ANALYSIS OF NATURAL REGENERATION IN A 200 YEARS OLD BEECH STAND.

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Abstract

A 200 year old beech stand near Brussels (Belgium) has been studied on some regeneration characteristics. As the stand is entering the natural degradation phase, a score of big trees have been uprooted during the past 6 years, creating canopy gaps and causing local soil tillage. The study focuses principally on the possibly beneficial effect of these gaps on natural regeneration. Number, age, height and browsing damage of seedlings are measured. Seedling number is found more influenced by soil tillage than by light input. Finally, some predictions of the future development of the stand are formulated.

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1. INTRODUCTION

Degeneration is an important phenomenon in natural dynamics of forested ecosystems. Destabilisation of the ecosystem after perturbation is followed by a reorganisation period in which natural regeneration is essential in recovering biotic regulation (BORMANN & LIKENS 1979).

Applying natural regeneration in forest management has been for centuries a delicate and labour-intensive practice, requiring much expertness; therefore, it has often been neglected and replaced by artificial regeneration (LEIBUNDGUT 1984 ; VAN MIEGROET 1976).

The high costs of artificial regeneration, a broader import of nature preservation ideas, and recent studies on forest dynamics are the main factors causing the actual interest in natural regeneration.

The failure or success of natural regeneration in forest practice is determined by several factors (FANTA 1982; LEIBUNDGUT 1984) : soil conditions, light intensity, browsing level, soil vegetation and the presence of seed-trees. The impact of the different factors varies with tree species. In beech stands e.g., soil conditions are frequently mentioned as the most inhibiting factor (COLLEAUX 1923; LE TACON 1981; PERIN 1981). Although beech is considered as a shade-tolerant species, several authors state that beech seedlings do not mature beneath the full shade of parent trees and regeneration is restricted to canopy gaps (WATT 1923, 1925 ; AMON 1973; OSWALD 1981; PACKHAM & HARDING 1982 ; ELLENBERG et all 1986).

In Flanders, there are very little possibilities to investigate spontaneous forest regeneration under so called " natural " circumstances. Up to now, no forest reserves without human intervention are officially established.

In some state owned forests, however, particular stands are that old, they slowly attain the degradation phase. Considering their scarcity, these stands are of extreme scientific importance.
According to this, one of the oldest beech stand of the Zoniën Forest has been reserved for scientific purposes a few years ago.
An ecological basic-inventory has been carried out in 1985-'87 by VERLINDEN et al. (in press).

The present study on natural regeneration is executed on this location. Special attention is paid to the possibly beneficial effects of local soil preparation induced by uprooted trees.

2. SITE DESCRIPTION

2.1. Zoniën Forest

The Zoniën Forest is located south of Brussels (fig. 1). Total forest surface amounts up to 4380 ha.

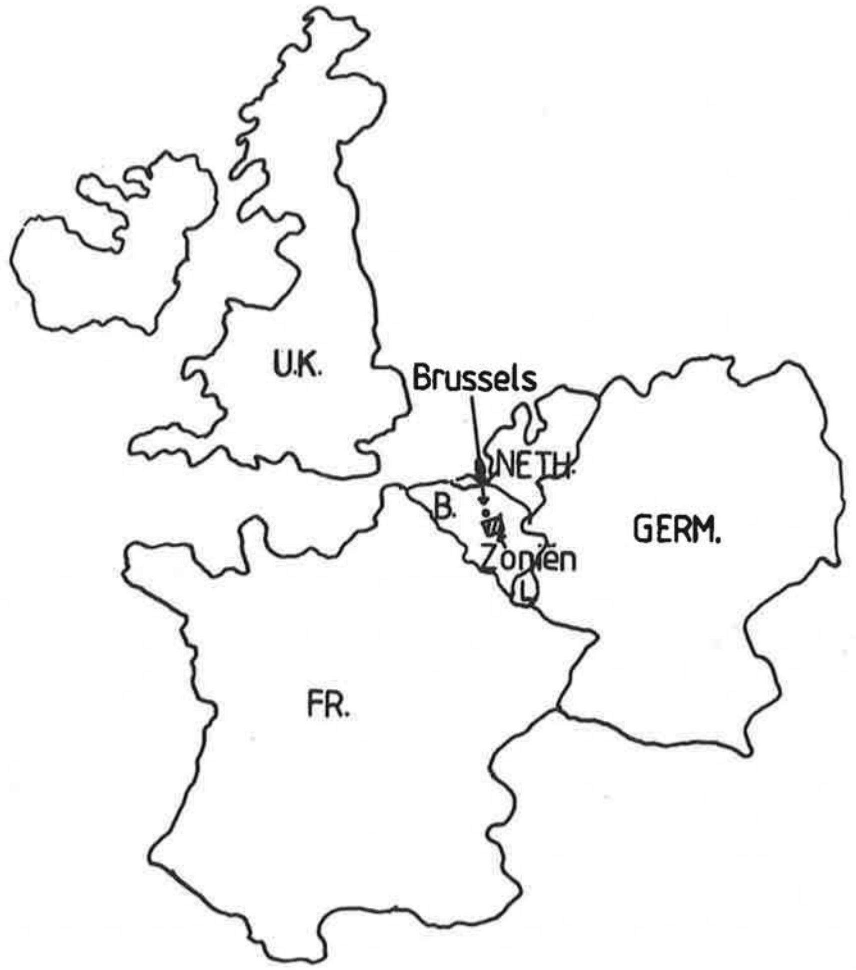


Figure 1 : Localisation of the research area.

Altitude above sea-level varies from 60 to 120 metres. Annual temperature average 9.5°C ; yearly precipitation totals 750 mm, and the prevailing wind-direction is south-west. Soil is of a loamy texture and is classified as grey brown podzolic. Soil compaction and soil degradation are severe restrictions in the Zoniën Forest management. Winddamage is unusually high and thus treatens forest stability. MANIL (1951), DUDAL (1953) and GALOUX (1953) considered two centuries of beech monocultures as the main soil degrading factor, while more recently others stress on deeper soil compaction through paleoperiglacial phenomena (LANGOHR & PAJARES, 1981; LANGHOHR & VERMEIRE, 1982).

Soil surface compaction is probably a result of uncontrolled horseriding and employment of heavy logging equipment in recent times.
As all Belgian forests, the Zoniën Forest has throughout its history been submitted to important human impact.Nevertheless, the forest always remained forest, although its composition has been thorougly modified. In fact, since 1780, large parts of the forest have been converted to beech monocultures. Nowadays, these monocultures are still the most striking aspect of the forest.

2.2. Investigated stand (based on VERLINDEN et al, in press).

The research stand dates from 1790 and takes up a total surface of 18 ha. In the central part of the stand (10.5 ha), no forest management practices have been carried out since 1983. All mature trees (over 600 with dbh > 0.30 m) have individually been mapped and measured on their main characteristics. The biggest trees reach up to a height of over 45 m, and have a circumference (at breast height) of over 4 m.
Beech absolutely dominates the stand (table 1). Total stand volume averages 368 m^3 ha^{-1} (710 m^3 ha^{-1} when branches included). Although there has locally been some natural preregeneration in the last decades, the actual stand consists by far of old trees.

Table 1 : Composition of tree species (dbh > 0.07 m)

Species	N	N/ha	%
Fagus sylvatica L.	1563	152	97.7
Quercus robur L. x Q. petraea LIEBLEIN	32	3.0	2.0
Acer pseudoplatanus L.	1	0.1	-
Fraxinus excelsior L.	1	0.1	-
Populus canescens (AIT.) SMITH	1	0.1	-
Robinia pseudoacacia L.	1	0.1	-
Total	1599	152.2	99.7

Since November 1983, several old beeches have been uprooted, resulting in local soil disturbance and creating canopy gaps of varying size.
The plant-community is to be globally classified in the Milio-Fagetum (NOIRFALISE & ROISIN 1981) association (NOIRFALISE 1984), more specifically in the subassociation athyrietosum with Athyrium filix-femina (L.) ROTH, Dryopteris dilatata (HOFFM.) A GRAY ; Dryopteris carthusiana (VILL.) H.P. FUCKS, Deschampsia caespitosa (L) BEAUV. and Carex remota JUSL. ex L.
Furthermore, three subdivisions can be distinguished :

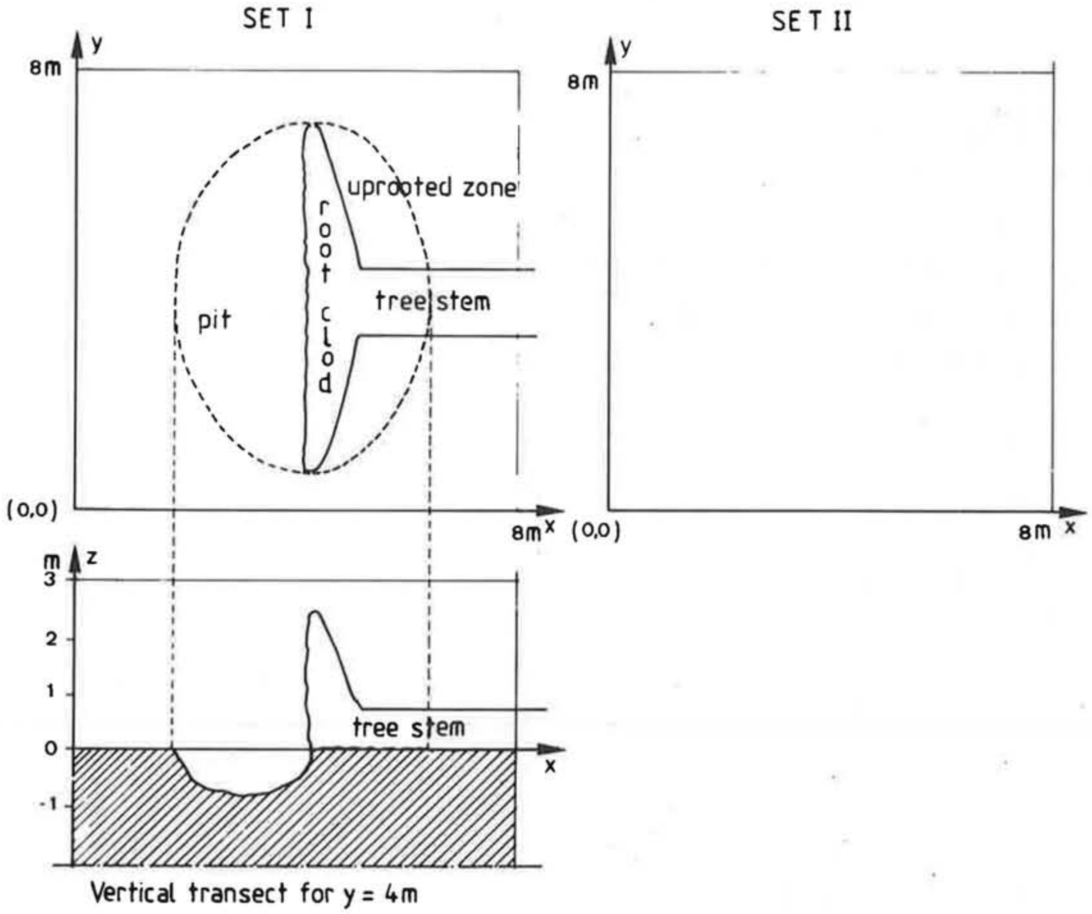
- a type with Deschampsia flexuosa (L.) TRIN., on the higher and drier parts of the plateau;
- a type with Pteridium aquilinum (L.) KUHN Luzula pilosa (L.) WILLD. but without Deschampsia flexuosa and Lonicera periclynenum L.,
- a type with absolute dominance of Pteridium aquilinum, much poorer in species diversity than the other types.

Forest soil pH averages 4,65 in the upper 10 cm and 5.44 at a depth between 10 and 20 cm.

3. METHODS

All data are collected during the summer of 1988. A total of 28 plots (8 m x 8 m) were selected, well spread over the stand.
Special attention was given to a variety of situation.
So, as windthrow can be considered the most important cause of perturbation in the stand, ten plots were selected with an uprooted tree basis as plot centre (further on called ' set I ') - fig.2).
The location of the remaining 18 plots (' set II ') was choosen in accordance with the variability of canopy coverage and herbal vegetation (dominant species and coverage).

Fig. 2. Comparison between plots of set I and set II.



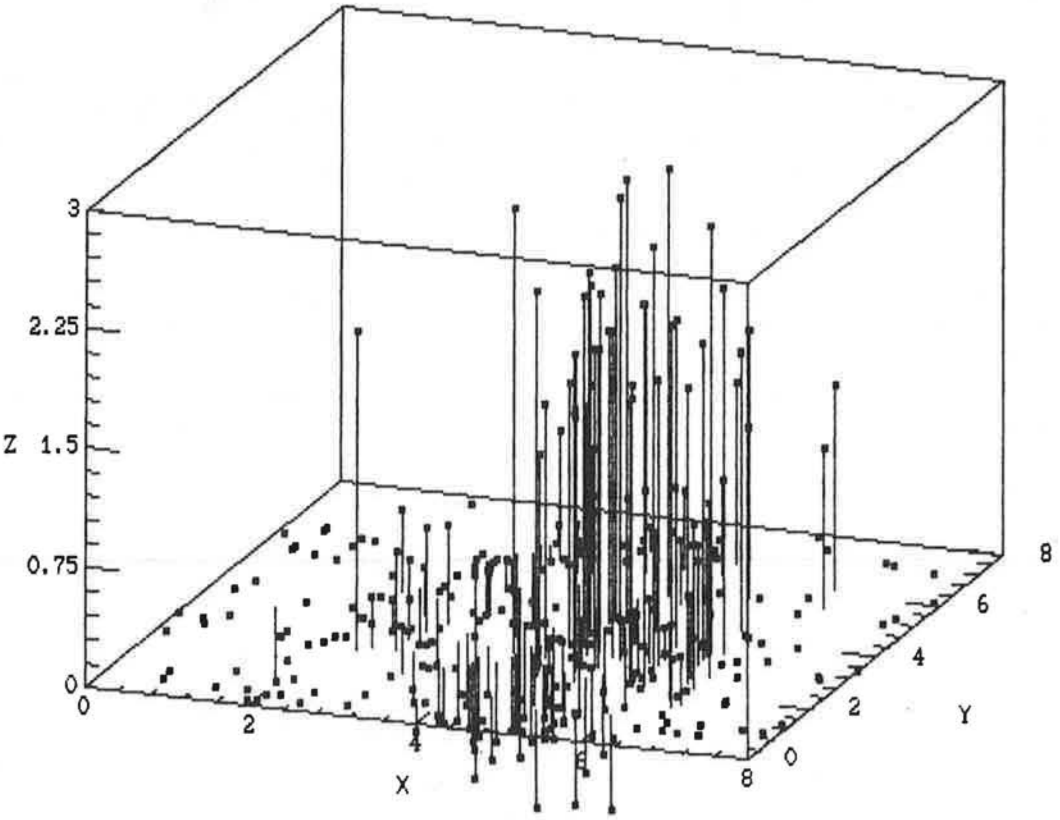
In every plot, the following measurements were executed :

- a phytosociological survey based on the classical method of BRAUN-BLANQUET (see annex) ;
- location of the seedlings in an X,Y,Z - axessystem. The Z-axis is only considered to indicate the position of seedlings in set I below or above the original forest floor level (i.e. in the pit or on the root clod). The origin of the axessystem (0,0) in fig. 2) is taken as reference level;
- recording and identification of all seedlings.;
- measurement of height and determination of the age of the seedlings
- checking all seedlings for obvious game browsing damage.

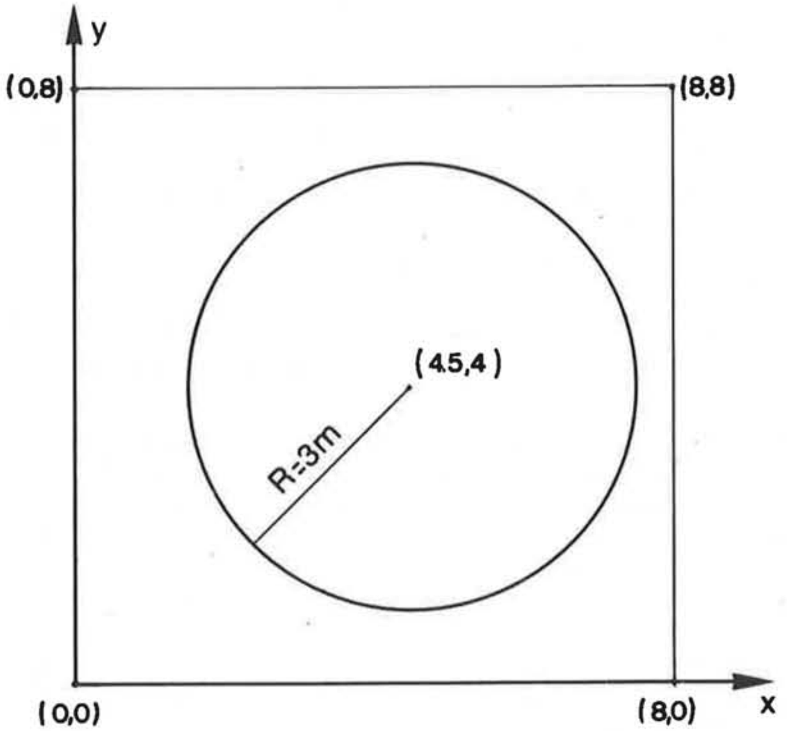
In this way, for every seedling a record containing 12 variables is compiled:1. set, 2. plot, 3. canopy cover, 4. herbal cover, 5. dominant herbal species (i.e. with a covering value of at least 3 on the BRAUN-BLANQUET scale), 6. species, 7. age, 8. height, 9. browsing damage, 10 : X-co-ordinate, 11. : Y -co-ordinate, and 12. : Z-co-ordinate
The obtained matrix is the starting point for all analyses.

In order to separate the uprooted zone from the surrounding part of the plots (set I), a cercle has been constructed so that nearly all seedlings with a Z-coordinate different from 0 (i.e. standing on the root clod or in the pit of the uprooted zone) are enclosed (fig. 3).

fig. 3 : a) three-dimensional localisation of all seedlings. The seedlings with Z-value ≠ 0 localise the pit and the root clod.



b) two-dimensional localisation of the cercle enclosing nearly all seedlings of the uprooted zone.



4. RESULTS

4.1. Species and number of seedlings

On a total of 28 investigated plots, 344 seedlings were found (table 2), i.e. a mean regeneration number of 12 seedlings per plot (64 m²) or 1920 seedlings per ha.

Seven different species were found : 263 beeches (Fagus sylvatica L.), 63 goat willows (Salix caprea L.), 8 Salix aurita L., 5 durmast oak (Quercus petraea LIEBL.), 2 common oak (Quercus robur L.), 2 grey birches (Betula pubescens EHRH.) and 1 European mountain ash (Sorbus aucuparia L.).

Beech totals 77 % of all regeneration, being obviously inferior to its share in the present stand (cfr. table 1).
Comparing both sets, differences in species diversity and in total number of seedlings can be noticed. In set I,6 species are found, in set II only 2 (table 2).
Fig.4 shows that nearly all non-beech seedlings are found in uprooted zones.
Analysis of variance shows a significant difference in total number of seedlings between both sets : plots of set I contain approximately 23 seedlings, those of set II only 7.

As 77 % of all seedlings are beeches, the distribution of this species is computed separately. The difference is still significant, yet not so clear, as could be expected because of the verly limited presende of other species in set II. Set I averages 15 beech seedlings, set II only 7.

Thus, the seedling surplus in set I can not only be ascribed to the appearence of pioneer species, but also to a greater abundance of beech regeneration.

To estimate the relative importance of sol-tillage and ight intensity on seedling number, all seedlings of both setcs enclosed in the above mentioned cercle are repulsed, and the analysis is recomputed on the remaining seedlings (fig. 6). In this way soil-tillage effect is excluded, and ight effect can be analysed.

After recomputing, analysis of variance couldn't detect significant differences between both sets : 4.1 ± 1.1 seedlings in set I, 2.9 ± seedling in set II.

Table 2 : Number of seedlings per plot. Set I contains plots including a root clod of a fallen tree, set II contains plots without root clod.

Set	Plot	Number							
		Fagus sylvatica	Salix caprea	Salix aurita	Quercus petraea	Quercus rovur	Betula pubescens	Sorbus aucuparia	Total
I	1	16	13						29
	2	21	2	7					30
	3	8					1		9
	4	3	4						7
	5	17	8						25
	6	7			1				8
	7	25	8						8
	8	28	14				1	1	44
	9	13	13	1	4				31
	10	8	1						9
Subtotal		146	63	8	5	0	2	1	225
II	1	10							10
	2	7							7
	3	15							15
	4	12							12
	5	2							2
	6	3							3
	7	1							1
	8	7							7
	9	6							6
	10	20							20
	11	1				1			2
	12	1							1
	13	1							1
	14	10							10
	15	12							12
	16	4				1			5
	17	4							4
	18								0
Subtotal		116	0	0	0	2	0	0	118
Total	28	262	63	8	5	2	2	1	343

Fig. 4 : Seedling distribution of the different species in set I. The cercle includes the uprooted zone. Legend : 1. : *Fagus sylvatica* L., 2 : *Quercus robur* L., 3. : *Quercus petraea Lieblein*, 4. : *Sorbus aucuparia* L., S : *Salix caprea* L. *Salix aurita* L. 7 : *Betula pubescens* Ehrh.

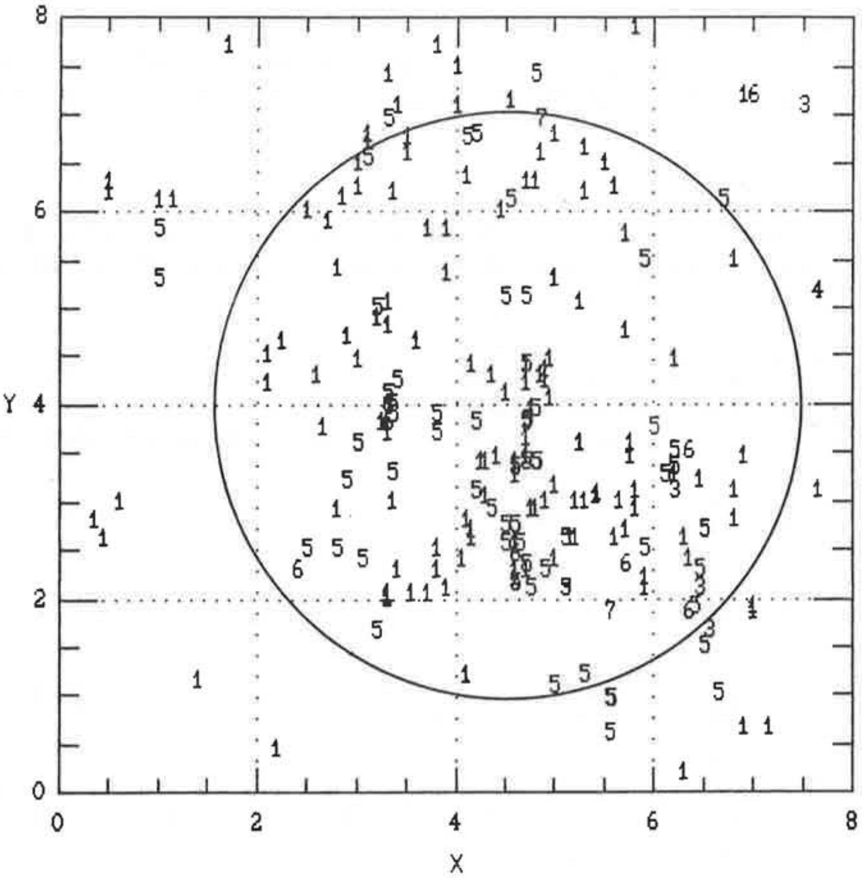
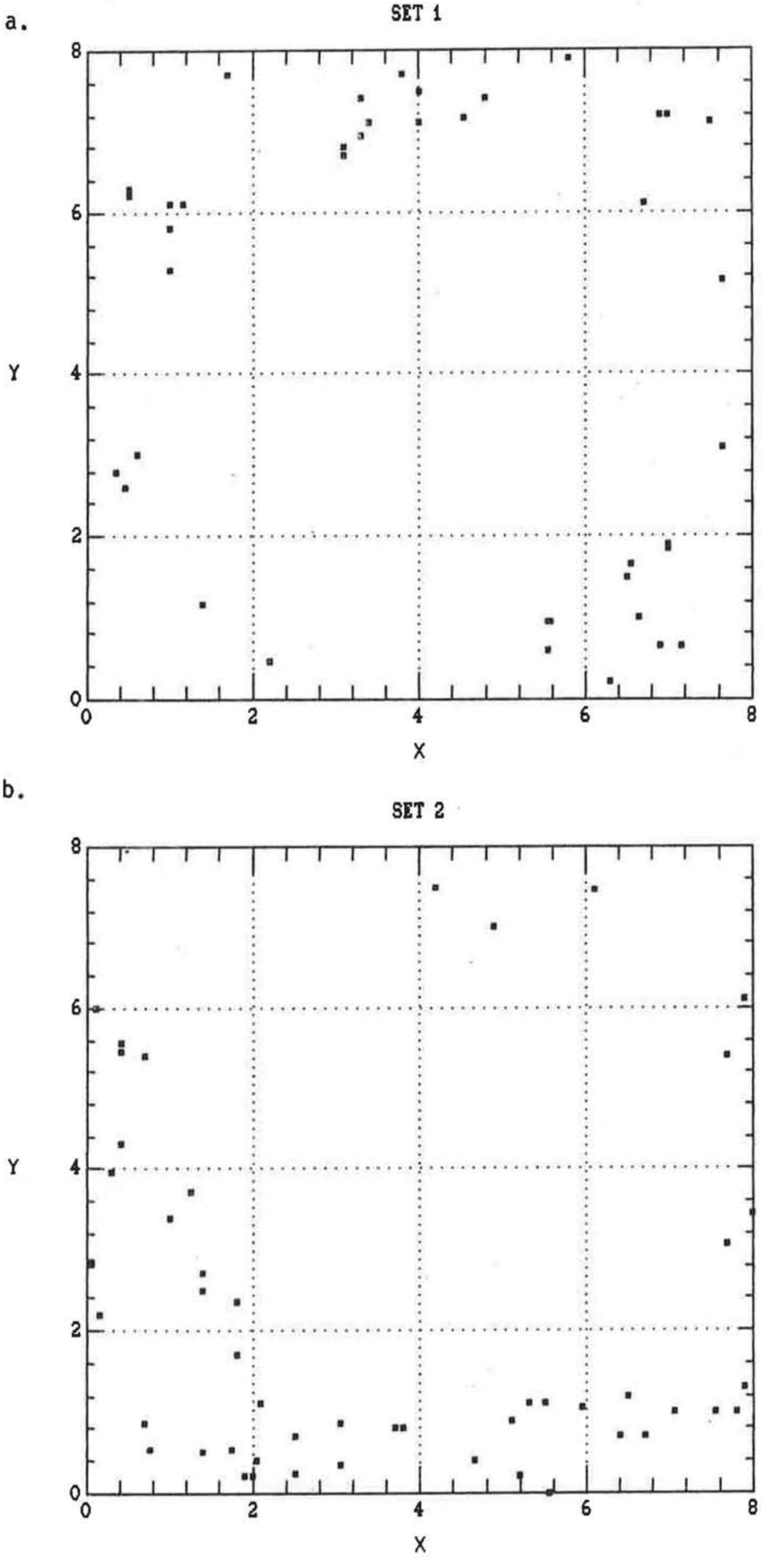


Fig. 5 : View of the uprooted trees

Fig. 6 : Seedling distribution of both sets after repulsing the seedlings in the cercle corresponding with the uprooted zone in set I.



4.2. Height of the seedlings

The height of the seedlings can be an indication for their age, for their growth and vitality, or may be function of the browsing frequency. Height of seedlings is analysed as a function of these factors.
No significant differences in height can be perceived between both sets : height averages 11 cm in set I, 10 cm in set II (table 3).

As different species, each with their own growth characteristics are involved, it's more important to compare height for the species individually in this respect, only beech has to be considered since 98.3 of all seedlings in set II are beeches.
Beech seedlings are significantly higher in set I (level 0.05).

Differences in height between plots within a set are found higer than between sets. Particularly the height of Salix caprea L. seedlings varies considerably. The influence of the canopy closure is not obvious, yet seedling height globally varies from 3 to 11 cm under a canopy cover of 50-100 %, and from 9 to 16 cm under a cover of 0-50 %.

Age doesn't seem a factor of great importance neither : seedlings of 1,2 and 3 years old average 10 cm in height, 4 year old seedlings are about 25cm high.
No influence of browsing on seedling height could be detected.

4.3. Browsing level

There is significantly more browsing damage in set I : about 13 % of seedlings are damaged, in set II only 3 % (table 3). When only beech is considered, the difference remains : 17 % in set I, 3 % in set II.
The difference remains also after repulsing the uprooted zone and recomputing the data.
No differences in palatability between the seedling species appear to exist, since no significantly differing browsing levels are found.

Browsing is higher in plots with vegetation of ferms (Pteridium aquilium (L.) KUHN and Dryopteris dilatata (Hoffm. A. GRAY).
Browsing levels between 0 and 7 % are found in scare (< 35 %) and very thick (> 85 %) ground vegetation, browsing levels between 12 and 27 % are found in moderately dense ground vegetations (35 - 85 %).

4.4. Age of seedlings

All regeneration in both sets ages four years or less. Seedlings of set I are found younger than those in set II : 1,95 ± 0.05 versus 2.25 ± 0.06 years old (table 3).

For beech, no significant differences can be registered, since the lower mean age in set I is caused by the presence of young Salix seedlings : beech seedlings are in general 2.25 ± 0.04 years old, goat willows seedlings 1.25 ± 0.08 years.

Table 3 : Mean age, height and browsing frequency of seedlings per plot

Set	Plot	Number		age (years)		Height (cm)		Browsing frequency (%)	
		all species	beech	all sp.	beech	all sp.	beech	all spp.	beech
	1	29	16	2.28	2.94	10.24	12.19	0	0
	2	30	21	2.30	1.67	15.83	13.81	0	0
	3	9	8	2.67	2.75	8.11	8.75	0	0
	4	7	3	1.57	2.00	17.86	21.67	0	0
I	5	25	17	1.68	1.94	10.60	11.76	12.0	11.8
	6	8	7	1.75	1.86	14.37	12.14	50.0	57.1
	7	33	25	1.94	2.20	9.85	10.40	30.3	32.0
	8	44	28	1.82	2.25	8.93	11.07	13.6	31.4
	9	31	13	1.45	1.85	8.58	9.46	9.7	15.4
	10	9	8	2.00	2.13	9.44	10.00	33.3	37.5
	Total	22.5	14.6	1.92	2.25	10.84	11.42	12.8	17.1
	1	10	10	2.90	2.90	8.50	8.50	0	0
	2	7	7	2.00	2.00	16.43	16.43	0	0
	3	15	15	1.87	1.87	14.33	14.33	0	0
	4	12	12	1.92	1.92	12.92	12.92	16.7	16.7
	5	2	2	2.00	2.00	10.00	10.00	0	0
	6	3	3	1.67	1.67	10.00	10.00	0	0
	7	1	1	2.00	2.00	15.00	15.00	0	0
II	8	7	7	1.86	1.86	7.56	7.86	0	0
	9	6	6	2.00	2.00	11.67	11.67	0	0
	10	20	20	2.00	2.00	10.00	10.00	5	5
	11	2	1	1.50	2.00	12.50	10.00	0	0
	12	1	1	2.00	2.00	7.00	7.00	0	0
	13	1	1	1.00	1.00	5.00	5.00	0	0
	14	10	10	3.00	3.00	8.50	8.50	0	0
	15	12	12	3.00	3.00	-	-	0	0
	16	5	4	3.00	3.00	9.00	7.5	20	0
	17	4	4	2.25	2.25	10.50	10.50	0	0
	18	0	-	-	-	-	-	-	-
	Total	6.6	6.4	2.25	2.26	9.95	9.86	3.4	2.6

5. DISCUSSION

Seedling presence is very limited in all plots. Without considering the(scarce) regeneration older than 10 years, maximum age in the plots does not exceed 4 years. This preliminary statement stresses the problem of natural regeneration in beech stands, and justifies the attention paid to the subject.

Many factors can play a limiting role in the establishment of a good regeneration. Abundant seed production during mast years is of course a preliminary requirement for obtaining abundant natural regeneration.
From 1982 on, i.e. the period in consideration in this study since the oldest root clods date from November 1983, there has only been one real beech mast year (1982). 1983 was not bad in this respect; 1986 was rather good. In the other years, nearly no beechnuts matures (J. ZWAENEPOEL, verbal information). Considering all this, the present study focuses on the importance of light intensity, soil tillage, browsing, and herbaceous vegetation.

Seedlings in plots of set I were significantly more abundant than plots of set II. This can be explained by a higher ecological heterogeneity or by a higher insolation in set I.
Indeed, the uprooting of trees creates several microsites, all with their own specific characteristics of humidity, exposition, temperature and vegetation development (HUTNIK, 1952; Koop 1981). As a consequence of the gap coated in the forest canopy, insolation locally increases. The higher input of photosynthetic active radiation could induce a quick emergence of a.o. heliophilous pioneer species as Salix and Betula, especially with major gap sizes (LEMEE et al., 1986 ; PICKETT & WHITE, 1985). However, fig. 4 show that almost all ' heliophilous ' species are found in the zone tilled by uprooting. This observation gives an important indication to conclude that the colonisation of the so called heliophilous pioneer species is at least as dependent on the presence of a favourable germination bed than on increased insolation. In this way, light response must be seen as only one characteristic in a total strategy of pioneer species.

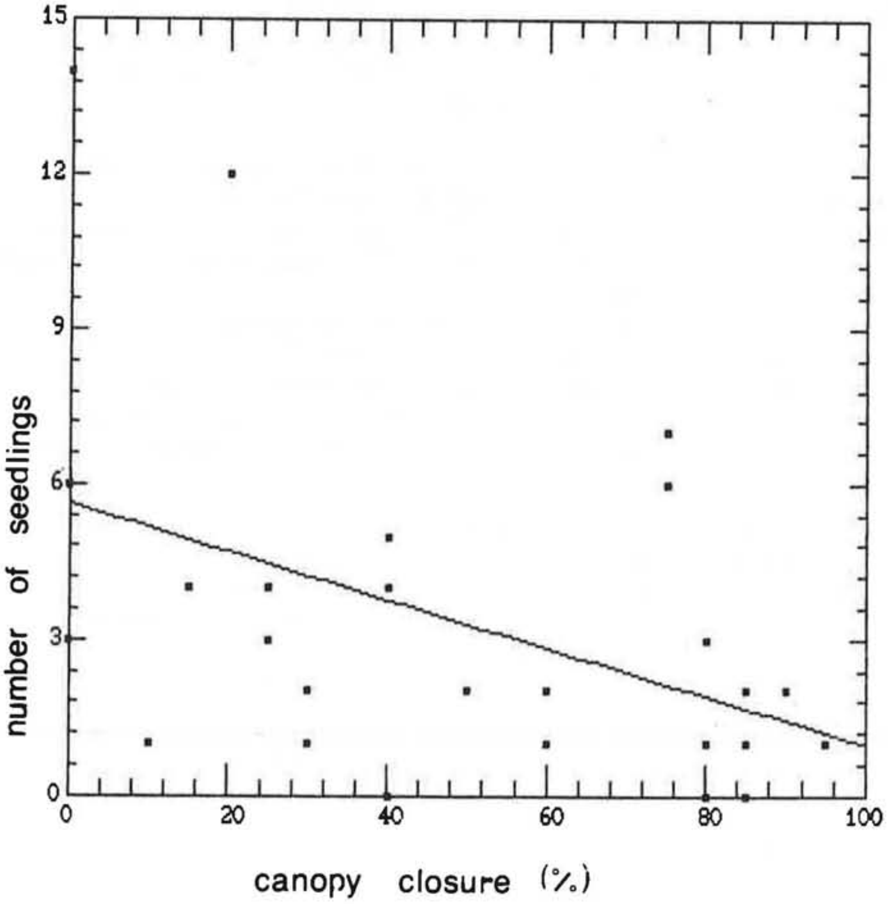
Plots of set II receive less light (average canopy cover 66 % versus 18 % in set I) and have no soil condition favourable for germination of small pioneer seeds. These plots are necessarily colonised by rather shade-tolerent species with heavy seeds. If not transported by birds or mammals, they germinate in the direct surroundings of the seed-trees, which are beeches, rarely oaks.
The higher concentration of(beech) seedlings in set I and more particularly in the uprooted part of it, can, just like the species diversity described above, be caused by several factors.
Uprooted trees may create better possibilities for germination of seeds, because of the absence of a thick holorganic layer (which is very difficult to penetrate for seedling roots, or in which beechnuts easily get attacked by fungi); the absence of concurrential herbal vegetation; the crumbling of the extremely compacted loam soil (resulting in a better soil moistening and aeration) or the decrease of soil acidity as a result of the exposition

of deeper (i.e. less lessivated) soil layers (LE TACON, 1981 ; PERRIN, 1981).

The increase of insolation is, of course, also in this matter an important aspect, stimulating the germination and development of seedlings. Intenser forest soil insolation increases mineralisation and nitrification as a result of better breakdown of the regeneration inhibiting holorganic layer (KOOP, 1981).
Beech litter production locally decreases, and herbal litter production increases, resulting in a more favourable C/N -ratio and a higher nutrient availability.

In general, regeneration of all encountered species seems to be favoured by soil disturbance, while light intensity is of secundary importance. However, it has to be remarked that the influence of the forest canopy is not to be neglected. After excluding the uprooted zone, procentual cover of the canopy still shows slightly significant influence on the number of tree seedlings. A negative correlation (not clear however : $r = -0.44$) was found after regression estimation of the seedling number as a function of canopy closure (fig. 6).

Fig. 6 Regression line of seedling number as a function of procentual canopy closure, after excluding uprooting influence



Statistically, seedling height does not clearly seem to be determined by a particular factor, although canopy coverage and seedling age certainly will not be without influence on it.

Browsing damage is low, but significantly higher in set I compared to set II. Being very common mammals in the Zoniën Forest and particularly in the studied area, roe-deer (Capreolus capreolus) and chipmunks (Eutamias sibericus) are likely to be responsible for it, since here, rabbit, squirreland other rodents are rather scarcely represented.
The difference in browsing rate can be explained from the ecology of both roe-deer and chipmunk.
Chipmunks obviously profit of the increased spatial micro-structures caused by fallen trees for hiding and breeding. Consequently, the fouraging rate will be higher at these places.

As, in general, browsing damage increases in plots with high herbaceous vegetation of ferns (with excellent hiding possibilities for bigger animals), roe-deer are likely to take part in it. However, the difference in browsing between set I and set II remains, even after repulsing the uprooted zone and recomputing. Perhaps, as roe-deer are known to be very selective feeders, they spend a longer time fouraging at the immediate surroundings of the root clod, because of the locally increased abundance of seedlings in plots of set I.
Other plant species do not seem to attract roe-deer or to hold them longer at the place. Indeed, the herbaceous species diversity of both sets is well comparable (see annex : average 14.70 species in plots of set I, 12.00 species in plots of set II), while the presence of Rubus sp. (the only favourite food-plants globally occurring more in set I), is not related with high browsing levels within the plots (compare annex to table 3).
Furthermore, browsing levels globally are less in plots with very scarce or very thick ground-vegetations. This can be explained by the interaction of two factors : the detectability of the seedlings on the one hand, and the possibility to hide in vegetation on the other hand.

For beech seedlings, no significant age-differences are found between both sets. Within set I, some difference can be detected between the species. Beech seedlings are in general older than goat willow seedlings (2.25 versus 1.25 years). Perhaps all older willow seedlings have, for some reason (drought, browsing, competition), simply failed to survive.
As beech seedling age averages about 2 years, most of the seedlings will state from 1986, what was indeed a year with rather lots of beech nuts (cfr. above). Furthermore, no seedlings were found older than 4 years. This means that the abundant fructifications of 1982 and, to a lesser extent however, of 1983, are not at all reflected in the actual state of regeneration, although several root clods date from 1983.

There is no specific explanation for this penomenon, but it is a clear indication that natural regeneration is not self-evident at all.
Since the life-power of burned beechnuts is at most 2-3 years (ROHMEDER, 1972) and for several root clods, the distance to neighbouring seed-trees is too extent, beech colonisation at some gap sites may stop soon. As a remarkable fact however, it must be noticed that lots of seedlings were even found on the former under-surface of the root system, where they certainly cannot have been burried spontaneously. Beechnuts hided by animals for food supply are a plausible explanation for this phenomenon, obviously not being without importance for future natural beech regeneration at these sites (PACKMAN & HARDING, 1982).

6. CONCLUSION

Natural regeneration is globally favoured at gap sites caused by fallen trees. Typical ' pioneer trees ' only occur at these sites, and beech regeneration is clearly more abundant. It is explained by the local tillage effect of the uprooting and, in a lesser extent, by increased insolation. Nevertheless, natural regeneration certainly does not proceed without difficulties. Most of the seedlings are not older than 1 or 2 years, although gap sites yet exist for 6 years. Apparently, lots of seedlings must have failed to survive even in the near past.

As things are now, predictions on the future forest development remain very precarious.

As all the trees are getting older, it can be expected that the number of gap sites will increase, while the size of the existing gaps will probably increase as a consequence of side-effect. In this way, a temporary and local dominance of pioneer trees as Salix and Betula e.g. is possible. However, as beech seedlings are abundantly represented in present regeneration, beech is likely to take again its dominant position within a measurable time.

7. ACKNOWLEDGEMENTS

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Annex : Phytosociological survey of the research plots (method BRAUN-BLANQUET).
Period of the survey : 1/6 - 15/8/1988.

Set	I										II																	
Plot	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Total cover %																												
Tree layer	0		15	25	25	25	0	0	30	30	60	40	40	50	60	85	10	80	0	20	80	85	0	70	10	80	90	80
Shrub layer	15		0	0	20	5	0	0	0	<5	0	5	0	0	0	0	5	0	85	0	0	0	25	20	80	5	5	0
Herb layer	30		40	95	50	70	35	30	15	60	40	90	90	75	75	30	95	20	0	90	5	30	<5	65	<5	40	20	85
Moss layer	10	5	10	5	20	10	10	25	20	10	<5	<5	<5	<5	0	<5	0	5	<5	<5	0	0	<5	<5	<5	<5	<5	<5
Herb. layer																												
Anemona nemorosa						+									+			+			+	+				+		
Athyrium filix-femina	+	2	+	2	+	2		+	1	+	+	+				+	2	+				+	+	2	+	1	+	1
Betula pubescens			r					r																				
Carex ovalis					+																							
Carex pilufera																											+	
Carex remota	+	1	2	+	+	1	+		+	1	2	+		+		+	3	1		1		1		2	+	+	+	4
Carex sp.	+		+																				+					
Circaea lutetiana													+				+											1
Convallaria majalis											1																	
Deschampsia cespitosa	+	+	+	1	+	2					+	+	+			+	1	+						+		+		1
Deschampsia flexuosa			+	1														+								1	2	
Dryopteris carthusiana	+	+	+	2	+	+	+		+						+	1	+	1		+	+	1	+	+	1	2	+	
Dryopteris dilatata		+	+	2	3	2				+	+	1			+	+	2	+		1		+		2	1	+	+	
Dryopteris filix mas																		+				+			+			
Epilobium augustifolium																	+											
Epilobium sp.				+					+								+											
Fagus sylvatica	+	+	+	+	+	+	1	1	+	+	1	+	+	1	+	+	r	+	+	+	r	r	r		1	+	+	
Hedera helix			+																r									
Holcus mollis	3	4	3	3	+					4	3	3	3		2	2	4	+		2	1	2		3		2	2	2
Juncus conglomeratus				1																								
Juncus effusus	1	2	+	1	+	+	+	+	+	1	+		+			+	2							+				+
Lamium galeoldolar	+	+	+	+	1	1				1					+	2	1							2		+		2
Lemna sp.																	+											
Lotus sp.									r																			
Lonicera periclymenum																										+		
Luzula pilosa	+	+	+	+	+	+				+	+					+		+						+		+	1	
Luzula sylvatica											+														+	2		
Luzula sp.	+																										+	
Majanthemum bifolium																										1		
Melilotus sp.							r																					
Milium effusum			1	1	+	1			+	+		+			1	1	1	2		1	+	+		1		+	+	2
Moehringia trinervia											+											+				+		
Oxalis acetosella	+	1	1	1	1	+			2	1	1	2	2		2	3	1	2		2	1	2		1	+	1	+	1
Polygonum multiforum																+		+										
Polygonum hydropiper	+	+										+					1											+

Set	I										II																	
Plot	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pteridium aquilinum						2	3	3	2	2	3	4	5	5	4		+		+	2	+	1	+			2		+
Quercus petraea						r			+					+				+								+		
Quercus robur																					r					r		
Rubus idaeus	+	+	+	+	+	1				+			+															
Rubus div.sp.	+	1	+	2	1	2			+	+	+	+	+	+	+	+	1	+		+		+		1		1	1	+
Salix aurita		+							r																			
Salix caprea	+	+	1	+	+				+	r																		
Scroplularia nodosa																												+
Sorbus aucuparia								r																				
Stellaria holostea		+									+				+	+	+					+		+		+		
Stellaria uliginosa																	+											
Tencrium scorodonia						+																					+	
Urtica dioica		+					+					+																1
Veronica sp.							1	1																				+