Monitoring natural stand change in the forest reserve of Liedekerke, Flanders (Belgium)

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Abstract

Natural stand changes in the forest reserve of Liedekerke were analysed during the period 1986-1996, using a permanent grid of circular plots. The monitoring concentrated on natural changes in species composition, using stem number and basal area as indicators, and changes in spatial distribution and colonization capacities of trees and shrubs, with special interest in the competition between exotic and indigenous species. After only a decade of monitoring important natural changes in the woody layer were detected. The pioneer forest is gradually maturing through self-thinning processes and shifts in species composition. The overall stem number decreased with 33.6%, while the basal area increased with 20.9%. Birch (*Betula pendula/pubescens*) and indigenous oak (*Quercus robur/petraea*) remained dominant. More tolerant exotic species, like Red oak (*Quercus rubra*) and Sweet chestnut (*Castanea sativa*), are slowly increasing their share in the species composition and expanding their range. Pioneer species on the other hand, like Aspen (*Populus tremula*), willow (*Salix caprea/cinerea/aurita*), Alder buckthorn (*Frangula alnus*) and Common (*Alnus glutinosa*) and Grey alder (*A. incana*), strongly declined. Black cherry (*Prunus serotina*) seems to be slowly invading the forest due to its massive natural regeneration. Strong competition may be expected especially from Rowan ash (*Sorbus aucuparia*), which showed similar regeneration and colonization capacities. Elder (*Sambucus nigra*) dramatically extented its range, though its share remains marginal. Beech remained absent most probably due to the lack of mature trees in the vacinity of the forest. Finally this change detection allowed that general predictions could be made on the future natural development and composition of this forest reserve, which could serve forest management decisions.

1. Introduction

Long-term observations of natural changes in Western European unmanaged lowland woodlands are generally rare and often limited to the last decades (e.g. Broekmeyer et al 1995, Clerkx et al 1995, 1996, Kirby et al 1996, Koop 1989, Mountford & Peterken 1998, Peterken &

Backmeroff 1988, Peterken & Mountford 1996). Such woodlands are mostly legally protected as forest or nature reserves. In Flanders the legal basis of the concept of forest reserves was only recently formed by the 'Flemish Forest Decree' of 1990 and the 'Implementation Order on Forest Reserves' of 1993. Besides their nature conservation value, forest reserves fulfil a scientific goal in providing a better understanding of natural dynamic processes through intensive long-term monitoring and research. Research results should ultimately offer a scientific basis for close-to-nature forestry (Vandekerkhove & Van Den Meersschaut 1999).

This study in the forest reserve of Liedekerke will try to illustrate to what extent important information on natural forest development is retrieved from a limited monitoring period of only ten years. The research focusses on natural changes in species composition using stem number and basal area as indicators. Changes in spatial distribution and colonization capacities of trees and shrubs are also studied, highlighting the competition between exotic and indigenous species. Finally, by combining these results, predictions are made on the future natural development and composition of this forest reserve.

2. Material and methods

2.1. Study site

The forest reserve of Liedekerke is located in the central part of Belgium and covers an area of 22.5 ha. The elevation varies between 24 and 36 m above sea level. Its western and northern boundary are formed by the state forest of Liedekerke (54 ha), whereas the east and the south side are bordered by pasture and farmland.

A moderately wet, loamy soil occurs throughout the forest, together with some very wet sites in the small valleys. The meso-relief is rather uniform, except for some local depressions.
During the Roman occupation (57 B.C.-407 A.D.) the forest reserve was still embedded in the ancient 'coal forest' or 'Carbonaria Sylva', a massive forest complex stretching from south-west to north-east, north of the river Hene and east of the river Zenne (Tack et al 1993). The need for agricultural lands resulted in the fragmentation of this forest complex, which started in the eighth century and continued through the Middle Ages. By 1775 the forest fragment surrounding the forest reserve of Liedekerke was reduced to roughly about 650 ha. It was further diminished to some 400 ha by 1850. Forty years later only about 80 ha of forest remained. The military map of this period shows that parts of the forest reserve were converted into farmland, while the remaining deciduous forest was replaced by conifers, most probably Scots pine (*Pinus sylvestris*). Twenty years later these farmlands were abandoned and replaced by forest (military map of 1911). This map also shows that half of the conifers were replaced by deciduous trees again. In 1926 a short wave radio receiving-station was installed in the current forest reserve. Large parts of the reserve were cut for the construction of antennae. In order to receive radio signals fluently the treelayer was kept low and the forest was managed as coppice. These open woodland conditions induced the development of heathland. Regular coppicing continued upto the middle of this century, while heathland still covered more than 40% of the surface. The most recent hu-

man intervention dates back to World War II and consisted of widespread felling by the local population for firewood. For more than 50 years now this ecosystem remained unmanaged, which makes it quite unique for Belgium. During its evolution since the 1940's it showed a steady regression of the heath, leading to its disappearance in 1970, and a progression of coppice elements into the upperstorey (De Cuyper 1993).

The intensive management in the past resulted in a severe degradation of the loamy soils and thus a species composition resembling the acid psammophylous type of the *Querco-Betuletum* (Quercion) (Noirfalise 1984). Dominating tree species are primarily birch (*Betula pendula* and *B. pubescens*) (approx. 55%) and indigenous oak (*Quercus robur* with some *Q. petraea*) (approx. 15%). Since the last cuttings in WW-II soil quality probably improved again, partly due to the occurence of birch (pioneer phase in succession). Despite the current composition of the woody layer, the potential natural vegetation (PNV), as defined by van der Werf (1991), is therefore not that of an Oligotrofic Pedunculate Oak-Birch forest (*Betulo-Quercetum roboris*) but rather that of a Sessile Oak-Beech forest (*Fago-Quercetum petraeae*). Besides the soil properties themselves also the current herbal layer, with Bracken (*Pteridium aquilinum*) and *Teucrium scorodonia*, reflects this forest type. Bramble (*Rubus sp.*) dominates the herbal layer. On the flanks of the small valleys alongside the brook bordering the eastern side of the forest reserve fragments of Mixed Atlantic Bluebell Oak forest (*Endymio-Carpinetum*) occur, with Bluebell (*Hyacinthoides non-scripta*) as differentiating species (Noirfalise 1984). Exotic tree species like Red oak (*Quercus rubra*), Sweet chestnut (*Castanea sativa*) and Black cherry (*Prunus serotina*), are locally embedded in the canopy, thus offering interesting possibilities to study their natural colonization rates and competition vigour compared to indigenous species.

2.2. Monitoring set-up

In 1986 a 40 × 50 m grid was installed in a part (12.9 ha) of the forest reserve characterized by a rather homogeneous and uniform forest structure and tree species composition. In order to study and monitor natural changes in the woody layer 66 circular plots with a radius of 15 m (700 m^2) were established at the intersections of this grid (Fig. 1). The centre of each plot was clearly marked in situ with an aluminium stick and tagged with its corresponding number. A similar kind of monitoring set-up with a grid of circular plots is also used in other European countries (Albrecht 1990, Althoff et al 1993, Broekmeyer & Szabo 1993, Bücking et al 1986) and will form the basis for future monitoring in Flemish forest reserves (Vandekerkhove & Van Den Meersschaut 1998). In 1992 an additional number of 46 similar plots was established on the remaining part (9.6 ha) of the forest reserve. These plots are not included in this study.

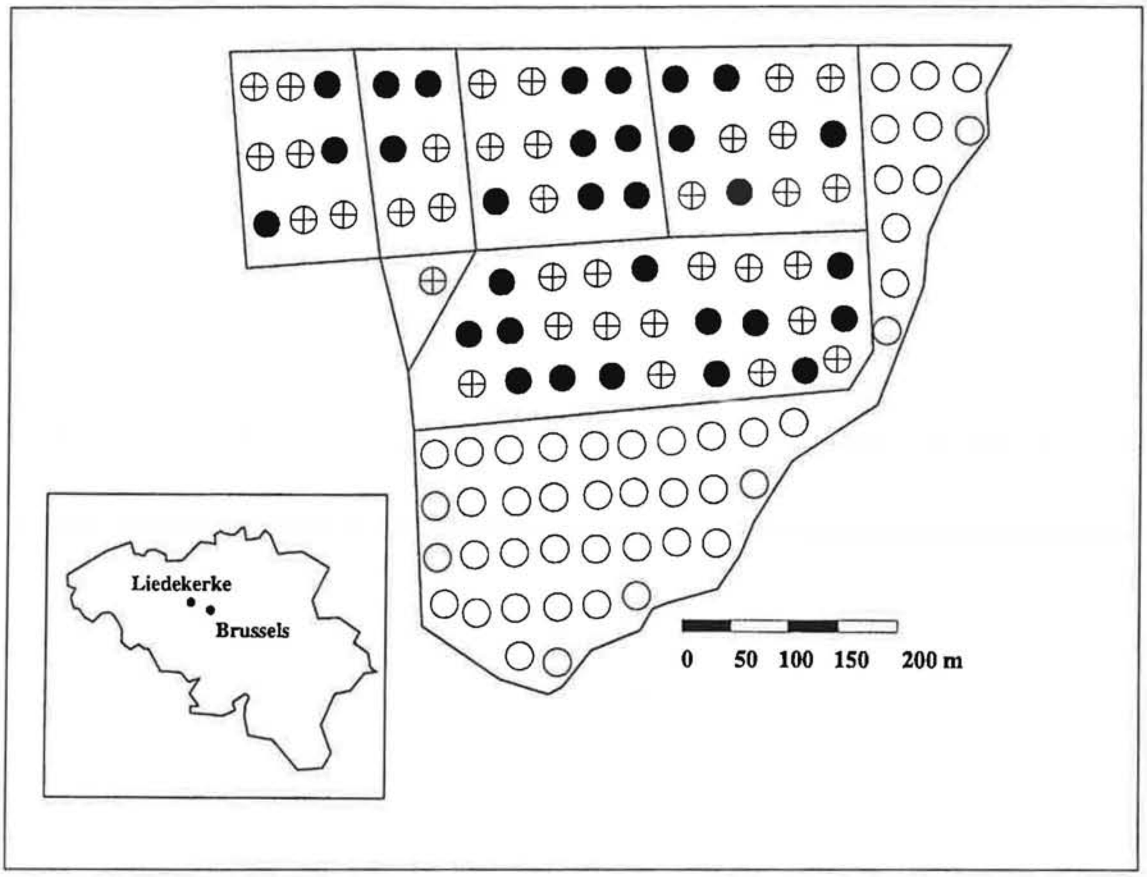


Figure 1. *Distribution of the circular plots in the forest reserve of Liedekerke; ● = randomly selected plots inside the homogeneous part; ⊕ = non-selected plots inside the homogeneous part; O = plots outside the homogeneous part.*

The woody layer of the 66 plots, covering approximately 36% of the total surface, was inventoried for the first time in 1986. Every tree with a diameter at breast height (dbh) exceeding 2 cm and taking root in the plot was taken into account. The trees were identified and their dbh was measured with an accuracy of 1 mm. Birch, indigenous oak and willow were not identified to the species level.

In 1996 the same measurements were repeated in 31 of these 66 plots, covering approximately 17% of the total surface. The monitoring of the woody layer in this study is based on these 31 randomly selected plots only and limited to three major aspects, namely natural changes in species frequencies or stem number, in basal area and in species distribution. Van Den Meersschaut et al. (1998) proved that with this plot density an accuracy of 5% and 10% is reached for basal area respectively stem number, at a probability level of $p=0.05$. In order to study colonization rates in more detail natural regeneration was measured separately in 1998. Young trees higher than 0.5 m and with dbh < 2 cm were identified and counted in the same circular plots (radius = 15 m) as previously mentioned. In a smaller circular plot with radius = 2.5 m (19.6 m²) seedlings smaller than 0.5 m high were identified and counted.

3. Results

3.1 Changes in stem number

Within ten years (1986-1996) the mean total stem number decreased with 33.6% or 687 trees per ha, due to natural mortality (Fig. 2). Most trees are situated in dbh class 10 cm. Large trees with a dbh > 40 cm are rare in this rather young forest. Only a few indigenous oaks and Red oaks reach such proportions yet. The diameter distribution shows an expectable shift towards larger dbh classes. A similar shift also occurs more specifically for birch, indigenous oak, Red oak, Sweet chestnut and Rowan ash.

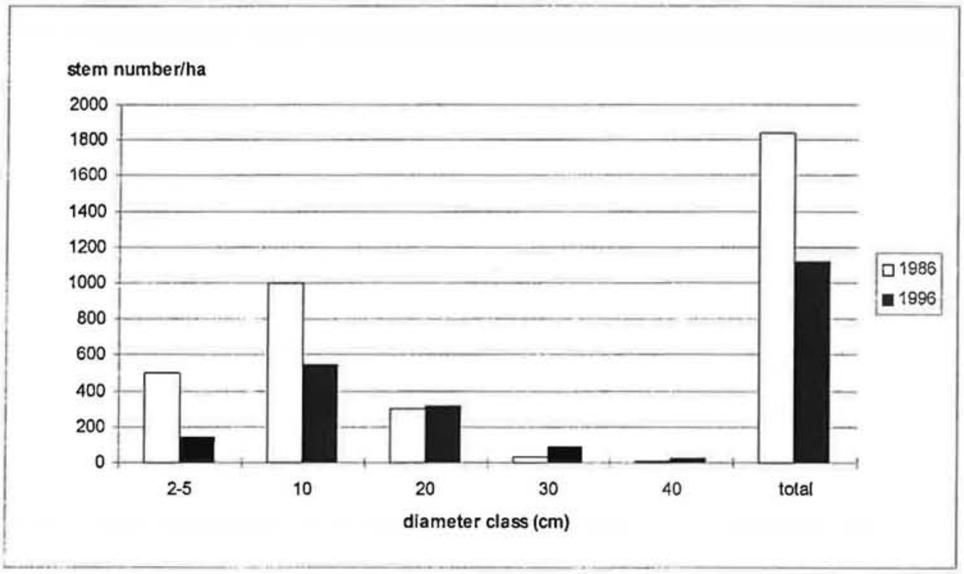


Figure 2. *Natural evolution of the total stem number and diameter distribution for all tree species.*

The stem number of pioneer species for this site like Common alder more than halved while that of willow (*Salix caprea*, *Salix cinerea* and *Salix aurita*), Aspen, Grey alder and Alder buckthorn even decreased with more than 70% (Fig. 3). The only species with increasing stem numbers are more tolerant ones like Black cherry and Elder. The latter shows a spectacular increase of seven times its original stem number.

Birch and indigenous oak remain most abundant after ten years (Fig. 4). Their share in the total stem number even increased, together with that of more tolerant species like Red oak, Sweet chestnut, Rowan ash and Hazel (*Corylus avellana*). The share of Alder buckthorn drastically decreased.

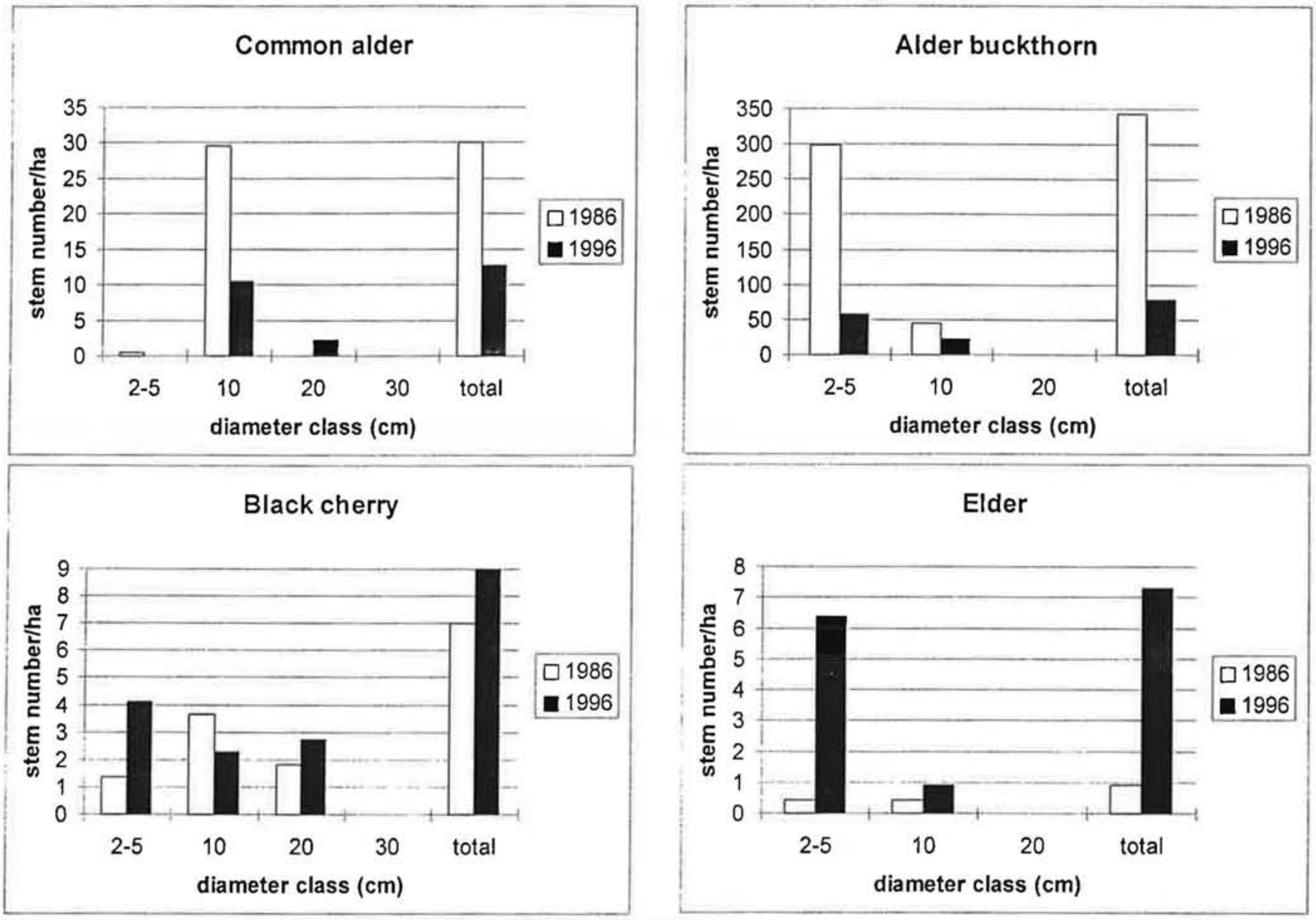


Figure 3. *Natural evolution of the total stem number and diameter distribution for Common alder, Alder buckthorn, Black cherry and Elder.*

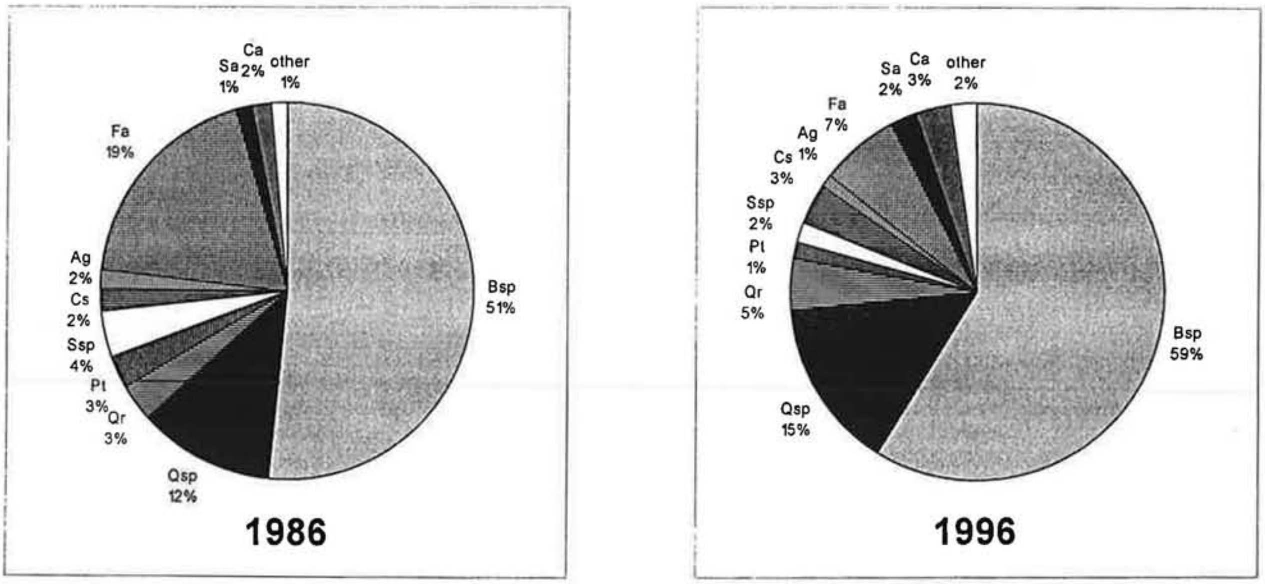


Figure 4. T*ree species composition for the stem number in 1986 and 1996* (Bsp *Betula spp.*; Qsp *Quercus spp.*; Qr *Quercus rubra*; Pt *Populus tremula*; Ssp *Salix spp.*; Cs *Castanea sativa*; Ag *Alnus glutinosa*; Fa *Frangula alnus*; Sa *Sorbus aucuparia* and Ca *Corylus avellana*).

The significance of differences in mean stem number over this ten year period (1986-1996) were statistically tested. First normality of the mean stem number distribution of the 31 plots was checked for each individual tree species and both inventory periods. The same was done for the whole woody layer (all tree species) (Table 1). Because not all tree species were found in all 31 plots, different kinds of normality tests (χ^2 or *Kolmogorov-Smirnov*) were performed depending on the size of the datasets. If datasets of both periods proved to have a normal distribution a t-test was performed, comparing average stem numbers. If one or both datasets proved not to be normally distributed, a non-parametric test (Wilcoxon signed rank test for paired observations) was performed, comparing medians.

Table 1 shows that only for the woody layer in general and for the tree species birch, indigenous oak, willow, Common alder, Aspen, Alder buckthorn and Elder statistically significant differences in mean stem number could be detected.

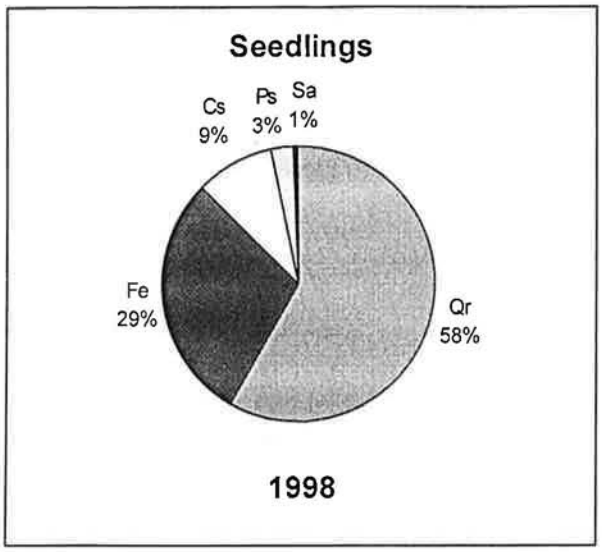
The previous results are limited to trees with dbh > 2 cm. In order to complete the knowledge about the composition of the whole woody layer, natural regeneration (trees with dbh < 2 cm) was assessed in 1998. Unfortunately no comparison could be made with 1986, due to a lack of data. The average stem number of seedlings and young trees amounted to 81,508 respectively 258 trees per ha. Fig. 5 shows the species composition for both categories. The species diversity of young trees (17 species) is three times higher than that of the seedlings (5 species) and almost equals that of the larger tree dimensions (18 species). The species composition itself is completely different between both categories. More than two thirds of the seedlings consist of exotic tree species. Their share drops to around 40% in the category young trees. These young trees are dominated by Black cherry and Rowan ash while the seedlings are dominated by Red oak and Ash. The first two species are also found as seedling but in a smaller share. Of the latter only young trees of Red oak are found, also in a much smaller share. Considering the exotic species this means that Black cherry has a lead over Red oak concerning the developmental stage of their natural regeneration. Another exotic species is Sweet chestnut which also occurs in both categories. Despite its dramatic decrease Alder buckthorn still occupies one tenth of the total number of young trees and therefore temporary remains an important species in the current global species composition.

Table 1. *Normality tests and statistical comparison of the datasets of the average stem number, per tree species and for the woody layer in general, for the period 1986-1996*

Tree species	**Inventory period**	**Mean stem number (#/ha)**	**Normality**		**Comparison of the population in 1986 vs 1996**	
			Type of test [1]	**Significance level [2]**	**Type of Test**	**Significance level [2]**
Betula spp.	1986	949	χ^2	N.S.		
Betula spp.	1996	658	χ^2	N.S.	t-test	*
Quercus spp.	1986	214	χ^2	N.S.		
Quercus spp.	1996	163	χ^2	*	Wilcoxon signed ranks	***
Quercus rubra	1986	59	χ^2	N.S.		
Quercus rubra	1996	52	χ^2	*	Wilcoxon signed ranks	N.S.
Salix spp.	1986	72	K-S	*		
Salix spp.	1996	21	K-S	N.S.	Wilcoxon signed ranks	***
Alnus glutinosa	1986	30	K-S	N.S.		
Alnus glutinosa	1996	13	K-S	N.S.	t-test	**
Alnus incana	1986	13	K-S	N.S.		
Alnus incana	1996	3	K-S	N.S.	t-test	N.S.
Castanea sativa	1986	39	K-S	N.S.		
Castanea sativa	1996	39	K-S	N.S.	t-test	N.S.
Populus tremula	1986	52	K-S	N.S.		
Populus tremula	1996	14	K-S	N.S.	t-test	**
Frangula alnus	1986	344	χ^2	**		
Frangula alnus	1996	79	χ^2	*	Wilcoxon signed ranks	***
Sorbus aucuparia	1986	26	K-S	**		
Sorbus aucuparia	1996	25	K-S	*	Wilcoxon signed ranks	N.S.
Corylus avellana	1986	32	K-S	N.S.		
Corylus avellana	1996	33	K-S	N.S.	t-test	N.S.
Prunus serotina	1986	7	K-S	N.S.		
Prunus serotina	1996	9	K-S	N.S.	t-test	N.S.
Crataegus monogyna	1986	4	K-S	N.S.		
Crataegus monogyna	1996	6	K-S	N.S.	t-test	N.S.
Sambucus nigra	1986	1	K-S	*		
Sambucus nigra	1996	7	K-S	N.S.	Wilcoxon signed ranks	*
All tree species	1986	1844	χ^2	N.S.		
All tree species	1996	1124	χ^2	N.S.	t-test	***

[1] K-S = Kolmogorov-Smirnov test for normality

[2] N.S. = not significant; *= significant at $p < 0.05$; **= significant at $p < 0.01$; ***= significant at $p < 0.001$



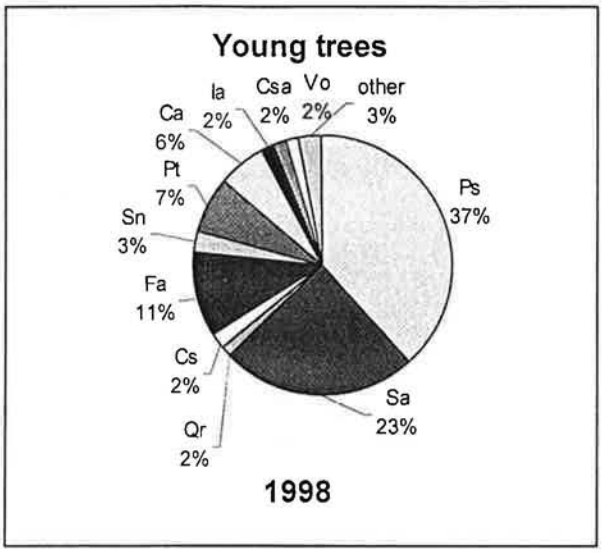


Figure 5. *Species composition of seedlings (height < 0.5 m) and young trees (height > 0.5 m and dbh < 2 cm) in 1998* (Qr *Quercus rubra*; Fe *Fraxinus excelsior;* Cs *Castanea sativa*; Ps *Prunus serotina;* Sa *Sorbus aucuparia*; Fa *Frangula alnus*; Sn *Sambucus nigra;* Pt *Populus tremula*; Ca *Corylus avellana;* Ia *Ilex aquifolium*; Csa *Cornus sanguinea* and Vo *Viburnum opulus*).

3.2. Changes in basal area

Despite the decrease of the total stem number, the total basal area increased with 20.9% or 4.9 m²/ha (Fig. 6). The basal area of Red oak and Sweet chestnut even doubled while that of indigenous oak and birch increased with respectively 50% and 13%. Although it's share is still small the basal area of Black cherry rose with almost one third. The basal area of shrubs like Hazel, Rowan ash and Elder remained virtually unchanged while that of Alder buckthorn shows a remarkable decline of 80%. Trees from the upperstorey like Aspen, Common and Grey alder and willow show a decrease of 30% to more than 60%.

Also concerning basal area birch and indigenous oak remain dominant although the share of birch slightly decreased in favour of indigenous oak, Red oak and Sweet chestnut (Fig. 7). Besides these species only Aspen and willow keep a share of 1% or more of the total basal area.

The significance of differences in mean basal area over this ten year period (1986-1996) was statistically tested. The same procedure as for the stem number was used with the exception that the mean basal area is based on all individual trees regardless of the individual circular plots. Therefore the non-parametric Mann-Whitney U test for unpaired observations was used, when one or both datasets proved to have no normal distribution (Table 2).

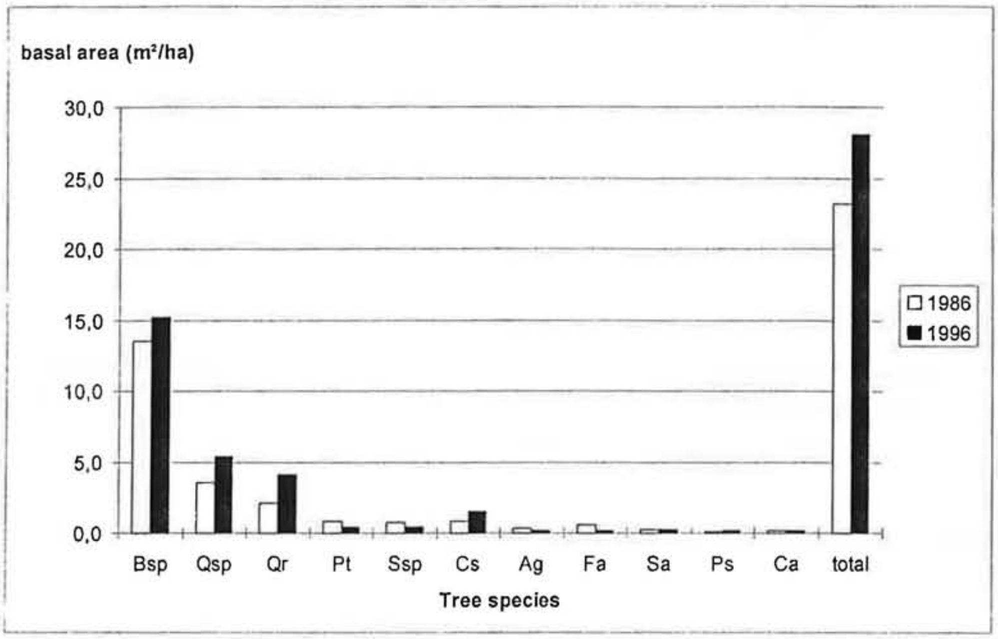
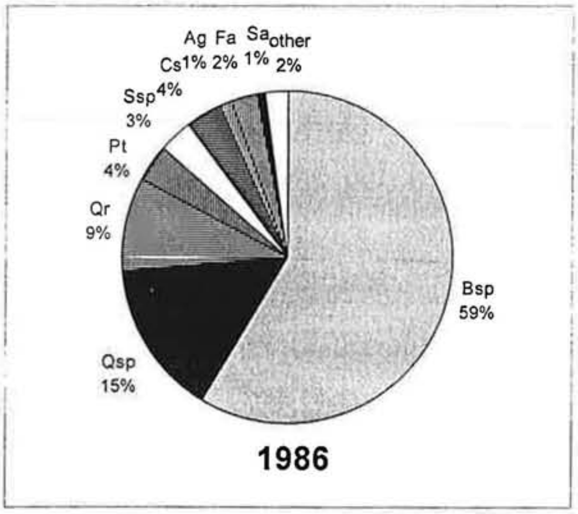


Figure 6. *Natural evolution of the basal area for the most important tree species and for all trees* (Bsp *Betula spp.*; Qsp *Quercus spp.*; Qr *Quercus rubra*; Pt *Populus tremula*; Ssp *Salix spp.*; Cs *Castanea sativa*; Ag *Alnus glutinosa*; Fa *Frangula alnus*; Sa *Sorbus aucuparia*; Ps *Prunus serotina* and Ca *Corylus avellana*).



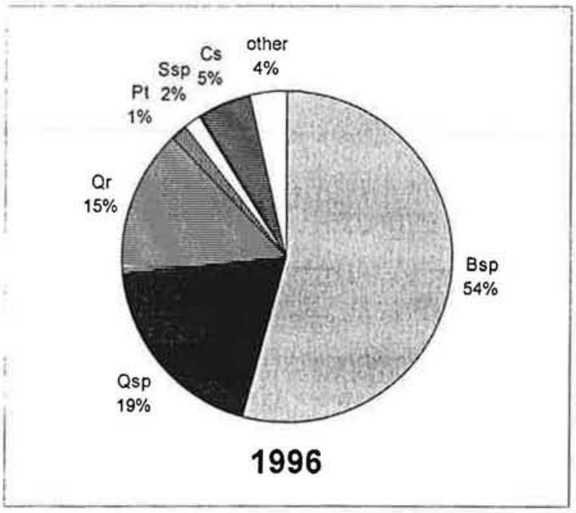


Figure 7. *Tree species composition for the basal area in 1986 and 1996* (Bsp *Betula spp.*; Qsp *Quercus spp.*; Qr *Quercus rubra*; Pt *Populus tremula*; Ssp *Salix spp.*; Cs *Castanea sativa*; Ag *Alnus glutinosa*; Fa *Frangula alnus* and Sa *Sorbus aucuparia*)

Table 2 shows that only for the woody layer in general and for the tree species birch, indigenous oak, Red oak, willow, Common and Grey alder, Aspen, Alder buckthorn and Hazel statistically significant differences in mean basal area could be detected.

Table 2. *Normality tests and statistical comparison of the datasets of the average basal area, per tree species and for the woody layer in general, for the period 1986-1996*

Tree species	Inventory period	Mean basal area (m²/ha)	Normality		Comparison of the Population in 1986 vs 1996	
			Type of test [1]	Significance level [2]	Type of Test	Significance Level [2]
Betula spp.	1986	13.53	χ^2	***		
Betula spp.	1996	15.20	χ^2	***	Mann-Whitney U	***
Quercus spp.	1986	3.55	χ^2	***		
Quercus spp.	1996	5.36	χ^2	***	Mann-Whitney U	***
Quercus rubra	1986	2.11	χ^2	***		
Quercus rubra	1996	4.09	χ^2	***	Mann-Whitney U	***
Salix spp.	1986	0.74	χ^2	***		
Salix spp.	1996	0.45	χ^2	***	Mann-Whitney U	**
Alnus glutinosa	1986	0.30	χ^2	N.S.		
Alnus glutinosa	1996	0.17	χ^2	N.S.	t-test	***
Alnus incana	1986	0.09	χ^2	***		
Alnus incana	1996	0.03	K-S	N.S.	Mann-Whitney U	*
Castanea sativa	1986	0.83	χ^2	***		
Castanea sativa	1996	1.49	χ^2	***	Mann-Whitney U	N.S.
Populus tremula	1986	0.86	χ^2	***		
Populus tremula	1996	0.41	χ^2	*	Mann-Whitney U	***
Frangula alnus	1986	0.55	χ^2	***		
Frangula alnus	1996	0.14	χ^2	***	Mann-Whitney U	***
Sorbus aucuparia	1986	0.25	χ^2	***		
Sorbus aucuparia	1996	0.26	χ^2	***	Mann-Whitney U	N.S.
Corylus avellana	1986	0.21	χ^2	***		
Corylus avellana	1996	0.18	χ^2	***	Mann-Whitney U	*
Prunus serotina	1986	0.11	χ^2	***		
Prunus serotina	1996	0.14	χ^2	***	Mann-Whitney U	N.S.
Crataegus monogyna	1986	0.02	K-S	N.S.		
Crataegus monogyna	1996	0.03	K-S	*	Mann-Whitney U	N.S.
Sambucus nigra	1986	0.00	K-S	N.S.		
Sambucus nigra	1996	0.01	K-S	*	Mann-Whitney U	N.S.
Fraxinus excelsior	1986	0.06	K-S	N.S.		
Fraxinus excelsior	1996	0.08	K-S	N.S.	t-test	N.S.
All tree species	1986	23.21	χ^2	***		
All tree species	1996	28.06	χ^2	***	Mann-Whitney U	***

[1] K-S = Kolmogorov-Smirnov test for normality
[2] N.S. = not significant; *= significant at $p < 0.05$; **= significant at $p < 0.01$; ***= significant at $p < 0.001$

3.3 Changes in spatial distribution of species

The systematic grid of circular plots, covering the whole forest reserve, gives an overall view of the spatial distribution of species and the natural colonization. Changes in spatial distribution were studied by comparing presence/absence of all species over the ten year period (1986-1996) in the 31 permanent circular plots. Results are given in Fig. 8. The dominant tree species birch and indigenous oak remain present in all plots. Red oak and Sweet chestnut have slightly expanded their range while Aspen, willow and Common and Grey alder occur in less plots. Shrubs like Rowan ash, Hazel and Hawthorn (*Crataegus monogyna*) are extending their range, while Alder buckthorn is less widespread than ten years earlier. Black cherry almost doubled its occurrence throughout the forest reserve. Together with a larger stem number Elder even extended its distribution eightfold. Dogwood (*Cornus sanguinea*) and Guelder rose (*Viburnum opulus*) are no longer found inside the plots. Both species remain present in the forest reserve but are found outside the plots and/or as natural regeneration.

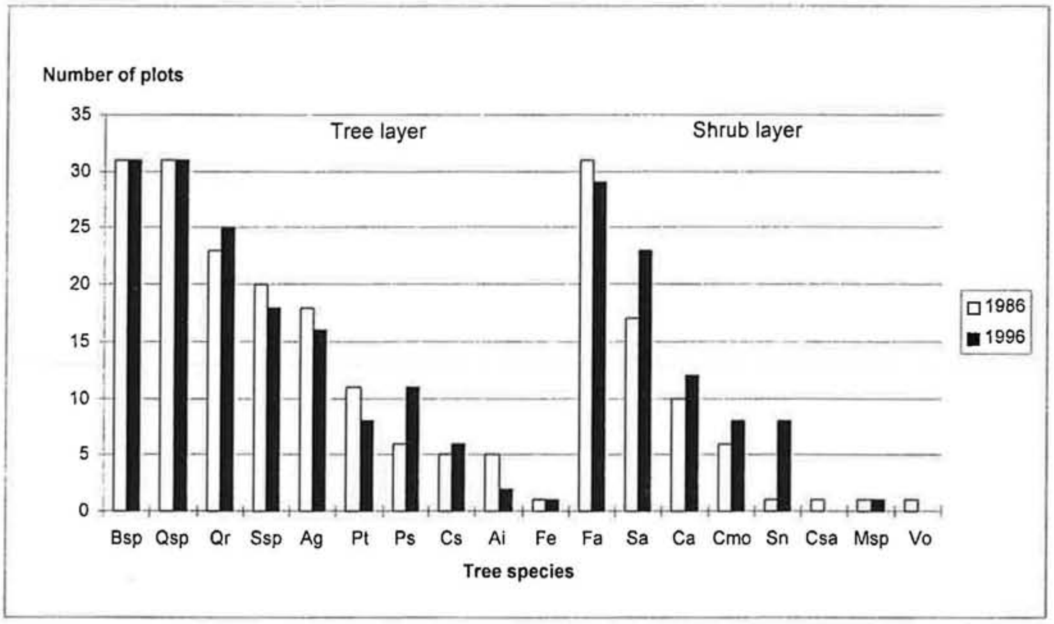


Figure 8. *Natural evolution of the spatial distribution of tree species during the period 1986-1996 (trees with dbh > 2 cm)* (Bsp *Betula spp.*; Qsp *Quercus spp.*; Qr *Quercus rubra*; Ssp *Salix spp.*; Ag *Alnus glutinosa*; Pt *Populus tremula*; Ps *Prunus* serotina; Cs *Castanea sativa*; Ai *Alnus incana*; Fe *Fraxinus* excelsior; Fa *Frangula alnus*; Sa *Sorbus aucuparia*; Ca *Corylus avellana*; Cmo *Crataegus monogyna*; Sn *Sambucus nigra*; Csa *Cornus sanguinea*; Msp *Malus spp.* and Vo *Viburnum opulus*).

Since dynamics of natural colonization are more apparent in smaller tree dimensions (trees with dbh < 2 cm), the spatial distribution of the natural regeneration was studied (Fig. 9).

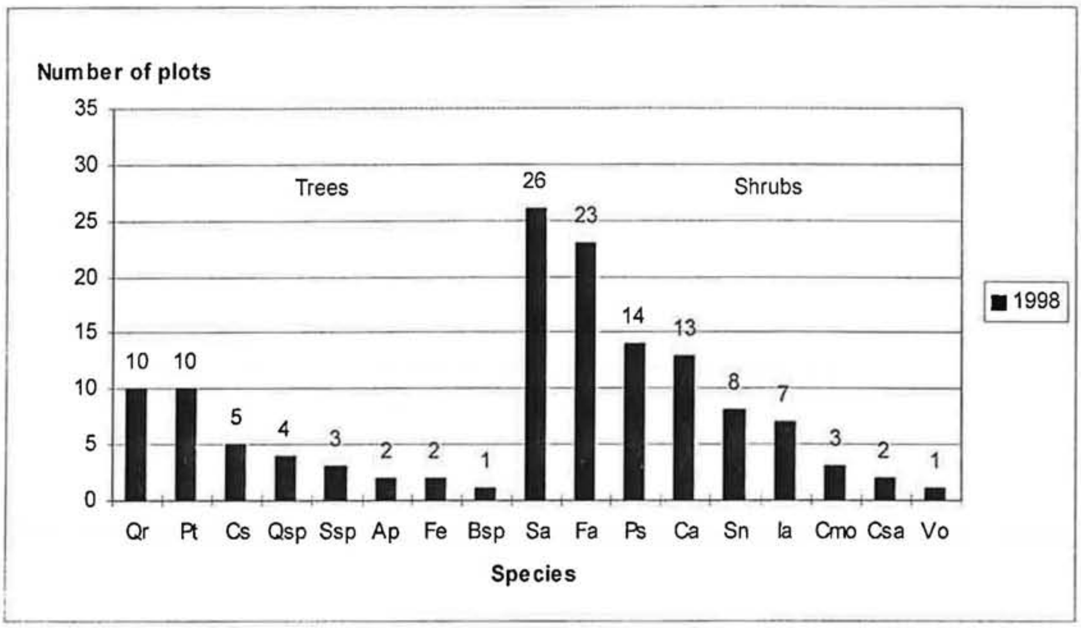


Figure 9. *Spatial distribution of small trees in 1998 (trees with dbh < 2 cm)* (Qr *Quercus rubra*; Pt *Populus tremula*; Cs *Castanea sativa*; Qsp *Quercus spp.*; Ssp *Salix spp.*; Ap *Acer pseudoplatanus*; Fe *Fraxinus* excelsior; Bsp *Betula spp.*; Sa *Sorbus aucuparia*; Fa *Frangula alnus*; Ps *Prunus* serotina; Ca *Corylus avellana*; Sn *Sambucus nigra*; Ia *Ilex aquifolium*; Cmo *Crataegus monogyna*; Csa *Cornus sanguinea* and Vo *Viburnum opulus*).

Fig. 9 shows that, contrary of what would be expected, no tree species drastically colonizes the forest reserve through its smaller dimensions. Only Black cherry and Rowan ash occupy three more plots compared to the distribution of their larger dimensions. Remarkable is the occurrence of Holly (*Ilex aquifolium*) and to a smaller extend of Sycamore (*Acer pseudoplatanus*) in these smaller dimensions. The species were completely missed in the previous assessments. The distribution of smaller dimensions of Hazel, Elder, Ash and Sweet chestnut is more or less the same as for the larger dimensions. Alder buckthorn is represented in more than two thirds of the plots and is still the second most frequent species. Dogwood and Guelder rose, which disappeared in the larger dimensions, still persist as natural regeneration. Regeneration of birch and indigenous oak, as dominant species in the tree layer, are only found in one or a few plots. On the other hand, Red oak and Aspen are, besides the shrubspecies, the most successful regenerating tree species with an occurrence in one third of the investigated plots. Regeneration of the latter probably consists primarily of root suckers. The distribution of willows, found in more than half of the plots as larger trees, dropped to only three plots in the smaller dimensions. Regeneration of Common and Grey alder wasn't found at all.

4. Discussion

Despite of the decrease of the mean stem number with 33.6% the mean basal area increased with 20.9% after ten years of natural development. Important shifts from pioneer to more tolerant tree species could be monitored, resulting in a higher structural diversity.

In the upperstorey birch and indigenous oak still dominate the forest and will probably do so for an indefinite time in the future. Due to a minimal natural regeneration, especially of birch, their dominance is probably not assured though. Tolerant exotic species like Red oak and Sweet chestnut increased their share by keeping their mean stem number at the same level and doubling their basal area. Both species are gradually expanding their spatial distribution and have locally started to regenerate massively. Therefore they will most probably gain importance in the near future. Instead pioneer species like Aspen, willow and Common and Grey alder strongly declined. Both alder species don't even regenerate so that their future role in the forest ecosystem will probably be minimized. Aspen on the other hand will be able to survive for a longer period through vegetative regeneration.

In the understorey the stem number and basal area of Alder buckthorn showed a spectacular decline, though it remained globally distributed over the entire surface. Black cherry on the other hand seems to be slowly invading the forest. Although its average stem number and basal area didn't change significantly, the species doubled its spatial distribution and showed a typical massive local natural regeneration around mature individuals. Therefore its role in this forest ecosystem will most probably increase. Whether the species will be able to dominate the understorey or the woody layer in general is unclear. Immediate competition may be expected especially from the indigenous Rowan ash (Wallis de Vries 1986). This species is also massively regenerating and expanding its range but, unlike Black cherry, its natural regeneration is evenly distributed over almost the entire forest reserve. Elder, another potential competitor of Black cherry (Wallis de Vries 1987), showed an even more remarkable expansion of its stem number and distribution, though its presence remains marginal. Besides improved micro-climatic and soil conditions, another possible reason for this expansion could be the high nitrogen input of around 25 kg N/ha/year (Vanongeval et al. 1998) from the surrounding agricultural activity. The assessment of the natural regeneration resulted in the detection of a few individuals of Sycamore. Due to its natural regenerating capacities and successes in forests on richer soils in Flanders, a further expansion of this species can be expected, resulting in strong competition with other species like e.g. Black cherry. Therefore Sycamore may well become determinant for the outlook of the forest reserve in the far future. Beech (*Fagus sylvatica*), another tolerant and very competitive indigenous tree species, remains absent, although ideal ecological circumstances (favourable soil conditions; a thin canopy, providing enough light and protection;...) are present. One of the major reasons is probably the lack of mature seed bearing beech trees in the vicinity of the forest reserve.

On a long term gap dynamics will most probably start to prevail, complicating the further evolution of the forest ecosystem even more. What kind of role the different tree and shrub species will play at this point is unclear, due to a general lack of detailed knowledge on their ecological behaviour. In this framework this forest reserve offers a unique and excellent opportunity, even on an international scale, for future research on natural forest development and species ecology, in which the competition between exotic and indigenous tree species can play a key role.

5. Conclusion

Over a monitoring period of only ten years important natural changes in the woody layer were detected. The pioneer forest is gradually maturing through self-thinning processes and shifts in species composition. The detected changes allow predictions on future natural development and composition of this forest reserve. These predictions are valuable for the determination of future management e.g. towards the necessity of measures to control exotic species like Black cherry and Red oak. This case study therefore clearly illustrates the importance of monitoring strict forest reserves in providing general basic knowledge for close-to-nature forestry.

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