SOIL AND FOREST FLOOR CHARACTERISTICS OF SCOTS PINE STANDS ON DRIFT SANDS*

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ABSTRACT

In Flanders, important drift sand areas were afforestated with Scots pine (*Pinus sylvestris* L.) during the last century. Drought stress and limited nutrient availability are two major factors limiting tree growth on these sites. Nevertheless, afforestation succeeded extremely well and tree growth can be considered as satisfactory.

Chemical soil analysis stresses the very poor quality of the mineral soil. Nutrient content of the mineral soil is even poorer than that of neighbouring heathland soils.

The formation of a well developed forest floor is the most important feature of soil evolution during the last century. A seventy year old stand has built up a thick forest floor, with a biomass of over 10 kg/m2. This layer functions as a main nutrient source in the ecosystem.

Annually, 4000 to 5000 kg of tree litter per hectare return to the forest soil. Sixty percent of this fraction consists of shed needles. Needles also have a dominant share in the nutrient amounts returned with tree litter. Annually, about 42 kg of N, 8 kg of K, 15 kg of Ca and 2 kg of P and Mg are returned to the soil with tree litter. These values are, with exception of N, very low compared to other forest ecosystems.
The herbaceous layer, poor in species and dominated by wavy-hair grass (*Deschampsia flexuosa* (L.) Trin.), also produces over 2500 kg of litter per year and per hectare, and plays an equally important role in the nutrient supply of the growing vegetation.

Key words : Scots pine, drift sand, forest floor, litter

1. INTRODUCTION

A considerable part of the Flemish territory (Belgium) is covered by sandy soils, often of very poor quality. The original vegetation, an oak-birch forest type, has virtually completely disappeared, due to human influences in the last five thousand years, yet mainly during the Middle Ages. Instead, massive heathland areas appeared and degraded the soil even more. On some places the degradation and the external disturbance were so strong that movable land dunes appeared on a relatively big scale.

The bulk of the heathlands was afforestated between 1850 and 1930, with the help of increasing technical and financial means. Finally, it was also tried to afforestate the land dunes, protected meanwhile, at least partially, by surrounding young forests.

Of course the choice of tree species for that afforestation programme was very limited. So, it was decided to use Scots pine (*Pinus sylvestris L.*) monocultures, since only this species was known for its rather good growth on extremely poor, dry soils.
A bit surprisingly, those afforestations succeeded quite well, even on the drift sands. The question arises about the dynamics of these forest stands. Fundamental ecological research on primary succession in drift sands is still very rare (FANTA, 1986 ; FANTA & VAN HEES, 1990). In Flanders, special attention was focused on regeneration patterns in established forests on drift sands (VAN MIEGROET, 1983 ; DE SCHEPPER, 1988).

The current research of Scots pine stands on drift sands, as a part of an intensive research programme on Scots pine ecosystems, especially aims at the following subjects :

- forest soil development ;
- litter layer and litter production ;
- forest floor vegetation.

2. THE RESEARCH SITE

The research was carried out in the state forest Pijnven, located in the Campine region in the North-East of Belgium. Although the climate in this region can still be called atlantic, some continental aspects are already noticeable. Average temperature amounts up to 9,0 °C and total precipitation is about 800 mm. Rainfall is relatively equally spread over the year, with an amount of 360 mm during the growing season.

It is obvious that the recently established land dunes show little soil development up to now. ROGISTER (1959) still classified the young plantation in the Corynephoretum-canescentis agrostetosum caninae Tüxen (1937) community. Several typical species of this community (*Corynephorus canescens, Festuca ovina, Agrostis canina, Poa nemoralis*) where still present at that time.

The research stand has a total area of 3,06 ha. It was established in 1920 with pure Scots pine. Later on, exotic tree species, especially Black cherry (*Prunus serotina Ehrh.*), spontaneously settled. Standing volume is 213 m^3 per ha ; stem number is 413/ha. Canopy closure was estimated at 50 %.

3. SOIL CHARACTERISTICS

In order to examine the physical soil characteristics two profiles were described, one on top of a dune (blown-over heathland soil) and one in a depression (blown-out soil). Samples from all horizons were collected for analysis on soil texture, soil acidity (tables 1 & 2), bulk density and water retention capacity (pF-curve).

Table 1. Grain size distribution and pH of the mineral soil in pit 1 on a dune top (blown-over podzol).

Horizon	%									pH	
(cm)	0-2 µm clay	2-50 µm silt	> 50 µm sand	50-100 µm	100-200 µm	200-500 µm	> 500 µm	Organic matter	CaCO3	H2O	KCl
Al (0-7)	1.6	1.8	96.6	10.0	66.1	19.6	0.9	1.46	-	3.9	3.1
Cl (7-30)	1.0	2.8	96.2	15.2	65.5	15.3	0.2	0.63	-	4.4	4.0
C2 (30-65)	0.7	2.0	97.3	8.2	75.1	14.0	0	0.31	-	4.6	4.4
C3 (65-77)	1.2	2.0	96.8	13.4	55.6	26.5	1.3	0.31	-	4.5	4.4
Alb (77-84)	0	3.6	96.4	10.6	56.5	26.2	3.1	2.12	-	4.7	3.9
A2b (84-92)	0	2.3	97.7	10.0	56.7	27.3	3.7	0.55	-	4.7	4.0
B2hb (92-94)	1.0	3.2	95.8	6.1	60.6	25.4	3.7	11.00	-	4.4	3.9
B2hirb (94-100)	0.3	3.2	96.5	11.3	55.0	27.1	3.1	1.88	-	4.3	4.0
B3b (100-145)	1.7	3.2	95.1	17.3	56.5	19.9	1.4	0.47	-	5.1	4.4
Cb (> 145)	1.6	2.5	95.9	16.3	54.4	24.0	1.2	0.12	-	4.6	4.4

All horizons on the dune top are of very sandy composition. Over 95 per cent of the soil consists of sand particles, with the fine (100-200 µm) and medium (200-500 µm) fractions dominating. This is not so for the horizons in the blown-out profile : the share of clay and loam fractions is generally higher and amounts to 10 % in the top layer. Remarkable are some clay or loam lenses in the subsoil : 28.2 % loam at a depth of 40-50 cm and 29.2 % clay plus 17.8 % loam at a depth of 80 to 110 cm.

Table 2. Grain size distribution and pH of the mineral soil in pit 2 in a depression (blown-out soil).

Horizon (cm)	%									pH	
	0-2 µm clay	2-50 µm silt	> 50 µm sand	50-100 µm	100-200 µm	200-500 µm	> 500 µm	Organic matter	CaCO3	H2O	KCl
Al (0-3)	5.3	3.9	90.8	17.9	62.5	9.9	0.5	3.29	-	3.9	3.0
AC (3-18)	4.2	3.8	92.0	15.3	61.6	14.5	0.6	0.86	-	4.3	3.6
IIC1g (3-38/52)	6.6	28.2	65.2	14.1	33.2	15.6	2.3	0.39	-	4.6	4.1
IIIC2g (38/52-77)	4.2	1.0	94.8	14.8	54.1	23.1	2.8	0.08	-	4.6	4.6
IVC3g (77-107)	29.2	17.8	53.0	3.6	13.5	29.0	6.9	0.24	-	4.3	3.6
VC4g (> 107)	9.6	5.2	85.2	2.6	13.5	62.8	6.3	0.08	-	4.6	4.1

There is a slight but normal accumulation of organic matter in the upper soil horizon on the dune top. Underneath, the organic matter content is low, except for the illuviation horizon at a depth of 92-94 cm, where it goes up to 11 %. The profile clearly shows that the original heathland podzol is still present in the subsoil. In the depression the organic matter is only accumulated in the A1 horizon.

The soils are completely decalcified. The acidity of the upper soil horizon is located in the Aluminium Buffer Range (pH_{H2O} : 3.0-4.2), while the deeper soil horizons are still in the Cation Exchange Buffer Range (pH_{H2O} : 4.2-5.0) (KHANNA & ULRICH, 1984 ; MEIWES ET AL., 1984).

Bulk density is, of course, remarkable in the illuviation horizons, where it amounts to more than 1.6. Although PRITCHETT & FISHER (1979) mention only bulk densities of 1.75 as critical for the possibility of root development in compacted sandy soils, root penetration of these illuviation horizons was virtually never remarked. In most cases, roots form a well developed mat just on top of these layers, where water and/or nutrients are found.

Total pore volume varies between 38 and 45 %, which is quite normal for sandy soils (range 30-65 %). Severely compacted sandy soils, e.g. caused by logging or recreation, have pore volumes of less than 30 per cent and can lead to serious problems (PRITCHETT & FISHER, 1979).

The water holding capacity of the soils is very low. The plant available water holding capacity can be defined as the difference between moisture content at field capacity (pF-value 2.54) and moisture content at permanent wilting point (pF-value

4.2). Following values were measured :

- dune top : 168.10³ litres/ha
- dune depression : 368.10³ litres/ha (for the upper 50 cm layer).

Stands on drift sands generally have little available water, and normally less than stands on former heathlands (250 à 400.10³ l/ha in neighbouring stands). Yet the presence of loamy and clay horizons in the subsoil considerably increases this quantity. PRITCHETT and FISHER mention water uses of 75.000 litres per hectare by trees on sunny summer days. This means that in a couple of days, the whole water reserve on land dunes can be exhausted. So it is obvious that possible drought stress is certainly an important limiting factor in growth potentials on these sites.
Surprisingly, tree growth in the depression is comparable to that on the dune top. This is to be explained by the presence of impenetrable clay horizons in the top of the profile in the former.

The chemical analysis of the upper mineral soil horizon was carried out and compared with an original heathland soil and with a Scots pine stand on former heathland (Tables 3 and 4).

Table 3. Chemical analysis of the upper (0-30 cm) mineral soil horizon (C in % ; other elements in $mg.kg^{-1}$)*.

Stand	pH KCl	C	N	Na	K	Ca	Mg	Al	Fe	Mn	P	SO4
dune	3.46	1.69	508	6.67	4.1	5.7	4	142	212	0.32	7.71	95
heathland	3.19	2.69	907	4.52	5.8	7.8	4.6	170	238	0.44	3.57	80
former heathl.	3.26	2.34	477	6.03	2.4	4.3	3	209	173	0.19	3.51	89

* C, N, P, SO_4 : total amounts ; cations : plant available quantities measured after 0,5 n NH_4Ac-EDTA-extraction

Table 4. Cation exchange capacity* (meq/100 g) and percent base saturation of the upper mineral soil horizon.

Stand	Na	Ca	K	Mg	Al	Tot. CEC	Perc. Base Sat.
dune	0.0011	0.000	0.006	0.014	0.449	2.85	0.77
heathland	0.0088	0.068	0.019	0.027	0.067	5.72	1.98
former heathl.	0.0000	0.027	0.013	0.018	0.893	3.92	1.57

* 1 n NH_4Ac-extraction at pH 7

The results clearly show the very poor soil quality in all stands. Macro-nutrient (N, P, K, Ca, Mg) concentrations in this layer are extremely low and very insufficient for good tree growth (LAMBERT *et al.*, 1990). Cation exchange capacity is also very low and especially the percent base saturation is extremely low (less than 2 per cent).

Compared to the original or afforestated heathland soils, the drift sands are even poorer in quality.
The effect of fertilisation is neither retraceable in the upper mineral soil. This coincides with MILLER's (1981) view that fertilisations are generally beneficial to tree growth, and not to the site quality.

4. FOREST FLOOR AND LITTER PRODUCTION

One of the main characteristics in the evolution of many forest soils is the development of an organic soil horizon on top of the mineral soil horizons. This litter layer provides a food source and habitat for many microflora and fauna (KLINKA et al., 1990). It plays an important role in the nutrient cycling of the ecosystem. In certain forest soils, especially poor sandy soils, the forest floor may represent the major reserve of nutrients for tree growth (PRITCHETT and FISHER, 1979).
The forest floor also plays an important role in the establishment of a new forest generation. Certain tree species, like birch or Scots pine, find it very difficult to grow up in a well developed forest floor, while others (e.g. oaks) require such a horizon for a good regeneration (OLBERG, 1957 ; CANHAM & MARKS, 1985 ; FANTA, 1986).

It is to be expected that on sand dunes, with their very poor mineral soils, the forest floor is extremely important for the stand vitality and productivity. Therefore due attention should be paid to the physical and chemical properties of this horizon.

4.1. The organic profile

The organic soil profile was described on basis of 23 different soil cores collected by use of a shallow profile sampler. For each sample three organic soil horizons were distinguished : the L-layer (litter horizon), the F-layer (fermentation horizon) and the H-layer (Humus-horizon).
Thickness of every layer was measured and the dominant herbal vegetation on each site was recorded. On six of the sites, above ground soil vegetation and the total organic floor biomass on a 50 x 50 centimeter plot were harvested. The average forest floor thickness is about 7.4 cm, divided as follows : L-layer : 0.30 cm ; F-layer : 5.00 cm ; H-layer : 2.10 cm.
The development of an important F-horizon under pine and *Deschampsia* is also mentioned by METTIVIER-MEYER et al. (1986).
A well developed fermentation layer and a thin humus horizon are remarkable.
No significant differences in forest floor profile thickness can be noticed with regard to the dominant herbaceous vegetation present (*Deschampsia flexuosa (L.) Trin., Vaccinium myrtillus L.*, regeneration of *Pinus sylvestris L.* or bare soil). (Table 5)

Table 5. Thickness (in cm) of organic soil horizons under different vegetation types

	Deschampsia	Vaccinium	Pinus seedlings	bare
L-layer	0,22	0,77	0,99	0,61
F-layer	5,17	4,73	4,51	4,46
H-layer	1,61	1,87	2,31	2,09
Overall	7,00	7,37	7,81	7,16

Only the L-layer is significantly thinner under Deschampsia. Yet, this difference may be the result of the very hard identification of the litter horizon in a Deschampsia vegetation.
The absence of a relationship between the forest floor profile and the different herbal vegetation types is surprising, since Scots pine natural regeneration is normally associated with absence or disturbance of organic soil horizons (OLBERG, 1957). On these land dunes however, the natural regeneration of Scots pine has clearly taken place in a well developed organic soil layer.

The forest floor biomass of the 70 years old pine stand on drift sands averages 10,77 kg/m^2, with a minimum of 5.06 kg/m^2 and a maximum of 14.30 kg/m^2. This value is equal to that of stands located on former heathlands. It is estimated that the annual accumulation between the ages of 45 and 80 equals around 1 T/ha. It is not clear if the forest floor biomass already reached a steady-state. As for the profile thickness, no relationship between the herbal layer and the forest floor biomass could be detected. The herbal vegetation amounts on average to 262 g/m^2 (with a standard deviation of 121). It is largely dominated by *Deschampsia* and is much more developed than in surrounding more or less similar stands. An identical organic soil profile development is described by BERGHEM ET AL. (1986).

The average nutrient content of the forest floor in g/m^2 equals :

C	N	P	Na	K	Ca	Mg	Al	Cl	Mn	Fe	C/N	C/P
5256	143.2	6.6	1.1	4.8	2.7	3.2	23.9	1.7	0.4	23.5	37	800

In comparison with stands on former heathland there is a slight higher C/N value, a clearly higher C/P ratio and a lower Ca ratio. The importance of the forest floor as a nutrient source is stressed by comparison with the mineral soil data. Available nutrient content of the upper horizon of the mineral soil is much lower than in the forest floor. Its importance as a nutrient source for trees and herbaceous vegetation is further stressed by the high root presence in this horizon.

4.2. The litter production

As nutrient availability is an important limiting factor for forest growth on drift sands, it should be interesting to study nutrient input with litter. Litter sampling was performed in specially designed litter traps, as already recommended by NEWBOULD (1968). Twelve litter traps were installed, evenly dispersed over the stand. Litter collection started in June 1988 and went on till the end of 1990.

4.2.1. Annual quantities and components

The total litter production and its distribution over the foliage and non foliage fractions over that period can be presented as follows (table 6).

Table 6. Annual litter production over a 31 month period (in g.m^{-2})

Fraction	1988 (Jun-Dec)			1989			1990		
	AVG	STD	%	AVG	STD	%	AVG	STD	%
Foliage	242	26	69	252	41	56	292	41	55
Non-foliage	107	90	31	197	113	44	238	75	45
Total	348	100	100	449	130	100	530	113	100

The total annual litter production can be estimated at about 4,500 to 5,300 kg/ha. This value can be considered as relatively high, compared with literature data. MÄLKONEN (1974) cites values between 575 and 1,655 kg/ha for poor soils in southern Finland. According to BRAY & GORHAM (1964) litter production in the cool temperature climate averages 3.4 tons per hectare, with 2.5 tons consisting of foliage. COLE & RAPP (1981), who compiled the biomass and nutrient quantity data obtained from the different I.B.P.-research sites all over the world, mention average litter production in temperate coniferous forests to be 4,377 kg/ha/year. Litter production varies from year to year, as is also mentioned by BRAY & GORHAM's review. In this case the variations are relatively small (= 15 %).

On average the non-foliage part amounts to about 30-40 %. BRAY & GORHAM (1964) mention average values of 30 %.
Litter production in this forest ecosystem is very high, compared to that one in the former heathland ecosystem that dominated this region in the past. CORMACK & GIMINGHAM (1964) measured litter productions by *Calluna vulgaris* L., that varied between 50 and 700 kg/ha/yr, this is 5 to 10 times less than in the current research.

About 50 per cent of the annually shed tree litter consists of pine needles. The share of Black cherry leaves is still very low (< 5 %), but increasing. Amounts of more than 1000 kg/ha/yr are already measured under the canopy of older pine stands.

Cones and branch & bark have about equal shares in total litter (15 to 20 %). The miscellaneous group (black cherry fruits, bud scales, inflorescences and other fractions) still produces over 10 % of total litter.

4.2.2. Seasonal variation

The seasonal variation in litter production of the most important fractions for the years 1989 and 1990 is demonstrated in fig. 1.

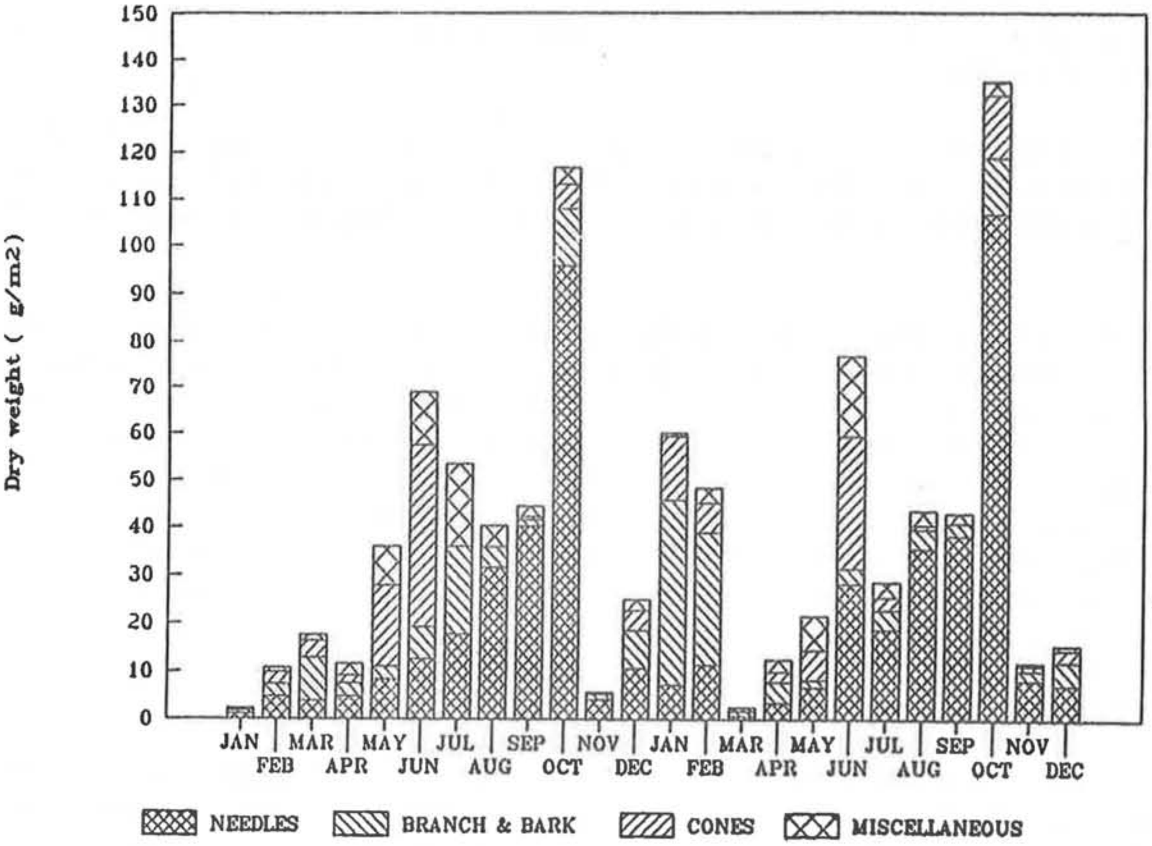

Figure 1. Monthly production of the main litter components over a two year period (Jan 89 - Dec 90).

Needle litter is mainly produced in the month of October. The share however is relatively low, namely 40 %. In both years, an important fraction of the needles was also shed in the period June-September (resp. 37 and 30 %). During the period January-May and November-December, less than 10 % of the annual needle litter is produced.
The early needle fall in the summers of 1989 and especially 1990 may be the result of drought stress, since both summers were very warm and dry. This phenomenon

did not take place in the normal summer of 1988. HOFFMANN & KRAUSS (1988) mention that over a 5 year span about 20 per cent of total Scots pine needle litter was shed in July-August and 39 per cent in September-October.

Unlike pines, Black cherry leaf abscission peaks only in November (50-75 %). An important number of leaves are also shed in October (15-20 %) and December 89 (19 %). But important early leaf fall (May-June : 10 %) was also recorded.
Cones form a considerable part of the non-foliage production in the Scots pine stands. Most cones are shed during the months of May and June. Yet in October a slight secundary peak is noticeable. The cone production in this stand was relatively comparable over the three years, unlike other stands where the production was the highest in 1988.

Branches and bark are irregularly but continuously shed. For most months this production is less than 10 g per square metre, yet some months reach the double and of course peaks occur with storms (January and February 1990, with 38 and 27 $g.m^{-2}$).

The miscellaneous fraction peaks in the months May to July. This is the result of important inflorescence abscission and pine seed release in these months. Later in the year, black cherry fruits form a major part in this fraction. They contributed with 6.75 and 4.94 grammes per square metre in September and October 1990. Average weight of one cherry seed amounts to 0.097 grammes. This results in an average cherry fruit input of 120 individuals per square metre. It was already mentioned that cherry will rapidly dominate the understorey of this stand. The very high seed production of these young trees will increase this evolution considerably.

4.2.3. Nutrient input with litter

During the period 1988-1989 a total of 66 combined samples obtained in different stands from monthly litter fall were analysed. Analysis of variance did not detect significant differences between different Scots pine stands and/or sampling period, for most nutrient concentrations of the different tree fractions.
Therefore, average nutrient concentrations per fraction were used for determination of nutrient input quantities (tables 7 and 8).

Chemical analysis indicated high nutrient concentrations of red oak and black cherry leaves in comparison to Scots pine needles. The latter have, however, the highest Al content. Very high Magnesium quantities in black cherry leaves are noticeable. The miscellaneous fraction displays high nutrient concentrations, namely the highest N and P concentrations of all litter fractions. Nutrient content of the cones is very low.
On drift sands the nutrient input, which is restituted to the forest floor with the annual shed litter is low :

42 kg N ; 15 kg Ca ; 7 kg SO_4 ; 7 kg K ; 2 kg Cl ; P and Mg ; 1 kg Al and less than 1 kg for the other minerals.

Table 7. Average nutrient concentrations of the main litter fractions (in mg.kg^{-1}, unless mentioned otherwise)

FRACTION	C(%)	N(%)	Ca	Mg	K	Na	P	Mn	Fe	Al	Cl	SO4
Needles	52.00	0.94	4575	439	1403	208	432	189	142	237	688	1489
Red oak leaves	48.58	1.63	4983	943	4223	138	887	280	100	173	650	2221
Black cherry	46.96	1.49	6327	2240	5838	200	762	250	193	165	478	3517
Branch+Bark	51.26	0.64	2298	241	952	97	411	66	368	264	137	2541
Miscellaneous	48.40	1.97	1909	705	3248	116	1264	107	405	404	918	1450
Cones	47.05	0.32	320	168	379	55	84	15	68	107	97	590

Table 8. Nutrient input with litter during 1989 (in kg/ha ; sem = standard error of the mean).

FRACTION		C	N	Ca	Mg	K	Na	P	Mn	Fe	Al	Cl	SO4
Needles	avg	1222	22.19	10.75	1.03	3.30	0.49	1.01	0.44	0.33	0.56	1.62	3.50
	sem	35	2.26	0.91	0.07	0.43	0.08	0.10	0.05	0.06	0.05	0.29	0.93
Cherry leaves	avg	69	2.19	0.93	0.33	0.86	0.03	0.11	0.04	0.03	0.02	0.07	0.52
	sem	13	0.49	0.21	0.07	0.22	0.01	0.02	0.01	0.01	0.01	0.02	0.14
Cones	avg	342	2.35	0.23	0.12	0.28	0.04	0.06	0.01	0.05	0.08	0.07	0.43
	sem	69	0.62	0.04	0.02	0.09	0.01	0.02	0.00	0.01	0.02	0.02	0.29
Branch+Bark	avg	355	4.46	1.59	0.17	0.66	0.07	0.28	0.05	0.26	0.18	0.09	1.76
	sem	51	1.00	0.42	0.04	0.24	0.01	0.07	0.02	0.07	0.04	0.02	0.53
Miscellaneous	avg	266	10.83	1.05	0.39	1.79	0.06	0.70	0.06	0.22	0.22	0.51	0.80
	sem	7	1.48	0.20	0.07	0.46	0.01	0.14	0.01	0.04	0.04	0.15	0.17
Total	avg	2255	42.01	14.56	2.04	6.88	0.69	2.17	0.60	0.89	1.06	2.36	7.00
	sem	174	5.86	1.79	0.27	1.45	0.11	0.35	0.09	0.19	0.15	0.50	2.05

Most of the macro-nutrient input (about 50 %) with the litter is incorporated in the foliage fraction (fig. 2). The share is especially high (74 %) for the calcium input.

In this stand the importance of the miscellaneous fraction as a nutrient source is very high, like in other pine stands. It contributes 12 % in total litter biomass, but is of much higher importance in all macro-nutrient inputs, with the exception of calcium (7 %). For phosphorus it reaches even more than 30 %.

Black cherry foliage contribution in total annual macro-nutrient input with litter is not yet considerable, though it is higher than the leaves share in biomass. It is an important source of potassium and magnesium.
Branches and bark show a different pattern. In all they produce 15 % of the annual litter biomass, but their share in the macro-nutrient input is never higher than

10 %. The lowest share is recorded in deciduous stands. They mostly contribute to phosphorus and the least to potassium.

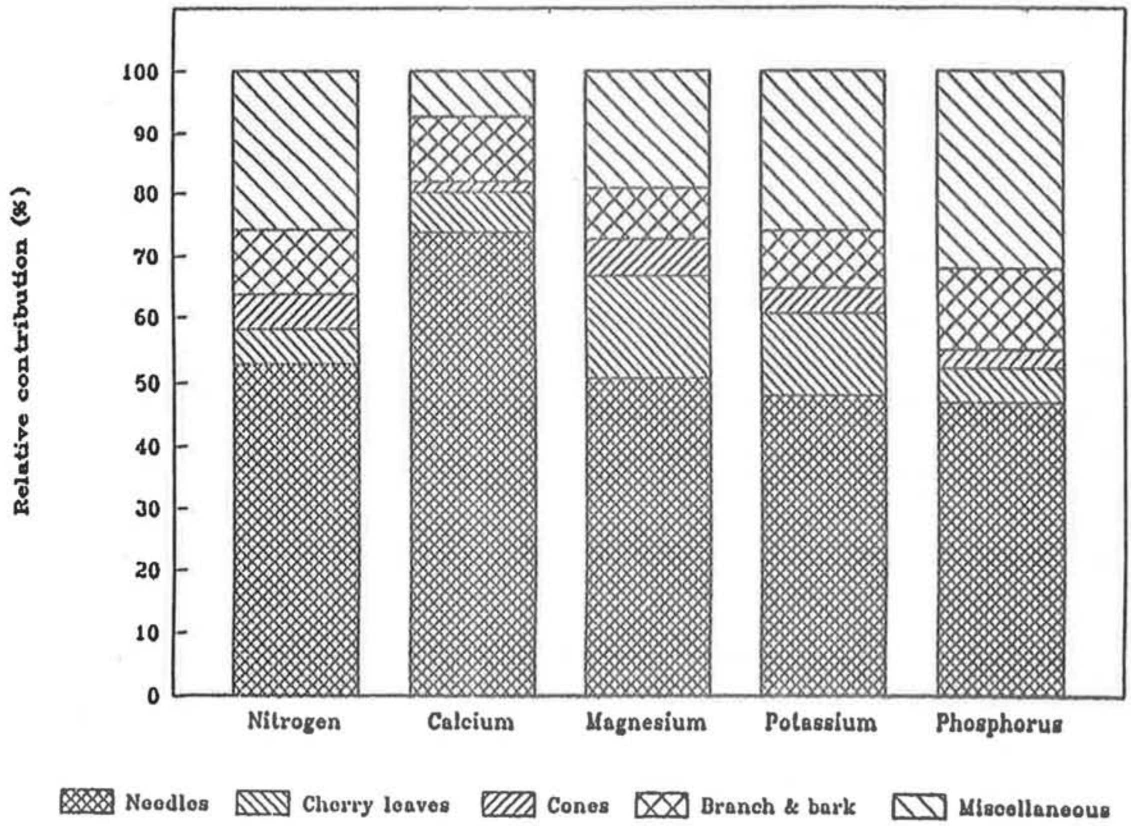

Figure 2. Share of the litter fractions in total annual macro-nutrient input with litter.

Macro-nutrient input to the forest floor is 5 to 10 times higher than values given by MÄLKÖNEN (1974) for Scots pine in Southern Finland. The nitrogen input is comparable to the data presented by COLE & RAPP (1981) for temperate coniferous ecosystems. But nutrient return for potassium, calcium, magnesium and phosphorus are all lower. The relatively high nitrogen content of the litter is probably the result of the high atmospheric N-deposition with averages 38 kg.ha^{-1} in Belgium.

Finally in addition to the input with tree litter, the nutrient input with herbaceous litter should be determined (table 9). It is clear that the herbaceous vegetation contributes in an important manner to total nutrient return, except for calcium. For all other elements, nutrient return with herbal litter is equal or much bigger (K) than return with tree litter.

Table 9. Nutrient input with herbaceous litter (in kg/ha) and its relation to the tree litter quantities

	N	K	Ca	P	Mg
absolute amounts	41.9	37.1	2.6	3.1	2.0
in % of total tree litter input	100	539	18	143	98

5. SUMMARY AND CONCLUSIONS

In Flanders drift sands were afforestated with Scots pine during the last century. The composition of the drift sands is not completely homogeneous : clay and loam fractions up to 10 % appear in depressions, while on dune tops the original podzol still can be found.

The water holding capacity of the soils is very low, so drought stress is an important growth-limiting factor. Macronutrient concentrations and especially the percent base saturation are extremely low.

Forest floor thickness of a seventy years old Scots pine stand equals 7,4 cm and biomass amounts up to 10.8 kg/m^2. Its different layers are independant from the dominant herbaceous vegetation. Available nutrient content of the forest floor is much higher than the one in the upper mineral soil horizon. The annual nutrient input with shed litter is low compared with literature data. Nevertheless, the forest floor is very important as a nutrient source for trees and herbaceous vegetation. This is also proved by the high root presence in this horizon.

Total annual tree litter production is estimated at 4.5 to 5.3 tons/ha. Non-foliage compartment reaches 40 per cent. Herbaceous vegetation plays an important role in the ecosystem, although the variety of plant species is very limited. *Deschampsia flexuosa* dominates with a ground-cover of over 75 %. For all macro-nutrients (except for Ca) nutrient return with herbal layer is equal or higher (K) than return with tree litter.

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