GROWTH AND MANAGEMENT OF MIXED PINUS SYLVESTRIS - QUERCUS ROBUR STANDS IN FLANDERS, BELGIUM

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ABSTRACT

Mature Scots pine (*Pinus sylvestris L.*) stands are dominating large parts of the Flemish forest area. Broadleaved species regenerate spontaneously under this pine canopy. This study studied the growth and development of two planted pine stands with an older natural regeneration, dominated by pedunculate oak (*Quercus robur L.*), and discussed management options for similar stands.

The results indicated a rather good growth of the stands, with current annual increments of 5 $m^3.ha^{-1}.yr^{-1}$. The pine overstorey is growing into valuable sawwood dimensions, while the broadleaved understorey slowly grows into the upperstorey. The quality of the regeneration is moderate but can be improved by silvicultural measurements (pruning, early selection).

In both stands, an interesting (timber production, nature conservation) admixture of secondary tree species is present in the regeneration. Stand management is evolving from the classical clearcut system towards a combination of a type of selection and group selection system.

Key words : Mixed pine-oak stands, natural regeneration, growth, management.

SOMMAIRE

Une grande partie des forêts de Flandres constituent de pineraies. Souvent, une régénération naturelle composée d'essences feuillus est présente sous le couvert des pins.

Dans cette étude, la croissance et le développement de deux peuplements de pins ayant une régénération avancée, dominée par le chêne pédoncule, ont été analysée. Finalement, des considérations sur l'aménagement de ce type de forêt sont proposées.

Les résultats indiquent une assez bonne croissance des deux peuplements. L'accroisement annuel est de 5 $m^3.ha^{-1}.a^{-1}$. Les vieux pins se développent en grand bois d'oeuvre, pendant que la sous-étage se développe lentement. La qualité de la régénération est moyenne, mais peut-être améliorée par des techniques silvicoles (élagage, sélection des

arbres futures).

Dans les deux cas, un nombre d'essences secondaires est présent dans la régénération. L'aménagement de ce type de forêt va évoluer d'une coupe a blanc classique vers un type de coupe jardinatoire ou coupe jardinatoire par bouquets.

1. INTRODUCTION

Large parts of North-East Belgium forests are consisting of first or second generation of Scots pine (*Pinus sylvestris L.*) stands. These stands are all located on rather poor, sandy spodosols, formerly occupied by heathlands.
All these forests are very susceptible to natural disturbances. Government policy is striving towards the creation of more natural, mixed stands, and therefore special attention is given to the conversion of these pine monocultures.
Natural regeneration of broadleaved species is a well-known feature in older pine stands (Van Miegroet, 1985 ; Lust, 1987).
However, the possibilities of creating a valuable new forest generation starting from this regeneration are not well studied. In this research, two pine stands with a well developed, pedunculate oak (*Quercus robur L.*) dominated, substorey, were studied in detail.

2. METHODS

The study sites are located in the Communities of Ravels and Neeroeteren (figure 1). The stand surface is 8.8 ha in Neeroeteren and 13.5 ha in Ravels.

Scots pine was planted in 1918 in Neeroeteren and in 1908 in Ravels. Both stands are first generation forests, created on former heathland. Broadleaved seed trees are present in fire belts surrounding the pine stands.

The soils are relatively poor with about 85 to 93 % of sand in the particle size distribution. The groundwater table is out of reach of the tree roots in Neeroeteren, and is rather high in Ravels (water table at 20-40 cm in winter - early spring).
In each stand, an area of one hectare (made up of 10 meter wide strip transects) was selected.

For each transect, all trees bigger than 15 centimeter in circumference at breast height were measured. Their position was recorded, as well as tree height and circumference. For every naturally established tree, a quality analysis was made. Used criteria were presence of a 4 meter long branch-free bole, regular crown development, well developed terminal shoot, absence of frost cracks or other stem defaults, absence of tree forks and absence of water sprouts.

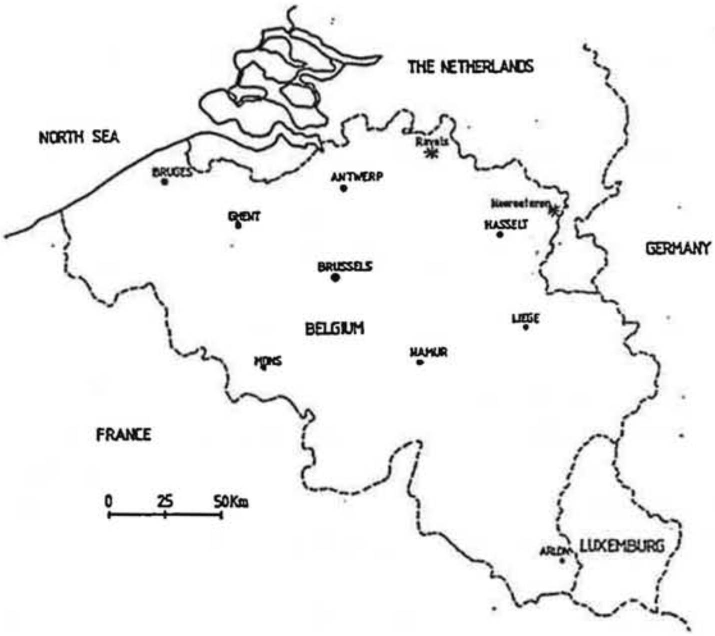


Figure 1 : Location of the research sites.

Tree ring analysis was performed on a subsample of the present tree species in order to determine age distribution, stand increment and growth characteristics of the trees. The crown area of these trees was also estimated.

3. RESULTS

3.1. Inventory

The results of the inventory of the two stands are presented in table 1. In both stands, total tree number is virtually the same (± 850 stems/ha). Old pines are present at higher densities in Ravels (194 vs 128 stems). Average pine diameter is much higher in Neeroeteren, despite of their younger age. Natural regeneration is strongly dominated by pedunculate oak in Neeroeteren (524 stems), while pedunculate oak and red oak (*Quercus rubra L.*) have similar densities in Ravels (252 Vs 207 stems). Black cherry (*Prunus serotina Ehrh.*) is well represented in both stands. In Ravels, it is the dominating species in the lower diameter class. Scots pine regeneration is absent in Ravels, and very limited in Neeroeteren.

Table 1 : Inventory of the two sites.

Stand	Species	Stem number ($N.ha^{-1}$)		Basal area ($m^2.ha^{-1}$)		Volume ($m^3.ha^{-1}$)		Avg DBH	Avg height
		abs	%	abs	%	abs	%	cm	cm
Ravels	Pedunc. oak	252	29.7	4.0	16.0	25.9	13.6	13.3	12.0
	Red oak	207	24.4	4.2	16.9	28.2	14.8	15.4	14.0
	Black cherry	173	20.4	1.6	6.3	8.3	4.4	9.7	8.7
	Scots pine	194	22.8	14.9	60.0	127.4	66.8	31.0	19.4
	Others	24	2.8	0.3	1.2	0.8	2.4		
	Total	850	100.0	24.9	100.0	190.6	100.0	17.0	13.4
Neeroeteren	Pedunc. oak	524	61.0	5.7	27.0	30.2	19.8	10.5	8.5
	Red oak	36	4.1	1.0	4.5	6.2	4.1	16.8	12.9
	Scots pine								
	- planted	128	14.9	12.8	60.1	110.3	72.3	35.3	19.8
	- regeneration	34	4.0	0.2	1.1	1.0	0.6	9.1	8.3
	Black cherry	55	6.4	0.2	0.9	0.5	0.4	6.2	6.8
	Others	82	9.6	1.4	6.4	4.3	2.8	-	-
	Total	859	100.0	21.3	100.0	152.6	100.0	14.1	10.2

Secondary tree species are virtually absent in Ravels (24 per ha), and are rather well represented in Neeroeteren (82 per ha). These species consist mainly of birch (*Betula sp.*), trembling aspen (*Populus tremula L.*), beech (*Fagus sylvatica L.* - planted in Neeroeteren), rowan (*Sorbus aucuparia L.*), alder buckthorn (*Frangula alnus Mill.*) and larch (*Larix kaempferi (Lambert) Carr.* - planted in Neeroeteren).

The old Scots pines are still very much dominating in basal area and standing volume (resp. 60 and 70 % of the total).

Tree diameter distribution is presented in figure 2.

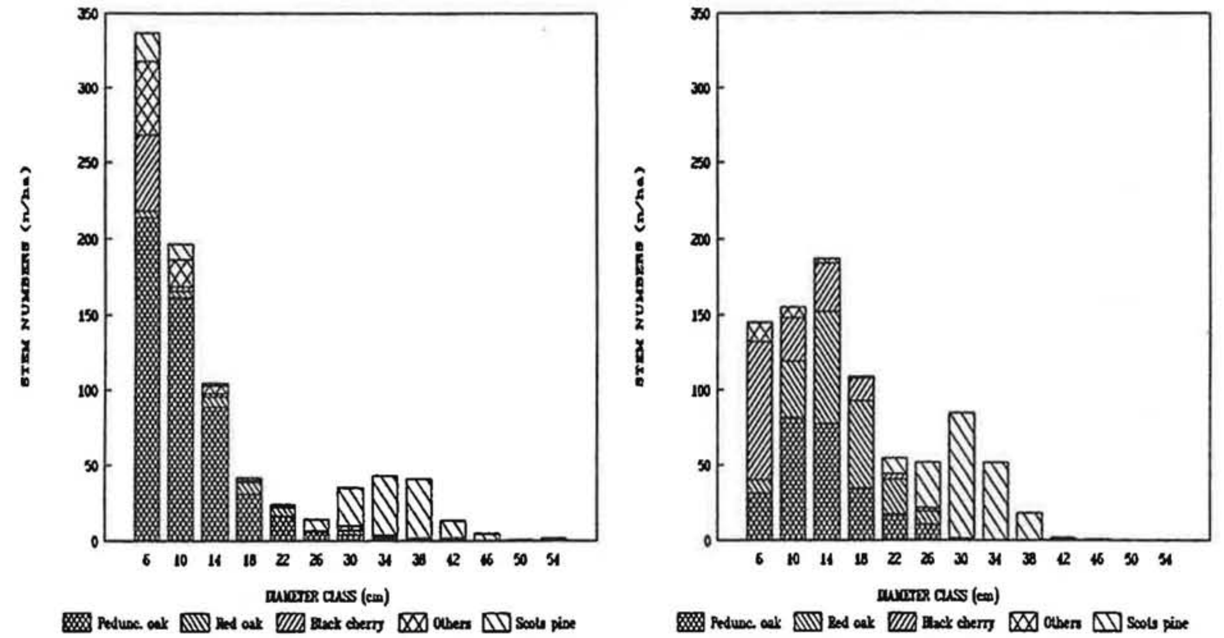


Figure 2 : Diameter distribution in Neeroeteren (left) and in Ravels (right).

Both stands are clearly nearing the reversed J-curve, which is typical for all aged stands. In Neeroeteren, the biggest pine is already over 50 centimeters in diameter ; in Ravels, maximum tree diameter is much lower. The largest broadleaves are already over 30 centimeters in diameter. Average oak diameter is higher in Ravels compared to Neeroeteren (13.3 vs 10.5 cm).

Oak regeneration is very well spread over the stand area. The distance from seed trees has no significant effect on the number of oaks present.

3.2. Tree quality analysis

Table 2 gives an overview of the quality of the pedunculate and red oak regeneration in the stands.

Table 2 : Quality estimation of the oak regeneration (in % of total amount).

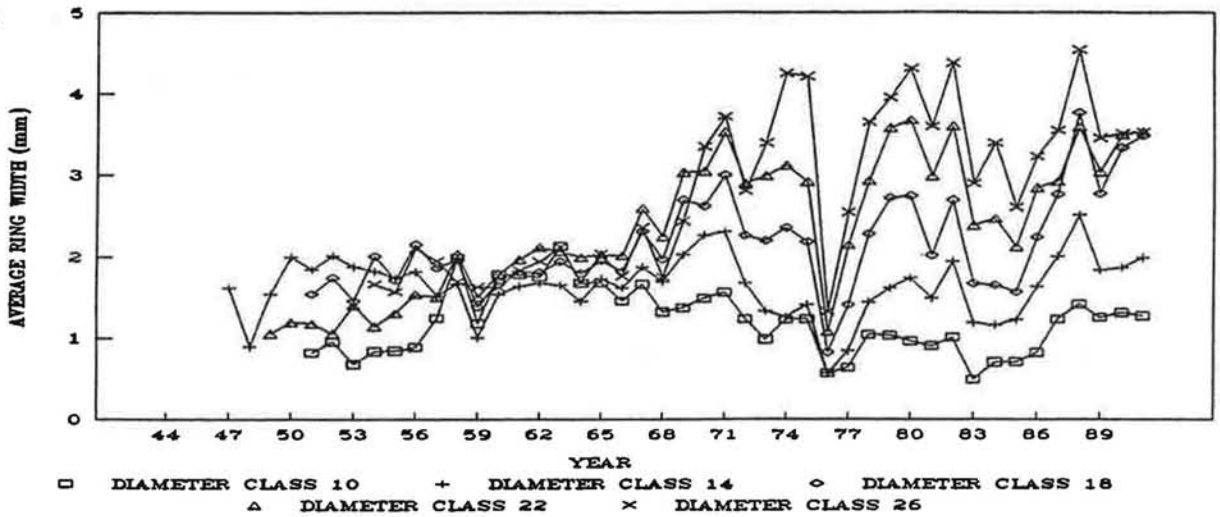
Stand	Species	No of trees (abs)	4 m branch-free bole	Good stem quality	Good terminal shoot	No tree forks	No Water-sprouts	Good trees (free of all defects)
Ravels	Pedunc. oak	253	70	60	55	72	37	11 %
	Red oak	211	84	60	85	60	76	21 %
Neeroeteren	Pedunc. oak	526	56	21	80	75	94	9 %
	Red oak	34	62	32	97	85	100	18 %

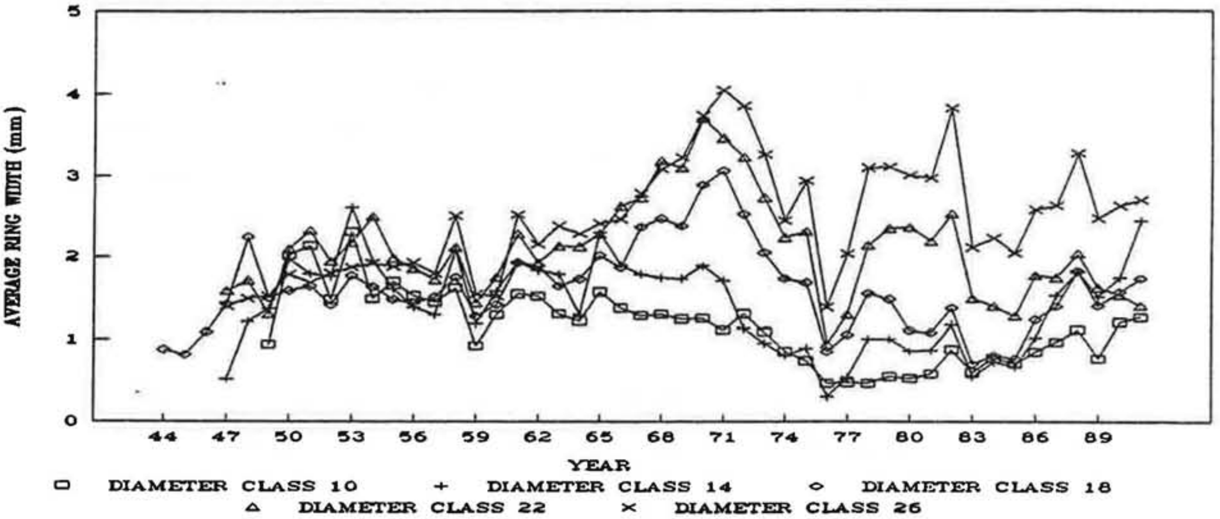
The results are quite different for both species and stand. Generally, red oak quality is better than pedunculate oak. Oaks free of all defects are present in very limited numbers (62 in Neeroeteren, 74 in Ravels). The bad quality is mainly due to stem defects (especially in Neeroeteren).
Frequent observed stem defects are frost cracks, distortions of the stem, felling damage and especially badly overgrown dead branches. Watersprouts occur frequently on pedunculate oak in Ravels, but they are almost absent in Neeroeteren. In Neeroeteren, less than 60 % of all oaks have a 4 meter long branch-free bole. Shoot growth of the oaks is generally good.

3.3. Age and growth analysis

Tree ring analysis indicated important differences between both stands. In Neeroeteren, the oak regeneration was clearly uneven-aged and its age ranged between 15 and over 50 years. In Ravels, the oak regeneration was relatively even-aged with pedunculate oak of about 45-50 years old, and red oak that proved slightly younger (40-45 years old).

The evolution of tree ring growth of the oak regeneration over the last decades is presented in figure 3. Bigger trees clearly produce larger tree ring increments than





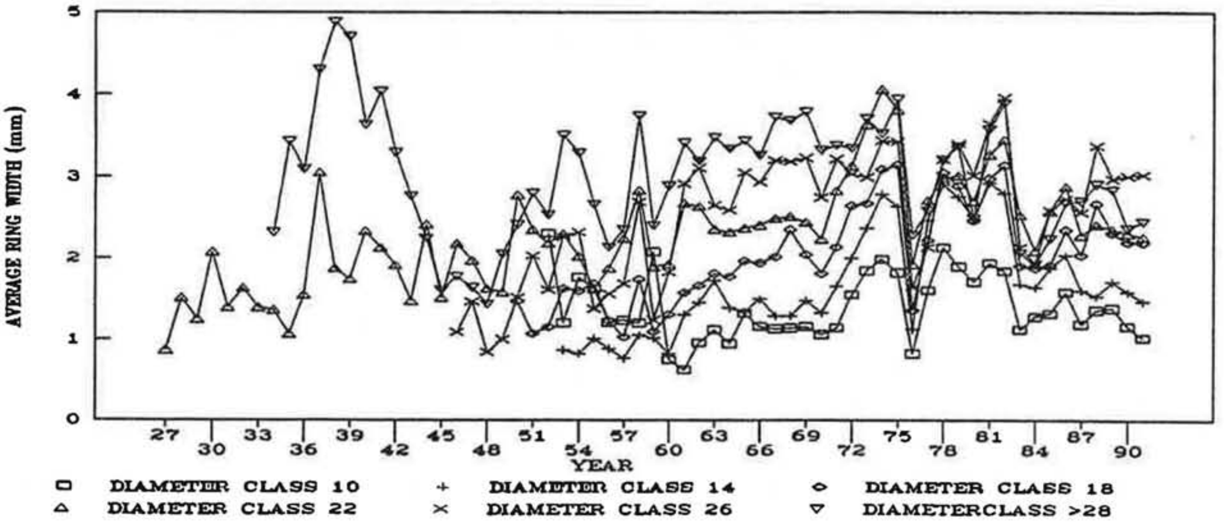


Figure 3 : Evolution of the tree ring growth of the oak regeneration. (top = Red oak Ravels ; middle = Pedunculate oak Ravels ; bottom = Pedunculate oak Neeroeteren).

small trees of the same species. Tree ring width is very much fluctuating over the last decades. Growth crises are clearly noticeable in 1976 and 1959 and, to a lesser extent, in 1983-1985.

In Ravels, tree growth of red oak is faster than that of pedunculate oak. Average tree diameter of red oak is 15 cm while only 13 cm for pedunculate oak. Diameter increment over the last years of the pedunculate oak with mean diameter was 2.5 mm, while 4.4 for the average red oak tree (table 3). Current annual increment of pedunculate oak was estimated at 1.2 $m^3.ha^{-1}.yr^{-1}$, while 1.9 $m^3.ha^{-1}.yr^{-1}$ for red oak. These data must be interpreted with some caution, since red oak trees develop much bigger crowns than pedunculate oaks. If one compares the growth per crown area unit (1000 m^2), this results in 0.68 m^3 of annual wood production for red oak against 0.53 m^3 for pedunculate oak. Red oak still grows faster than pedunculate oak but the difference is much lesser than when diameter increments are compared.

In Neeroeteren, average oak volume increment was about 1.8 $m^3.ha^{-1}.yr^{-1}$. The growth of the overstorey pines is very much different in both stands (fig. 4). Growth is very poor in Ravels with an average annual diameter increment of 2.5 mm over the last two decades. In Neeroeteren, the pine growth continues to be very good with average annual diameter increments of 5.2 mm. In this stand, pine showed very poor growth in the period 1930-1940, but recovered very well afterwards.

Here too, some decline in growth rate is noticeable in 1959 and 1976. During the last years, pine diameter growth is showing a downward trend (figure 4). Over the last 6 years, average diameter increment is 2.2 mm in Ravels and 4.2 mm in Neeroeteren (table 3). Current annual increment of the pine trees is estimated at 2.9 $m^3.ha^{-1}.yr^{-1}$ in Neeroeteren and 2.2 $m^3.ha^{-1}.yr^{-1}$ in Ravels. Total stand increment is about 5 $m^3.ha^{-1}.yr^{-1}$ in both stands.

Table 3 : Average diameter growth and current annual increment (CAI) of the main tree species over the last 6 years.

Stand	Species	Avg diameter increment (mm)	C.A.I.
Ravels	Red oak	4.4	1.9
	Pedunculate oak	2.5	1.2
	Pine	2.2	2.2
	Total	-	5.3
Neeroeteren	Pedunculate oak	2.8	1.8
	Pine	4.2	2.9
	Total	-	4.7

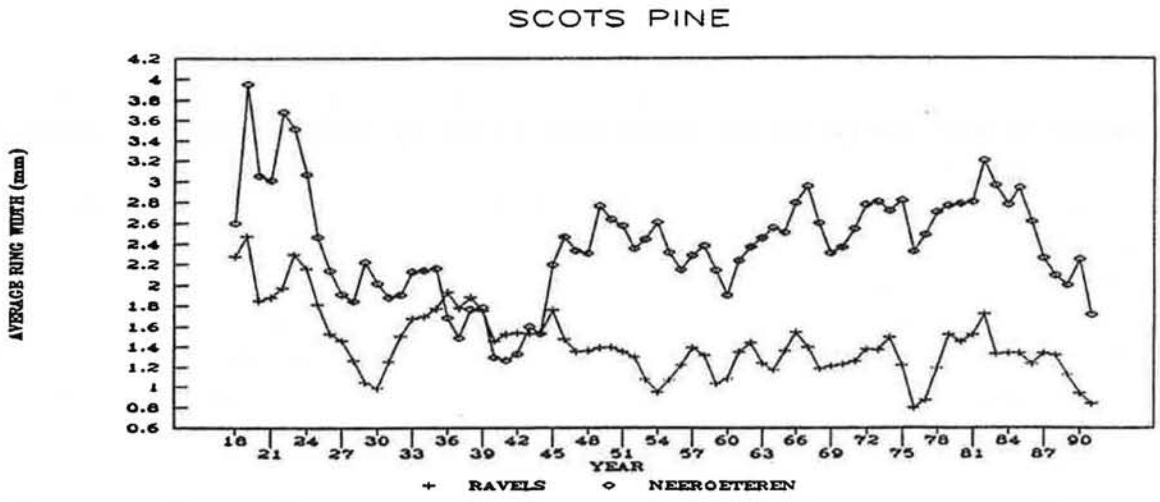


Figure 4 : Evolution of tree ring growth of Scots pine in Ravels and Neeroeteren.

4. DISCUSSION AND CONCLUSIONS

Conversion of pine stands by underplanting of oak is used in Germany (Ebeling & Hanstein, 1988 ; Seefelder, 1991). This technique has the advantage that the young trees are well protected against the extreme climatological circumstances (drought, insolation, frost) that generally occur on clearcut areas and that cause a lot of young crops to perish. The use of natural generation is not so well spread (Ebeling, 1992).

In both stands, natural regeneration has developed into a well stocked, good growing deciduous substorey, while an important part of the pines is still present. All seed came from the broadleaved fire belts around the stands. The regeneration is well spread over the whole stand area. Distances up to 150 metres are no problem for satisfying oak regeneration numbers.

Current annual increment of both stands is about 5 $m^3.ha^{-1}.yr^{-1}$. 40 to 60 percent of this fraction is produced by the broadleaved regeneration. The old pines still continue to produce important diameter increments (especially in Neeroeteren) and can develop into big, valuable trees. German research proved that this species can continue to produce valuable increments up to an age of 150-200 years (Junack, 1972, Erteld, 1990, Lück & Pump, 1992).

Excessive drought was recorded in 1959 and 1976 and this had very clear negative effects on tree growth of all species.

The quality of the oak regeneration is not much affected by the pine overstorey. Enough trees have developed a good habitus and can already be considered as future trees.

In Neeroeteren, the regeneration is dominated by pedunculate oak, but other species are also present and can form an interesting admixture. In Ravels, red oak and pedunculate oak are present in equal amounts. Here too, some other species are individually intermixed. Scots pine regeneration is only present in Neeroeteren.

Red oak is growing faster than pedunculate oak in Ravels. The former also produces much bigger, branchy crowns. This may cause some problems for the survival of the slower growing pedunculate oaks and other secondary species. Selective cutting can solve this problem easily. Black cherry regenerates easily in both stands and may prevent new oak regeneration in the future. The possibilities of this species producing valuable timber on poor soils are very much limited and therefore cherry combat operations may have to be considered in the future (Muys et al., 1992).

In both stands, natural regeneration started 30 to 40 or more years ago, when stand density of the pines was still relatively high. In the future, stand management will be concentrating on harvesting of full-grown trees and on the selection of well formed future trees (Reininger, 1989). A minimum of trees can eventually be pruned in order to increase stand quality. This pruning operation can be repeated with intervals of 2 to 3 decades. In absence of natural regeneration, seeding or planting of groups of trees can be considered. This way, new species can be introduced. The formerly used clearcut system will be rejected in favour of a type of selection or group selection system, based on natural regeneration (Matthews, 1989). Larger groups can be created in order to regenerate Scots pine.

Possible problems can arise with harvesting damage but these can be minimized by using skidding tracks or winches. In the first period, Scots pine, with its small crowns, will probably cause few problems in this manner.

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