Chemical fertility of forest soils: basic concepts

Arnaud Legout, Karna Hansson, Gregory van Der Heijden, Jean-Paul Laclau, Laurent Augusto, Jacques Ranger

To cite this version:

Arnaud Legout, Karna Hansson, Gregory van Der Heijden, Jean-Paul Laclau, Laurent Augusto, et al.. Chemical fertility of forest soils: basic concepts. Revue forestière française, 2015, SP, pp.Fr.], ISSN 0035. 10.4267/2042/56262. hal-03197772

HAL Id: hal-03197772
https://hal.inrae.fr/hal-03197772

Submitted on 24 Nov 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

CHEMICAL FERTILITY OF FOREST SOILS: BASIC CONCEPTS

ARNAUD LEGOUT – KARNA HANSSON – GREGORY VAN DER HEIJDEN – JEAN-PAUL LACLAU – LAURENT AUGUSTO – JACQUES RANGER

This paper is the English translation of: « Fertilité chimique des sols forestiers : concepts de base » – Revue forestière française*, 4-2014. http://documents.irevues.inist.fr/handle/2042/4752.*

INTRODUCTION

Fertility is a very old concept and many definitions are available in literature. The first edition of the *Dictionnaire de l'Académie Française* in 1694 defines fertility as: "quality of that which is fertile; good farming is that which contributes most to the fertility of the soil" *(the capacity of a soil to produce a large harvest)*. A more accurate definition appeared in the 18th century in the *Dictionnaire Critique de la Langue Française* (1787): "Fertility refers exclusively to soil and plants: Fecundity refers to animals". At the beginning of the 19th century, the first scientific studies on fertility enabled to characterize soil properties and measure water and mineral uptake in the perspective of increasing crop yields. In this context, fertility referred to the "chemical richness" of a soil in terms of the presence of mineral elements essential to plant growth: both macronutrients (N, P, K, Ca, Mg, S) and micronutrients (Cu, Zn, Fe). The "natural" fertility of the soil is, in this case, defined as the potential of a soil to provide these mineral elements and may be supplemented with an "artificial" fertility related to added fertilizers. Barbier (1955) proposes two visions of fertility; that which can be characterized by i) a production (fertility levels thus depend on the soil properties as well the cultivation techniques), or ii) the capacity to produce (the fertility of a soil determines a potential production capacity without taking into account cultivation techniques). All of these studies in the field of agronomy perfectly illustrate the complexity of the concept of soil fertility.

The concept of fertility was further developed in the 20th century with a soil science perspective. Fertility (in the strict sense of the capacity of a soil to provide an abundant production) was then divided into three interrelated components: physical (which includes, for example, soil depth), biological (wich includes for example the presence or organisms such as earthworms), and chemical (which includes plant –available nutrient contents), all of which interact with human activities (agriculture, pollution). In practice, this definition remains difficult to apply and the assessment of fertility in agronomy is often limited to the chemical component; a budget aimed at compensating the "soil-reservoir" deficit for a given crop is then calculated. Fertility standards defined by Bonneau (1995) for forest ecosystems rely on this concept where the soil is considered to be reservoir of nutrients available to plants. The pool of available nutrients is quantified at a given time and is then compared to nutrient requirements established for the different tree species.

The definition of fertility inherited from agronomy which is better adapted to naturally rich or enriched environments, has only limited interest when considering forest soils. These soils are

Table I **Characteristics of the 11 experimental sites used in this study**

Several plots, different tree ages and species can be found on the same site.
In grey, experimental sites located outside of France (Brazil and Congo).

Site	Abreviation	Location	Elevation (m)	Mean annual rainfall (mm·yr^{-1})	Mean annual temperature (°C)
Abreschviller, Vosges	Abr	48°38'N 7°05'E	400	1 250	8,5
Monthermé, Ardennes	Ard	49°52'N 4°48'E	390	1 100	8
Aubure 1, Vosges	Au1	48°12'N 7°11E	1 080	1 400	8,5
Aubure 2, Vosges	Au2	48°12'N 7°11E	1 080	1 400	8,5
Bonhomme, Vosges	Bon	48°10N 7°01'E	1 100	1 544	5
Breuil, Morvan	Bre	46°30'N 4°38'E	650	1 280	9
Fougères, Bretagne	Fou	48°23'N 1°8'W	175	868	12,9
Gemaingoutte, Vosges	Gem	48°15'N 7°5'E	650	1 120	8,5
Vauxrenard, Beaujolais	Vau	46°10'N 4°38E	770	1 000	7
Itatinga, São Paulo, Brazil	Ita	23°02'S 48°38'W	850	1 370	19,2
Kondi, Pointe-Noire, Congo	Kon	4°33'S 11°54'E	100	1 200	25

generally poor in terms of nutrient content, sometimes very poor, and are colonized by perennial plants adapted to this context in a set of processes described as the biogeochemical cycling of nutrients (Ranger and Turpault, 1999). The objectives of this article are i) to illustrate the limits of applying the agronomy concept (soil = reservoir of plant-available nutrients) to assess the chemical fertility of forest ecosystems, and ii) to provide the basic principles for a new concept which takes into account the specificity of the chemical fertility of forest soils as compared to agricultural soils.

MATERIALS AND METHODS

To redefine the concept of chemical fertility, we studied a database of results acquired from 11 experimental forest sites (9 in France, 1 in the Congo and 1 in Brazil) some of which date back to

Tree species	Year of stand establishment	Sampling years	Bedrock	Soil type (WRB)
Abies alba Mill.	1940	1994; 1998; 2007	Sandstone	Dystric cambisol
Picea abies (L.) Karst; *Quercus petraea* (Matt.) Liebl.	1831; 1931	1977; 1997	Shale	Dystric cambisol
Picea abies (L.) Karst.	1900; 1958; 1978	1985; 1991; 1994; 1996	Granite	Dystric cambisol
Fagus sylvatica L.	1850	1985; 1991; 1994	Granite	Podzolic cambisol
Picea abies (L.) Karst.	1918	1988	Granite	Podzolic cambisol
Abies nordmanniana Spach; *Fagus sylvatica* L.; *Picea abies* (L.) Karst.*; Pinus nigra* Arnold*; Pseudotsuga menziesii* (Mirb.) Franco; *Quercus petraea* (Matt.) Liebl.	1826; 1976	1974; 2001	Granite	Dystric cambisol
Fagus sylvatica L.	1851; 1915; 1971; 1988	1996; 2001; 2003	Granite	Dystric cambisol
Picea abies (L.) Karst.	1904	1988; 1991	Gneiss	Dystric cambisol
Pseudotsuga menziesii (Mirb.) Franco	1950; 1970	1993	Vosges Volcanic tuf	Dystric cambisol
Eucalyptus grandis W. Hill ex Maiden	1998; 2004	2003; 2005; 2007	Detrictic, fine sand	Ferralsol
Eucalyptus hybride (inconnu)	1992; 1998; 2005	1998; 2000; 2001; 2006	Continental sand	Ferralic Arenosols

the 1970s, detailed in table I. This database does not include results from sites on limestone and the pH_{water} of surface layers is lower than 5.

Numerous measurements were made in the different experimental sites: analysis of the chemical and physical properties of the soil, of the litter layer, of aboveground biomass to quantify the nutrient pools in the different ecosystem compartments, and the nutrient fluxes between the compartments:

— the soil analysis performed on the different soil horizons (“soil layers”) included: pH_{water}, C, N, exchangeable cations (K, Ca, Mg, Na) and available P. The bulk density and the thickness of the soil layers enabled to calculate plant-available nutrient stocks in the soil, i.e. easily mobilized nutrients (exchangeable base cations K, Ca, Mg, Na and available P);

— the chemical analysis of the litter layer gives the nutrient content (K, Ca, Mg, P...) which were then converted to nutrient stocks using the mass of litter (dry matter) per hectare. These nutrient stocks were not considered as "available" nutrients because the nutrients in litter must be mineralized before being available to plant uptake. These nutrient stocks, the lifetime of which is relatively short (< 20 years), represent an important nutrient capital which can eventually return to the soil and benefit to the forest stand;

— the chemical analysis of the different tree compartments (leaves, branches, bark and wood of the bole, roots) with their dry weight enable to estimate nutrient stocks present in aboveground biomass. The difference in these nutrient stocks between two given dates estimated the net uptake by trees (annual net immobilization in the aboveground biomass);

— the measurements of litter fall per unit area (dry weight) and the corresponding chemical analysis were used to estimate the annual nutrient fluxes in litterfall. These fluxes were measured on experimental sites over several years to integrate annual variations.

LIMITS OF CONVENTIONAL APPROACHES FOR CHARACTERIZING THE CHEMICAL FERTILITY OF FOREST SOILS

Different indicators do not lead to the same assessment of the chemical fertility

Different indicators of the physical and chemical properties of forest soils are used in published studies to assess chemical fertility. We decided to select several of these indicators and focus on comparing their values for eleven study sites: C/N, water pH, exchangeable base cations and available phosphorous.

Table II (p. 25) shows a classification of the eleven sites according to each individual indicator (1 = most fertile, 11 = least fertile, wherein a site is considered fertile if the pH_{water} or exchangeable cations or available phosphorous pools are high, or if the C/N ratio in the soil is low). The soil chemical fertility classification of the studied ecosystems differs according to the relevant indicator. The conclusions are similar if other soil layers are considered (0-70 cm, for example). Furthermore, for a given indicator, several measurement methods may exist which may lead to different values (for example, there are different methods to measure available phosphorous: Duchauour, Olsen). This lack of standardization limits the interest of these indicators. Our goal here is not to assign value to individual indicators, but to show that the comparison itself highlights how difficult it is to identify easily measured, reliable and accurate indicators of chemical fertility in soils.

Soil nutrient stocks are not always reliable indicators of chemical fertility

As mentioned in the introduction, it is still a common approach to measure the chemical fertility of forest soil by evaluating plant-available soil nutrient stocks. This approach, typically used in agronomy, considers the soil as a reservoir (= stock) storing plant-available nutrients. The stocks are evaluated at a given time and are equal to the product of the concentration of a chemical element (g of chemical element per kg of dry soil) and the weight of soil per hectare (volume of soil of a defined thickness, multiplied by the bulk density). This approach has several limitations, as explained below.

Uncertainties in the size of the nutrient reservoir

The soil layer used to calculate the size of the reservoir is generally defined as the "zone explored by the fine roots (measuring less than 2 mm in diameter)". Determining the rooting depth and root distribution in the soil profile requires heavy measures on site and does not take into account possible root specialization (such as for water and nutrient uptake…). In the absence of this measurement, calculations are often made for the 0-70 cm soil layer (Bonneau, 1995) although the

TABLE II **Classification of experimental sites according to different indicators related to the physicochemical properties of the 0-10 cm soil layer, selected to assess chemical fertility**

(1 = the most fertile, 11 = the least fertile).
In grey, experimental sites located outside of France (Brazil and Congo).

Site	H_0/H_{max}*	pH_{eau}	C/N	Ca**	K**	Mg**	Ca + K + Mg + Na**	P_2O_5***
Abr	1,00	4	9	8	9	9	8	9
Gem	1,00	8	5	2	7	2	2	10
Vau	0,97	3	1	1	4	4	3	1
Kon	0,89	1	10	11	10	11	10	8
Bre	0,80	5	8	9	8	8	9	5
Ita	0,80	2	4	10	11	10	11	6
Fou	0,74	6	11	3	2	1	1	4
Ard	0,69	7	2	4	6	3	4	7
Au1	0,64	10	3	7	1	5	6	3
Bon	0,61	11	7	5	3	6	5	11
Au2	0,60	9	6	6	5	7	7	2

* Productivity Index: the ratio between the dominant stand height at a given age and the regional average of the dominant height of stands of the same age.
** Stock of exchangeable base cations.
*** Stock of available phosphorous (Duchaufour method).

rooting depth depends on several parameters: species autecology, soil physicochemical properties, soil depth, and obstacles that would prevent root growth (bodies of water, stoniness, etc.). Figure 1 (p. 26) presents the stocks of exchangeable cations (Ca + K + Mg + Na) for different soil layers on the eleven experimental sites. Rooting depth varies considerably between the different sites and the stocks of nutrient cations in the soil are very different depending on the soil layers considered. On these eleven sites, stocks in the soil layer at 0-70 cm depth are very different from stocks in the 0-rooting depth layer. Selecting the thickness of soil to consider for this method of calculating stocks is therefore essential.

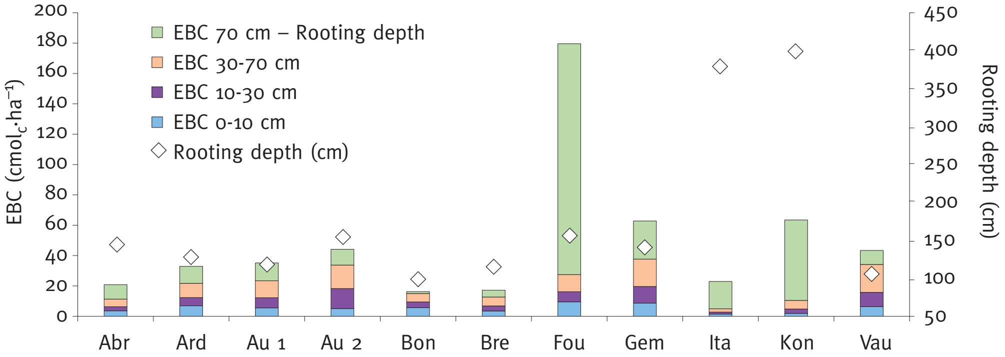
Additionally, common approaches to calculate soil nutrient stocks assume that the roots are able to access the whole plant-available nutrient stocks present in a given soil horizon. This strong assumption is difficult to verify and the quantity of roots present in a given soil horizon could affect the amount of nutrients available for plant uptake. Root mycorhization may also play a major role in the uptake of less mobile ions by considerably increasing the colonization factor.

The autecology of tree species is not taken into account

The conventional approach to measure chemical fertility does not take into account actual species nutrient requirements. Soil fertility is typically measured by considering the reservoir of nutrients which are potentially available for plant uptake, without integrating the requirements specific to each species, their nutrient-uptake strategies relative to the environment (content and balance between nutrients present), moisture of the soil (species tolerance, avoidance, etc.), and the extent of mycorrhizae colonization of the soil reservoir.

Figure 1 **STOCKS OF EXCHANGEABLE CATIONS EBC (Ca + K + Mg + Na) FOR DIFFERENT SOIL LAYERS (LEFT AXIS) AND ROOTING DEPTHS (RIGHT AXIS) ON THE ELEVEN EXPERIMENTAL SITES**

The rooting depth corresponds here to soil depth including 95 per cent of fine roots.



The relation between biomass production and soil nutrient stocks is still misunderstood

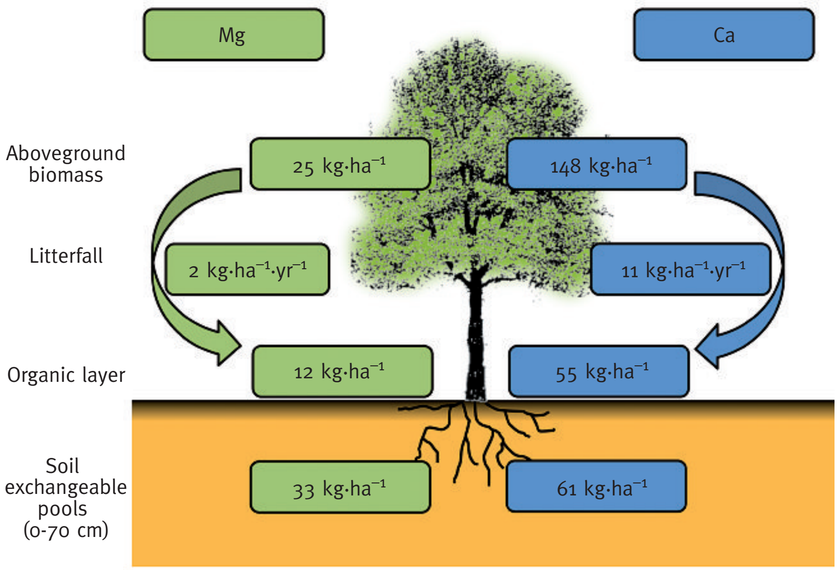
In certain cases, the production rates within forest ecosystems may be elevated although plant-available nutrient stocks are very low. Table II (p. 25) presents productivity index (Ho/Hmax) that corresponds to the ratio between the dominant stand height at a given age and the regional average of the dominant height of stands of the same age. When comparing this productivity index to the classification of fertility obtained from the stocks of plant-available nutrient cations (Ca + Mg + K + Na) in the soils, no clear relationship is evident: the most productive ecosystems do not have the highest stocks and vice versa. When soil nutrient stocks are low, the concept of fertility defined as a nutrient reservoir does not correctly explain production.

Figure 2 (p. 27) illustrates the importance of calcium and magnesium net uptake relatively to the stocks in the soil-plant system. In this ecosystem, the stock of exchangeable Ca is similar to the stock in the litter layer and about three times lower than the stock in the aboveground biomass. The stock of exchangeable Mg is roughly the same as the stock in aboveground biomass. Annual litterfall represents 11 kg.ha^{-1}.yr^{-1} of Ca and 2 kg.ha^{-1}.yr^{-1} of Mg, *i.e.* about twice the annual net uptake (5.6 kg.ha^{-1}.yr^{-1} of Ca and 1.2 kg.ha^{-1}.yr^{-1} of Mg). These figures illustrate the importance of the biological cycle (litterfall), which contributes to (i) replenishing the soil reservoir essential for stand growth or (ii) tree nutrition directly by bypassing the soil reservoir. The same observation has been made for numerous ecosystems developed on soils with low nutrient content: for example, an experiment conducted on a tropical ecosystem developed on very poor soil (Nzila *et al.*, 2002) showed that the removal of slash over a period of 3 years resulted in significantly lower growth rates for eucalyptus stands. The biological component is therefore a major pillar of tree nutrition in these ecosystems and any disruption of this cycle can result in reduced growth rates which is all the more stronger and immediate than the soil is nutrient poor.

TOWARDS REDEFINING THE CONCEPT OF CHEMICAL FERTILITY OF FOREST SOILS

Redefining the concept of chemical fertility is fundamental to understand how forest ecosystems function and identify the causes of their dysfunction. The agronomy-inherited notion of fertility,

FIGURE 2 POOLS AND FLUXES OF MAGNESIUM AND CALCIUM WITHIN THE BEECH PLOT AT THE BREUIL EXPERIMENTAL SITE



mainly based on available nutrient stocks in the soil, does not integrate and account for the nutrient fluxes and nutrient cycling (biogeochemical cycling). This agronomy concept needs to be amended with two important concepts: i) the lower activation threshold of the biological component of nutrient cycling, and ii) the amount of nutrients capable of insuring through recycling the agro-biogeochemical functioning of the soil.

The concept of chemical fertility of forest soils needs to take into account:

— current fertility levels, which integrate i) the plant-available nutrient stocks in the soil (highly variable, from very low in poor soils to elevated in chemically rich soils), ii) active fluxes of nutrients in limited quantity (from the soil, litterfall, atmospheric inputs, plant internal cycling and possible liming or fertilizer inputs), iii) as well as soil characteristics allowing for nutrient retention (organic matter and clay content), which may or may not lead to a very conservative system which limits nutrient losses;

— long-term chemical fertility levels, which integrate i) the capacity of the soil to maintain or even restore its fertility in the context of a given environment and a given management and ii) the nutrient fluxes resulting from mineral weathering, litter decomposition and atmospheric inputs.

These concepts describe only the potential or capacity to produce that will be used relatively to the following constraints including:

— hydrological constraints (excess or deficit);

— tree species nutrient requirements (autecology, rate of development and production);

— colonization of the soil by roots depending on physical constraints (compaction, hypoxia, water saturation, etc.) and the uptake strategy of species (water uptake relative to the soil water potential, temporal changes in the vertical distribution of uptake in the soil profile, etc.).

This revisited concept of chemical fertility can be related to the typology of forest ecosystem functioning based on the relative importance of the different components of the biogeochemical cycles, BIO and GEO. When the geochemical component of the cycle is predominant (inputs through mineral weathering and/or atmospheric inputs, or even inputs from capillary rise of deep groundwater), sufficient nutrients are provided to the plant-soil system to ensure growth and the soil reservoir, thus, participates significantly to tree nutrition. Conversely, when the geochemical component of the cycle brings to few nutrients to the plant-soil system, the biological (litterfall, foliar leaching, etc.), and/or biochemical (plant internal cycling) components of the cycle become predominant in tree nutrition. The importance of these two components becomes all the greater than the nutrient reservoir in the soil is low: tree nutrition could also bypass the soil reservoir in certain cases of soils with extremely low nutrient content.

Forest management must take into account this typology of forest ecosystem functioning because it directly impacts the biological cycle through for example forest biomass exports. Given the current context of increased demand for energy-wood, this typology clearly shows that managing residues of harvest is crucial, particularly when stand nutrition relies primarily on the biological component of nutrient cycles.

THE RELATIONSHIP BETWEEN CHEMICAL FERTILITY AND THE WATER RESERVE

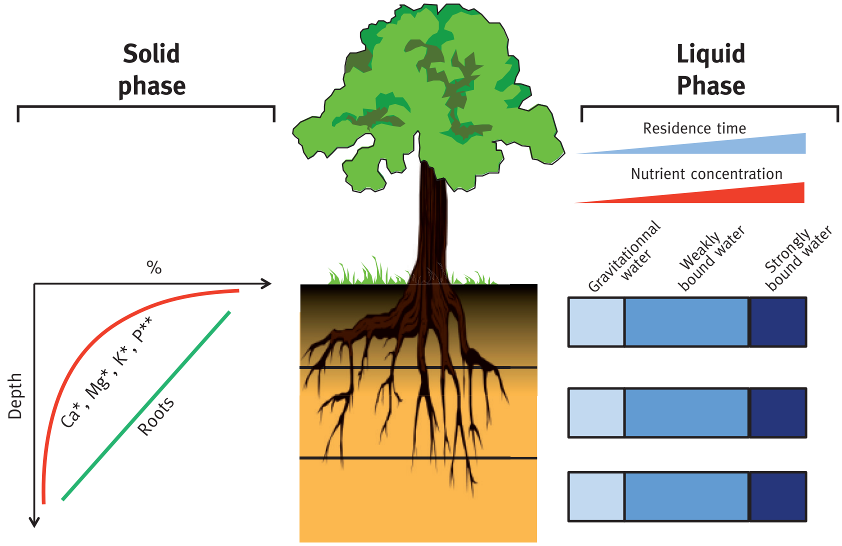
As mentioned earlier, a number of constraints need to be considered when assessing the chemical fertility of soils. We will briefly illustrate this connection by describing the relationship between fertility and water availability in the soil profile. Water is the carries the mineral elements within the ecosystem and, as such, water availability is involved in nutrient bioavailability because most of nutrients are taken up in the soil solution (a soil which is rich chemically, but which is dry, is a poor soil with regards to bioavailable elements).

When considering the "nutrient reservoir" function of the soil , this reservoir must be considered as a variable-geometry reservoir which depends on the availability of water in the soil profile, itself dependent on a number of variables such as climate, the water flow regime within the soil profile, its water retention capacity, or even the tree species. The geometry of the reservoir varies in space (size and location of the reservoir), and time (changes occur throughout the year). These variations can cause changes in the plant-available reservoir. Figure 3 (p. 29) illustrates this by showing an example of the distribution of nutrients in the context of an acidic soil. Desiccation of the soil profile during the growing season will result in a decrease in soil volume where nutrients may be absorbed by the roots, or even displacement of the uptake in the soil profile (moving from the surface to depth): the size and location of the reservoir can therefore also change. The reservoir can also change qualitatively: differences in the chemical composition of different available water types, changes in the ratios between nutrients present, symbiotic associations present, etc. Nutrition requirements can be modified and the tree could react with certain adaptations, for example, the hydrological lift (I.Phenomenon which allows trees to take up water in the deep soil layers for partial redistribution in the superficial dry horizons, which allows nutrients to be transported and absorbed by the trees), but also more commonly, by a balance between water and nutrient uptake from the soil, and remobilization of plant-internal reserves.

In the current context of climate change and potential changes in water regimes within the soil profile, the location of uptake (water more or less retained to the soil matrix, different chemical composition) and the variables controlling this variable geometry should be identified in the coming years, integrating the dimension of time.

FIGURE 3 **EXAMPLE DIAGRAM SHOWING NUTRIENT DISTRIBUTION IN ACIDIC SOIL**

* Exchangeable base cations EBC, ** Available phosphorous.



CONCLUSION

The chemical fertility of forest soils is a complex concept and is only one component of overall fertility. The chemical fertility is closely related to the other fertility components (physical and biological) that were not discussed here.

The chemical fertility of forest soils should not be limited to the agronomy concept of a plant-available nutrient reservoir in the soil at a given time (static aspect); it should also include the circulation of elements and biogeochemical cycles (dynamic aspect). When a soil is characterized as having a low chemical content, the concept of a reservoir is indeed not enough to characterize chemical fertility. The process of nutrient recycling becomes that much more important when the nutrient reservoir is low.

Maintaining fertility levels in the forest is not a recent concern (see excerpt from the course by Henry in 1894) but it is advisable today, in a context of increased demand for wood energy, to adapted forestry practices to the capacity of forest ecosystems. The forest manager has the opportunity today to intervene on a number variables to benefit from the production of the ecosystem in a sustainable manner, through the length of the stand rotations, the biomass compartments exported, harvesting methods and slash management (Augusto *et al.*, 2000; Ranger *et al.*, 2011). When the point of no return has been reached and the chemical fertility of the forest ecosystem has been too severely depleted, liming is an alternative to restore and improve the overall functioning of the ecosystem (soils, forest stands, surface water). This curative approach can also be applied for preventive purposes in order to maintain a desired level of fertility (by compensating for nutrient losses related to biomass harvesting; or by providing sufficient nutrients required by organisms for normal functioning).

> *“The loss resulting from the exportation of wood, while small, is real and would on the long-term lead to the impoverishment of forest soils if it was not soundly compensated, as previously said, by the ceaseless transfer of a part of the soil reserve to plant available forms.*
>
> *If the supply of available nutrients becomes lower than a certain minimum, the soil production decreases immediately.*
>
> *A soil is said to be ‘depleted’ when it is deprived of one or more nutrients. It is evident that soil depletion occurs faster for nutrients which are poorly present in the soil.”*

Quote from a lecture by E. Henry, *École nationale des Eaux et Forêts, 1894*

Arnaud LEGOUT – Karna HANSSON – Gregory Van der HEIJDEN – Jacques RANGER
INRA – Centre de Nancy-Lorraine
Unité Biogéochimie des écosystèmes forestiers
F-54280 CHAMPENOUX
(legout@nancy.inra.fr) (karna.hansson@nancy.inra.fr)
(gregory.vanderheijden@nancy.inra.fr) (ranger@nancy.inra.fr)

Jean-Paul LACLAU
CIRAD
UMR Eco&Sols
Écologie fonctionnelle & biogéochimie des sols
& agro-écosystèmes
2 place Viala
F-34060 MONTPELLIER
(jean-paul.laclau@cirad.fr)

Laurent AUGUSTO
INRA – Centre de Bordeaux
UMR Transfert sol-plante
et Cycle des éléments minéraux
F-33883 VILLENAVE D’ORNON
(laugusto@bordeaux.inra.fr)

Aknowledgements

This work was funded by GIP-ECOFOR and ONF.

The Research Unit « Biogéochimie des écosystèmes forestiers » is supported by the French National Agency throught The Laboratory of Excellence ARBRE (ANR-12-LABXARBRE-01).

REFERENCES

AUGUSTO (L.), RANGER (J.), BONNEAU (M.). — Influence des essences sur la fertilité chimique des sols. Conséquences sur les choix sylvicoles. — *Revue forestière française*, vol. LII, n° 6, 2000, pp. 507-518.

BARBIER (M.G.). — Essai de définition de la fertilité de la terre. — *Économie rurale*, vol. 23, 1955, pp. 3-6.

BONNEAU (M.). — Fertilisation des forêts dans les pays tempérés. — Nancy : ENGREF, 1995. — 367 p.

NZILA (J.-D.), BOUILLET (J.-P.), LACLAU (J.-P.), RANGER (J.). — The effects of slash management on nutrient cycling and tree growth in Eucalyptus plantations in the Congo. — *Forest Ecology and Management*, vol. 171, n° 1-2, 2002, pp. 209-221.

RANGER (J.), AUGUSTO (L.), BERTHELOT (A.), BOUCHON (J.), CACOT (E.), DAMBRINE (E.), GAVALAND (A.), LACLAU (J.-P.), LEGOUT (A.), NICOLAS (M.), NYS (C.), PONETTE (Q.), OTTORINI (J.-M.), SAINT-ANDRÉ (L.). — Sylviculture et protection des sols. — *Revue forestière française*, vol. LXIII, n° 2, 2011, pp. 245-264.

CHEMICAL FERTILITY OF FOREST SOILS: BASIC CONCEPTS (Abstract)

The chemical fertility of a forest is generally defined as the pool of plant-available nutrients in the soil which is quantified at a given time and compared t to nutrient requirements established for the different tree species. This concept inherited from agronomy is often unreliable and many forest ecosystems developed on chemically poor soils (particularly in Ca, Mg, K) are highly productive. The objective of this article is to illustrate the limits of the “fertility = soil reservoir” concept and to propose the basic principles of a new concept which takes into account the specificity of the chemical fertility of forest ecosystems. To support this new concept, a comprehensive database of results acquired since the 1970s from 11 experimental sites was used. The results demonstrate that the definition of the chemical fertility of forest ecosystems should not be limited to the pool of plant-available nutrients in the soil but must also integrate the cycling and recycling of nutrients characteristic of biogeochemical cycling.