	2515	11	0.753399	0.000003
2411	7164	19	0.729347	0.000004
<d.l.	1212	11	0.730029	0.000003
215	2133	12	0.724282	0.000003

lots in µg/g. OL corresponds to the horizon of recognizable

	Depth	C	pH_{H2O}	Clay	Silt	Sand	CEC
	cm	%		%	%	%	
							Initial values
Beech Plot (BP)	0-5	22.9	3.52	29.9	25.1	45	16.1
	5-10	4.2	3.56	16.8	22.7	60.5	8.49
	10-20	4.4	3.69	15	19.7	65.3	7.64
	20-40	2.6	4.12	15.5	20.5	64	8.35
	40-60	2.3	4.45	13.8	23.1	63.1	4.09
	60-80	1.6	4.59	8.6	26.7	64.7	2.41
Spruce Plot (SP)	0-5	22.8	3.85	30.4	20.9	48.7	17.9
	5-10	8.1	3.54	18.9	17.3	63.8	9.97
	10-20	2.2	3.79	15.2	13.4	71.4	8.85
	20-40	1.3	4.04	19.5	19	61.5	8.8
	40-60	0.8	4.17	17.8	16.5	65.7	7.99
	60-80	0.6	4.33	16	16.1	67.9	7.13

		CEC
BP	0-5	14.00
BP	5-10	7.15
BP	10-20	6.93
BP	20-40	5.44
BP	40-60	3.04
BP	60-80	<1.5
SP	0-5	16.1
SP	5-10	10.8
SP	10-20	8.04
SP	20-40	8.86
SP	40-60	7.81
SP	60-80	6.93

BP	0-5	-13
BP	5-10	-16
BP	10-20	-9
BP	20-40	-35
BP	40-60	-26
BP	60-80	-
SP	0-5	-10
SP	5-10	8
SP	10-20	-9

SP	20-40	1
SP	40-60	-2
SP	60-80	-3

Table 3: Soil description (particles smaller than 2 mm diameter) from the beech and spruce plots at th
exchange capacity, determined with cobaltihexamine. Data from the initial soils before leaching and a
The variation corresponds to the ratio between the exchangeable element X normalized by the CEC of
(ExchXf/CECf)-(ExchXi/CECi))/ExchXf/CECf) x 100).

Ca_{exch}	Mg_{exch}	K_{exch}	Na_{exch}	Al_{exch}	H_{exch}
cmol/kg					
3.09	0.86	0.73	0.07	5.62	5.87
0.31	0.16	0.19	0.03	6.21	2.24
0.1	0.08	0.12	0.02	7.04	1.1
0.07	0.04	0.09	0.03	8.93	<0.05
0.05	0.02	0.05	0.03	4.7	<0.05
0.03	0.01	0.03	0.02	2.68	<0.05
3.31	1.05	0.77	0.11	5.52	4.88
0.69	0.25	0.22	0.03	6.53	2.89
0.2	0.09	0.11	0.04	7.66	0.79
0.16	0.05	0.1	0.02	8.93	0.21
0.09	0.03	0.1	0.02	8.61	0.27
0.07	0.03	0.1	0.02	7.81	0.13
Ca_{exch}	Mg_{exch}	K_{exch}	Na_{exch}	Al_{exch}	H_{exch}
cmol/kg					
After experimentation					
2.22	0.51	0.25	0.05	5.00	4.3
0.18	0.09	0.34	0.1	5.04	0.96
0.08	0.07	0.28	0.08	5.71	0.36
0.04	0.04	0.25	0.06	4.77	<0.05
0.03	0.02	0.17	0.04	2.83	<0.05
0.03	0.02	0.16	0.04	1.72	<0.05
2.84	0.9	0.36	0.03	6.36	4.32
0.56	0.28	0.45	0.04	7.31	1.62
0.09	0.16	0.49	0.04	6.34	0.13
0.07	0.12	0.49	0.03	7.47	<0.05
0.04	0.13	0.52	0.03	6.71	<0.05
0.05	0.18	0.64	0.04	5.75	<0.05
Variation (%)					
-17	-32	-61	-18	2	-16
-31	-33	112	296	-4	-49
-12	-4	157	341	-11	-64
-12	53	326	207	-18	-
-19	35	357	79	-19	-
-	-	-	-	-	-
-5	-5	-48	-70	28	-2
-25	3	89	23	3	-48
-50	96	390	10	-9	-82

-57	138	387	49	-17	-
-55	343	432	53	-20	-
-27	517	558	106	-24	-

e Strengbach catchment. CEC: Cation
fter the end of the experimentation.
f the final and initial soils:

	Depth	Kaolinite	Illite	Vermiculite	Smectite
	cm	%	%	%	%
Beech Plot	*0-5*	1.4	22.0	1.3	5.2
(BP)	*5-10*	1.5	10.0	0.0	5.3
	10-20	1.1	7.8	1.3	4.8
	20-40	0.8	6.8	3.7	4.2
	40-60	1.4	6.4	2.5	3.5
	60-80	1.1	4.6	1.2	1.7
Spruce Plot	*0-5*	1.5	20.1	0.4	8.5
(SP)	*5-10*	0.5	10.7	0.0	7.7
	10-20	0.2	8.9	0.0	6.1
	20-40	0.2	8.6	1.3	9.3
	40-60	0.2	9.2	1.1	7.3
	60-80	0.1	7.3	1.1	7.5

Table 4: Mineral composition of soils from beech and spruce plots, calculated from XRD

Muscovite	Biotite	Quartz	Orthose	Albite	OM
%	%	%	%	%	%
5.7	0.6	8.3	9.6	6.5	39.4
8.8	0.8	21.3	27.6	17.5	7.2
10.8	0.7	18.9	25.8	21.4	7.5
15.0	0.6	19.6	21.0	24.0	4.4
20.4	0.6	13.8	23.5	24.0	3.9
20.5	1.1	22.1	19.4	25.5	2.8
4.7	0.0	16.0	6.6	3.3	39.1
14.4	0.8	38.9	7.7	5.3	14.0
22.6	0.8	39.4	11.6	6.6	3.7
20.9	0.0	32.9	20.0	4.5	2.2
22.3	0.0	37.8	12.9	7.9	1.3
17.6	0.0	39.0	15.4	11.0	1.0

analyses on bulk soils and clays, and from organic matter content (see text).

	Depth	*Si*	*Al*	*Na*
	cm	*mg/g*	*mg/g*	*mg/g*
Bulk soil				
Beech Plot	0-5	167.48	21.76	7.4
(BP)	5-10	290.94	36.94	13.23
	10-20	297.9	39.13	13.52
	20-40	303.32	40.62	13.79
	40-60	303.65	40.63	13.13
	60-80	295.84	44.96	14.83
Spruce Plot	0-5	182.3	20.09	2.1
(SP)	5-10	292.95	33.35	3.23
	10-20	332.91	33.93	3.26
	20-40	310.43	43.29	4.4
	40-60	314.68	43.31	4.61
	60-80	315.43	44.02	4.73
Clays				
Beech Plot	0-5	56.47	11.01	2.48
(BP)	5-10	40.68	11.35	1.08
	10-20	28.66	8.67	0.68
	20-40	32.29	10.83	0.21
	40-60	24.59	8.6	0.62
	60-80	14.43	5.51	0.38
Spruce Plot	0-5	52.24	12.95	0.75
(SP)	5-10	43.27	12.58	0.4
	10-20	30.23	9.76	0.19
	20-40	37.62	12.07	0.87
	40-60	36.39	12.16	0.22
	60-80	33.45	11.26	0.2

Table 5: Chemical and Sr isotopic composition of bulk soils and clays from the be

K	*Mg*	*Ca*	*Sr*	$^{87}Sr/^{86}Sr$	err (2σ)
mg/g	*mg/g*	*mg/g*	µg/g		
21.87	1.22	1.13	31.34	0.789114	0.000014
39.32	1.79	0.89	45.51	0.806601	0.000016
41.91	1.99	0.86	46.7	0.809622	0.000012
41.73	1.97	0.84	48.29	0.806266	0.000012
41.7	1.97	0.82	43.67	0.811786	0.00001
40.62	2.54	1.11	43.12	0.809955	0.000026
18.9	1.78	0.79	35.4	0.757335	0.000014
31.36	2.8	0.33	53.87	0.764484	0.000012
34.4	2.75	0.36	51.24	0.764455	0.00001
40	3.53	0.29	76.23	0.764404	0.000014
41.8	3.42	0.32	72.43	0.768632	0.000016
42.54	3.49	0.41	73.8	0.768716	0.000012
8.23	0.87	0.29	15.7	0.771566	0.000004
7.08	1.03	0.1	7.17	0.83199	0.000003
5.04	0.81	0.06	4.26	0.845975	0.000004
7.03	1.21	0.03	4.99	0.848006	0.000006
4.21	0.73	0.05	3.94	0.8329	0.000004
2.38	0.46	0.03	2.24	0.825962	0.000004
9.61	1.35	0.21	21.94	0.751935	0.000004
9.24	1.37	0.07	12.68	0.745304	0.000007
6.77	1.1	0.03	5.02	0.836336	0.000003
6.57	1.12	0.08	5.9	0.84285	0.000003
7.84	1.38	0.04	5.22	0.857096	0.000003
7.27	1.28	0.04	4.84	0.862445	0.000003

ech and spruce plots at the Strengbach catchment.

Plot	Depth	Ca		Mg	
-	*cm*	kg·ha^{-1}	*%*	kg·ha^{-1}	*%*
Beech Plot (BP)	00-05	199	*54.83*	34	*8.61*
	05-10	20	*7.01*	6	*1.09*
	10-20	13	*2.38*	6	*0.47*
	20-40	22	*1.72*	8	*0.27*
	40-60	12	*1.16*	3	*0.12*
	60-80	6	*0.52*	1	*0.05*
	Total	*272*		*58*	
Spruce Plot (SP)	00-05	142	*83.61*	27	*7.17*
	05-10	30	*42.18*	6	*1.08*
	10-20	17	*11.00*	5	*0.40*
	20-40	39	*11.50*	7	*0.17*
	40-60	24	*5.66*	5	*0.11*
	60-80	15	*3.40*	3	*0.09*
	Total	*267*		*53*	

Table 6: Evaluation of the stock of exchangeable cation par soil layer (expressed in kg/hecta
Na, and K (expressed in %). The total corresponds to the sum over the whole soil profile.

Na		K	
$kg \cdot ha^{-1}$	*%*	$kg \cdot ha^{-1}$	*%*
5	*0.23*	92	*1.31*
2	*0.05*	23	*0.19*
3	*0.04*	30	*0.11*
9	*0.04*	53	*0.08*
7	*0.04*	22	*0.04*
6	*0.03*	13	*0.03*
32		*233*	
5	*1.17*	65	*1.59*
2	*0.24*	18	*0.27*
3	*0.22*	19	*0.13*
6	*0.11*	46	*0.10*
7	*0.11*	49	*0.09*
4	*0.08*	41	*0.09*
27		*238*	

ıre) and proportion of exchangeable pool in the bulk soils for Ca, Mg,

	Depth	Si	Al	Na
	µg/g	µg/g	µg/g	µg/g
Bulk soil	***initial***			
Beech Plot	0-5	167484.2	21760.4	7403.8
(BP)	5-10	290935.4	36936.8	13234.8
	10-20	297900.2	39125.3	13516.7
	20-40	303322.6	40615.2	13791.2
	40-60	303649.8	40628.4	13131.0
	60-80	295843.5	44960.4	14829.8
Spruce Plot	0-5	182302.0	20087.9	2099.5
(SP)	5-10	292945.4	33353.8	3227.1
	10-20	332911.6	33925.4	3256.8
	20-40	310427.7	43293.2	4399.2
	40-60	314681.4	43306.4	4614.4
	60-80	315429.3	44015.7	4725.7
Clays				
Beech Plot	0-5	56465.0	11010.9	2477.7
(BP)	5-10	40678.6	11351.4	1081.8
	10-20	28663.5	8674.4	682.1
	20-40	32285.2	10833.9	205.8
	40-60	24590.0	8604.9	617.3
	60-80	14431.8	5515.0	376.4
Spruce Plot	0-5	52236.7	12950.4	753.3
(SP)	5-10	43272.1	12578.7	399.6
	10-20	30225.1	9755.4	189.4
	20-40	37618.0	12071.4	866.5
	40-60	36385.3	12162.2	216.6
	60-80	33453.8	11263.9	198.2
Exch Initial		*Si*	*Al*	*Na*
Beech Plot	0-5	12.4	505.45	16.81
(BP)	5-10	6.6	558.52	6.16
	10-20	5.4	633.17	4.9
	20-40	14.00	803.15	6.16
	40-60	17.8	422.71	5.77
	60-80	25.00	241.04	5.03
Spruce Plot	0-5	13.6	496.46	24.6
(SP)	5-10	7.6	587.3	7.77
	10-20	2.8	688.93	7.26
	20-40	8.4	803.15	4.69

	40-60	9.2	774.37	5.13
	60-80	10.2	702.42	3.91
Exch Final				
Beech Plot	0-5	5.82	449.69	11.36
(BP)	5-10	3.98	453.29	22.00
	10-20	4.66	513.55	17.86
	20-40	5.98	429.01	13.27
	40-60	9.38	254.53	9.26
	60-80	11.18	154.69	9.08
Spruce Plot	0-5	6.36	572.01	5.89
(SP)	5-10	4.58	657.45	10.12
	10-20	4.54	570.21	9.47
	20-40	6.6	671.84	6.87
	40-60	8.56	603.49	7.22
	60-80	10.3	517.15	9.68
Bulk soil	***Final***			
Beech Plot	0-5	180619.3	23888.0	7774.7
(BP)	5-10	301873.5	36952.7	13442.5
	10-20	305379.3	38934.8	13049.4
	20-40	309679.8	41276.7	13405.5
	40-60	302855.1	41917.1	12849.1
	60-80	300424.4	43817.2	14221.5
Spruce Plot	0-5	190716.0	21850.4	2255.3
(SP)	5-10	290234.2	34195.3	3368.1
	10-20	323375.8	35931.3	3115.8
	20-40	303883.5	44148.0	4236.0
	40-60	308651.4	43703.4	4109.9
	60-80	307295.8	44457.6	4658.9
Cumul Leach				
Beech Plot	0-5	2734.9	1318.61	53.42
(BP)	5-10	3802.07	1882.27	118.32
	10-20	3097.11	1571.13	112.29
	20-40	970.15	431.98	91.77
	40-60	582.85	315.81	75.95
	60-80	491.69	305.42	66.36
Spruce Plot	0-5	3393.17	1647.26	36.92
(SP)	5-10	4627.06	2444.36	50.04
	10-20	3406.41	1640.92	56.59
	20-40	769.93	184.3	41.67
	40-60	749.09	148.82	41.95
	60-80	796.28	146.34	46.77
Organic matter				
Beech Plot	0-5	21673.19	3270.9	938.6

(BP)	5-10	3975.0	599.9	172.15
	10-20	4164.28	628.47	180.34
	20-40	2460.71	371.37	106.57
	40-60	2176.78	328.52	94.27
	60-80	1514.28	228.53	65.58
Spruce Plot	0-5	6123.89	777.49	83.37
(SP)	5-10	2175.59	276.21	29.62
	10-20	590.9	75.02	8.04
	20-40	349.17	44.33	4.75
	40-60	214.87	27.28	2.93
	60-80	161.15	20.46	2.19

Appendix A. Supplementary material

Chemical compositions (expressed in µg/g of soil) for initial and final (after experimentation) bulk soils, com
exchangeable pool, organic matter as total cumulated experimental leachate calculated for 1 g of soil

K	*Mg*	*Ca*	*Sr*	$^{87}Sr/^{86}Sr$	err (2σ)
µg/g	µg/g	µg/g	µg/g		
21874.5	1218.1	1129.2	31.3	0.789114	0.000014
39324.3	1791.0	886.2	45.5	0.806601	0.000016
41906.0	.0	857.6	46.7	0.809622	0.000012
41731.7	1971.9	836.2	48.3	0.806266	0.000012
41698.5	1965.9	821.9	43.7	0.811786	0.00001
40619.3	2538.8	1114.9	43.1	0.809955	0.000026
18902.5	1779.0	793.3	35.4	0.757335	0.000014
31363.1	2804.1	328.8	53.9	0.764484	0.000012
34401.5	2749.9	364.5	51.2	0.764455	0.00001
39996.7	3533.8	285.9	76.2	0.764404	0.000014
41798.1	3419.2	321.6	72.4	0.768632	0.000016
42537.0	3485.6	414.5	73.8	0.768716	0.000012
8228.3	867.3	286.4	15.7	0.771566	0.000004
7076.5	1032.4	103.3	7.2	0.83199	0.000003
5035.7	809.6	59.0	4.3	0.845975	0.000004
7032.0	1213.3	33.2	5.0	0.848006	0.000006
4211.3	727.3	46.4	3.9	0.8329	0.000004
2375.2	457.9	33.2	2.2	0.825962	0.000004
9612.6	1354.8	210.7	21.9	0.751935	0.000004
9236.6	1367.7	72.9	12.7	0.745304	0.000007
6771.0	1100.9	32.6	5.0	0.836336	0.000003
6565.8	1116.0	78.0	5.9	0.84285	0.000003
7837.6	1378.3	38.2	5.2	0.857096	0.000003
7269.5	1277.5	36.6	4.8	0.862445	0.000003
K	*Mg*	*Ca*	*Sr*	*87Sr/86Sr*	err (2σ)
286.59	104.88	619.21	2.64	0.723266	0.000004
73.11	19.57	62.12	0.29	nd	nd
46.14	9.31	20.44	0.14	0.726888	0.000003
34.41	5.27	14.35	0.09	nd	nd
17.83	2.27	9.56	0.06	0.728579	0.000002
12.04	1.26	5.77	0.08	nd	nd
301.45	127.6	663.29	2.74	0.724128	0.0000069
84.84	30.26	138.67	0.57	nd	nd
44.18	10.89	40.08	0.26	0.72737087	0.00002
38.2	6.03	32.86	0.12	nd	nd

37.42	3.71	18.22	0.1	0.736045	0.00002
39.49	3.17	14.11	0.09	nd	nd
95.79	62.46	444.87	3.35	0.726558	0.00002
130.98	11.39	35.27	0.77		
108.3	8.12	16.63	0.56	0.778818	0.00004
98.53	5.27	8.82	0.49		
66.47	2.78	6.39	0.43	0.7446	0.00002
60.6	2.78	6.67	0.35		
141.54	109.62	569.11	4.71	0.726483	0.000003
176.72	33.66	112.22	1.62		
191.58	19.32	18.64	1.16	0.753777	0.00002
190.41	14.22	13.15	0.79		
201.36	16.28	8.62	0.84	0.762804	0.00004
248.27	21.27	10.04	0.97		
25078.9	1266.4	1107.8	29.6	0.797721	0.000012
40652.5	1670.4	886.2	42.8	0.807514	0.000012
41308.3	1917.7	814.8	44.0	0.812608	0.000008
41789.8	2086.5	850.5	44.8	0.81377	0.000014
40445.0	2195.1	829.0	41.6	0.814216	0.000008
40395.2	2382.0	1000.6	42.7	0.816388	0.000012
19575.0	1917.7	807.6	33.6	0.764611	0.000038
32093.6	2846.4	307.3	54.6	0.765714	0.00001
35098.8	3015.2	214.4	51.5	0.771332	0.000004
40420.1	3678.6	250.1	65.0	0.772802	0.00001
41922.6	3576.0	271.6	59.1	0.778583	0.000026
42296.2	3612.2	364.5	66.8	0.774415	0.00001
721.6	139.91	161.08	0.8	0.764283	0.00002
727.25	133.31	45.38	0.48	nd	nd
612.38	105.63	19.75	0.37	0.826984	0.00004
326.99	26.18	14.26	0.23	nd	nd
267.1	16.38	11.41	0.19	0.85638	0.00003
268.29	15.22	9.46	0.21	nd	nd
843.55	128.01	74.26	0.52	0.763848	0.00004
1099.15	167.92	66.02	0.68	nd	nd
918.21	110.49	27.02	0.62	0.760167	0.00002
441.7	20.91	20.75	0.34	nd	nd
475.91	18.21	17.63	0.34	0.779635	0.00004
509.44	17.74	17.33	0.36	nd	nd
2789.02	300.5	937.63	7.51		

511.52	55.11	171.97	1.38		
535.88	57.74	180.16	1.44		
316.66	34.12	106.46	0.85		
280.12	30.18	94.17	0.75		
194.87	21.0	65.51	0.52		
826.94	208.02	1346.29	3.57		
293.78	73.9	478.29	1.27		
79.79	20.07	129.91	0.34		
47.15	11.86	76.76	0.2		
29.02	7.3	47.24	0.13		
21.76	5.47	35.43	0.09		

ıpared with the contribution of different reservoirs as clay minerals, initial and final

site -	Depth cm	time -	- -	Mg µg/gsol	Ca µg/gsol	Na µg/gsol	K µg/gsol
BP	00-05 cm	T1	mean	17.18	37.97	12.12	122.17
BP	00-05 cm	T1	SD	0.2	0.3	0.2	1.9
BP	05-10 cm	T1	mean	7.82	11.54	6.10	27.42
BP	05-10 cm	T1	SD	0.1	0.1	0.1	0.3
BP	10-20 cm	T1	mean	5.16	4.78	5.63	18.98
BP	10-20 cm	T1	SD	0.1	0.1	0.1	0.6
BP	20-40 cm	T1	mean	2.58	3.19	4.20	10.41
BP	20-40 cm	T1	SD	0.1	0.1	0.1	0.4
BP	40-60 cm	T1	mean	1.81	2.74	5.36	8.60
BP	40-60 cm	T1	SD	0.1	0.1	0.1	0.1
BP	60-80 cm	T1	mean	0.95	2.27	4.65	6.34
BP	60-80 cm	T1	SD	0.1	0.1	0.1	0.1
BP	00-05 cm	T2	mean	9.59	21.89	5.67	80.80
BP	00-05 cm	T2	SD	0.2	0.6	0.1	2.1
BP	05-10 cm	T2	mean	4.45	5.72	2.03	20.08
BP	05-10 cm	T2	SD	0.3	0.1	0.1	1.3
BP	10-20 cm	T2	mean	3.21	2.63	1.97	15.52
BP	10-20 cm	T2	SD	0.3	0.1	0.1	1.4
BP	20-40 cm	T2	mean	1.33	2.24	1.66	8.90
BP	20-40 cm	T2	SD	0.1	0.1	0.1	0.4
BP	40-60 cm	T2	mean	0.65	1.76	1.73	7.07
BP	40-60 cm	T2	SD	0.1	0.1	0.1	0.1
BP	60-80 cm	T2	mean	0.30	1.35	1.46	5.34
BP	60-80 cm	T2	SD	0.1	0.1	0.1	0.1
BP	00-05 cm	T3	mean	8.09	13.48	3.01	58.24
BP	00-05 cm	T3	SD	0.4	0.6	0.1	2.9
BP	05-10 cm	T3	mean	5.38	4.74	2.81	26.28
BP	05-10 cm	T3	SD	0.2	0.1	0.1	1.1
BP	10-20 cm	T3	mean	3.97	2.08	2.83	21.93
BP	10-20 cm	T3	SD	0.5	0.1	0.1	2.1
BP	20-40 cm	T3	mean	0.84	1.64	2.38	11.17
BP	20-40 cm	T3	SD	0.1	0.1	0.1	0.6
BP	40-60 cm	T3	mean	0.43	1.25	1.99	8.720
BP	40-60 cm	T3	SD	0.1	0.1	0.1	0.5
BP	60-80 cm	T3	mean	0.31	0.96	1.67	8.750
BP	60-80 cm	T3	SD	0.1	0.1	0.1	0.2
BP	00-05 cm	T4	mean	7.22	9.82	2.11	46.21
BP	00-05 cm	T4	SD	0.8	0.5	0.1	3.1
BP	05-10 cm	T4	mean	5.82	3.89	3.68	32.12
BP	05-10 cm	T4	SD	0.5	0.1	0.1	2.5

BP	10-20 cm	T4	mean	3.70	1.68	3.60	24.34
BP	10-20 cm	T4	SD	0.3	0.1	0.1	1.4
BP	20-40 cm	T4	mean	0.70	1.22	3.12	14.20
BP	20-40 cm	T4	SD	0.1	0.1	0.1	0.7
BP	40-60 cm	T4	mean	0.44	0.94	2.47	11.71
BP	40-60 cm	T4	SD	0.1	0.1	0.2	0.4
BP	60-80 cm	T4	mean	0.39	0.74	2.10	10.72
BP	60-80 cm	T4	SD	0.1	0.1	0.1	0.3
BP	00-05 cm	T5	mean	6.42	8.21	1.67	37.37
BP	00-05 cm	T5	SD	1.1	0.5	0.1	4.6
BP	05-10 cm	T5	mean	5.56	3.23	3.53	32.01
BP	05-10 cm	T5	SD	0.5	0.1	0.2	2.2
BP	10-20 cm	T5	mean	3.96	1.33	3.41	26.12
BP	10-20 cm	T5	SD	0.7	0.1	0.1	2.6
BP	20-40 cm	T5	mean	0.55	0.98	2.85	13.90
BP	20-40 cm	T5	SD	0.1	0.1	0.1	0.3
BP	40-60 cm	T5	mean	0.38	0.78	2.26	10.74
BP	40-60 cm	T5	SD	0.1	0.1	0.1	0.2
BP	60-80 cm	T5	mean	0.34	0.53	1.79	9.86
BP	60-80 cm	T5	SD	0.1	0.1	0.1	0.7
BP	00-05 cm	T6	mean	9.10	8.63	1.94	45.30
BP	00-05 cm	T6	SD	0.5	0.5	0.1	1.0
BP	05-10 cm	T6	mean	10.01	2.69	4.89	51.85
BP	05-10 cm	T6	SD	1.5	0.1	0.2	7.2
BP	10-20 cm	T6	mean	7.36	1.09	4.70	41.04
BP	10-20 cm	T6	SD	1.5	0.1	0.3	6.5
BP	20-40 cm	T6	mean	0.66	0.96	3.40	17.51
BP	20-40 cm	T6	SD	0.1	0.1	0.2	0.7
BP	40-60 cm	T6	mean	0.51	0.67	2.74	13.40
BP	40-60 cm	T6	SD	0.1	0.1	0.2	0.6
BP	60-80 cm	T6	mean	0.49	0.5	2.27	12.71
BP	60-80 cm	T6	SD	0.1	0.1	0.1	0.9
BP	00-05 cm	T7	mean	8.48	9.00	2.07	40.19
BP	00-05 cm	T7	SD	1.6	0.5	0.1	7.1
BP	05-10 cm	T7	mean	7.19	2.60	5.89	43.46
BP	05-10 cm	T7	SD	1.0	0.2	0.3	3.2
BP	10-20 cm	T7	mean	5.29	1.11	5.87	36.27
BP	10-20 cm	T7	SD	0.7	0.1	0.1	2.8
BP	20-40 cm	T7	mean	0.72	0.79	4.61	20.46
BP	20-40 cm	T7	SD	0.1	0.1	0.2	1.0
BP	40-60 cm	T7	mean	0.67	0.55	3.68	16.93
BP	40-60 cm	T7	SD	0.1	0.1	0.3	0.8
BP	60-80 cm	T7	mean	0.67	0.45	3.1	16.88

BP	60-80 cm	T7	SD	0.1	0.1	0.1	0.7
BP	00-05 cm	T8	mean	7.90	9.21	2.69	35.68
BP	00-05 cm	T8	SD	0.4	0.7	0.1	2.9
BP	05-10 cm	T8	mean	8.44	2.33	8.44	53.48
BP	05-10 cm	T8	SD	1.2	0.1	0.2	4.0
BP	10-20 cm	T8	mean	6.07	1.05	8.43	44.88
BP	10-20 cm	T8	SD	0.2	0.1	0.1	0.9
BP	20-40 cm	T8	mean	0.99	0.73	6.40	25.58
BP	20-40 cm	T8	SD	0.1	0.1	0.3	0.7
BP	40-60 cm	T8	mean	0.98	0.56	5.19	22.92
BP	40-60 cm	T8	SD	0.1	0.1	0.5	0.9
BP	60-80 cm	T8	mean	0.97	0.50	4.29	22.21
BP	60-80 cm	T8	SD	0.1	0.1	0.2	1.5
BP	00-05 cm	T9	mean	14.94	13.08	4.45	58.10
BP	00-05 cm	T9	SD	0.5	0.4	0.2	1.5
BP	05-10 cm	T9	mean	17.94	3.18	15.04	97.72
BP	05-10 cm	T9	SD	5.2	0.1	0.5	19.9
BP	10-20 cm	T9	mean	11.02	1.41	14.09	72.14
BP	10-20 cm	T9	SD	2.9	0.1	0.6	8.8
BP	20-40 cm	T9	mean	1.66	0.99	10.54	38.59
BP	20-40 cm	T9	SD	0.1	0.1	0.2	0.1
BP	40-60 cm	T9	mean	1.62	0.72	8.80	34.89
BP	40-60 cm	T9	SD	0.1	0.1	0.2	1.3
BP	60-80 cm	T9	mean	1.73	0.70	7.32	36.05
BP	60-80 cm	T9	SD	0.1	0.1	0.6	2.2
BP	00-05 cm	T10	mean	26.68	15.84	8.36	100.53
BP	00-05 cm	T10	SD	6.2	1.3	1.1	26.7
BP	05-10 cm	T10	mean	33.3	3.07	29.79	176.16
BP	05-10 cm	T10	SD	7.4	0.2	1.1	27.1
BP	10-20 cm	T10	mean	27.93	1.34	27.87	149.29
BP	10-20 cm	T10	SD	6.3	0.1	1.8	27.4
BP	20-40 cm	T10	mean	2.48	0.73	21.02	56.04
BP	20-40 cm	T10	SD	0.1	0.1	2.0	2.3
BP	40-60 cm	T10	mean	2.43	0.69	17.30	54.46
BP	40-60 cm	T10	SD	0.1	0.1	0.9	1.8
BP	60-80 cm	T10	mean	2.80	0.77	13.58	55.39
BP	60-80 cm	T10	SD	0.1	0.1	1.3	3.6
BP	00-05 cm	T11	mean	24.80	13.86	9.14	97.05
BP	00-05 cm	T11	SD	2.8	0.4	0.9	12.9
BP	05-10 cm	T11	mean	26.97	2.38	36.19	165.58
BP	05-10 cm	T11	SD	6.2	0.2	4.0	31.7
BP	10-20 cm	T11	mean	28.87	1.18	34.18	165.54
BP	10-20 cm	T11	SD	5.5	0.1	2.4	25.1

BP	20-40 cm	T11	mean	13.25	0.73	31.32	107.76
BP	20-40 cm	T11	SD	6.1	0.1	0.7	25.2
BP	40-60 cm	T11	mean	6.49	0.66	24.55	79.19
BP	40-60 cm	T11	SD	3.5	0.1	5.6	18.2
BP	60-80 cm	T11	mean	5.56	0.60	23.62	80.52
BP	60-80 cm	T11	SD	3.6	0.1	1.5	11.7

Appendix B. Supplementary material

Mean chemical composition and standard deviation (SD) of the leaching solution from ea
triplicates (see Table 1).

Chemical compositions are expressed in µg/g of soil

Sr	site	Depth	time		Mg	Ca	Na	K
µg/gsol	-	cm	-	-	µg/gsol	µg/gsol	µg/gsol	µg/gsol
0.168	SP	00-05 cm	T1	mean	3.08	4.20	9.13	59.30
0.005	SP	00-05 cm	T1	SD	0.1	0.1	0.1	1.3
0.055	SP	05-10 cm	T1	mean	6.97	12.39	7.16	40.56
0.001	SP	05-10 cm	T1	SD	0.5	0.5	0.1	2.4
0.029	SP	10-20 cm	T1	mean	4.35	5.59	4.43	25.05
0.001	SP	10-20 cm	T1	SD	0.2	0.1	0.3	1.3
0.018	SP	20-40 cm	T1	mean	2.64	5.87	4.91	16.5
0.001	SP	20-40 cm	T1	SD	0.1	0.1	0.1	0.2
0.019	SP	40-60 cm	T1	mean	2.28	5.66	4.65	19.49
0.001	SP	40-60 cm	T1	SD	0.1	0.1	0.1	0.4
0.017	SP	60-80 cm	T1	mean	1.98	5.93	3.90	22.74
0.001	SP	60-80 cm	T1	SD	0.1	0.2	0.1	0.2
0.088	SP	00-05 cm	T2	mean	2.67	2.51	5.38	48.23
0.002	SP	00-05 cm	T2	SD	0.2	0.1	0.1	1.6
0.028	SP	05-10 cm	T2	mean	4.56	6.51	2.11	29.52
0.001	SP	05-10 cm	T2	SD	0.1	0.1	0.1	1.2
0.018	SP	10-20 cm	T2	mean	3.43	3.52	1.21	21.96
0.001	SP	10-20 cm	T2	SD	0.5	0.1	0.1	3.5
0.014	SP	20-40 cm	T2	mean	1.65	3.77	1.16	13.57
0.001	SP	20-40 cm	T2	SD	0.1	0.1	0.1	0.4
0.014	SP	40-60 cm	T2	mean	1.37	3.56	1.07	15.40
0.001	SP	40-60 cm	T2	SD	0.1	0.1	0.1	0.1
0.011	SP	60-80 cm	T2	mean	1.25	3.64	0.92	16.42
0.001	SP	60-80 cm	T2	SD	0.1	0.1	0.1	0.4
0.042	SP	00-05 cm	T3	mean	4.67	2.61	3.54	49.20
0.031	SP	00-05 cm	T3	SD	0.3	0.1	0.1	2.2
0.028	SP	05-10 cm	T3	mean	7.45	5.69	1.45	45.41
0.001	SP	05-10 cm	T3	SD	0.6	0.1	0.1	3.7
0.017	SP	10-20 cm	T3	mean	5.31	3.13	1.54	38.79
0.001	SP	10-20 cm	T3	SD	1.0	0.1	0.1	5.6
0.012	SP	20-40 cm	T3	mean	1.31	2.88	1.25	19.39
0.001	SP	20-40 cm	T3	SD	0.1	0.1	0.1	0.5
0.006	SP	40-60 cm	T3	mean	0.97	2.42	1.13	21.18
0.006	SP	40-60 cm	T3	SD	0.1	0.2	0.1	0.6
0.009	SP	60-80 cm	T3	mean	0.91	2.17	1.20	24.47
0.001	SP	60-80 cm	T3	SD	0.1	0.1	0.1	0.1
0.041	SP	00-05 cm	T4	mean	5.99	3.56	2.86	54.49
0.017	SP	00-05 cm	T4	SD	0.5	0.1	0.1	2.8
0.026	SP	05-10 cm	T4	mean	8.61	5.06	1.57	55.30
0.001	SP	05-10 cm	T4	SD	0.9	0.1	0.1	4.6

0.017	SP	10-20 cm	T4	mean	5.93	2.53	1.96	49.58
0.001	SP	10-20 cm	T4	SD	0.6	0.1	0.1	4.1
0.011	SP	20-40 cm	T4	mean	1.18	1.83	1.49	26.34
0.001	SP	20-40 cm	T4	SD	0.1	0.1	0.1	0.9
0.009	SP	40-60 cm	T4	mean	0.92	1.44	1.39	28.37
0.003	SP	40-60 cm	T4	SD	0.1	0.1	0.1	0.3
0.009	SP	60-80 cm	T4	mean	0.95	1.26	1.58	32.49
0.001	SP	60-80 cm	T4	SD	0.1	0.1	0.1	0.6
0.040	SP	00-05 cm	T5	mean	6.95	3.39	2.08	53.77
0.003	SP	00-05 cm	T5	SD	0.5	0.1	0.1	2.8
0.024	SP	05-10 cm	T5	mean	9.09	4.63	1.48	57.65
0.001	SP	05-10 cm	T5	SD	0.7	0.1	0.1	3.6
0.017	SP	10-20 cm	T5	mean	5.10	2.42	1.76	46.60
0.001	SP	10-20 cm	T5	SD	0.7	0.1	0.1	3.4
0.010	SP	20-40 cm	T5	mean	1.16	1.71	1.27	26.53
0.001	SP	20-40 cm	T5	SD	0.1	0.1	0.1	0.7
0.010	SP	40-60 cm	T5	mean	1.05	1.20	1.27	28.79
0.001	SP	40-60 cm	T5	SD	0.1	0.1	0.1	0.5
0.008	SP	60-80 cm	T5	mean	1.08	0.98	1.35	31.19
0.001	SP	60-80 cm	T5	SD	0.1	0.1	0.1	0.5
0.050	SP	00-05 cm	T6	mean	9.72	4.16	1.72	65.41
0.006	SP	00-05 cm	T6	SD	0.9	0.2	0.1	5.3
0.033	SP	05-10 cm	T6	mean	13.75	4.44	1.83	84.14
0.003	SP	05-10 cm	T6	SD	1.4	0.1	0.1	8.4
0.022	SP	10-20 cm	T6	mean	8.83	2.16	2.20	69.09
0.002	SP	10-20 cm	T6	SD	1.0	0.1	0.1	5.5
0.013	SP	20-40 cm	T6	mean	1.21	1.29	1.47	28.97
0.001	SP	20-40 cm	T6	SD	0.1	0.1	0.1	0.8
0.011	SP	40-60 cm	T6	mean	1.10	0.86	1.48	31.01
0.001	SP	40-60 cm	T6	SD	0.1	0.1	0.1	0.8
0.009	SP	60-80 cm	T6	mean	1.16	0.71	1.61	34.22
0.001	SP	60-80 cm	T6	SD	0.1	0.1	0.1	0.5
0.050	SP	00-05 cm	T7	mean	8.15	4.96	1.48	55.79
0.002	SP	00-05 cm	T7	SD	0.5	0.1	0.1	2.6
0.026	SP	05-10 cm	T7	mean	10.15	4.29	2.15	68.99
0.001	SP	05-10 cm	T7	SD	1.5	0.2	0.1	8.2
0.021	SP	10-20 cm	T7	mean	6.33	1.77	2.88	61.28
0.001	SP	10-20 cm	T7	SD	1.6	0.1	0.1	9.2
0.013	SP	20-40 cm	T7	mean	1.39	0.85	2.22	37.06
0.001	SP	20-40 cm	T7	SD	0.2	0.2	0.1	1.7
0.012	SP	40-60 cm	T7	mean	1.35	0.66	2.17	38.83
0.001	SP	40-60 cm	T7	SD	0.1	0.1	0.1	2.5
0.010	SP	60-80 cm	T7	mean	1.30	0.69	2.28	38.47

0.001	SP	60-80 cm	T7	SD	0.1	0.2	0.2	5.9
0.047	SP	00-05 cm	T8	mean	9.71	7.28	1.57	63.24
0.001	SP	00-05 cm	T8	SD	0.8	0.2	0.1	4.6
0.028	SP	05-10 cm	T8	mean	11.55	4.55	3.17	84.14
0.001	SP	05-10 cm	T8	SD	1.4	0.2	0.1	6.5
0.023	SP	10-20 cm	T8	mean	8.41	1.69	4.36	82.63
0.001	SP	10-20 cm	T8	SD	1.5	0.1	0.1	8.0
0.014	SP	20-40 cm	T8	mean	1.57	0.85	3.15	44.80
0.001	SP	20-40 cm	T8	SD	0.1	0.1	0.1	1.3
0.014	SP	40-60 cm	T8	mean	1.62	0.62	3.14	48.74
0.002	SP	40-60 cm	T8	SD	0.1	0.1	0.1	0.4
0.014	SP	60-80 cm	T8	mean	1.73	0.57	3.62	53.33
0.001	SP	60-80 cm	T8	SD	0.1	0.1	0.1	0.6
0.058	SP	00-05 cm	T9	mean	21.35	11.49	2.18	113.3
0.002	SP	00-05 cm	T9	SD	3.8	0.7	0.2	18.8
0.031	SP	05-10 cm	T9	mean	24.23	6.00	6.26	155.63
0.004	SP	05-10 cm	T9	SD	3.2	0.2	1.7	16.5
0.024	SP	10-20 cm	T9	mean	11.01	1.89	6.94	109.82
0.001	SP	10-20 cm	T9	SD	3.1	0.1	0.6	21.1
0.020	SP	20-40 cm	T9	mean	2.03	0.83	4.55	58.15
0.001	SP	20-40 cm	T9	SD	0.1	0.1	0.2	2.7
0.018	SP	40-60 cm	T9	mean	2.32	0.55	4.82	64.81
0.001	SP	40-60 cm	T9	SD	0.1	0.1	0.1	1.5
0.020	SP	60-80 cm	T9	mean	2.45	0.60	5.34	69.86
0.001	SP	60-80 cm	T9	SD	0.1	0.1	0.2	2.1
0.116	SP	00-05 cm	T10	mean	26.9	14.44	3.18	137.70
0.011	SP	00-05 cm	T10	SD	3.6	0.8	0.2	18.6
0.087	SP	05-10 cm	T10	mean	34.9	6.54	9.71	226.92
0.016	SP	05-10 cm	T10	SD	4.4	0.2	0.8	22.1
0.070	SP	10-20 cm	T10	mean	26.67	1.37	13.12	207.52
0.037	SP	10-20 cm	T10	SD	6.6	0.2	0.4	34.0
0.031	SP	20-40 cm	T10	mean	2.59	0.51	8.36	75.76
0.002	SP	20-40 cm	T10	SD	0.3	0.1	0.6	3.8
0.034	SP	40-60 cm	T10	mean	2.15	0.35	8.90	80.90
0.002	SP	40-60 cm	T10	SD	0.1	0.1	0.2	0.9
0.062	SP	60-80 cm	T10	mean	1.78	0.35	10.05	83.02
0.041	SP	60-80 cm	T10	SD	0.1	0.1	0.9	2.1
0.110	SP	00-05 cm	T11	mean	29.13	15.87	3.83	146.00
0.010	SP	00-05 cm	T11	SD	7.1	2.1	0.4	36.00
0.108	SP	05-10 cm	T11	mean	35.11	5.73	12.77	244.32
0.022	SP	05-10 cm	T11	SD	3.6	0.3	1.2	20.1
0.118	SP	10-20 cm	T11	mean	23.28	1.02	15.57	196.72
0.020	SP	10-20 cm	T11	SD	8.5	0.1	3.6	54.3

0.067	SP	20-40 cm	T11	mean	4.11	0.37	11.91	95.59
0.025	SP	20-40 cm	T11	SD	1.1	0.1	0.7	7.0
0.038	SP	40-60 cm	T11	mean	2.94	0.29	11.96	97.44
0.007	SP	40-60 cm	T11	SD	0.7	0.1	2.3	6.7
0.029	SP	60-80 cm	T11	mean	3.11	0.36	14.83	104.74
0.010	SP	60-80 cm	T11	SD	0.5	0.1	1.5	2.4

ch experiment at the eleven time steps from the three

Sr µg/gsol
0.018
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0.141
0.029
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0.015
0.209
0.064

0.054
0.009
0.047
0.012
0.065
0.012

Plot	Depth	Ca	Mg	Na	K
-	*cm*	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}
Bulk soils					
Beech Plot (BP)	00-05	362	391	2375	7017
	05-10	284	575	4246	12615
	10-20	550	1277	8672	26886
	20-40	1285	3029	21187	64112
	40-60	1013	2423	16183	51389
	60-80	1226	2793	16313	44682
Spruce Plot (SP)	00-05	170	381	450	4050
	05-10	70	601	691	6719
	10-20	156	1178	1395	14740
	20-40	341	4220	5253	47760
	40-60	423	4494	6065	54937
	60-80	429	3604	4886	43982
Ini Exch					
Beech Plot (BP)	00-05	199	34	5	92
	05-10	20	6	2	23
	10-20	13	6	3	30
	20-40	22	8	9	53
	40-60	12	3	7	22
	60-80	6	1	6	13
Spruce Plot (SP)	00-05	142	27	5	65
	05-10	30	6	2	18
	10-20	17	5	3	19
	20-40	39	7	6	46
	40-60	24	5	7	49
	60-80	15	3	4	41
Final Exch					
Beech Plot (BP)	00-05	143	20	4	32
	05-10	12	3	7	41
	10-20	10	5	12	70
	20-40	13	8	18	147
	40-60	7	3	9	75
	60-80	6	2	12	69
Spruce Plot (SP)	00-05	122	23	1	30
	05-10	24	7	3	37
	10-20	8	9	3	85

	20-40	17	17	9	225
	40-60	11	22	11	255
	60-80	11	18	8	262
Clays					
Beech Plot (BP)	00-05	92	278	795	2640
	05-10	33	331	347	2270
	10-20	38	519	438	3231
	20-40	51	1864	316	10803
	40-60	57	896	761	5190
	60-80	37	504	414	2613
Spruce Plot (SP)	00-05	45	290	161	2059
	05-10	16	293	86	1979
	10-20	14	472	81	2901
	20-40	93	1333	1035	7840
	40-60	50	1812	285	10301
	60-80	38	1321	205	7516
OM					
Beech Plot (BP)	00-05	614	88	32	288
	05-10	112	16	6	53
	10-20	234	34	12	110
	20-40	328	47	17	154
	40-60	233	34	12	110
	60-80	150	21	8	70
Spruce Plot (SP)	00-05	1422	37	8	117
	05-10	509	13	3	42
	10-20	269	7	2	22
	20-40	446	12	2	37
	40-60	290	7	2	24
	60-80	176	5	1	14

Appendix C. Supplementary material

Evaluation of the stock of Ca, Mg, Na and K in bulk soil and in the different reservoirs: initial and fin organic matter in each soil layer (expressed in kg/hectare). This calculation considers the proportio the bulk soils.

ıal exchangeable cations, clays, and
ın of these different reservoirs inside

site	depth	Duplicate	time		Mg
-	-		-	-	µg/gsol
BP	00-05 cm	#1	T1	value	16.9
BP	00-05 cm	#2	T1	value	17.4
BP	00-05 cm	#3	T1	value	17.3
BP	00-05 cm		T1	mean	17.2
BP	00-05 cm		T1	SD	0.2
BP	05-10 cm	#1	T1	value	7.78
BP	05-10 cm	#2	T1	value	7.85
BP	05-10 cm	#3	T1	value	7.86
BP	00-05 cm		T1	mean	7.83
BP	00-05 cm		T1	SD	0.04
BP	10-20 cm	#1	T1	value	5.3
BP	10-20 cm	#2	T1	value	5.2
BP	10-20 cm	#3	T1	value	5.1
BP	10-20 cm		T1	mean	5.2
BP	10-20 cm		T1	SD	0.1
BP	20-40 cm	#1	T1	value	2.61
BP	20-40 cm	#2	T1	value	2.59
BP	20-40 cm	#3	T1	value	2.55
BP	20-40 cm		T1	mean	2.58
BP	20-40 cm		T1	SD	0.03
BP	40-60 cm	#1	T1	value	1.79
BP	40-60 cm	#2	T1	value	1.86
BP	40-60 cm	#3	T1	value	1.79
BP	40-60 cm		T1	mean	1.81
BP	40-60 cm		T1	SD	0.04
BP	60-80 cm	#1	T1	value	0.92
BP	60-80 cm	#2	T1	value	1.01
BP	60-80 cm	#3	T1	value	0.95
BP	60-80 cm		T1	mean	0.96
BP	60-80 cm		T1	SD	0.05
BP	00-05 cm	#1	T2	value	9.7
BP	00-05 cm	#2	T2	value	9.3
BP	00-05 cm	#3	T2	value	9.8
BP	00-05 cm		T2	mean	9.6
BP	00-05 cm		T2	SD	0.3
BP	05-10 cm	#1	T2	value	4.9
BP	05-10 cm	#2	T2	value	4.4

BP	05-10 cm	#3	T2	value	4.1
BP	05-10 cm		T2	mean	4.5
BP	05-10 cm		T2	SD	0.4
BP	10-20 cm	#1	T2	value	3
BP	10-20 cm	#2	T2	value	3.6
BP	10-20 cm	#3	T2	value	3
BP	10-20 cm		T2	mean	3.2
BP	10-20 cm		T2	SD	0.3
BP	20-40 cm	#1	T2	value	1.32
BP	20-40 cm	#2	T2	value	1.36
BP	20-40 cm	#3	T2	value	1.33
BP	20-40 cm		T2	mean	1.34
BP	20-40 cm		T2	SD	0.02
BP	40-60 cm	#1	T2	value	0.64
BP	40-60 cm	#2	T2	value	0.64
BP	40-60 cm	#3	T2	value	0.67
BP	40-60 cm		T2	mean	0.65
BP	40-60 cm		T2	SD	0.02
BP	60-80 cm	#1	T2	value	0.31
BP	60-80 cm	#2	T2	value	0.31
BP	60-80 cm	#3	T2	value	0.28
BP	60-80 cm		T2	mean	0.3
BP	60-80 cm		T2	SD	0.02
BP	00-05 cm	#1	T3	value	7.8
BP	00-05 cm	#2	T3	value	7.9
BP	00-05 cm	#3	T3	value	8.6
BP	00-05 cm		T3	mean	8.1
BP	00-05 cm		T3	SD	0.5
BP	05-10 cm	#1	T3	value	5.2
BP	05-10 cm	#2	T3	value	5.3
BP	05-10 cm	#3	T3	value	5.6
BP	05-10 cm		T3	mean	5.4
BP	05-10 cm		T3	SD	0.2
BP	10-20 cm	#1	T3	value	4.1
BP	10-20 cm	#2	T3	value	4.4
BP	10-20 cm	#3	T3	value	3.4
BP	10-20 cm		T3	mean	4
BP	10-20 cm		T3	SD	0.5
BP	20-40 cm	#1	T3	value	0.89
BP	20-40 cm	#2	T3	value	0.84
BP	20-40 cm	#3	T3	value	0.8
BP	20-40 cm		T3	mean	0.84
BP	20-40 cm		T3	SD	0.04

BP	40-60 cm	#1	T3	value	0.42
BP	40-60 cm	#2	T3	value	0.43
BP	40-60 cm	#3	T3	value	0.45
BP	40-60 cm		T3	mean	0.43
BP	40-60 cm		T3	SD	0.02
BP	60-80 cm	#1	T3	value	0.306
BP	60-80 cm	#2	T3	value	0.314
BP	60-80 cm	#3	T3	value	0.321
BP	60-80 cm		T3	mean	0.314
BP	60-80 cm		T3	SD	0.007
BP	00-05 cm	#1	T4	value	8.2
BP	00-05 cm	#2	T4	value	6.6
BP	00-05 cm	#3	T4	value	6.8
BP	00-05 cm		T4	mean	7.2
BP	00-05 cm		T4	SD	0.9
BP	05-10 cm	#1	T4	value	6.1
BP	05-10 cm	#2	T4	value	5.2
BP	05-10 cm	#3	T4	value	6.1
BP	05-10 cm		T4	mean	5.8
BP	05-10 cm		T4	SD	0.5
BP	10-20 cm	#1	T4	value	3.7
BP	10-20 cm	#2	T4	value	3.4
BP	10-20 cm	#3	T4	value	4
BP	10-20 cm		T4	mean	3.7
BP	10-20 cm		T4	SD	0.3
BP	20-40 cm	#1	T4	value	0.694
BP	20-40 cm	#2	T4	value	0.704
BP	20-40 cm	#3	T4	value	0.707
BP	10-20 cm		T4	mean	0.702
BP	10-20 cm		T4	SD	0.007
BP	40-60 cm	#1	T4	value	0.42
BP	40-60 cm	#2	T4	value	0.45
BP	40-60 cm	#3	T4	value	0.47
BP	40-60 cm		T4	mean	0.45
BP	40-60 cm		T4	SD	0.03
BP	60-80 cm	#1	T4	value	0.38
BP	60-80 cm	#2	T4	value	0.4
BP	60-80 cm	#3	T4	value	0.4
BP	60-80 cm		T4	mean	0.4
BP	60-80 cm		T4	SD	0.01
BP	00-05 cm	#1	T5	value	6
BP	00-05 cm	#2	T5	value	5
BP	00-05 cm	#3	T5	value	8

BP	00-05 cm		T5	mean	6
BP	00-05 cm		T5	SD	1
BP	05-10 cm	#1	T5	value	5.3
BP	05-10 cm	#2	T5	value	5.2
BP	05-10 cm	#3	T5	value	6.2
BP	05-10 cm		T5	mean	5.6
BP	05-10 cm		T5	SD	0.6
BP	10-20 cm	#1	T5	value	3.9
BP	10-20 cm	#2	T5	value	4.8
BP	10-20 cm	#3	T5	value	3.3
BP	10-20 cm		T5	mean	4
BP	10-20 cm		T5	SD	0.7
BP	20-40 cm	#1	T5	value	0.58
BP	20-40 cm	#2	T5	value	0.53
BP	20-40 cm	#3	T5	value	0.57
BP	20-40 cm		T5	mean	0.56
BP	20-40 cm		T5	SD	0.02
BP	40-60 cm	#1	T5	value	0.39
BP	40-60 cm	#2	T5	value	0.38
BP	40-60 cm	#3	T5	value	0.4
BP	40-60 cm		T5	mean	0.39
BP	40-60 cm		T5	SD	0.01
BP	60-80 cm	#1	T5	value	0.34
BP	60-80 cm	#2	T5	value	0.34
BP	60-80 cm	#3	T5	value	0.37
BP	60-80 cm		T5	mean	0.35
BP	60-80 cm		T5	SD	0.02
BP	00-05 cm	#1	T6	value	9.4
BP	00-05 cm	#2	T6	value	8.5
BP	00-05 cm	#3	T6	value	9.4
BP	00-05 cm		T6	mean	9.1
BP	00-05 cm		T6	SD	0.6
BP	05-10 cm	#1	T6	value	12
BP	05-10 cm	#2	T6	value	9
BP	05-10 cm	#3	T6	value	10
BP	05-10 cm		T6	mean	10
BP	05-10 cm		T6	SD	2
BP	10-20 cm	#1	T6	value	8
BP	10-20 cm	#2	T6	value	6
BP	10-20 cm	#3	T6	value	8
BP	10-20 cm		T6	mean	7
BP	10-20 cm		T6	SD	2
BP	20-40 cm	#1	T6	value	0.65

BP	20-40 cm	#2	T6	value	0.67
BP	20-40 cm	#3	T6	value	0.66
BP	20-40 cm		T6	mean	0.66
BP	20-40 cm		T6	SD	0.01
BP	40-60 cm	#1	T6	value	0.502
BP	40-60 cm	#2	T6	value	0.518
BP	40-60 cm	#3	T6	value	0.518
BP	40-60 cm		T6	mean	0.512
BP	40-60 cm		T6	SD	0.009
BP	60-80 cm	#1	T6	value	0.5
BP	60-80 cm	#2	T6	value	0.47
BP	60-80 cm	#3	T6	value	0.51
BP	60-80 cm		T6	mean	0.49
BP	60-80 cm		T6	SD	0.02
BP	00-05 cm	#1	T7	value	7
BP	00-05 cm	#2	T7	value	10
BP	00-05 cm	#3	T7	value	8
BP	00-05 cm		T7	mean	8
BP	00-05 cm		T7	SD	2
BP	05-10 cm	#1	T7	value	6
BP	05-10 cm	#2	T7	value	8
BP	05-10 cm	#3	T7	value	7
BP	05-10 cm		T7	mean	7
BP	05-10 cm		T7	SD	1
BP	10-20 cm	#1	T7	value	5.9
BP	10-20 cm	#2	T7	value	5.5
BP	10-20 cm	#3	T7	value	4.5
BP	10-20 cm		T7	mean	5.3
BP	10-20 cm		T7	SD	0.7
BP	20-40 cm	#1	T7	value	0.7
BP	20-40 cm	#2	T7	value	0.72
BP	20-40 cm	#3	T7	value	0.77
BP	20-40 cm		T7	mean	0.73
BP	20-40 cm		T7	SD	0.03
BP	40-60 cm	#1	T7	value	0.65
BP	40-60 cm	#2	T7	value	0.67
BP	40-60 cm	#3	T7	value	0.69
BP	40-60 cm		T7	mean	0.68
BP	40-60 cm		T7	SD	0.03
BP	60-80 cm	#1	T7	value	0.65
BP	60-80 cm	#2	T7	value	0.67
BP	60-80 cm	#3	T7	value	0.71
BP	60-80 cm		T7	mean	7.9

BP	60-80 cm		T7	SD	0.5
BP	00-05 cm	#1	T8	value	7.8
BP	00-05 cm	#2	T8	value	8.5
BP	00-05 cm	#3	T8	value	7.5
BP	00-05 cm		T8	mean	7.9
BP	00-05 cm		T8	SD	0.5
BP	05-10 cm	#1	T8	value	8
BP	05-10 cm	#2	T8	value	10
BP	05-10 cm	#3	T8	value	7
BP	05-10 cm		T8	mean	8
BP	05-10 cm		T8	SD	1
BP	10-20 cm	#1	T8	value	6
BP	10-20 cm	#2	T8	value	6.4
BP	10-20 cm	#3	T8	value	5.8
BP	10-20 cm		T8	mean	6.1
BP	10-20 cm			SD	0.3
BP	20-40 cm	#1	T8	value	0.99
BP	20-40 cm	#2	T8	value	0.98
BP	20-40 cm	#3	T8	value	1.01
BP	20-40 cm		T8	mean	0.99
BP	20-40 cm		T8	SD	0.02
BP	40-60 cm	#1	T8	value	0.96
BP	40-60 cm	#2	T8	value	0.99
BP	40-60 cm	#3	T8	value	1.01
BP	40-60 cm		T8	mean	0.98
BP	40-60 cm		T8	SD	0.03
BP	60-80 cm	#1	T8	value	0.96
BP	60-80 cm	#2	T8	value	0.95
BP	60-80 cm	#3	T8	value	1.02
BP	60-80 cm		T8	mean	0.98
BP	60-80 cm		T8	SD	0.04
BP	00-05 cm	#1	T9	value	15.1
BP	00-05 cm	#2	T9	value	15.5
BP	00-05 cm	#3	T9	value	14.3
BP	00-05 cm		T9	mean	14.9
BP	00-05 cm		T9	SD	0.6
BP	05-10 cm	#1	T9	value	23
BP	05-10 cm	#2	T9	value	19
BP	05-10 cm	#3	T9	value	12
BP	05-10 cm		T9	mean	18
BP	05-10 cm		T9	SD	5
BP	10-20 cm	#1	T9	value	13
BP	10-20 cm	#2	T9	value	8

BP	10-20 cm	#3	T9	value	12
BP	10-20 cm		T9	mean	11
BP	10-20 cm		T9	SD	3
BP	20-40 cm	#1	T9	value	1.66
BP	20-40 cm	#2	T9	value	1.63
BP	20-40 cm	#3	T9	value	1.7
BP	20-40 cm		T9	mean	1.67
BP	20-40 cm		T9	SD	0.03
BP	40-60 cm	#1	T9	value	1.67
BP	40-60 cm	#2	T9	value	1.61
BP	40-60 cm	#3	T9	value	1.58
BP	40-60 cm		T9	mean	1.62
BP	40-60 cm		T9	SD	0.05
BP	60-80 cm	#1	T9	value	1.7
BP	60-80 cm	#2	T9	value	1.7
BP	60-80 cm	#3	T9	value	1.9
BP	60-80 cm		T9	mean	1.7
BP	60-80 cm		T9	SD	0.1
BP	00-05 cm	#1	T10	value	20
BP	00-05 cm	#2	T10	value	29
BP	00-05 cm	#3	T10	value	32
BP	00-05 cm		T10	mean	27
BP	00-05 cm		T10	SD	6
BP	05-10 cm	#1	T10	value	31
BP	05-10 cm	#2	T10	value	42
BP	05-10 cm	#3	T10	value	27
BP	05-10 cm		T10	mean	33
BP	05-10 cm		T10	SD	7
BP	10-20 cm	#1	T10	value	23
BP	10-20 cm	#2	T10	value	35
BP	10-20 cm	#3	T10	value	26
BP	10-20 cm		T10	mean	28
BP	10-20 cm		T10	SD	6
BP	20-40 cm	#1	T10	value	2.43
BP	20-40 cm	#2	T10	value	2.44
BP	20-40 cm	#3	T10	value	2.59
BP	20-40 cm		T10	mean	2.49
BP	20-40 cm		T10	SD	0.09
BP	40-60 cm	#1	T10	value	2.5
BP	40-60 cm	#2	T10	value	2.3
BP	40-60 cm	#3	T10	value	2.4
BP	40-60 cm		T10	mean	2.4
BP	40-60 cm		T10	SD	0.1

BP	60-80 cm	#1	T10	value	2.8
BP	60-80 cm	#2	T10	value	2.7
BP	60-80 cm	#3	T10	value	2.9
BP	60-80 cm		T10	mean	25
BP	60-80 cm		T10	SD	3
BP	00-05 cm	#1	T11	value	25
BP	00-05 cm	#2	T11	value	22
BP	00-05 cm	#3	T11	value	27
BP	00-05 cm		T11	mean	27
BP	00-05 cm		T11	SD	6
BP	05-10 cm	#1	T11	value	33
BP	05-10 cm	#2	T11	value	20
BP	05-10 cm	#3	T11	value	28
BP	05-10 cm		T11	mean	29
BP	05-10 cm		T11	SD	6
BP	10-20 cm	#1	T11	value	32
BP	10-20 cm	#2	T11	value	32
BP	10-20 cm	#3	T11	value	22
BP	10-20 cm		T11	mean	13
BP	10-20 cm		T11	SD	6
BP	20-40 cm	#1	T11	value	8
BP	20-40 cm	#2	T11	value	20
BP	20-40 cm	#3	T11	value	12
BP	20-40 cm		T11	mean	6
BP	20-40 cm		T11	SD	4
BP	40-60 cm	#1	T11	value	10
BP	40-60 cm	#2	T11	value	7
BP	40-60 cm	#3	T11	value	3
BP	40-60 cm		T11	mean	6
BP	40-60 cm		T11	SD	4
BP	60-80 cm	#1	T11	value	3
BP	60-80 cm	#2	T11	value	4
BP	60-80 cm	#3	T11	value	10
BP	60-80 cm		T11	mean	6
BP	60-80 cm		T11	SD	4

Ca	Na	K	Sr	site	depth	Duplicate
µg/gsol	µg/gsol	µg/gsol	µg/gsol	-	-	
37.8	11.9	120	0.173	SP	00-05 cm	#1
37.8	12.3	123	0.171	SP	00-05 cm	#2
38.3	12.2	123	0.162	SP	00-05 cm	#3
38	12.1	122	0.169	SP	00-05 cm	
0.3	0.2	2	0.006	SP	00-05 cm	
11.56	6	27.4	0.0566	SP	05-10 cm	#1
11.57	6.1	27.7	0.0552	SP	05-10 cm	#2
11.49	6.2	27.1	0.0552	SP	05-10 cm	#3
11.54	6.1	27.4	0.0557	SP	00-05 cm	
0.04	0.1	0.3	0.0008	SP	00-05 cm	
4.9	5.7	19.7	0.0303	SP	10-20 cm	#1
4.7	5.7	18.6	0.0299	SP	10-20 cm	#2
4.7	5.5	18.6	0.0298	SP	10-20 cm	#3
4.8	5.6	19	0.03	SP	10-20 cm	
0.1	0.1	0.6	0.0003	SP	10-20 cm	
3.15	4.25	10	0.0179	SP	20-40 cm	#1
3.21	4.21	10.9	0.018	SP	20-40 cm	#2
3.21	4.17	10.3	0.0188	SP	20-40 cm	#3
3.19	4.21	10.4	0.0182	SP	20-40 cm	
0.03	0.04	0.5	0.0005	SP	20-40 cm	
2.7	5.4	8.67	0.0189	SP	40-60 cm	#1
2.9	5.2	8.61	0.0201	SP	40-60 cm	#2
2.7	5.4	8.54	0.0188	SP	40-60 cm	#3
2.7	5.4	8.61	0.0193	SP	40-60 cm	
0.1	0.1	0.06	0.0007	SP	40-60 cm	
2.1	4.58	6.32	0.0175	SP	60-80 cm	#1
2.4	4.7	6.39	0.0179	SP	60-80 cm	#2
2.3	4.7	6.34	0.0173	SP	60-80 cm	#3
2.3	4.66	6.35	0.0176	SP	60-80 cm	
0.1	0.07	0.03	0.0003	SP	60-80 cm	
21.9	5.6	81	0.091	SP	00-05 cm	#1
21.2	5.6	78	0.085	SP	00-05 cm	#2
22.6	5.8	83	0.089	SP	00-05 cm	#3
21.9	5.7	81	0.089	SP	00-05 cm	
0.7	0.1	2	0.003	SP	00-05 cm	
5.73	2.05	22	0.03	SP	05-10 cm	#1
5.73	2.06	19	0.028	SP	05-10 cm	#2

5.71	1.98	19	0.027	SP	05-10 cm	#3
5.73	2.03	20	0.028	SP	05-10 cm	
0.01	0.04	1	0.001	SP	05-10 cm	
2.62	1.96	15	0.0182	SP	10-20 cm	#1
2.67	2.02	17	0.0191	SP	10-20 cm	#2
2.62	1.93	14	0.0178	SP	10-20 cm	#3
2.64	1.97	16	0.0184	SP	10-20 cm	
0.03	0.05	1	0.0006	SP	10-20 cm	
2.2	1.65	9.4	0.0138	SP	20-40 cm	#1
2.24	1.71	8.8	0.0143	SP	20-40 cm	#2
2.31	1.63	8.5	0.0144	SP	20-40 cm	#3
2.25	1.66	8.9	0.0141	SP	20-40 cm	
0.06	0.05	0.5	0.0003	SP	20-40 cm	
1.71	1.77	6.9	0.0144	SP	40-60 cm	#1
1.84	1.67	7.1	0.0145	SP	40-60 cm	#2
1.74	1.76	7.2	0.0134	SP	40-60 cm	#3
1.76	1.73	7.1	0.0141	SP	40-60 cm	
0.07	0.05	0.1	0.0006	SP	40-60 cm	
1.31	1.52	5.1	0.0113	SP	60-80 cm	#1
1.44	1.44	5.5	0.0115	SP	60-80 cm	#2
1.32	1.43	5.4	0.0107	SP	60-80 cm	#3
1.36	1.46	5.3	0.0112	SP	60-80 cm	
0.07	0.05	0.2	0.0004	SP	60-80 cm	
13.4	3.01	56	0.06	SP	00-05 cm	#1
12.9	2.93	57	0.01	SP	00-05 cm	#2
14.2	3.11	62	0.06	SP	00-05 cm	#3
13.5	3.02	58	0.04	SP	00-05 cm	
0.6	0.09	3	0.03	SP	00-05 cm	
4.72	2.82	26	0.0282	SP	05-10 cm	#1
4.79	2.78	26	0.0279	SP	05-10 cm	#2
4.71	2.85	28	0.028	SP	05-10 cm	#3
4.74	2.82	26	0.0281	SP	05-10 cm	
0.04	0.04	1	0.0002	SP	05-10 cm	
2.09	2.87	22	0.018	SP	10-20 cm	#1
2.05	2.84	24	0.018	SP	10-20 cm	#2
2.12	2.79	20	0.0173	SP	10-20 cm	#3
2.09	2.83	22	0.0178	SP	10-20 cm	
0.04	0.04	2	0.0004	SP	10-20 cm	
1.63	2.33	10.8	0.012	SP	20-40 cm	#1
1.65	2.44	10.8	0.0121	SP	20-40 cm	#2
1.67	2.39	12	0.0122	SP	20-40 cm	#3
1.65	2.39	11.2	0.0121	SP	20-40 cm	
0.02	0.05	0.7	0.0001	SP	20-40 cm	

1.22	1.9	8.9	0.003	SP	40-60 cm	#1
1.28	2.2	9.2	-	SP	40-60 cm	#2
1.28	1.9	8.1	0.011	SP	40-60 cm	#3
1.26	2	8.7	0.007	SP	40-60 cm	
0.03	0.2	0.6	0.006	SP	40-60 cm	
0.94	1.6	8.5	0.0098	SP	60-80 cm	#1
1.04	1.8	8.8	0.0099	SP	60-80 cm	#2
0.93	1.6	8.9	0.0096	SP	60-80 cm	#3
0.97	1.7	8.8	0.0097	SP	60-80 cm	
0.06	0.1	0.2	0.0002	SP	60-80 cm	
10.1	2.3	50	0.05	SP	00-05 cm	#1
9.2	2	44	0.02	SP	00-05 cm	#2
10.2	2.1	45	0.05	SP	00-05 cm	#3
9.8	2.1	46	0.04	SP	00-05 cm	
0.6	0.1	3	0.02	SP	00-05 cm	
3.92	3.7	34	0.0262	SP	05-10 cm	#1
3.83	3.5	29	0.0255	SP	05-10 cm	#2
3.92	3.9	33	0.0268	SP	05-10 cm	#3
3.89	3.7	32	0.0262	SP	05-10 cm	
0.06	0.2	3	0.0007	SP	05-10 cm	
1.7	3.66	25	0.018	SP	10-20 cm	#1
1.66	3.57	23	0.018	SP	10-20 cm	#2
1.7	3.58	26	0.016	SP	10-20 cm	#3
1.69	3.6	24	0.018	SP	10-20 cm	
0.02	0.05	1	0.001	SP	10-20 cm	
1.18	3	13.6	0.0115	SP	20-40 cm	#1
1.2	3	13.9	0.0115	SP	20-40 cm	#2
1.28	3.3	15.1	0.0113	SP	20-40 cm	#3
1.22	3.1	14.2	0.0114	SP	10-20 cm	
0.05	0.2	0.8	0.0001	SP	10-20 cm	
0.91	2.2	11.2	0.006	SP	40-60 cm	#1
0.96	2.7	12	0.012	SP	40-60 cm	#2
0.97	2.5	11.9	0.01	SP	40-60 cm	#3
0.95	2.5	11.7	0.01	SP	40-60 cm	
0.03	0.3	0.4	0.003	SP	40-60 cm	
0.71	2	10.3	0.0092	SP	60-80 cm	#1
0.82	2.2	10.8	0.0094	SP	60-80 cm	#2
0.71	2.1	11.1	0.0089	SP	60-80 cm	#3
0.75	2.1	10.7	0.0091	SP	60-80 cm	
0.07	0.1	0.4	0.0002	SP	60-80 cm	
8.3	1.7	36	0.043	SP	00-05 cm	#1
7.6	1.5	34	0.036	SP	00-05 cm	#2
8.7	1.9	43	0.042	SP	00-05 cm	#3

8.2	1.7	37	0.04	SP	00-05 cm	
0.5	0.2	5	0.004	SP	00-05 cm	
3.15	3.4	32	0.024	SP	05-10 cm	#1
3.25	3.4	30	0.023	SP	05-10 cm	#2
3.31	3.8	34	0.026	SP	05-10 cm	#3
3.24	3.5	32	0.024	SP	05-10 cm	
0.08	0.3	2	0.001	SP	05-10 cm	
1.36	3.41	26	0.018	SP	10-20 cm	#1
1.35	3.44	29	0.018	SP	10-20 cm	#2
1.31	3.39	24	0.015	SP	10-20 cm	#3
1.34	3.41	26	0.017	SP	10-20 cm	
0.03	0.03	3	0.002	SP	10-20 cm	
1.01	2.7	13.5	0.011	SP	20-40 cm	#1
0.96	2.8	13.9	0.0108	SP	20-40 cm	#2
0.98	3.1	14.3	0.0104	SP	20-40 cm	#3
0.98	2.9	13.9	0.0107	SP	20-40 cm	
0.02	0.2	0.4	0.0003	SP	20-40 cm	
0.73	2.1	10.6	0.01	SP	40-60 cm	#1
0.86	2.4	10.7	0.012	SP	40-60 cm	#2
0.75	2.3	11	0.009	SP	40-60 cm	#3
0.78	2.3	10.7	0.011	SP	40-60 cm	
0.07	0.1	0.2	0.002	SP	40-60 cm	
0.51	1.83	9.3	0.0085	SP	60-80 cm	#1
0.6	1.8	9.6	0.0088	SP	60-80 cm	#2
0.49	1.75	10.7	0.0082	SP	60-80 cm	#3
0.54	1.79	9.9	0.0085	SP	60-80 cm	
0.06	0.04	0.8	0.0003	SP	60-80 cm	
8.5	2.1	46	0.056	SP	00-05 cm	#1
8.2	1.8	44	0.043	SP	00-05 cm	#2
9.2	2	46	0.052	SP	00-05 cm	#3
8.6	1.9	45	0.05	SP	00-05 cm	
0.5	0.1	1	0.007	SP	00-05 cm	
2.71	5	59	0.037	SP	05-10 cm	#1
2.77	4.6	45	0.03	SP	05-10 cm	#2
2.61	5.1	51	0.033	SP	05-10 cm	#3
2.7	4.9	52	0.033	SP	05-10 cm	
0.08	0.3	7	0.003	SP	05-10 cm	
1.05	4.9	46	0.024	SP	10-20 cm	#1
1.11	4.4	34	0.019	SP	10-20 cm	#2
1.12	4.8	43	0.023	SP	10-20 cm	#3
1.09	4.7	41	0.022	SP	10-20 cm	
0.04	0.3	7	0.002	SP	10-20 cm	
0.94	3.1	17.2	0.0128	SP	20-40 cm	#1

0.98	3.4	17	0.0134	SP	20-40 cm	#2
0.97	3.6	18.4	0.0133	SP	20-40 cm	#3
0.96	3.4	17.5	0.0132	SP	20-40 cm	
0.02	0.2	0.8	0.0003	SP	20-40 cm	
0.66	2.5	12.7	0.012	SP	40-60 cm	#1
0.68	3	13.8	0.013	SP	40-60 cm	#2
0.69	2.7	13.7	0.011	SP	40-60 cm	#3
0.68	2.7	13.4	0.012	SP	40-60 cm	
0.02	0.2	0.6	0.001	SP	40-60 cm	
0.49	2.28	12	0.00992	SP	60-80 cm	#1
0.55	2.19	12	0.00982	SP	60-80 cm	#2
0.49	2.36	14	0.00982	SP	60-80 cm	#3
0.51	2.28	13	0.00985	SP	60-80 cm	
0.04	0.08	1	0.00006	SP	60-80 cm	
8.6	1.9	35	0.053	SP	00-05 cm	#1
8.8	2.3	48	0.051	SP	00-05 cm	#2
9.6	2	38	0.049	SP	00-05 cm	#3
9	2.1	40	0.051	SP	00-05 cm	
0.5	0.2	7	0.002	SP	00-05 cm	
2.4	5.5	40	0.025	SP	05-10 cm	#1
2.9	6	47	0.029	SP	05-10 cm	#2
2.6	6.2	44	0.026	SP	05-10 cm	#3
2.6	5.9	43	0.026	SP	05-10 cm	
0.2	0.3	3	0.002	SP	05-10 cm	
1	5.96	39	0.023	SP	10-20 cm	#1
1.1	5.84	36	0.021	SP	10-20 cm	#2
1.2	5.83	33	0.019	SP	10-20 cm	#3
1.1	5.88	36	0.021	SP	10-20 cm	
0.1	0.07	3	0.002	SP	10-20 cm	
0.76	4.4	20	0.0125	SP	20-40 cm	#1
0.82	4.5	20	0.0133	SP	20-40 cm	#2
0.81	4.9	22	0.0133	SP	20-40 cm	#3
0.8	4.6	20	0.013	SP	20-40 cm	
0.03	0.3	1	0.0005	SP	20-40 cm	
0.548	3.3	15.9	0.012	SP	40-60 cm	#1
0.561	4	17.2	0.014	SP	40-60 cm	#2
0.565	3.8	17.7	0.011	SP	40-60 cm	#3
0.46	3.1	16.9	0.0109	SP	40-60 cm	
0.03	0.06	0.7	0.0002	SP	40-60 cm	
0.43	3.04	16.2	0.0107	SP	60-80 cm	#1
0.49	3.12	16.7	0.0111	SP	60-80 cm	#2
0.45	3.15	17.7	0.0108	SP	60-80 cm	#3
9.2	2.7	36	0.048	SP	60-80 cm	

0.7	0.2	3	0.002	SP	60-80 cm	
8.8	2.8	36	0.047	SP	00-05 cm	#1
8.8	2.7	39	0.047	SP	00-05 cm	#2
10.1	2.5	33	0.05	SP	00-05 cm	#3
9.2	2.7	36	0.048	SP	00-05 cm	
0.7	0.2	3	0.002	SP	00-05 cm	
2.2	8.2	54	0.028	SP	05-10 cm	#1
2.5	8.6	57	0.03	SP	05-10 cm	#2
2.3	8.4	49	0.028	SP	05-10 cm	#3
2.3	8.4	53	0.029	SP	05-10 cm	
0.2	0.2	4	0.001	SP	05-10 cm	
1.02	8.6	45	0.024	SP	10-20 cm	#1
1.12	8.4	46	0.025	SP	10-20 cm	#2
1.03	8.3	44	0.022	SP	10-20 cm	#3
1.06	8.4	45	0.024	SP	10-20 cm	
0.06	0.2	1	0.001	SP	10-20 cm	
0.73	6.1	25	0.0142	SP	20-40 cm	#1
0.73	6.3	25.4	0.015	SP	20-40 cm	#2
0.75	6.8	26.4	0.0157	SP	20-40 cm	#3
0.73	6.4	25.6	0.015	SP	20-40 cm	
0.01	0.3	0.8	0.0008	SP	20-40 cm	
0.55	4.6	22	0.013	SP	40-60 cm	#1
0.58	5.8	23	0.017	SP	40-60 cm	#2
0.57	5.2	24	0.013	SP	40-60 cm	#3
0.57	5.2	23	0.015	SP	40-60 cm	
0.02	0.6	1	0.002	SP	40-60 cm	
0.48	4.1	21	0.0139	SP	60-80 cm	#1
0.52	4.2	21	0.0142	SP	60-80 cm	#2
0.52	4.6	24	0.0143	SP	60-80 cm	#3
0.51	4.3	22	0.0141	SP	60-80 cm	
0.03	0.2	2	0.0002	SP	60-80 cm	
12.6	4.2	58	0.056	SP	00-05 cm	#1
13.4	4.5	60	0.061	SP	00-05 cm	#2
13.2	4.6	56	0.06	SP	00-05 cm	#3
13.1	4.5	58	0.059	SP	00-05 cm	
0.4	0.2	2	0.003	SP	00-05 cm	
3.3	15.7	117	0.036	SP	05-10 cm	#1
3.2	14.7	99	0.03	SP	05-10 cm	#2
3	14.7	77	0.028	SP	05-10 cm	#3
3.2	15	98	0.031	SP	05-10 cm	
0.2	0.6	20	0.004	SP	05-10 cm	
1.44	13.5	76	0.0244	SP	10-20 cm	#1
1.34	14	62	0.0231	SP	10-20 cm	#2

1.45	14.8	78	0.0249	SP	10-20 cm	#3
1.41	14.1	72	0.0241	SP	10-20 cm	
0.06	0.6	9	0.0009	SP	10-20 cm	
1.01	10.4	38.7	0.02	SP	20-40 cm	#1
1.03	10.8	38.6	0.021	SP	20-40 cm	#2
0.94	10.4	38.4	0.019	SP	20-40 cm	#3
0.99	10.5	38.6	0.02	SP	20-40 cm	
0.05	0.2	0.1	0.001	SP	20-40 cm	
0.71	9.1	36	0.0188	SP	40-60 cm	#1
0.75	8.7	36	0.0189	SP	40-60 cm	#2
0.73	8.6	33	0.0191	SP	40-60 cm	#3
0.73	8.8	35	0.019	SP	40-60 cm	
0.02	0.3	1	0.0002	SP	40-60 cm	
0.65	6.8	34	0.02	SP	60-80 cm	#1
0.74	7.1	35	0.02	SP	60-80 cm	#2
0.72	8	39	0.023	SP	60-80 cm	#3
0.7	7.3	36	0.021	SP	60-80 cm	
0.05	0.6	2	0.002	SP	60-80 cm	
14	7	70	0.1	SP	00-05 cm	#1
16	8	110	0.12	SP	00-05 cm	#2
17	10	121	0.12	SP	00-05 cm	#3
16	8	101	0.12	SP	00-05 cm	
1	1	27	0.01	SP	00-05 cm	
3.1	29	168	0.09	SP	05-10 cm	#1
3.3	30	206	0.1	SP	05-10 cm	#2
2.8	31	154	0.07	SP	05-10 cm	#3
3.1	30	176	0.09	SP	05-10 cm	
0.3	1	27	0.02	SP	05-10 cm	
1.28	26	126	0.11	SP	10-20 cm	#1
1.45	30	180	0.07	SP	10-20 cm	#2
1.31	28	142	0.03	SP	10-20 cm	#3
1.35	28	149	0.07	SP	10-20 cm	
0.09	2	27	0.04	SP	10-20 cm	
0.77	19	54	0.032	SP	20-40 cm	#1
0.77	23	59	0.029	SP	20-40 cm	#2
0.69	20	55	0.034	SP	20-40 cm	#3
0.74	21	56	0.032	SP	20-40 cm	
0.05	2	2	0.002	SP	20-40 cm	
0.7	18	56	0.033	SP	40-60 cm	#1
0.69	17	54	0.032	SP	40-60 cm	#2
0.71	16	53	0.037	SP	40-60 cm	#3
0.7	17	54	0.034	SP	40-60 cm	
0.01	1	2	0.003	SP	40-60 cm	

0.75	13	54	0.04	SP	60-80 cm	#1
0.8	13	53	0.04	SP	60-80 cm	#2
0.79	15	60	0.11	SP	60-80 cm	#3
13.9	9	97	0.11	SP	60-80 cm	
0.4	1	13	0.01	SP	60-80 cm	
13.6	9	92	0.11	SP	00-05 cm	#1
13.6	9	87	0.1	SP	00-05 cm	#2
14.3	10	112	0.12	SP	00-05 cm	#3
2.4	36	166	0.11	SP	00-05 cm	
0.3	4	32	0.02	SP	00-05 cm	
2.7	40	195	0.12	SP	05-10 cm	#1
2.1	32	132	0.08	SP	05-10 cm	#2
2.4	37	170	0.12	SP	05-10 cm	#3
1.18	34	166	0.12	SP	05-10 cm	
0.09	2	25	0.02	SP	05-10 cm	
1.24	36	178	0.13	SP	10-20 cm	#1
1.23	36	182	0.13	SP	10-20 cm	#2
1.08	31	137	0.09	SP	10-20 cm	#3
0.7	31.3	108	0.07	SP	10-20 cm	
0.2	0.8	25	0.03	SP	10-20 cm	
0.6	30.4	85	0.05	SP	20-40 cm	#1
0.9	31.9	135	0.1	SP	20-40 cm	#2
0.6	31.7	103	0.06	SP	20-40 cm	#3
0.66	25	79	0.038	SP	20-40 cm	
0.03	6	18	0.008	SP	20-40 cm	
0.65	30	96	0.047	SP	40-60 cm	#1
0.63	25	82	0.037	SP	40-60 cm	#2
0.7	19	60	0.032	SP	40-60 cm	#3
0.66	25	79	0.038	SP	40-60 cm	
0.03	6	18	0.008	SP	40-60 cm	
0.58	22	74	0.02	SP	60-80 cm	#1
0.57	23	73	0.02	SP	60-80 cm	#2
0.66	25	94	0.04	SP	60-80 cm	#3
0.6	24	81	0.03	SP	60-80 cm	
0.05	2	12	0.01	SP	60-80 cm	

time		Mg	Ca	Na	K	Sr
-	-	µg/gsol	µg/gsol	µg/gsol	µg/gsol	µg/gsol
T1	value	2.9	4	9	58	0.0175
T1	value	3.2	4.3	9.2	60	0.0185
T1	value	3.2	4.3	9.3	60	0.0191
T1	mean	3.1	4.2	9.1	59	0.0184
T1	SD	0.2	0.1	0.2	1	0.0008
T1	value	7.3	13	7.2	42	0.063
T1	value	7.3	12.3	7.2	42	0.058
T1	value	6.4	11.9	7	38	0.055
T1	mean	7	12.4	7.2	41	0.059
T1	SD	0.5	0.5	0.1	2	0.004
T1	value	4.6	5.7	4.8	26	0.036
T1	value	4.4	5.6	4.4	26	0.036
T1	value	4.1	5.4	4.1	24	0.034
T1	mean	4.4	5.6	4.4	25	0.035
T1	SD	0.3	0.1	0.3	1	0.001
T1	value	2.63	5.89	4.9	16.7	0.035
T1	value	2.65	5.82	4.96	16.2	0.038
T1	value	2.66	5.91	4.89	16.7	0.038
T1	mean	2.65	5.87	4.92	16.5	0.037
T1	SD	0.01	0.05	0.04	0.3	0.001
T1	value	2.3	5.5	4.6	19.3	0.0356
T1	value	2.25	5.9	4.7	19.2	0.0354
T1	value	2.31	5.6	4.7	20	0.0356
T1	mean	2.29	5.7	4.7	19.5	0.0355
T1	SD	0.03	0.2	0.1	0.5	0.0001
T1	value	2.03	5.9	3.85	23	0.0341
T1	value	2	6.2	3.92	22.7	0.0335
T1	value	1.93	5.7	3.94	22.6	0.0353
T1	mean	1.99	5.9	3.9	22.7	0.0343
T1	SD	0.05	0.2	0.05	0.2	0.0009
T2	value	2.5	2.46	5.32	48	0.0131
T2	value	3	2.59	5.41	50	0.0137
T2	value	2.6	2.48	5.42	47	0.0129
T2	mean	2.7	2.51	5.38	48	0.0132
T2	SD	0.3	0.07	0.05	2	0.0004
T2	value	4.8	6.7	2.2	31	0.0366
T2	value	4.5	6.5	2.1	29	0.0359

T2	value	4.4	6.4	2	28	0.035
T2	mean	4.6	6.5	2.1	30	0.0358
T2	SD	0.2	0.2	0.1	1	0.0008
T2	value	3.9	3.59	1.4	24	0.028
T2	value	3.7	3.56	1.2	23	0.029
T2	value	2.8	3.43	1.1	18	0.026
T2	mean	3.4	3.52	1.2	22	0.027
T2	SD	0.6	0.08	0.1	4	0.002
T2	value	1.61	3.82	1.19	13.4	0.026
T2	value	1.68	3.72	1.12	13.2	0.026
T2	value	1.67	3.8	1.18	14.1	0.028
T2	mean	1.65	3.78	1.16	13.6	0.027
T2	SD	0.04	0.05	0.04	0.5	0.001
T2	value	1.35	3.4	1.02	15.5	0.0281
T2	value	1.38	3.6	1.1	15.2	0.028
T2	value	1.4	3.7	1.1	15.6	0.0288
T2	mean	1.38	3.6	1.07	15.4	0.0283
T2	SD	0.02	0.1	0.05	0.2	0.0004
T2	value	1.3	3.7	1.01	16.4	0.0255
T2	value	1.22	3.69	0.86	16.9	0.0258
T2	value	1.24	3.53	0.91	15.9	0.026
T2	mean	1.25	3.64	0.93	16.4	0.0258
T2	SD	0.05	0.09	0.08	0.5	0.0002
T3	value	4.4	2.5	3.4	48	0.0156
T3	value	4.6	2.6	3.5	48	0.0159
T3	value	5.1	2.7	3.7	52	0.0159
T3	mean	4.7	2.6	3.5	49	0.0158
T3	SD	0.3	0.1	0.1	2	0.0002
T3	value	7.6	5.74	1.46	46	0.0331
T3	value	6.8	5.63	1.4	41	0.0317
T3	value	8	5.72	1.52	49	0.0328
T3	mean	7.5	5.7	1.46	45	0.0326
T3	SD	0.7	0.06	0.06	4	0.0007
T3	value	5	3.18	1.5	36	0.024
T3	value	5	3.11	1.5	35	0.025
T3	value	7	3.12	1.7	45	0.025
T3	mean	5	3.14	1.5	39	0.025
T3	SD	1	0.03	0.1	6	0.001
T3	value	1.34	2.9	1.4	20	0.021
T3	value	1.3	2.9	1.2	18.8	0.021
T3	value	1.32	2.87	1.2	19.4	0.024
T3	mean	1.32	2.89	1.3	19.4	0.022
T3	SD	0.02	0.02	0.1	0.6	0.002

T3	value	0.94	2.2	1.12	21.6	0.021
T3	value	0.97	2.4	1.11	20.5	0.022
T3	value	1.02	2.7	1.19	21.5	0.025
T3	mean	0.98	2.4	1.14	21.2	0.023
T3	SD	0.04	0.2	0.05	0.6	0.002
T3	value	0.91	2.2	1.26	24.4	0.02
T3	value	0.92	2.23	1.12	24.6	0.021
T3	value	0.93	2.11	1.24	24.4	0.022
T3	mean	0.92	2.18	1.2	24.5	0.021
T3	SD	0.01	0.06	0.07	0.1	0.001
T4	value	6.6	3.58	2.85	58	0.0204
T4	value	5.6	3.54	2.84	52	0.0197
T4	value	5.8	3.56	2.89	54	0.0191
T4	mean	6	3.56	2.86	54	0.0197
T4	SD	0.5	0.02	0.03	3	0.0006
T4	value	8	5	1.55	53	0.0329
T4	value	10	5.2	1.63	61	0.0327
T4	value	8	5	1.56	53	0.0336
T4	mean	9	5.1	1.58	55	0.0331
T4	SD	1	0.1	0.04	5	0.0004
T4	value	6.7	2.57	2.05	54	0.025
T4	value	5.7	2.53	1.89	48	0.028
T4	value	5.4	2.5	1.97	46	0.027
T4	mean	5.9	2.53	1.97	50	0.027
T4	SD	0.7	0.04	0.08	4	0.002
T4	value	1.2	1.88	1.54	26	0.021
T4	value	1.17	1.83	1.48	26	0.022
T4	value	1.2	1.81	1.45	27	0.025
T4	mean	1.19	1.84	1.49	26	0.023
T4	SD	0.02	0.03	0.04	1	0.002
T4	value	0.9	1.3	1.4	28.2	0.023
T4	value	0.94	1.5	1.38	28.2	0.023
T4	value	0.95	1.6	1.41	28.8	0.027
T4	mean	0.93	1.4	1.4	28.4	0.024
T4	SD	0.02	0.2	0.01	0.4	0.003
T4	value	0.956	1.29	1.54	32.3	0.021
T4	value	0.966	1.27	1.56	32	0.022
T4	value	0.95	1.23	1.65	33.2	0.025
T4	mean	0.957	1.26	1.59	32.5	0.023
T4	SD	0.008	0.03	0.06	0.6	0.002
T5	value	7.5	3.42	2.06	57	0.025
T5	value	7	3.43	2.11	54	0.025
T5	value	6.4	3.33	2.09	51	0.023

T5	mean	7	3.39	2.09	54	0.024
T5	SD	0.5	0.06	0.02	3	0.001
T5	value	8.3	4.59	1.41	53	0.0338
T5	value	9.6	4.68	1.5	60	0.0352
T5	value	9.4	4.62	1.55	60	0.0348
T5	mean	9.1	4.63	1.49	58	0.0346
T5	SD	0.7	0.05	0.07	4	0.0007
T5	value	4.3	2.42	1.81	43	0.028
T5	value	5.7	2.5	1.66	49	0.032
T5	value	5.4	2.35	1.81	48	0.029
T5	mean	5.1	2.42	1.76	47	0.03
T5	SD	0.7	0.08	0.08	3	0.002
T5	value	1.18	1.74	1.33	26.9	0.022
T5	value	1.14	1.78	1.24	25.7	0.023
T5	value	1.17	1.63	1.26	27	0.028
T5	mean	1.16	1.72	1.27	26.5	0.024
T5	SD	0.02	0.08	0.05	0.7	0.003
T5	value	1.04	1	1.23	28.3	0.025
T5	value	1.04	1.2	1.3	28.7	0.024
T5	value	1.07	1.4	1.31	29.4	0.03
T5	mean	1.05	1.2	1.28	28.8	0.027
T5	SD	0.02	0.2	0.04	0.6	0.003
T5	value	1.079	1	1.39	31.7	0.023
T5	value	1.083	0.98	1.36	31.3	0.025
T5	value	1.089	0.97	1.31	30.6	0.03
T5	mean	1.084	0.98	1.36	31.2	0.026
T5	SD	0.005	0.02	0.04	0.5	0.003
T6	value	9	3.9	1.62	59	0.028
T6	value	10	4.4	1.78	67	0.033
T6	value	11	4.2	1.76	70	0.033
T6	mean	10	4.2	1.72	65	0.031
T6	SD	1	0.3	0.09	5	0.002
T6	value	13	4.5	1.8	80	0.041
T6	value	13	4.3	1.7	78	0.039
T6	value	15	4.5	2	94	0.044
T6	mean	14	4.4	1.8	84	0.042
T6	SD	1	0.1	0.1	8	0.003
T6	value	8	2.2	2.2	63	0.034
T6	value	9	2.2	2.16	69	0.039
T6	value	10	2	2.26	75	0.037
T6	mean	9	2.2	2.21	69	0.037
T6	SD	1	0.1	0.05	6	0.003
T6	value	1.23	1.3	1.51	29.4	0.021

T6	value	1.13	1.29	1.42	28	0.022
T6	value	1.28	1.28	1.49	29.6	0.029
T6	mean	1.21	1.29	1.48	29	0.024
T6	SD	0.08	0.01	0.05	0.9	0.004
T6	value	1.11	0.8	1.58	30.8	0.024
T6	value	1.08	0.9	1.43	30.3	0.024
T6	value	1.12	1	1.46	32	0.022
T6	mean	1.1	0.9	1.49	31	0.023
T6	SD	0.02	0.1	0.08	0.9	0.001
T6	value	1.18	0.72	1.67	34	0.029
T6	value	1.16	0.71	1.57	34.9	0.023
T6	value	1.16	0.7	1.6	33.7	0.027
T6	mean	1.17	0.71	1.62	34.2	0.027
T6	SD	0.01	0.01	0.05	0.6	0.003
T7	value	8.6	5.01	1.46	58	0.037
T7	value	7.5	4.89	1.47	53	0.033
T7	value	8.4	4.98	1.52	57	0.034
T7	mean	8.2	4.96	1.48	56	0.035
T7	SD	0.6	0.06	0.03	3	0.002
T7	value	12	4.6	2.2	78	0.042
T7	value	9	4.1	2.09	62	0.035
T7	value	10	4.2	2.17	66	0.035
T7	mean	10	4.3	2.15	69	0.037
T7	SD	2	0.2	0.06	8	0.004
T7	value	8	1.9	3	72	0.039
T7	value	5	1.8	2.8	54	0.034
T7	value	6	1.7	2.8	58	0.032
T7	mean	6	1.8	2.9	61	0.035
T7	SD	2	0.1	0.1	9	0.004
T7	value	1.2	1	2.2	35	0.022
T7	value	1.7	1	2.4	39	0.032
T7	value	1.2	0.6	2.2	37	0.023
T7	mean	1.4	0.9	2.2	37	0.026
T7	SD	0.3	0.2	0.1	2	0.005
T7	value	1.4	0.72	2.1	38	0.027
T7	value	1.2	0.7	2	37	0.03
T7	value	1.4	0.58	2.4	42	0.024
T7	mean	1.4	0.67	2.2	39	0.027
T7	SD	0.1	0.08	0.2	3	0.003
T7	value	1.4	0.6	2.3	42	0.025
T7	value	1.4	0.6	2.5	42	0.03
T7	value	1.1	0.9	2	32	0.021
T7	mean	1.3	0.7	2.3	38	0.025

T7	SD	0.2	0.2	0.2	6	0.004
T8	value	8.7	7.1	1.48	58	0.045
T8	value	10.1	7.3	1.65	66	0.047
T8	value	10.3	7.5	1.61	66	0.047
T8	mean	9.7	7.3	1.58	63	0.046
T8	SD	0.9	0.2	0.09	5	0.001
T8	value	11	4.8	3.1	83	0.045
T8	value	13	4.5	3.2	91	0.047
T8	value	10	4.4	3.2	79	0.038
T8	mean	12	4.6	3.2	84	0.043
T8	SD	1	0.2	0.1	7	0.005
T8	value	7	1.8	4.5	76	0.039
T8	value	10	1.8	4.3	92	0.048
T8	value	8	1.6	4.3	80	0.042
T8	mean	8	1.7	4.4	83	0.043
	SD	2	0.1	0.1	8	0.005
T8	value	1.57	0.86	3.25	45	0.025
T8	value	1.55	0.87	3.06	43	0.026
T8	value	1.61	0.84	3.16	46	0.037
T8	mean	1.58	0.85	3.15	45	0.029
T8	SD	0.03	0.02	0.09	1	0.007
T8	value	1.68	0.57	3.22	48.4	0.028
T8	value	1.59	0.66	3.12	48.5	0.028
T8	value	1.61	0.63	3.1	49.3	0.033
T8	mean	1.62	0.62	3.15	48.7	0.03
T8	SD	0.05	0.04	0.07	0.5	0.003
T8	value	1.71	0.54	3.65	53.1	0.026
T8	value	1.8	0.62	3.58	54	0.03
T8	value	1.69	0.55	3.64	52.9	0.033
T8	mean	1.74	0.57	3.62	53.3	0.03
T8	SD	0.06	0.04	0.04	0.6	0.004
T9	value	17	10.7	1.9	94	0.056
T9	value	25	12.1	2.4	131	0.059
T9	value	21	11.8	2.3	114	0.06
T9	mean	21	11.5	2.2	113	0.058
T9	SD	4	0.7	0.2	19	0.002
T9	value	21	5.8	5	138	0.045
T9	value	24	6.2	5	157	0.051
T9	value	27	6	8	171	0.053
T9	mean	24	6	6	156	0.05
T9	SD	3	0.2	2	17	0.004
T9	value	8	1.93	6.2	88	0.06
T9	value	11	1.95	7	111	0.04

T9	value	14	1.81	7.6	131	0.04
T9	mean	11	1.9	6.9	110	0.05
T9	SD	3	0.08	0.7	21	0.01
T9	value	2.05	0.82	4.7	59	0.028
T9	value	2.04	0.8	4.7	60	0.029
T9	value	2.01	0.87	4.3	55	0.035
T9	mean	2.04	0.83	4.6	58	0.03
T9	SD	0.02	0.04	0.2	3	0.004
T9	value	2.35	0.54	4.8	63	0.031
T9	value	2.31	0.57	4.81	66	0.033
T9	value	2.32	0.55	4.87	65	0.03
T9	mean	2.32	0.56	4.83	65	0.031
T9	SD	0.02	0.02	0.04	2	0.002
T9	value	2.39	0.6	5.1	68	0.036
T9	value	2.46	0.59	5.3	70	0.031
T9	value	2.52	0.62	5.7	72	0.032
T9	mean	2.46	0.61	5.3	70	0.033
T9	SD	0.07	0.01	0.3	2	0.002
T10	value	25	14	3	131	0.12
T10	value	24	13.9	3.1	123	0.14
T10	value	31	15.4	3.4	159	0.11
T10	mean	27	14.4	3.2	138	0.12
T10	SD	4	0.8	0.2	19	0.01
T10	value	33	6.5	9.2	214	0.11
T10	value	32	6.4	9.2	214	0.14
T10	value	40	6.8	10.7	252	0.18
T10	mean	35	6.5	9.7	227	0.15
T10	SD	4	0.2	0.8	22	0.03
T10	value	33	1.5	12.7	237	0.13
T10	value	27	1.5	13.7	215	0.13
T10	value	20	1.1	13	170	0.04
T10	mean	27	1.4	13.1	208	0.1
T10	SD	7	0.2	0.5	34	0.05
T10	value	2.6	0.52	8.5	76	0.039
T10	value	2.9	0.49	8.9	80	0.041
T10	value	2.3	0.55	7.7	72	0.038
T10	mean	2.6	0.52	8.4	76	0.039
T10	SD	0.3	0.03	0.6	4	0.002
T10	value	2.154	0.38	9	80.2	0.038
T10	value	2.147	0.36	8.7	81.9	0.037
T10	value	2.166	0.34	9	80.6	0.036
T10	mean	2.156	0.36	8.9	80.9	0.037
T10	SD	0.009	0.02	0.2	0.9	0.001

T10	value	1.84	0.38	9.2	81	0.03
T10	value	1.82	0.35	9.9	84	0.03
T10	value	1.7	0.34	11	84	0.07
T10	mean	1.79	0.36	10.1	83	0.04
T10	SD	0.08	0.02	0.9	2	0.02
T11	value	31	17	4.1	156	0.15
T11	value	21	14	3.3	106	0.11
T11	value	35	18	4.1	176	0.17
T11	mean	29	16	3.8	146	0.14
T11	SD	7	2	0.5	36	0.03
T11	value	32	5.7	11	225	0.15
T11	value	34	5.4	13	243	0.17
T11	value	39	6.1	14	265	0.18
T11	mean	35	5.7	13	244	0.16
T11	SD	4	0.4	1	20	0.02
T11	value	19	1.06	13	163	0.18
T11	value	18	1.07	14	168	0.16
T11	value	33	0.95	20	259	0.28
T11	mean	23	1.02	16	197	0.21
T11	SD	9	0.07	4	54	0.06
T11	value	5	0.42	12.1	102	0.062
T11	value	4	0.34	12.6	97	0.056
T11	value	3	0.37	11.1	88	0.044
T11	mean	4	0.38	11.9	96	0.054
T11	SD	1	0.04	0.8	7	0.009
T11	value	3.7	0.3	14	105	0.06
T11	value	2.4	0.31	9	91	0.04
T11	value	2.7	0.28	12	97	0.04
T11	mean	2.9	0.3	12	97	0.05
T11	SD	0.7	0.02	2	7	0.01
T11	value	3.6	0.39	15	107	0.07
T11	value	2.6	0.33	13	102	0.05
T11	value	3.1	0.36	16	106	0.07
T11	mean	3.1	0.36	15	105	0.07
T11	SD	0.5	0.03	2	2	0.01

Declaration of interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

CRediT author statement

Matthias Oursin: Methodology, validation, Investigation, Formal analysis, writing – original draft. **Marie-Claire Pierret**: Conceptualization, validation, Methodology, Investigation, visualization, Project administration, writing – review & editing, Supervision, Funding acquisition, Resources. **Emilie Beaulieu**: Software, Formal analysis, Data curation, Methodology, Writing – review & editing, Supervision. **Damien Daval**: Formal analysis, Methodology, software, Writing – review & editing. **Arnaud Legout:** Conceptualization, Methodology, Writing – review & editing, Supervision, Formal analysis, Resources, Supervision.

Is there still something to eat for trees in the soils of the Strengbach catchment?

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Supplementary material

Appendix A. Mineral and chemical composition of soils.

	Depth	Kaolinite	Illite	Vermiculite	Smectite	Muscovite	Biotite	Quartz	Orthose	Albite	OM
	cm	%	%	%	%	%	%	%	%	%	%
Beech Plot	*0-5*	1.4	22.0	1.3	5.2	5.7	0.6	8.3	9.6	6.5	39.4
(BP)	*5-10*	1.5	10.0	0.0	5.3	8.8	0.8	21.3	27.6	17.5	7.2
	10-20	1.1	7.8	1.3	4.8	10.8	0.7	18.9	25.8	21.4	7.5
	20-40	0.8	6.8	3.7	4.2	15.0	0.6	19.6	21.0	24.0	4.4
	40-60	1.4	6.4	2.5	3.5	20.4	0.6	13.8	23.5	24.0	3.9
	60-80	1.1	4.6	1.2	1.7	20.5	1.1	22.1	19.4	25.5	2.8
Spruce Plot	*0-5*	1.5	20.1	0.4	8.5	4.7	0.0	16.0	6.6	3.3	39.1
(SP)	*5-10*	0.5	10.7	0.0	7.7	14.4	0.8	38.9	7.7	5.3	14.0
	10-20	0.2	8.9	0.0	6.1	22.6	0.8	39.4	11.6	6.6	3.7
	20-40	0.2	8.6	1.3	9.3	20.9	0.0	32.9	20.0	4.5	2.2
	40-60	0.2	9.2	1.1	7.3	22.3	0.0	37.8	12.9	7.9	1.3
	60-80	0.1	7.3	1.1	7.5	17.6	0.0	39.0	15.4	11.0	1.0

Mineral composition of soils from beech and spruce plots, calculated from XRD analyses on bulk soils and clays, and from organic matter content.

	Depth	Si	Al	Na	K	Mg	Ca	Sr	$^{87}Sr/^{86}Sr$	err (2σ)
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g		
Bulk soil	***initial***									
Beech Plot	0-5	167484.2	21760.4	7403.8	21874.5	1218.1	1129.2	31.3	0.789114	0.000014
(BP)	5-10	290935.4	36936.8	13234.8	39324.3	1791.0	886.2	45.5	0.806601	0.000016
	10-20	297900.2	39125.3	13516.7	41906.0	1990.0	857.6	46.7	0.809622	0.000012
	20-40	303322.6	40615.2	13791.2	41731.7	1971.9	836.2	48.3	0.806266	0.000012
	40-60	303649.8	40628.4	13131.0	41698.5	1965.9	821.9	43.7	0.811786	0.00001
	60-80	295843.5	44960.4	14829.8	40619.3	2538.8	1114.9	43.1	0.809955	0.000026
Spruce Plot	0-5	182302.0	20087.9	2099.5	18902.5	1779.0	793.3	35.4	0.757335	0.000014
(SP)	5-10	292945.4	33353.8	3227.1	31363.1	2804.1	328.8	53.9	0.764484	0.000012
	10-20	332911.6	33925.4	3256.8	34401.5	2749.9	364.5	51.2	0.764455	0.00001
	20-40	310427.7	43293.2	4399.2	39996.7	3533.8	285.9	76.2	0.764404	0.000014
	40-60	314681.4	43306.4	4614.4	41798.1	3419.2	321.6	72.4	0.768632	0.000016
	60-80	315429.3	44015.7	4725.7	42537.0	3485.6	414.5	73.8	0.768716	0.000012
Clays										
Beech Plot	0-5	56465,0	11010.9	2477.7	8228.3	867.3	286.4	15.7	0.771566	0.000004
(BP)	5-10	40678.6	11351.4	1081.8	7076.5	1032.4	103.3	7.2	0.83199	0.000003
	10-20	28663.5	8674.4	682.1	5035.7	809.6	59,0	4.3	0.845975	0.000004
	20-40	32285.2	10833.9	205.8	7032,0	1213.3	33.2	5,0	0.848006	0.000006
	40-60	24590,0	8604.9	617.3	4211.3	727.3	46.4	3.9	0.8329	0.000004
	60-80	14431.8	5515,0	376.4	2375.2	457.9	33.2	2.2	0.825962	0.000004
Spruce Plot	0-5	52236.7	12950.4	753.3	9612.6	1354.8	210.7	21.9	0.751935	0.000004
(SP)	5-10	43272.1	12578.7	399.6	9236.6	1367.7	72.9	12.7	0.745304	0.000007
	10-20	30225.1	9755.4	189.4	6771,0	1100.9	32.6	5,0	0.836336	0.000003
	20-40	37618,0	12071.4	866.5	6565.8	1116,0	78,0	5.9	0.84285	0.000003
	40-60	36385.3	12162.2	216.6	7837.6	1378.3	38.2	5.2	0.857096	0.000003
	60-80	33453.8	11263.9	198.2	7269.5	1277.5	36.6	4.8	0.862445	0.000003
Exch Initial		*Si*	*Al*	*Na*	*K*	*Mg*	*Ca*	*Sr*	*87Sr/86Sr*	err (2σ)
Beech Plot	0-5	12.4	505.45	16.81	286.59	104.88	619.21	2.64	0.723266	0.000004
(BP)	5-10	6.6	558.52	6.16	73.11	19.57	62.12	0.29	nd	nd
	10-20	5.4	633.17	4.9	46.14	9.31	20.44	0.14	0.726888	0.000003
	20-40	14,00	803.15	6.16	34.41	5.27	14.35	0.09	nd	nd
	40-60	17.8	422.71	5.77	17.83	2.27	9.56	0.06	0.728579	0.000002
	60-80	25,00	241.04	5.03	12.04	1.26	5.77	0.08	nd	nd
Spruce Plot	0-5	13.6	496.46	24.6	301.45	127.6	663.29	2.74	0.724128	0.0000069
(SP)	5-10	7.6	587.3	7.77	84.84	30.26	138.67	0.57	nd	nd
	10-20	2.8	688.93	7.26	44.18	10.89	40.08	0.26	0.72737087	0.00002
	20-40	8.4	803.15	4.69	38.2	6.03	32.86	0.12	nd	nd
	40-60	9.2	774.37	5.13	37.42	3.71	18.22	0.1	0.736045	0.00002
	60-80	10.2	702.42	3.91	39.49	3.17	14.11	0.09	nd	nd
Exch Final										
Beech Plot	0-5	5.82	449.69	11.36	95.79	62.46	444.87	3.35	0.726558	0.00002
(BP)	5-10	3.98	453.29	22,00	130.98	11.39	35.27	0.77		
	10-20	4.66	513.55	17.86	108.3	8.12	16.63	0.56	0.778818	0.00004
	20-40	5.98	429.01	13.27	98.53	5.27	8.82	0.49		
	40-60	9.38	254.53	9.26	66.47	2.78	6.39	0.43	0.7446	0.00002
	60-80	11.18	154.69	9.08	60.6	2.78	6.67	0.35		
Spruce Plot	0-5	6.36	572.01	5.89	141.54	109.62	569.11	4.71	0.726483	0.000003
(SP)	5-10	4.58	657.45	10.12	176.72	33.66	112.22	1.62		
	10-20	4.54	570.21	9.47	191.58	19.32	18.64	1.16	0.753777	0.00002
	20-40	6.6	671.84	6.87	190.41	14.22	13.15	0.79		
	40-60	8.56	603.49	7.22	201.36	16.28	8.62	0.84	0.762804	0.00004
	60-80	10.3	517.15	9.68	248.27	21.27	10.04	0.97		
Bulk soil	***Final***									
Beech Plot	0-5	180619.3	23888.0	7774.7	25078.9	1266.4	1107.8	29.6	0.797721	0.000012
(BP)	5-10	301873.5	36952.7	13442.5	40652.5	1670.4	886.2	42.8	0.807514	0.000012
	10-20	305379.3	38934.8	13049.4	41308.3	1917.7	814.8	44,0	0.812608	0.000008
	20-40	309679.8	41276.7	13405.5	41789.8	2086.5	850.5	44.8	0.81377	0.000014
	40-60	302855.1	41917.1	12849.1	40445.0	2195.1	829.0	41.6	0.814216	0.000008
	60-80	300424.4	43817.2	14221.5	40395.2	2382.0	1000.6	42.7	0.816388	0.000012
Spruce Plot	0-5	190716.0	21850.4	2255.3	19575.0	1917.7	807.6	33.6	0.764611	0.000038
(SP)	5-10	290234.2	34195.3	3368.1	32093.6	2846.4	307.3	54.6	0.765714	0.00001
	10-20	323375.8	35931.3	3115.8	35098.8	3015.2	214.4	51.5	0.771332	0.000004
	20-40	303883.5	44148.0	4236.0	40420.1	3678.6	250.1	65,0	0.772802	0.00001
	40-60	308651.4	43703.4	4109.9	41922.6	3576.0	271.6	59.1	0.778583	0.000026
	60-80	307295.8	44457.6	4658.9	42296.2	3612.2	364.5	66.8	0.774415	0.00001
Cumul Leach										
Beech Plot	0-5	2734.9	1318.61	53.42	721.6	139.91	161.08	0.8	0.764283	0.00002
(BP)	5-10	3802.07	1882.27	118.32	727.25	133.31	45.38	0.48	nd	nd
	10-20	3097.11	1571.13	112.29	612.38	105.63	19.75	0.37	0.826984	0.00004
	20-40	970.15	431.98	91.77	326.99	26.18	14.26	0.23	nd	nd
	40-60	582.85	315.81	75.95	267.1	16.38	11.41	0.19	0.85638	0.00003
	60-80	491.69	305.42	66.36	268.29	15.22	9.46	0.21	nd	nd
Spruce Plot	0-5	3393.17	1647.26	36.92	843.55	128.01	74.26	0.52	0.763848	0.00004
(SP)	5-10	4627.06	2444.36	50.04	1099.15	167.92	66.02	0.68	nd	nd
	10-20	3406.41	1640.92	56.59	918.21	110.49	27.02	0.62	0.760167	0.00002
	20-40	769.93	184.3	41.67	441.7	20.91	20.75	0.34	nd	nd
	40-60	749.09	148.82	41.95	475.91	18.21	17.63	0.34	0.779635	0.00004
	60-80	796.28	146.34	46.77	509.44	17.74	17.33	0.36	nd	nd
Organic matter										
Beech Plot	0-5	21673.19	3270.9	938.6	2789.02	300.5	937.63	7.51		
(BP)	5-10	3975.0	599.9	172.15	511.52	55.11	171.97	1.38		
	10-20	4164.28	628.47	180.34	535.88	57.74	180.16	1.44		
	20-40	2460.71	371.37	106.57	316.66	34.12	106.46	0.85		
	40-60	2176.78	328.52	94.27	280.12	30.18	94.17	0.75		
	60-80	1514.28	228.53	65.58	194.87	21.0	65.51	0.52		
Spruce Plot	0-5	6123.89	777.49	83.37	826.94	208.02	1346.29	3.57		
(SP)	5-10	2175.59	276.21	29.62	293.78	73.9	478.29	1.27		
	10-20	590.9	75.02	8.04	79.79	20.07	129.91	0.34		
	20-40	349.17	44.33	4.75	47.15	11.86	76.76	0.2		
	40-60	214.87	27.28	2.93	29.02	7.3	47.24	0.13		
	60-80	161.15	20.46	2.19	21.76	5.47	35.43	0.09		

Chemical compositions (expressed in µg/g of soil) for initial and final (after experimentation) bulk soils, compared with the contribution of different reservoirs as clay minerals, initial and final exchangeable pool, organic matter as total cumulated experimental leachate calculated for 1 g of soil.

Appendix B. Composition of leaching solutions

Mean chemical composition and standard deviation (SD) from the three triplicates of the leaching solution at the eleven time-step of each experiment (see Table 1). Chemical compositions are expressed in µg/g of soil. *Data are provided as the excel file containing all tables, the table is too big to be copy directly in this document.*

Appendix C. Stock of Ca, Mg, Na and K

Plot	Depth	Ca	Mg	Na	K	Plot	Depth	Ca	Mg	Na	K
-	*cm*	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}	-	*cm*	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}	kg·ha^{-1}
Bulk soils						**Clays**					
Beech Plot	00-05	362	391	2375	7017	Beech Plot	00-05	92	278	795	2640
(BP)	05-10	284	575	4246	12615	(BP)	05-10	33	331	347	2270
	10-20	550	1277	8672	26886		10-20	38	519	438	3231
	20-40	1285	3029	21187	64112		20-40	51	1864	316	10803
	40-60	1013	2423	16183	51389		40-60	57	896	761	5190
	60-80	1226	2793	16313	44682		60-80	37	504	414	2613
Spruce Plot	00-05	170	381	450	4050	Spruce Plot	00-05	45	290	161	2059
(SP)	05-10	70	601	691	6719	(SP)	05-10	16	293	86	1979
	10-20	156	1178	1395	14740		10-20	14	472	81	2901
	20-40	341	4220	5253	47760		20-40	93	1333	1035	7840
	40-60	423	4494	6065	54937		40-60	50	1812	285	10301
	60-80	429	3604	4886	43982		60-80	38	1321	205	7516
Ini Exch						**OM**					
Beech Plot	00-05	199	34	5	92	Beech Plot	00-05	614	88	32	288
(BP)	05-10	20	6	2	23	(BP)	05-10	112	16	6	53
	10-20	13	6	3	30		10-20	234	34	12	110
	20-40	22	8	9	53		20-40	328	47	17	154
	40-60	12	3	7	22		40-60	233	34	12	110
	60-80	6	1	6	13		60-80	150	21	8	70
Spruce Plot	00-05	142	27	5	65	Spruce Plot	00-05	1422	37	8	117
(SP)	05-10	30	6	2	18	(SP)	05-10	509	13	3	42
	10-20	17	5	3	19		10-20	269	7	2	22
	20-40	39	7	6	46		20-40	446	12	2	37
	40-60	24	5	7	49		40-60	290	7	2	24
	60-80	15	3	4	41		60-80	176	5	1	14
Final Exch											
Beech Plot	00-05	143	20	4	32						
(BP)	05-10	12	3	7	41						
	10-20	10	5	12	70						
	20-40	13	8	18	147						
	40-60	7	3	9	75						
	60-80	6	2	12	69						
Spruce Plot	00-05	122	23	1	30						
(SP)	05-10	24	7	3	37						
	10-20	8	9	3	85						
	20-40	17	17	9	225						
	40-60	11	22	11	255						
	60-80	11	18	8	262						

Evaluation of the stock of Ca, Mg, Na and K in bulk soil, and in the different reservoirs: initial and final exchangeable cations, clays, and organic matter in each soil layer (expressed in kg/hectare). This calculation considers the proportion of these different reservoirs inside the bulk soils.

Appendix D. Evaluation and calculation of stocks available and leaching flux in Strengbach soils. *Fluxes and input-output budgets*

- Calculation of the total stock and the exchangeable stock expressed in kg/ha:

Element inventories are evaluated in the total soil and in the exchangeable phase based on the concentrations previously measured for each horizon studied. These inventories are expressed in $kg \cdot ha^{-1}$.

The leaching experiments were carried out with the fraction of the soil f< 2 mm, thus this fraction is used for the calculations:

$$m_{total\ horizon} \times f_{<2mm} = m_{f<2mm} \quad (0\text{-}1)$$

Each horizon has a defined surface area S of 2 m² and a thickness e (5,10 or 20 cm), which give the mass per unit of volume:

$$\rho_{f<2mm} = \frac{m_{f<2mm}}{V_{horizon}} = \frac{m_{f<2mm}}{S \times e} \quad (0\text{-}2)$$

This density is then used to determine the stocks available on a full hectare (10,000 m²). A horizon with a thickness *e* and with a surface area of 1 ha is considered. The stock for each chemical element i (expressed in $kg \cdot ha^{-1}$) was calculated with the elemental concentration Ci.

$$Stocki_{f<2mm} = Ci_{f<2mm} \times 10000 \times e \times \rho_{f<2mm} \quad (0\text{-}3)$$

The stocks were calculated for the bulk soil and for the exchangeable pool from the concentration in bulk soil and exchangeable fraction respectively.

This calculation is performed for each element and for each horizon of the two plots. To simplify certain calculations, the total stock in the entire profile is also used, which is expressed as the sum of the stocks of each horizon:

$$Stock_{total} = \sum Stock_i \quad (0\text{-}4)$$

- Calculation of total leached concentration expressed in kg/ha:

The same equation is used to calculate the total amount *A* of element leached during the experiment for one ha:

$$A_{leaching}(kg \cdot ha^{-1}) = C_{cumulative\ leaching}(kg \cdot kg_{soil}^{-1}) \times 10000 \times e \times \rho_{f<2mm} \quad (0\text{-}5)$$

With $C_{cumulative\ leaching}$ the cumulative concentration leached during the 11 steps of the 152 days of experimentation.

- Calculation of the leaching flux:

The leaching flux is calculated from the results of the leaching experiments, for each plot. The leaching experiments were carried out with 5 grams of soil. The time of experiment should be converted in corresponding in-situ field time in order to evaluate the leaching flux for each element in $kg \cdot ha^{-1}\ yr^{-1}$. The idea is to convert the water/material ratio in quantity or duration of rainfall in the site. The mean annual rainfall at the Strengbach catchment is 1400 mm (Pierret et al., 2018). The interception by vegetation is on average 300 mm/yr (Pierret et al., 2019). Thus the annual water flow infiltrating the soil is 1100 mm (1100 $L \cdot m^{-2}$ per year).

During the experiments, a $V_{experimental}$ volume of 440 mL of solution and a $m_{experimental}$ mass of 5 g were used. Thus, for a pit of mass m, the amount of rainfall, noted $V_{equivalent}$ required to leach in the same proportions is:

$$V_{equivalent}(L \cdot m^{-2}) = m_{f<2mm}(kg) \times \frac{V_{experimental}\ (L)}{m_{experimental}(kg)} \times \frac{1}{S(m^2)} \quad (0\text{-}6)$$

The equivalent time ($t_{equivalent}$ in year) corresponding to the experimental condition i.e. 152 days (Table 1) is then:

$$t_{equivalent} = \frac{V_{equivalent}}{V_{rain}} \qquad (0\text{-}7)$$

86

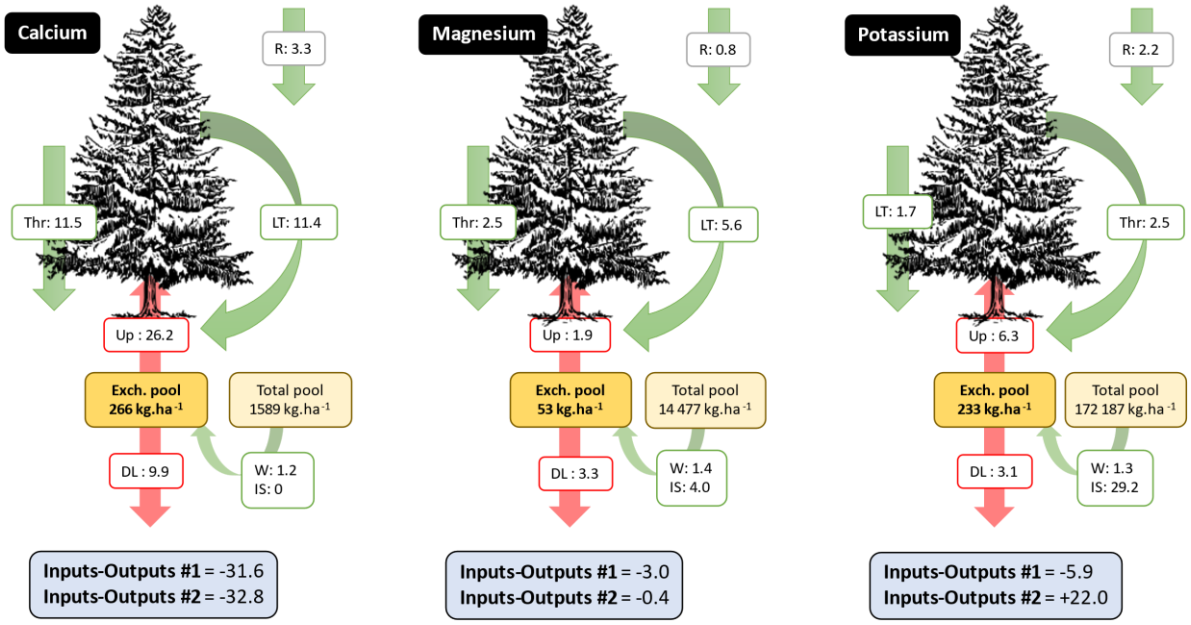
87 The result obtained give 42 years of rain for experiment with soils from the beech plot and 35
88 years with soils from the spruce plot. This equivalent time allows to calculate the equivalent
89 annual leaching flow according to:

$$flux_{leaching}(kg \cdot ha^{-1} \cdot yr^{-1}) = IS = \frac{A_{leaching} - Stock_{exchangeable}}{t_{leaching}} \qquad (0\text{-}8)$$

90

91 If the leaching flux is lower than the initial exchangeable pool, then IS is equal to 0 (see figures)

92



93

94 Fluxes and input-output budgets (in $kg.ha^{-1}.yr^{-1}$) for calcium, magnesium and potassium at the
95 SP site. IS is intrinsic flux from soil estimated from our leaching experiments (corrected for the
96 value of the initial exchangeable pool). W is the weathering flux, R is the atmospheric wet
97 deposition, Up is the net uptake flux by roots and DL is the deep leaching (see Beaulieu et al.
98 2020).

99

CRediT author statement

Matthias Oursin: Methodology, validation, Investigation, Formal analysis, writing – original draft. **Marie-Claire Pierret**: Conceptualization, validation, Methodology, Investigation, visualization, Project administration, writing – review & editing, Supervision, Funding acquisition, Resources. **Emilie Beaulieu**: Software, Formal analysis, Data curation, Methodology, Writing – review & editing, Supervision. **Damien Daval**: Formal analysis, Methodology, software, Writing – review & editing. **Arnaud Legout:** Conceptualization, Methodology, Writing – review & editing, Supervision, Formal analysis, Resources, Supervision.

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