REHABILITATION OF FOREST ECOSYSTEM ON FORMER HEATHLANDS BY A FIRST GENERATION OF SCOTS PINE

N. LUST, D. MADDELEIN & S. MEYEN *
Laboratory of Forestry, State University of Ghent

1. INTRODUCTION

The North-East of Belgium, known as the Campine region, is characterised by its poor, sandy soils. Various human activities have resulted into the disappearance of the former vegetation type (oak-birch forest) and have led to the presence of heathland areas. In an attempt to rehabilitate these valueless soils, the decision was taken mid last century to reafforestate this area (NN, 1904). The reafforestation programm was executed with Scots pine (*Pinus sylvestris L.*) as almost exclusive pioneer tree species.

Today most of those stands are fully grown and ready for reconversion. From ecological, economical, recreational and forestry management points of vue, voices are heard demanding future forest management to stress natural regeneration, mixture with deciduous tree species and small scale forestry.

This research fits in this framework and was executed in the state forest Pijnven near Hechtel-Eksel.

TABLE OF CONTENTS

2. THE STATE FOREST PIJNVEN : ORIGIN AND PRESENT DAY SITUATION

The state forest Pijnven covers about 800 hectares and was established early this century on former heathlands. Part of the forest is situated on continental sand dunes.

Before afforestation, the soil was completely ploughed (up to a depth of 30 cm) to break the iron-accumulation horizon.

Later lupines were grown for three consecutive years in order to fix nitrogen in the soil. Finally an additional fertilization with phosforus and lime was done.

The afforestation was executed by employing a geometrical pattern deviding the forest in rectangular stands with a surface of 4 to 5 hectares. The stands are separated by broad roads surrounded by a deciduous tree species shelterbelt. The shelterbelts originally consisted of various tree species, but are nowadays dominated by red oak (Quercus rubra L.).

Later, especially beyond 1930, most reafforestations were executed with Corsican pine (Pinus nigra Arnold subsp. laricio), that shows greater yield than Scots pine.

* Research conducted for the account of the Belgian State- Services of the Prime Minister, Programmation of Science Policy - and of the Commission of the European Communities.

The current forest composition is presented in table 1. Scots pine only amounts to 35 % of the total forest area, but the bulk of those stands are over 60 years old and ready for reconversion.

Table 1 : Species composition of the State Forest Pijnven

Species	ha	%
Pinus sylvestris L.	283,45	35,3
Pinus nigra Arnold subsp. laricio	415,27	51,7
Pseudotsuga menziesii	6,85	0,8
Larix spp.	2,34	0,3
Other conifers	13,69	1,7
Broad-leaves (oak)	22,67	2,8
Roads & barren	58,32	7,4
Total	802,59	100

3. REHABILITATION OF THE SITE BY THE PINE CULTURE

According to Burg (1979), it is very difficult to judge the impact of the pine plantation on site rehabilitation, for it is impossible to distinguish the separate effect of the fertilization.

Though it is clear that in a short period a typical forest ecosystem has developped on those extreme poor, degraded soils. Microclimate and soils are no more comparable to the former heathland ecosystem. The annual input of three to five tons of litter has started the development of a thick organic soil profile, with a dry weight of over 100 tons per hectare (Table 2). Soil acidity measured at 10-15 cm depth is somewhat lower under forest in comparison with heathland (pH-H_2O 4,22 vs 4,09).However, this difference is not significant at the 95 % level.
Today, a dynamic evolution is observed in the forest, indicating the potency of the site.

The typical forest microclimate, characterised by high relative humidity and smaller temperature fluctuations, is extra strengthened by the spontaneous settlement of a deciduous middle- and understory.

Virtually all plant species typical of the former ecosystem have disappeared after 70 years of afforestation (Maddelein & Meyen, 1989).

Table 2 : Thickness and dry weight of the organic soil profile in four Scots pine stands in the State Forest Pijnven

Stand	Age	Thickness organic horizon (cm)				Dry weight (tons/ha)
		L	F	H	Total	
1	45	0.2	5.3	1.2	6.7	76
2	69	0.4	5.0	1.9	7.3	107
3	69	0.8	4.6	1.5	6.9	133
4	75	0.8	4.8	2.1	7.7	105

4. RESEARCH ITEMS AND METHODS

The research consisted in two different fractions (A and B). The first object (A) was to investigate natural dynamics in the older Scots pine stands. Emphasis was laid upon the spontaneous ingrowth of deciduous tree species and the possibilities for indirect conversion of those stands.

The second element (B) evaluated management techniques exercised to stimulate natural regeneration of Scots pine.

Among others, a comparison was made between natural regeneration under the canopy of 45 and 70 year old pine stands, and regeneration on laboured clearcutted area.

In every research stand, a number of permanent plots were established, varying in size depending on the research item between 0,5 m_2 and 500 m_2. For every plot, all tree species were registered. Species, height and diameter were measured on every specimen. Age analysis was performed on a fraction of the trees in group A by use of a Pressler-corer and by counting the whorls on all specimen in group B.

5. RESULTS AND DISCUSSION

5.1. Spontaneous ingrowth of deciduous tree species

Deciduous tree species ingrowth was analysed in three older Scots pine stands (table 3).

The ingrowth result varies strongly according to plot or stand. In stand 1 a massive black cherry ingrowth is to be observed, while in stand 3 red oak is clearly dominating the substratum.

Height and height distribution show large differences between the stands and within the plots, especially for red oak (fig. 1 - table 3). In stand 3 several oak individuals have already reached the upper stratum (fig. 1. - fig. 2).
Red oak dominates black cherry in height by about three metres. This is due to two different reasons :

- average age of oak is higher than for black cherry (29 vs 22 years in stand 3 ; oldest oak 39 years, oldest cherry only 26 years) ;

- black cherry often displays a shrubby habitus, while only few species seem to develop a clear tree habitus.

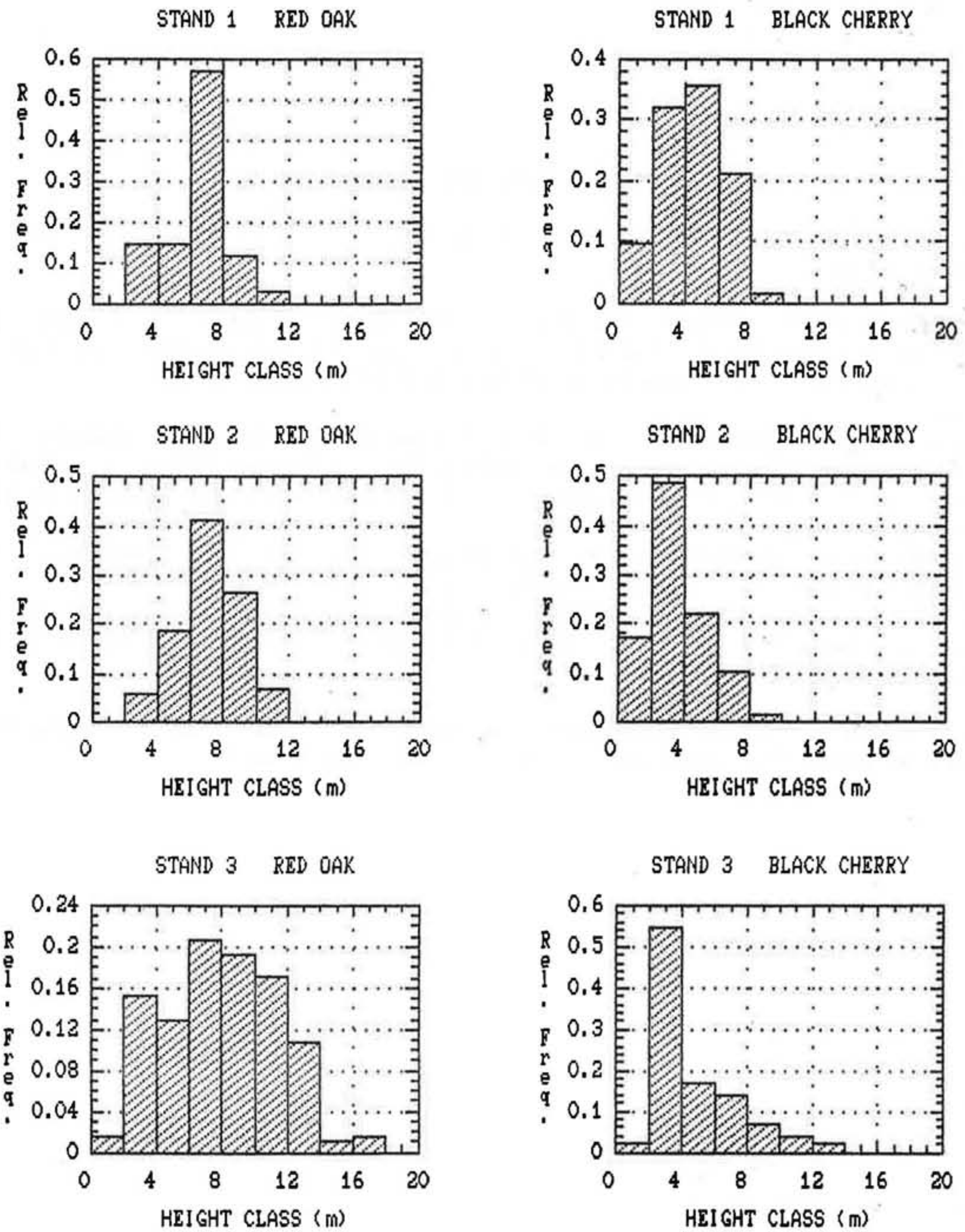

Figure 1: Relative height distribution of red oak and black cherry in the research stands

Globally red oak has settled earlier than black cherry. Regeneration period of oak took very long. Age of sampled individuals varied between 16 and 39 years. The first oak colonization started in a pine stand of only 40 years of age (stand 3), which clearly indicates the relatively tolerant character of this species. This feature is also mentioned by Crow (1988) and Stroempl (1987), but denied by Runkle (1985).

Locally, the massive appearance of black cherry is inhibiting the conversion towards a second generation forest dominated by red oak, causing severe problems in forest management (Lust, 1987 ; Borrmann, 1988). Positive is that this species produces a very mild litter and thus stimulates nutriënt cycling. A litterbag-experiment registered 55 % of black cherry leaf dry weight loss after three months of incubation in the field, compared to 20 % of weight loss for red oak and Scots pine (Maddelein & Meyen, 1989).

Considering the average and height of the red oaks and the tendency of the species to develop a wide crown habitus, one can state that the presence of at least ten oaks per are is necessary to consider indirect conversion, without taking special measures. Only three out of eleven plots fulfill this condition. Stand 3 is the only one to conduct the conversion, although several gaps will remain present. For the other stands it is recommended to establish a mixed oak-pine forest, although problems with steep edges will arise.

The situation can be improved by initiating the conversion by additional sowing or planting of deciduous species in open gaps under the pine canopy.

Besides red oak, there is also the possibility of introducing autochtonous tree species like oak and beech. Different authors have already mentioned this (Ebeling & Hanstein, 1988 ; Trillmich & Uebel, 1982).

5.2. Natural regeneration of Scots pine

Natural regeneration of Scots pine was studied in three different ecological situations :

- under canopy of Scots pine ;
- under canopy of Scots pine, after removal of soil vegetation and the organic soil profile ;
- on an intensively laboured clearcutted area.

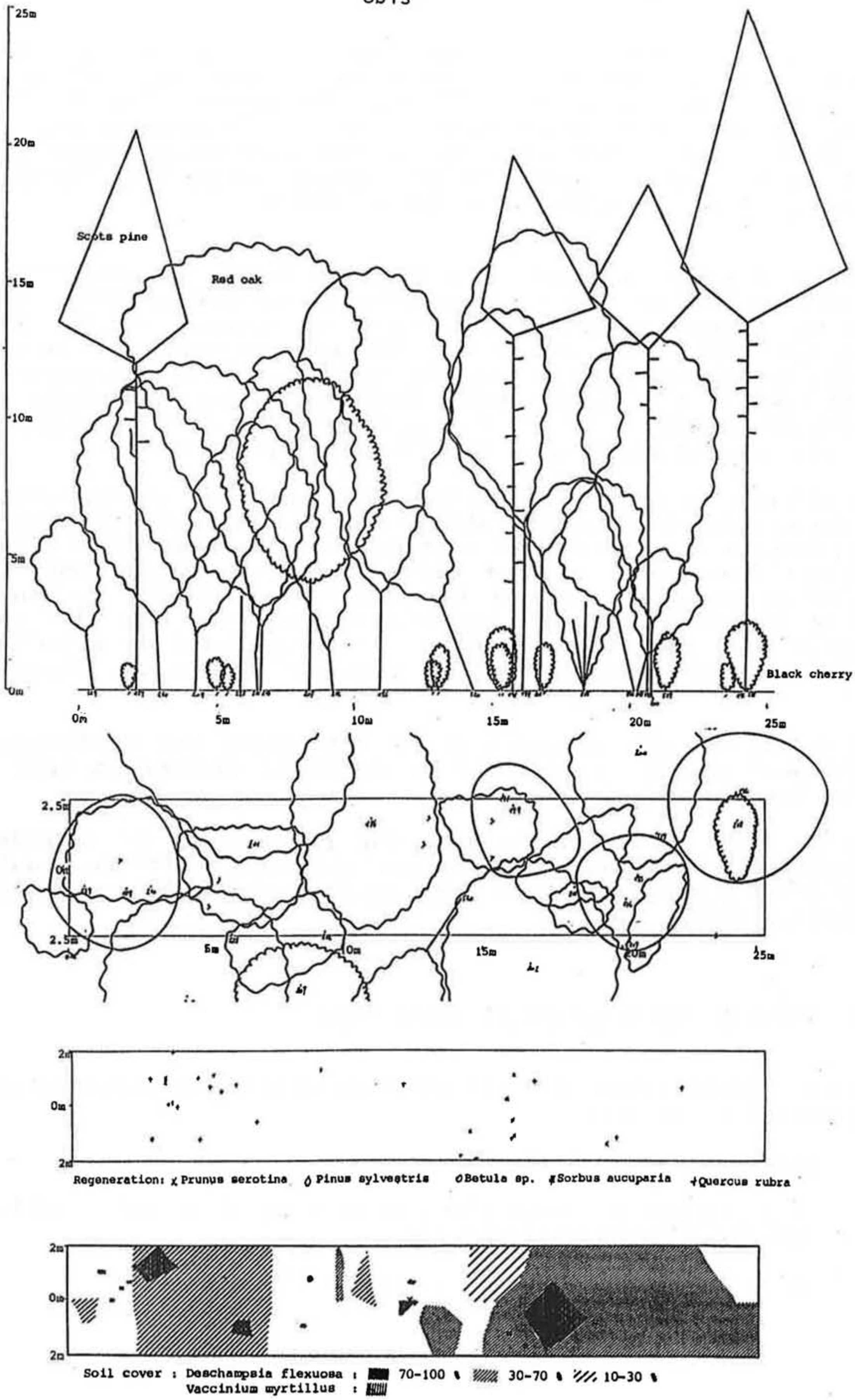

Fig. 2. Transect of a 75 year old Scots pine stand

5.2.1. Regeneration under canopy of Scots pine

A 69 year old stand[1] (N = 413/ha ; V = 212 m_3/ha ; Crown Area Index = 50 %, G = 24,60 m^2/ha), situated on continental sand dunes, displays an important regeneration located in a dense mat of wavy hair-grass (Deschampsia flexuosa (L.) Trin.) (fig. 3). This regeneration is dominated by Scots pine. Several deciduous species have also settled (Sorbus aucuparia, Quercus robur, Quercus rubra, Prunus serotina, and Frangula alnus), but their development is severely enhanced by browsing.

Besides the broadly spread pine seedlings, several already consolidated Scots pine regeneration groups can be detected. Two such groups have been investigated and compared. (Table 4).

Both groups have developped on a normally developped organic soil profile (thickness 7,3 cm ; organic soil biomass : 108 tons/ha). This shows that Scots pine, known for preferring mineral soil for its regeneration (Olberg, 1967), is capable to regenerate in an organic soil profile when circumstances are favourable.

Table 4 : Characteristics of two consolidated Scots pine regeneration groups

	group 1 (5 x 2 m)	group 2 (4 x 3 m)
number (per are)	3420	700
Av. height (m) h min h max	0.45 0.08 0.98	1.10 0.20 2.39
Av. diameter (cm) d min d max	0.62 0.1 1.7	1.63 0.3 5.2
Av. age (y) min max	5.5 1 10	7.8 3 11

In both groups, initial settlement occurred at about the same time (about ten years ago) but both have developped in a different manner. Remarkable differences exist in seedling number, height and diameter. In plot 1 most trees have settled about 5-6 years ago, while plot 2 has known a more gradual seedling settlement (Fig.4).

[1]Stand 2 in table 2

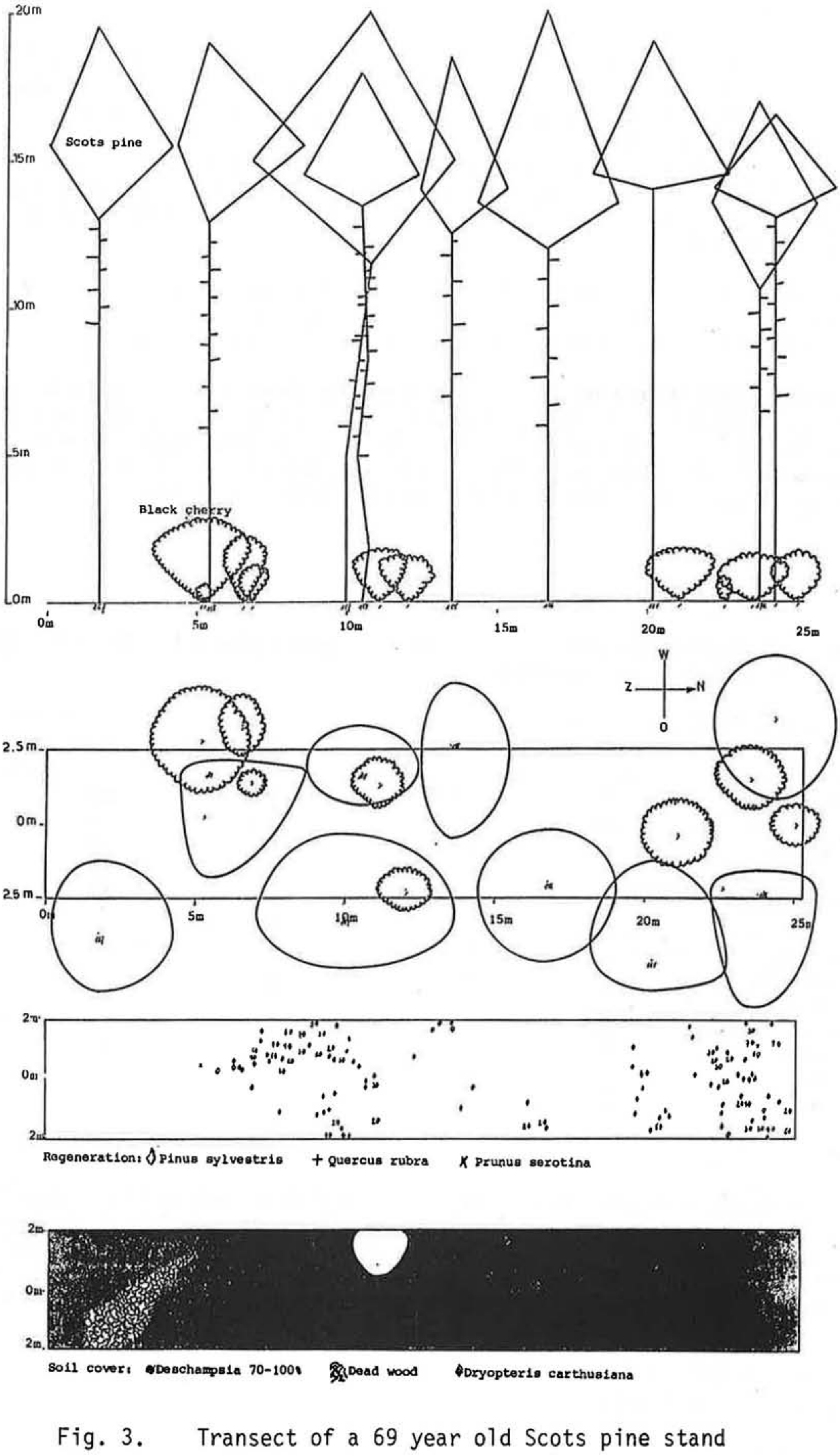

Fig. 3. Transect of a 69 year old Scots pine stand

Plot two displayed a good correlation between tree age and height (r_2 = 0,78), this was not the case for plot 1 (r_2 = 0,44).

5.2.2. Regeneration under canopy, after removal of the organic soil profile

This research was conducted in a 46 year old pine stand (N = 1100 ex/ha ; V = 210 m_3/ha ; C.A.I. = 70 %, G = 29,12 m_2/ha)*

Soil vegetation and the organic profile were removed locally during the spring of 1988. Afterwards four permanent plots (0,5 x 1 metre) were established and four seedling recordings have been executed since then (Table 5).

Only Scots pine has settled in the research plots. Regeneration numbers are very high and average 1 450 000 per hectare after one year. The mild winter of 1988-1989 has had little influence on seedling survival. After one year, one third of the initial seedling number has disappeared, the bulk in the first months after germination. The average seedling height is only 3.5 centimeters.

5.2.3. Regeneration on the clearcutted area

A 65 year old stand was clearcutted in 1987. In order to achieve a natural regeneration of Scots pine, all black cherry shrubs were excavated and the whole stand was ploughed at the end of 1987.

Seedling settlement was followed on nine permanent plots of 1 by 0.5 metre. These plots were located systematically from the stand edge at resp. 5, 20 and 50 metres.

Regeneration result after 1 year is very good, but still considerable lower than the regeneration under pine canopy (table 5).

Yet, average seedling height is twice as high compared to the regeneration under canopy (7,6 cm vs 3,5).

Comparing seedling height with distance from the stand edge, a significant difference (level 0,01) can be observed. Seedlings located in the center of the clearcut area showed the highest initial height growth. So, light seems to play an important role in seedling height growth.

* Stand 1 in table 2

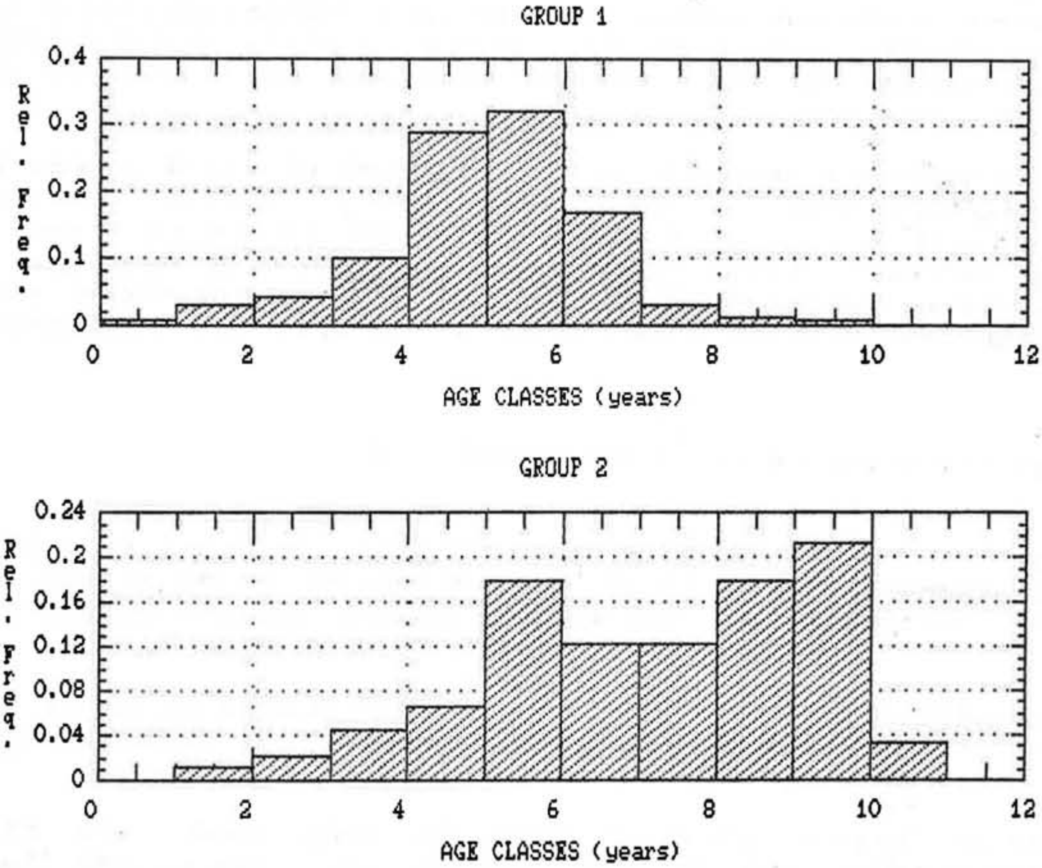

Figure 4: Age distribution in two regeneration groups of Scots pine

Table 5 : Natural Scots pine regeneration under pine canopy and on the clearcut area.

Date of recording	Under canopy		Clearcut area	
	N/are	av. height (cm)	N/are	av. height (cm)
July 1988	21 350	/	2 600	/
Oct. 1988	17 800	/	2 600	/
Ma. 1989	16 200	/	2 200	/
Juin 1989	14 500	3,5	2 700	7,6

6. SUMMARY AND CONCLUSIONS

In an attempt to rehabilitate degraded heathland areas, an important reafforestation program, based on the introduction of Scots pine, was executed at the end of the 19th century.

Today, after one generation of Scots pine, results can be considered to be very good.

On various locations a dense substratum, dominated by red oak and black cherry, has settled spontaneously under the pine canopy. This offers serious opportunities to conduct an indirect conversion towards mixed oak-pine forests or oak-dominated deciduous forests.

Massive presence of black cherry in the understory of many pine stands inhibits the settlement of other deciduous tree species or pine regeneration and thereby prevents the stand conversion.

The reintroduction of autochtonous tree species by underplanting or sowing under pine canopy deserves recommendation, keeping in mind the lack of seed trees and the high browsing damage on all seedlings present.

In absence of an understory a second pine generation can settle under canopy of an older pine stand. Natural regeneration is also dominated by Scots pine on the clearcutted areas and under canopy when the soil vegetation and organic horizons have been removed.

Summarising, can state that one generation of Scots pine has created various possibilities for the development of a complex, diverse and structural forest ecosystem. It is the task of the forest manager to fully turn to account these possibilities.

7. LITERATURE

BORRMANN, K., 1988 Ausbreitung und rationelle Bekämpfung der blühenden Traubenkirche (Prunus serotina). Soc. Forstwirtsch, 38, 12, 366-371.

BURG, J. van den, 1979. Veranderingen in heidegronden door bebossing. Ned. Bosbouwtijdschrift 51, 3, 69-81.

CROW, T.R., 1988. Reproductive mode and mechanisms for self-replacement of northern red oak (Quercus rubra) - a review. For. Science, 34, 1, 19-40.

DE LANGHE, J.E., et all, 1988. Flora van België, het Groothertogdom Luxemburg, Noord-Frankrijk en de aangrenzende gebieden. Nationale plantentuin van België, Meise, 972 pp.

DE SCHEPPER, C., 1988. Typology of the natural regeneration in a middle-aged Scots pine forest. Sylva Gand. 54, 29-60.

EBELING, K. and HANSTEIN, U., 1988. Eichenkulturen unter Kiefernaltholzschirm. Forst u. Holz, 18, 463-467.

LUST, N., 1987. An analysis of a spontaneous ingrowth of deciduous trees in 70 year old stands of Scots pine. Sylva Gand., 52, 1-27.

MADDELEIN, D. & MEYEN, S., 1989. Driving forces and limiting factors in long-term dynamics of forest ecosystems on sandy soils. Second Interim Report, State Univ. of Ghent, 66 p.

NN, 1904. De Kempen op boschbouwkundig gebied. Verslag van de commissie belast met het bestudeeren der Kempen op bosbouwkundig gebied. Uitg. dr. F. Van Buggenhout, Brussel, 205 p.

OLBERG, A., 1957. Beitrage zum Problem der Kiefern-Natürverjüngung. J.D. Sauerlander's Verlag, Frankfurt am Main.

RUNKLE, J.R., 1985. Disturbance regimes in temperate forests. In : The ecology of natural disturbances and patch dynamics. Ed. Pickett, S.T.A. & White, P.S., Academic Press inc, p. 17-34.

STROEMPL, G., 1987. Growth quality of red oak planted in a Jack pine plantation. Ont. Min. Nat. Resour. For. Res. Note No. 44, 4 p.

TRILLMICH, H.D. and UEBEL, E., 1982. Ergebnisse eines Roteichenvoranbaues unter einem 64-jährigen Kiefernbestand bei gleichzeitiger mineralischer Düngung. Beitr. f.d. Forstwirtschaft, 1, 34-39.

VAN MIEGROET, M., 1985. The early stages of spontaneous forest regeneration on poor soils and continental sand dunes in northern Belgium. Sylva Gand. 49, 47-73.