TYPOLOGY OF THE NATURAL REGENERATION IN A MIDDLE-AGED SCOTS PINE-FOREST

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Abstract

The study pictures the natural regeneration state of a forest on coarse sandy soils. The natural regeneration was studied in three different ecological conditions : in 30 to 60 year old Scots pine stands, in a 62 year old mixed stand of Pedunculate oak and Red Oak, and on the free field.
The analysis of the regeneration groups revealed that the first settler maintained a dominant social position during the following years after the settlement. The structural basis is consequently laid out early. This means that the forest practice has to consider the very first phase of the regeneration as determining for the following evolution of the regeneration groups.

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1. INTRODUCTION

1.1. Belgium, a country of deciduous forests ?

The forest area of Belgium amounts to 617.000 ha, corresponding with
an afforestation index of 20,2 %. In Flanders, the northern part of
the country, the afforestation index falls to nearly 9 %. Compared to
the Walloon region (490.275 ha of forest area) - the southern part
of the kingdom - Flanders forest area (126.643 ha) is by far the less
important. About 2/3 of the Flemish forest is to be situated in two pro-
vincies, namely Antwerp and Limburg. Although Belgium belongs to the core
of a vast natural hardwood region (RUBNER & REINHOLD, 1953), the deci-
duous forests cover only 53 % of the total forest area. This portion
drops to 34 % for the provinces of Antwerp and even to 24 % in Limburg.
Only a glance into the past helps to reveal this astonishing fact.

After the last ice-age (above 10.000 years B.c.) a mixed deciduous
forest of limited value arose in the region which is today better known
as the Campine. On the poor sandy soils appeared little dense formations
of Pedunculate oak (Quercus robur L.), Sessile oak (Quercus petraea
LIEBL.), Birch (Betula sp.) and European aspen (Populus tremula L.).
Species like Beech (Fagus sylvatica L.) and Scots pine (Pinus sylves-
tris L.) were less abundant.
The development of the human civilization, however, had a direct and nege-
tive effect on the forest. The destruction and degradation of forest rea-
ched a climax in the 12 - 13th century with the establishment of the mo-
nasteries. These religious centra quickly turned into agricultural centra
based on extensive agricultural exploitation. An important element in the
agricultural economy of those days was sheep-breeding for the benefit of
the Flemish woolindustry.
The practice of the grazing-fiels caused radical changes in the forest
image : the natural regeneration of the hardwood species became impossible
through which the heather vegetation was promoted.
After a new deforestation phase round 1800, the degradation of forest had
reached a dangerous level. Under the influence of legal provisions mass
softwood plantations were carried out with Scots pine and from 1950 on,
Corsican pine (Pinus nigra ARNOLD Subsp laricio (POIRET) MAIRE) beca-
me more and more in practice because of its higher yields. In this way
spacious forests emerged, homogeneous and uniform of formation predestined
to be cut as pit-props.

As was shown above, the past took care of forest recovery but today forest
maintenance it at order. A lot of changes have taken place in Flanders
forestery since the period of the large scale afforestation. Most of the
campine cool mines had to shut down causing a serious reduction in demand
for pitprops, several rotations of Scots pine weakened the stand producti-
vity, higher costs of afforestation severely affected the remunerativeness
of the clear cutting system, misfortunes of biotic and abiotic nature
meant additional costs and losses. Not only did these economic factors cau-
sed important changes but there was also a growing social pressure on the
forest in this highly industrialised country.

From this point of view, it is obvious that forestry policy should abandon the idea of monofunctional forest in favour of forest stability. A certain step in the right direction is to strive for mixed forests (LEIBUNDGUT, 1951).

1.2. The stand conversions-issue

A conversion of the nowadays homogeneous Pine stands seems desirable. In other parts of Europe foresters are also confronted with this conversion problem, wich has resulted in a fairly rich literature on the subject.

Generally speaking, forestry politics do not offer on unambiguous recipe for stand conversion, and the existence of several methods and techniques is not to be denied.
Although not everybody is convinced of the necessity for the conversion of pure Pine stands. PETRI (1978) stresses the fact that deciduous trees have difficulties in forming fully fledged stands on the poorer soils. HOCHTANNER (1978) suggests that it would be better to give the Pine stands a serious silvicultural treatment instead of planning an early conversion. According to HENKEL (1975) it would be harmful to mix certain hardwood species with Scots pine. Pine forests with à dominant social function, on the other hand are quite appropriate to be mixed, still according to the two latter authors.

A first possible conversion technique consists in establishing a mixed stand of Scots pine and several hardwood species, after a clear-cutting. JUNACK (1978) and SINNER (1978) strongly object to this method because of the pronounced pioneer character of Scots pine and its oppressive growth in the early phases.

More consensus will be found at the idea of starting the conversion in the course of the stand development. An important fact hereby in the concern for the forest soil and humic and litter layer (RACHOY, 1973). PREUHSLER & REHFUSS (1982) obtained favourable results with an artificial fertilization (Ca, P, K, Mg) combined with repeated donation of N-fertilizer. POLLANSCHUTZ (1973) and RACHOY (1973) were able to restore the soil conditions in secondary Pine forests by means of a combined action of liming, strong thinning and the introduction of Lupine and deep-rooting hardwood species.
In general, little improvement is expected from artificial fertilization, liming or soil preparation. FANTA (1982) states that soil preparation on a soil with a defective soil profile has a pernicious influence on the forest regeneration.

A more subtle way to obtain a forest conversion in the course of the stand development is introduced by SINNER (1978). It is possible to execute a stand conversion as soon as when the canopy of the Pine stand begins to disintegrate. This is besides the moment from wich spontaneous ingrowth of hardwoodspecies occur and natural regeneration of Scots pine is detectable.
This phenomenon is also mentioned by JUNACK (1978). This critical phase is the starting-point of the so-called biological stand conversion : only selective interventions in the dominating crown-layer determine proportion of the mixture development and growing-up of the new stand. By means of adapted thinnings, favourable ecological conditions are created for the benefit of

the degradation of the litter-layer. The long period of regeneration and the slow opening of the canopy combined with several degrees in opening of the canopy, assure the formation of a complex forest structure. JUNACK (1978), however, advocates the preservation of Scots pine in the upper-stratum and states that the maintenance of the growing stock in this stadium should have priority over the regeneration.

SINNER is an unconditional proponent of the use of natural regeneration and his method agrees with what ECKHART (1973), LEIBUNDGUT (1981) and ROTTMAN (1981) have proposed. The several advantages of natural regeneration are sufficiently known (VAN MIEGROET, 1967 ; LEIBUNDGUT, 1984), but a conversion based on natural regeneration still needs a thorough preparation and a solid planning. MLINSEK (1973) and SPIECKER (1967) also emphasize the benefit of natural regeneration in the case of Scots pine stand conversion. However, natural regeneration is not necessary, when we see that the main goal is obtaining sound and stable forests (MLINSEK, 1976). Making use of artificial regeneration or of a supple combination of artificial with natural regeneration, can just as well lead to success (VAN MIEGROET, 1967).

The above mentioned biological stand conversion is on the better sites only applicable to Pine stands of 70 to 80 years old (JUNACK, 1978). Therefore can it be interesting to mention the experiences of ABETZ (1972) and HUSS (1983). Both authors recommend early strong thinnings followed by a decreasing thinning-intensity in order toe produce heavy sawwood. Simultaneous with these strong thinnings a good opportunity is created for the artificial addition of a deciduous understratum (ABETZ, 1972) or the spontaneous ingrowth of secondary tree species, is promoted (HUSS, 1983).

1.3. The succession-model of FANTA

The conversion-issue of pure stands is based on the striving for more stable and steady forests. The discussion on natural forest formation and forest evolution is closely connected with this striving. In this context the study can be mentioned of FANTA (1982) on the natural forest regeneration on dry sandy soils. This author examined the determinating facts for forest regeneration and he worked out a forest succession-model (FIGURE 1). This model encloses a primary succession and a secondary succession. The primary succession is found on naked soils without any vegetation, like sand-dunes. This succession is a more or less direct proceeding evolution of treeless, initial and transition stages on to a terminal stage.
When this terminal stage is reached, the secondary succession starts. This secondary succession seems to be a cyclic process composed of consecutive forest stages but also including treeless stages. From the point of the terminal stage on, three possibilities can occur :

1. the vegetation declines but regeneration of the same kind of vegetation is possible.

2. the vegetation declines but regeneration of the same kind of vegetation is not possible and another vegetation type emerges.

3. the vegetation declines without regeneration and regression occurs.
   A treeless vegetation emerges in the case of forest decay, naked vegetationless sites appear in the case of a treeless vegetation.

Figure 1 : Theoretical model of the succession on dry sandy soils (FANTA, 1982)
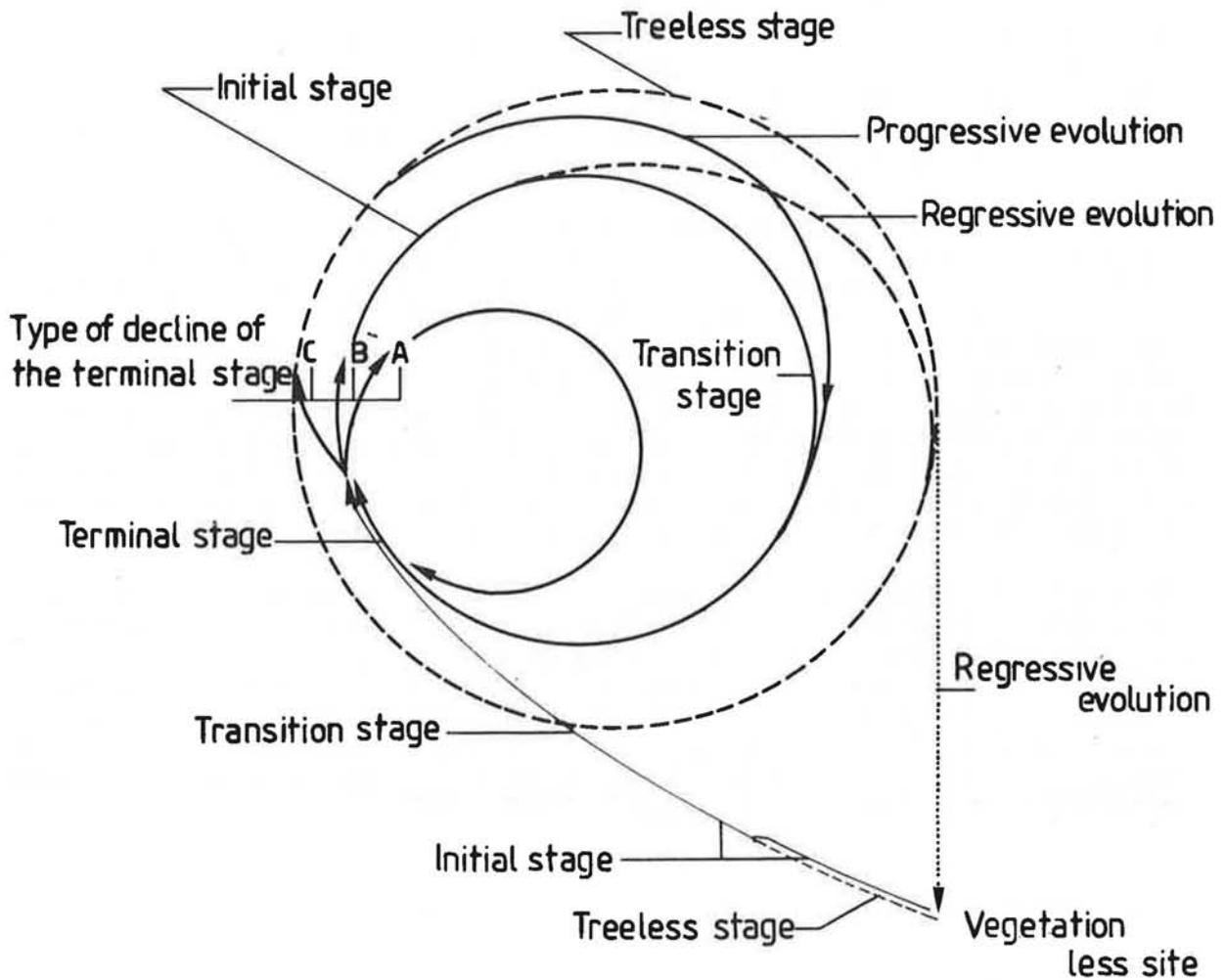
Legend

Type of decline

decline followed by regeneration of the same (tree) species
decline followed by regeneration of (an)other (tree) species
decline without regeneration

→ Forest development fitted in the whole of the secondary succession

- - -→ Development of the treeless stages fitted in the whole of secundary succession

- - -→ Forest development fitted in the whole of the primary succession

- - - -→ Development of the treeless stages fitted in the whole of primary succession

·············► Regressive evolution leading to a vegetation less site.

It is important to emphasize that according to FANTA a progressive forest evolution, primary as well as secondary, is coming about through the alternation of tree species in the succession. This means that a tree species is inclined to regenerate under the cover of another species, or in other words the succession proceeds in one way.

Important for the pine forests of the Campine is the fact that according to FANTA all indigenous hardwood species can regenerate under cover of Scots pine. Scots pine itself, however, regenerates only on those spots with a thin cover and on sites without any soil vegetation. This means that the share of Scots pine is future forest generations, in the case of a natural evolution, would strongly decrease in favour of the deciduous trees.

The study of natural regeneration and more specifically the spontaneous ingrowth of hardwood species in pure stands of Scots pine is of current interest in the Flemish forest research (VAN MIEGROET, 1983 ; LUST 1987). The present study tries to visualize the state of regeneration in 40 to 60 year old Scots pine stands growing on poor sandy soils without soil profile differentiation or continental sanddunes. The research was concentrated on initial regeneration phases and looked out for several regeneration types of which the composition and structure was closely examined.
The thorough research aimed at an occurate proving of the necessity for stable forests and the recognition of mixture as a means to obtain this.

2. THE STUDYCASE

The research was carried out in the municipal forest " In De Brand " at Hechtel-Eksel, Limburg. The forest is geografically to be situated between 51° 07' 15" - 51° 08' 01" N.L. and 5° 20' 28" - 5° 21' 35" E.L.
The forest occupies an area of 61 ha and consist for 2/3 out of Pine stands (43 % Scots pine, 23 % Corsican pine).
From a phyto-sociological point of view, the district can be characterized as the Birch-sessile (and pedunculate) oak forest region of Limburg (Querco sessiliflorae-Betuletum R.Tx.).
The mean altitude ranges from 60 to 65 m above sea level, with a local strong relief because of the sanddune formations.
Hechtel-Eksel has a " Campine climate " wich is more continental than the more moderate climate of the atlantic type in the lower parts of Belgium.

air temperature   - annual average   = 9,3° C

          - mean coldest month   = 2,1° C (January)

          - mean warmest month   = 17,3° C (July)

          - average in vegetation period   = 15,2° C

period free of frost (mean annual) = 171 days

rainfall   - annual average   = 867 mm

          - average in vegetation period   = 210 mm

The stands are growing on sandy soils whether or not with a soil profile differentiation. The most abundant soil type of the area is the humic-podsolic soil.
In the examined forest, however, the greater part is situated on not differentiated coarse sandy soils or continental sanddunes, which are partially still moving. These sands are of niveo-eolic origin deposited during the Würm ice-age in about two meter thick packets.
These soils have a quick intern drainage wich can lead to watershortage even in the early spring and especially in relatively dry years.
The foreststands are of artificial nature and the oldest stands are dated 1924. The earliest plantations, however, were carried out with Cluster pine (Pinus pinaster AIT.) in 1980, but largely failed.
The stands were not surrounded by firebelts, unlike other forests in the Campine (LUST, 1987).

3. THE REGENERATION TYPES

3.1. The criteria

One of the objectives of the research was to describe the initial natural regeneration state in the forest (at study) and to make a distincion between several regeneration types.
Strictly spoken, there are in the studied forest four possible ecological starting-conditions for natural regeneration :

1) regeneration under cover of Scots pine
2) regeneration under mixed cover of Red oak (<u>Quercus rubra</u> L.) and Pedunculate oak
3) regeneration on free field
4) regeneration under cover of Corsican pine

In the stands of Corsican pine, aged 22 to 32 years, no regeneration was found.

An other criterion in order to distinct several regeneration types are the species composition and the degree of mixture. Six tree species frequently come to regeneration, namely :

1) Scots pine
2) Pedunculate oak
3) Red oak
4) Birch
5) Black cherry (<u>Prunus serotina</u> EHRH.)
6) Alder buckthorn (<u>Frangula alnus</u> MILL.)

It is remarkable that on several sites always one species clearly dominates the regeneration. In this way it becomes possible to distinguish six regeneration types named after the dominating species. In combination with the diversity in ecological starting-conditions, the following regeneration-description arises :

1) regeneration under cover of Scots pine

    - Scots pine dominating   type P
    - Pedunculate oak dominating   type Q
    - Black cherry dominating   type Ps
    - Alder buckthorn dominating   type Fa

2) regeneration under mixed cover of Red oak and Pedunculate oak

    - Red oak dominating   type Qr

3) regeneration on free field

    - Birch dominating   type B

The research is concentrated on these six regeneration types. TABLE 1 gives a survey of the most important characteristics of the stands in which the natural regeneration is studied.
It is important to emphasize that this study deals with initial regeneration phases which have not been consolidated, and represents thus only the juvenile phase of establishment.

3.2. The composition of the regeneration types

Table 2 shows the specific composition of the several regeneration types.
The types Q, B, Ps and Fa can be considered as mixed regeneration types
while the types Qr and P rather appear as homogeneous regenerations.
Only two species, namely Alder buckthorn and Birch were found in all six
regeneration types. Scots pine is well represented in the several regene-
ration types except in the type Qr. Rowan tree and Holly (Sorbus aucupa-
ria L. and Ilex aqquifolium L.) do not occur in every regeneration type
and can rather be considered as rarities in the typology of the regene-
ration.

Extremely interesting is the comparison between Pedunculate oak and Red
oak. Pedunculate oak occurs in five of the six types while Red oak is
present in only two. Seedlings of Red oak were found in a stand of Red
oak and never in Scots pine stands. The pedunculate oak on the other hand
does not regenerate under its own cover but does so under cover of Scots
pine. Red oak appears to have a great affinity for its own cover and shows
a large inhibitionability.

Outside the foreststands Birch dominates the regeneration. Along with Scots
pine this species forms the pioneer settlement. However, species like Pe-
dunculate oak and in a lesser degree Black cherry and Alder buckthorn are
already present in this pioneer settlement.

3.3. The densities of regeneration

The mean regeneration density varies from 266 pro are (type Q) to 4166 pro
are (type Qr) (Table 2). Even when the poor soils and the absence of
silvicultural interventions are taken into account, this result can be qua-
lified as high.
Again, there is no clear difference between Pedunculate oak (type Q) and
Red oak (type Qr). The latter species regenerates in massive quantities,
while the establishment of Pedunculate oak looks more modest.
Notice the good regeneration result of Scots pine, showing a certain force
and potency.
The serving species Alder buckthorn and Black cherry seem to have no diffi-
culties to regenerate.
Furthermore, it can be remarked that the greater part of seedlings was found
in stands without any soil vegetation to speak of (Table 1 and Table 2).

4. SHORT-TIME VARIATIONS IN REGENERATION DENSITY

Four permanent rectangular plots were laid out per regeneration type., in
order to examine the short-time variations in the composition of the types.
The number of seedlings of each species in these plots has been observed
on several dates, namely :
                    T1 : end summer 1986
                    T2 : beginning spring 1987
                    T3 : end summer 1987

This arrangement makes it possible to examine the effect of the winter period 1986 - 1987 and to make a comparison between two equivalent surveys separated by a one year period. The results of these observations relating to the main species are given in Table 3. The analysis of these results, based on analysis of variance coupled to the DUNCAN-test, lead to the following conclusions :

1. The position of the principal species was never threatened during the observation period. The species that was regarded as the main species (based on their dominating stem number) during the first observation stayed dominant in the following observations.

2. The influence of the winter period stayed limited. It was never observed that a certain species disappeared as a result of the eliminating activity of the winter period. The density of regeneration of the main species was not sensible to the influence of the winter period except for Scots pine and Red oak. The lesser regeneration result of Red oak after the winter was due to a general rodent damage. The browsed seedlings, however, restored their growth in the following growing season. Only in the population of Scots pine there was a significant elimination of the weakest individuals during the winter period.

3. The best regeneration results were obtained during the third observation. A thinning during the winter was largely made up in the next growing season. It was frequently observed that in the course of the study period the number of species in a given regeneration type increased. This clearly shows that early regeneration phases are characterised by a high degree of variability.

4. Seen over a short period of time, strong variations were observed in the proportions of density between the secondary species of certain regeneration types. These variations were undoubtedly connected to differences in blooming and fructification periodicity and to local circumstances which are favourable to germination. In the last observation for example, Scots pine, Black cherry and Alder buckthorn on the one hand and Scots pine and Alder buckthorn on the other, climbed up to the density levels of the main species in the regeneration types Q and P_S respectively.

5. The geographical distribution of and the evolutions within the several regeneration types illustrate the complexity of the issue of succession. The different regeneration types can be considered as sources for forest regeneration. This means that the starting-points of forest succession are not similar and can differ strongly from place to place. Contradictory to the opinions of JUNACK (1978), SINNER (1978) and FANTA (1982), the spontaneous ingrowth seems not to wait for the geografical decline of the pine canopy. Early occupied positions can be determining for the following evolution of the regeneration. An initial settlement which can grow up to a well constructed regeneration layer can become an obstacle for the expected settlement of Pedunculate oak and Birch (FANTA, 1982). The later occuring decline of the pine stand could well come too late.

Furthermore, in the higher mentioned succession model of FANTA, abstraction has been made of the exotic tree species. However, it seems that species like Red oak and Black cherry can play an important part in the natural regeneration in pine stands. Especially with regard to the application of the succession model in forest practice, it can be interesting to mention the effect of these tree species on the forest regeneration and the development of the regeneration group.

5. THE AGE DISTRIBUTION

By determing the age of the several elements of a regeneration group, it becomes possible to form a notion of the age distribution and the process of settlement in this regeneration group. This was studied in the above mentioned permanent rectangular plots and some supplementary plots.

The results show that the establishment of the seedlings does not proceed in a similar way for all regeneration types. Pedunculate oak, a so-called climax species, belongs to the very first settlers but is not able to cover the whole forest area (Table 4). In other stands of the forest, other species appear as first settlers,though this settlement does not occur simultaneously with the settlement of Pedunculate oak. In this respect, it should be pointed out that a species characterised as main species in a given stand, can appear as secondary species in another or even in the same stand, and vice versa.

In this way, one site - which is more or less homogeneous in physical conditions - shows a clear mosaic-formed succession pattern which is in contradiction to the unidirectional succession theory. This is being confirmed by the fact that in each regeneration type the main species settles as first. The ability of succeeding in a first settlement seems to be determing with regard to the later domination in regeneration density (Figures 2).

Furthermore, it was never observed that certain tree species act as pioneers which prepare the site for the more tolerant tree species. This is by no means a confirmation of the Relay-floristics-theory of ODUM (1971).

The age distribution of the main species of the types of regeneration Q, B and Ps shows a pyramidal structure (Figures 2) where the dominating age class falls half-way down the age distribution. The appearance of such a year does not correspond to a maximal initial regeneration result but corresponds more with a maximal survival in that year due to favourable circumstances for settling and surviving. Such a distribution indicates an almost completed regenerationphase. It is remarkable that the secondary species of these regeneration types often settles after the dominating ageclass of the main species. This illustrates again the high variability of the regeneration phase. In the course of the evolution this variability will decrease as a result of the increasing geographical needs of the dominating elements.

The regeneration types P and Fa have a different age distribution. Here the one-year old seedlings are in the majority which is indicative of an early regeneration phase. Alder buckthorn seems to work on a definitive settlement whereas Scots pine has difficulties to regenerate under its own canopy. These rather pessimistic results are partially contradicted when the Southern edge (Redge in Figures 2) of the same stand is examined : here indeed Scots pine is able to grow up, be it in a typical edge-climate.

The regeneration type Qr takes up a special place in the typology. It was already higher mentioned that this dense regeneration suffers from rodent-damage, particularly caused by rabbits. In some cases, 3 year old seedlings were found showing four scars. Each time the leading shoot was decapitated but lateral buds restored the growth process. Because of this additional growth-stress it becomes impossible to say whether this regeneration is a contineous plenomenon during which the oldest seedlings are constantly eliminated or that the whole regeneration is only three years old.

Again these results illustrate the high variability in time and in space. This variability is due to micro-ecological site differences, the life history ad hoch of the tree species (VAN MIEGROET, 1983) and the seed-availability. The randomness of this variability seems to contradict the idea of the uniqueness of the forest succession.
Besides, it appears that the basis for future dominance is laid out in an early phase. This is an important finding as to the forest practice.

6. DIFFERENTIATION AND STRUCTURATION

6.1. The early differentiation

Important differences exist between the components of the regeneration groups caused by genetic facts, unequal demands as to location and light intensity differences in responding ability to changes in growth environment and age differences.
These disparities lead to variations in height and in this way to structural development and social differentiation.
The perception of these relative growth differences and the distinction of the social dominance have important consequences for forest practice. The developmental dynamics are most intensive in young forest stands, more specific in the period preceding the culmination of the current height increment. Within this period,thestructure of the forest stand must be established definitively.
The differentiation research can be carried out by means of comparison of the mean age between arbitrary chosen height classes. Such an investigation gives important information about the social dynamics (Table 5). Information of the same kind can be obtained by comparing

the average height of the seedlings belonging to consecutive age-classes
(Table 6).

The differentiation research shows that the higher mentioned social stra-
tification sets in quite early and is connected with age differences. In
the early phases of settling, age-classes seem to correspond with height-
classes. This means that a settling-lead of one year can be sufficient in
order to gain and maintain a dominant social position for the following
years. This is being confirmed by a positive correlation between age and
height of the seedlings. (Table 7).
The dominating elements arise out of the population of the very first
settlers after the natural selection of the first degree or the selection
due to external biotic and abiotic agents. The later settlers are not sub-
ject to social promotion which means that the early settlers do not func-
tion as pioneers which modify their direct surrounding in favour of the
later settlers.
The early start of the social differentiation has again important conse-
quences for the forest practice. Namely, social differentiation is closely
linked to functional differentiation : the treatment of the regeneration
groups must be concentrated on the phase of the initial settlement because
that is where the basis is laid for the future social relations. The choice
of the preserved species and individuals must consequently be carried out
early.
Thanks to these early interventions it becomes possible to pay attention to
the slightest variations in micro-ecological growth conditions in order to
obtain an appropriate new forest stand.

6.2. Social differentiation of the Red oak population

Table 6 shows that the regeneration type Qr shows a deviant differentiation
structure as a result of an incessant browsing activity of rabbits. The
seedlings which have not been damaged are on the average higher and younger
than the seedlings with one browsing-scar (Table 8). A single appearing
browsing has already a clear harmful effect on the height-growth of Red oak
seedlings. Growth recovery is not able to restore the suffered losses.
There is no difference in average height between seedlings which have been
browsed once or twice. The latter, however, are on average older than the
former. Incessant browsing has consequently a negative effect on the height-
growth and levels the social positions.

6.3. The specific growth properties

A comparison of the growth of the several main species (Table 7, Table 9)
indicates that Black cherry is the fastest growing species, followed by
Birch, even if it is growing in suitable conditions on the free field. In
falling order of growing power follows Pedunculate oak, Alder buckthorn,
Red oak and Scots pine.

Table 10 show the mean annual height increment pro age-class. A more or less constant course is perceivable in the case of Alder buckthorn and Scots pine, a slight increase is shown for Birch whereas Black cherry signs for a steady increase.
The situation is totally different for both Oak-species. The highest shoot length is realised in the very first growing season of the seedlings life, when the seedling can still dispose of its reserve piled up in the acorn. Later on, the growth falls back followed by a tardy growth inforcement.

The results point to a strong growth force and potential suppressionability of Black cherry. Early interventions are of the utmost importance in order to keep a strict hand upon the Black cherry population in favour of the planned composition of regeneration.
The high regeneration densities of Scots pine is outweighed by the weak growth performance. Special interventions such as thinning the upper canopy and a constant following of and intervening in the composition of the regeneration groups are necessary to give Scots pine a chance.
The growth of Pedunculate oak can be regarded as satisfactory but is coupled with rather low regeneration densities. A combination of natural and artificial regeneration could help if a forest conversion is the aim.

7. CONCLUSIONS

In the municipal forest " In De Brand " in the north-eastern part of Belgium, six natural regeneration types were characterised in forest stands growing on not-differentiated sandy soils by means of the dominance of a single species. On several sites under cover of 30 to 60 year old Scots pine stands, the regeneration is dominated respectively by Pedunculate oak, Scots pine, Alder buckthorn and Red oak, whereas Birch dominates on the free field. Red oak forms a homogeneous regeneration type in a 62 years old mixed stand of Pedunculate oak and Red oak.
This specific variation combined with a geographical variation shows a mosaic-formed succession pattern and contradicts the idea of the uniqueness of the forest succession linked to a given site.

The research of the age differences of the seedlings brought up that the main species of each regeneration type settles first. The early settlers keep on dominating the whole regeneration for several years. This might lead to the conclusion that settlement is rather determined by accidental facts such as the availability to supply seed on the right moment and the life history ad hoc of the treespecies, than by a directed internally controled succession.
This statement is fully confirmed by the analysis of the growth differentiation : social positions in a regeneration group are connected to age differences. The first settlers maintain a social dominant position during the years following settlement. It was never observed that the first settlers act as pioneers on behalf of the later settlers. This underlines the importance of early silvicultural intervention in natural regeneration groups.

The analysis of the regeneration types has frequently illustrated the high variability of the regeneration phase. During the research period it was more than once observed that the number of species in a given regeneration type increased. These late settlers, however, form a rather feeble sub-population and it is to be expected that this variability will fade away in the course of the evolution of the regeneration group is concern.

The perceived variations in composition of the regeneration types guarantee favourable prospects in view of the geografical variation and choice of the tree-species in case of a stand conversion. A stand regeneration carried out in groups stands close to the observed spontaneous processes.

Table 1   Stand characteristics (Summer 1986) with stemnumber pro ha N, mean girth on 1.50 m $\bar{o}$ (cm), mean height $\bar{h}$ (m) and basal area G (m²/ha)

R type	Stand n°	Plant year	Species	N	$\bar{o}$	$\bar{h}$	G	Soil vegetation
Q	24a	1924	S.Pine	540	77	18,8	25,84	Deschampsia flexuosa (L.) TRIN.
Ps	26	1949	S.Pine	1180	51	15,2	25,51	Deschampsia flexuosa(L.) TRIN.
P	28	1949	S.Pine	1050	53	15,9	24,57	-
Fa	36	1924-1926	S.Pine	820	71	18,8	34,04	Deschampsia flexuosa(L.) TRIN.
Qr	37	1924-1926	P.oak	870	33	11,7	8,32	-
			R.oak	270	66	16,7	11,20	-
			S.Pine	50	66	16,4	1,70	-
B	40b	-	-	-	-	-	-	Deschampsia + Calluna

Table 2   Species composition and density of regeneration N (stemnumber pro are) of the six regenerationtypes ranged pro species

R. type		P. oak	R. oak	S. pine	Birch	Bl. ch.	Al. bu	Rowan tree	Holly	TOTAL
Q	N	110,7	-	75	1	43,5	28,2	7,7	-	266
	%	41,6	-	28,2	0,4	16,4	10,6	2,9	-	100
Qr	N	-	4133,2	-	11	11	11	-	-	4166,2
	%	-	99,1	-	0,3	0,3	0,3	-	-	100
P	N	11,0	-	1414	13,8	5,5	44,3	2,8	2,8	1494
	%	0,7	-	94,6	0,9	0,4	3,0	0,2	0,2	100
B	N	17,2	1,2	95,2	562,5	1,2	3,8	-	-	681,2
	%	2,5	0,2	14,0	82,6	0,2	0,6	-	-	100
Ps	N	19,7	-	110,8	10,3	301,3	59	8,3	-	509,3
	%	3,9	-	21,7	2,0	59,2	11,6	1,6	-	100
Fa	N	40,3	-	56,3	18,3	-	1024	-	-	1138,8
	%	3,5	-	4,9	1,6	-	89,9	-	-	100

Table 3   Stemnumber pro are of the main species in the permanent plots
           of each regenerationtype ranged in order of observation time
           T1, T2, T3

Plot	T1	T2	T3	Plot	T1	T2	T3
Q I	92	84	92	B I	352	324	381
Q II	76	72	76	B II	714	695	705
Q III	164	164	168	B III	1000	914	943
Q IV	104	104	107	B 4	226	221	221
Qr 1	4356	0	2889	Ps 1	320	296	344
Qr 2	7778	1644	5911	Ps 2	139	123	139
Qr 3	7333	2800	4489	Ps 3	244	194	269
Qr 4	3822	1511	3244	Ps 4	453	413	453
P I	1211	667	1089	Fa I	1438	467	981
P II	1889	1278	2533	Fa II	667	311	1144
P III	978	633	1056	FA III	895	438	971
P IV	1089	578	978	FA IV	468	338	1000

Table 4   Review of the age distribution ranged pro regeneration type
with : youngest age-class l min. oldest age-class L. Max and the
dominating age-class DAC in years (between brackets : percentage
with regard to the total number of seedlings)

Plot	Main species		Total	
	l min / L Max	DAC (%)	l min / L. Max	DAC (%)
Q I	1 / 7	4 (47,8)	1 / 7	1 (42,6)
Q II	1 / 13	6 (21,1)	1 / 13	1 (66,7)
Q III	1 / 14	2 (26,5)	1 / 14	3 (27,7)
Q IV	1 / 10	7 (20,7)	1 / 10	1 (57,5)
Qr I	1 / 3	2 (72,3)	1 / 3	2 (72,0)
Qr II	1 / 3	2 (60,4)	1 / 3	2 (60,4)
Qr III	1 / 3	2 (70,8)	1 / 3	2 (70,8)
P I	1 / 2	1 (95,9)	1 / 2	1 (95,1)
P II	1 / 2	1 (96,1)	1 / 2	1 (95,7)
P III	1 / 2	1 (90,5)	1 / 3	1 (89,6)
P IV	1 / 1	1 (100,0)	1 / 3	1 (96,9)
Pedge	1 / 4	1 (60,0)	1 / 6	1 (56,0)
B I	1 / 6	3 (37,5)	1 / 6	1 (40,7)
B II	1 / 6	4 (31,1)	1 / 6	4 (29,5)
B III	2 / 6	4 (48,9)	1 / 6	4 (46,2)
Ps I	1 / 8	3 (45,2)	1 / 8	3 (40,8)
PS II	1 / 8	4 (25,0)	1 / 8	2 (23,6)
Ps III	1 / 6	3-4(23,8)	1 / 6	1 (33,3)
Fa I	1 / 3	1(71,8)	1 / 3	1 (70,1)
Fa II	1 / 4	1 (72,8)	1 / 5	1 (73,0)
Fa III	1 / 4	1 (47,1)	1 / 4	1 (53,3)
Fa IV	1 / 3	1 (61,0)	1 / 3	1 (60,5)

Table 5   Age differences (years) between consecutive heightclasses (cm)

Plot	Species	Height-class	Age	tw	Plot	Species	Height-class	Age	tw
Q III	P. oak	0-20 20-40 40-60 60-80	2,38 3,88 5,00 6,33	5,7933*** 2,9069** 1,6956	B II	Birch	0-20 20-40 40-60 60-80	1,50 2,85 3,57 5,00	5,5489*** 2,3453* 2,4495*
Q IV	P. oak	0-20 20-40 40-60 60-80 80-100	1,50 4,00 5,67 6,00 8,17	2,6207* 2,3146* 0,4879 3,2614**	Ps I	Bl.ch.	0-16 16-32 32-48 48-64 64-80 80-96 96-112	1,91 2,95 3,44 3,77 4,50 5,20 6,60	12,2245*** 3,9353*** 1,5186 1,9495 1,6724 4,4272**
P.edge	S. Pine	0-8 8-16 16-24 24-32	1,12 2,69 3,05 3,50	17,9743*** 2,4968* 1,461	Fa V	Al.bu.	0-16 16-32 32-48	1,01 2,29 3,33	8,3048*** 3,3213***
B I	Birch	0-20 20-40 40-60 60-80 80-100	2,00 2,82 4,16 4,77 5,33	2,7713* 6,0536*** 2,4087* 1,1000					

Table 6 Differences in average height (cm) between consecutive age-classe (years)

Plot	Species	Age	Height	tw	Plot	Species	Age	Height	tw
Q III	P. oak	2 / 3	10,92 / 21,00	3,4493**	PS I	Bl.ch.	1 / 2	8,62 / 11,64	3,4333***
		3 / 4	21,00 / 31,78	2,7403*			2 / 3	11,64 / 24,89	10,6340***
		4 / 5	31,78 / 39,50	1,4041			3 / 4	24,89 / 47,56	9,0004***
		5 / 6	39,50 / 60,67	2,4643*			4 / 5	47,56 / 72,00	4,0506***
Q IV	P. oak	4 / 5	38,00 / 56,00	2,7136*	Ps II	Bl ch.	1 / 2	7,00 / 17,11	3,4769**
		5 / 6	56,00 / 54,00	0,3158			2 / 3	17,11 / 36,15	3,2894**
		6 / 7	54,00 / 79,30	2,9698*			3 / 4	36,15 / 65,29	4,1048***
		7 / 8	79,30 / 82,00	0,2095			4 / 5	65,29 /108,46	4,0267**
Redge	S.pine	1 / 2	5,39 / 8,42	5,7494***			5 / 6	108,46 /151,14	2,2936*
		2 / 3	8,42 / 15,13	7,8429**	Fa II	Al.bu	1 / 2	7,87 / 16,11	5,8872***
		3 / 4	15,13 / 23,00	2,2415*			2 / 3	16,11 / 27,14	4,6006***
B I	Birch	1 / 2	10,00 / 22,36	2,8937*			3 / 4	27,14 / 30,00	0,8648
		2 / 3	22,36 / 34,27	3,4726**	FA V	Al.bu.	1 / 2	9,96 / 23,00	8,3373***
		3 / 4	34,27 / 43,33	1,9657			2 / 3	23,00 / 28,15	2,2372*
BII	Birch	1 / 2	8,67 / 23,00	3,1041*			3 / 4	28,15 / 32,00	1,1132
		2 / 3	23,00 / 32,11	2,0697*	Qr I	R oak	1 / 2	9,54 / 13,83	6,1005***
		3 / 4	32,11 / 54,00	6,1967***			2 / 3	13,83 / 12,00	1,0136
		4 / 5	54,00 / 58,27	1,1848					
		5 / 6	58,27 / 80,00	3,9453***	Qr II	R.oak	1 / 2	8,24 / 11,41	4,3711***
							2 / 3	11,41 / 11,87	0,3701
BIII	Birch	2 / 3	25,00 / 43,23	2,3712*					
		3 / 4	43,23 / 59,57	3,1445**	Qr III	R.oak	1 / 2	7,22 / 10,52	4,9854***
		4 / 5	59,57 / 85,20	3,5796**			2 / 3	10,52 / 10,52	0,2974

Table 7   Correlation between Age X (ears) and Height Y (cm)

Plot	Species	N	Regression	r	Fw
Redge	S. pine	230	Y = 0,03 + 5,04 X	0,81	456,89***
Q I	P. oak	23	Y =-2,31 + 11,26 X	0,74	26,063***
Q II	P. oak	19	Y =-11,57 + 11,98 X	0,84	41,61***
Q III	P. oak	49	Y =-33,51 + 17,89 X	0,90	204,69***
Q IV	P. oak	29	Y = -6,35 + 11,59 X	0,85	73,190***
B I	Birch	40	Y = -3,11 + 12,50 X	0,85	106,9407***
B II	Birch	74	Y = -5,94 + 13,82 X	0,84	168,347***
B III	Birch	47	Y = -2,35 + 15,37 X	0,67	37,19***
Ps II	Bl.ch	68	Y = -57,99 + 33,96 X	0,88	217,9391***
Ps III	Bl.ch	21	Y = -55,07 + 33,14 X	0,88	64,2497***
Fa I	Al. bu	103	Y = 1,86 + 4,92 X	0,66	77,4031***
Fa III	Al. bu	52	Y = 0,99 + 7,43 X	0,87	145,1104***
Qr II	R. Oak	164	Y = 6,36 + 2,31 X	0,31	17,6754***

Table 8   Comparison of mean height $\bar{Y}$ (cm) and mean age $\bar{X}$ (years) between
           several types of seedlings of Red oak (0 = no browsing ;
   1 = one scar ; 2 = two scars).

Plot	Type seedling	$\bar{Y}$	tw	$\bar{X}$	tw
Qr	0 / 1	13,76 / 10,79	3,2077**	1,61 / 2,08	4,4062***
	0 / 2	13,76 / 10,86	1,9332	1,61 / 2,43	4,7422***
	1 / 2	10,79 / 10,86	0,0626	2,08 / 2,43	3,0494***
Qr II	0 / 1	12,17 / 10,28	2,4241*	1,77 / 2,08	3,9052***
	0 / 2	12,17 / 10,19	2,9031**	1,77 / 2,29	4,2335***
	1 / 2	10,28 / 10,19	0,1052	2,08 / 2,29	2,109*
Qr III	0 / 1	15,92 / 12,51	3,1234**	1,76 / 1,96	2,671**
	0 / 2	15,92 / 12,13	2,8515**	1,76 / 2,00	
	1 / 2	12,51 / 12,13	0,3122	1,96 / 2,00	

Table 9   Review of mean height Ȳ (cm), mean age X̄ (years) and mean
   annual height in crement Ȳ / X̄ (cm/y) ranged pro main
          species

Plot	Species	Ȳ	X̄	Ȳ / X̄
Ps I	Bl.ch	27,06	2,84	9,52
Ps II	Bl.ch	77,82	4,00	19,46
Ps III	Bl.ch	64,86	3,62	17,92
B I	Birch	31,90	2,80	11,39
B II	Birch	46,16	3,77	12,24
B III	Birch	55,19	3,74	14,74
Q I	P. oak	40,79	3,83	10,66
Q II	P. oak	63,47	6,26	10,13
Q III	P. oak	34,41	3,80	9,06
Q IV	P. oak	61,17	5,83	10,49
Fa I	Al. bu	8,25	1,30	6,34
Fa II	Al. bu	11,13	1,38	8,07
Fa III	Al. bu	14,55	1,82	7,98
Fa IV	Al. bu	12,81	1,55	8,29
Fa V	Al. bu	14,69	1,48	9,89
Qr I	R. oak	12,75	1,81	7,03
Qr II	R. oak	10,49	1,79	5,87
Qr III	R. oak	9,80	1,87	5,23
P I	S. pine	5,55	1,04	5,33
P III	S. pine	6,00	1,09	5,48
Redge	S. pine	8,45	1,67	5,06

| Plot	Species	1	2	3	4	5	6	7	8	9	10
Q I	P.oak	6,00	11,00	10,00	10,50	12,00	9,45	-	-	-	-
Q II	P.oak	18,00	7,00	11,33	8,50	6,80	10,33	9,14	9,25	-	10,2
Q III	P.oak	18,00	5,46.	7,00	7,95	7,90	10,11	21,43	8,75	-	-
Q IV	P.oak	14,00	7,00	9,33	9,50	11,20	9,00	11,33	10,25	12,89	9,00
Pedge	S.pine	5,39	4,21	5,04	5,75	-	-	-	-	-	-
B I	Birch	10,00	11,18	11,42	10,83	13,20	12,30	-	-	-	-
B II	Birch	8,67	11,50	10,70	13,50	11,65	13,33	-	-	-	-
B III	Birch	-	12,50	14,41	14,89	17,04	11,33	-	-	-	-
Ps I	Bl.ch	8,62	5,82	8,29	11,89	14,40	15,50	14,19	16,42	-	-
Ps II	Bl.ch	7,00	8,56	12,05	16,32	21,69	25,19	31,00	24,25	-	-
Ps III	Bl.ch	6,31	5,50	12,40	15,30	22,80	28,33	-	-	-	-
Fa I	Al.bu	6,92	5,45	7,33	-	-	-	-	-	-	-
Fa II	Al.bu	7,87	8,05	9,05	7,50	-	-	-	-	-	-
Fa III	Al.bu	8,50	8,08	7,44	9,50	-	-	-	-	-	-
Fa IV	Al.bu	8,55	8,45	7,78	-	-	-	-	-	-	-
Fa V	Al.bu	9,96	11,50	9,38	8,00	9,20	-	-	-	-	-
Qr	R.oak	9,54	6,91	4,00	-	-	-	-	-	-	-
Qr II	R.oak	8,24	5,71	3,96	-	-	-	-	-	-	-
Qr III	R. oak	7,22	5,26	3,41	-	-	-	-	-	-	-

Table 10   Review of the mean annual height in crement (cm/year) of the main species at several ages.
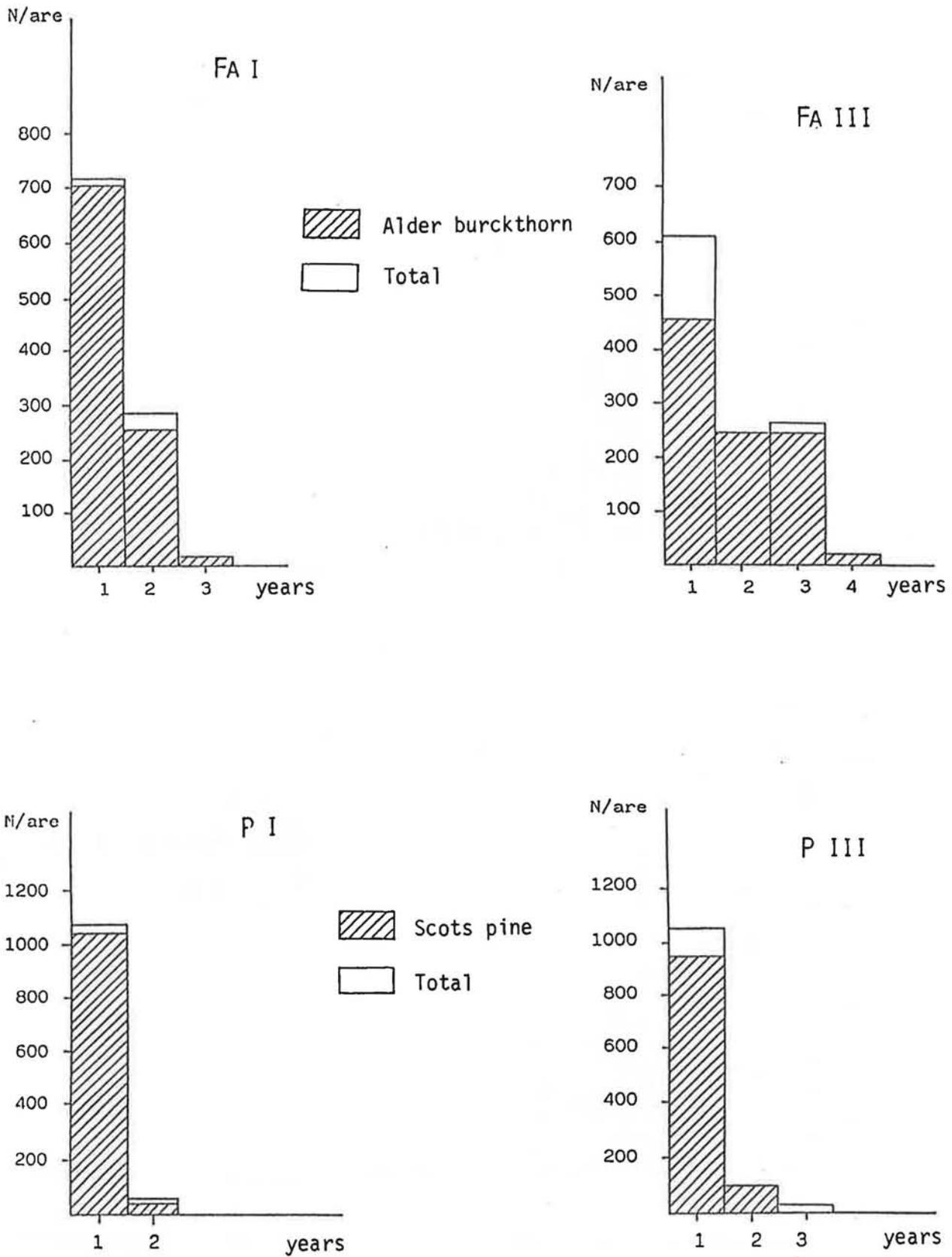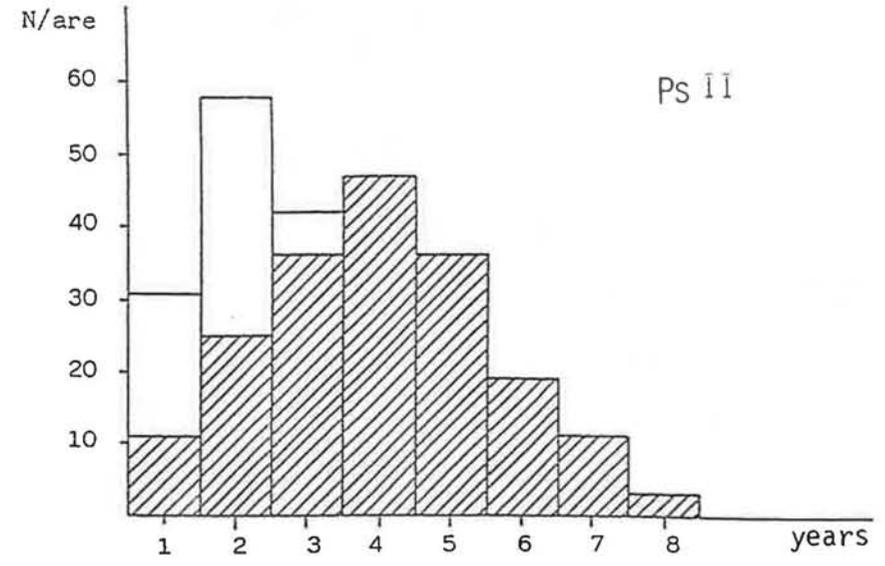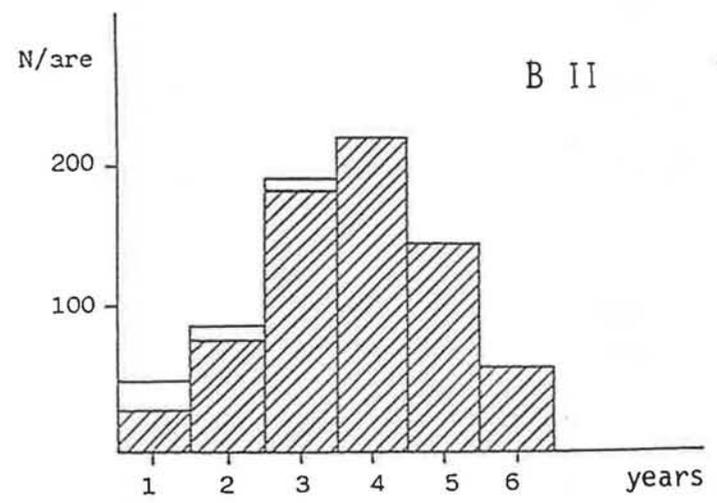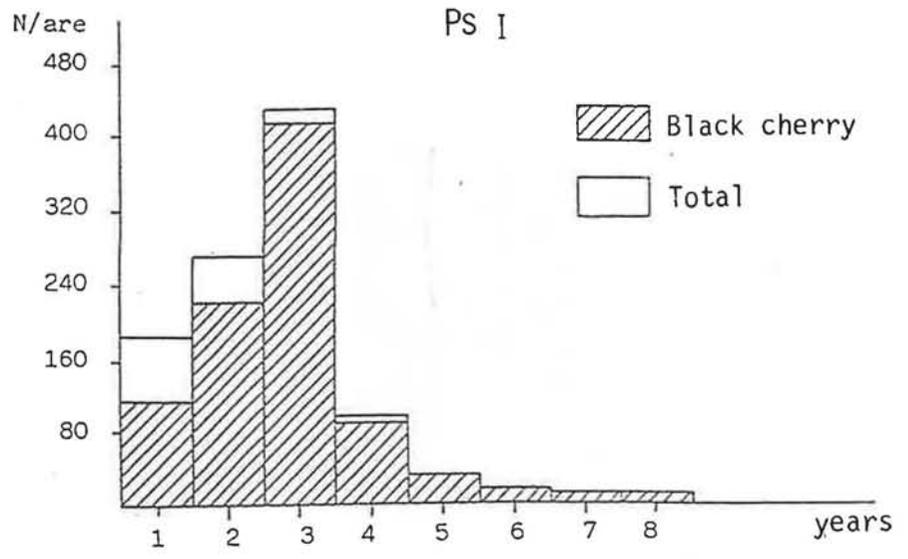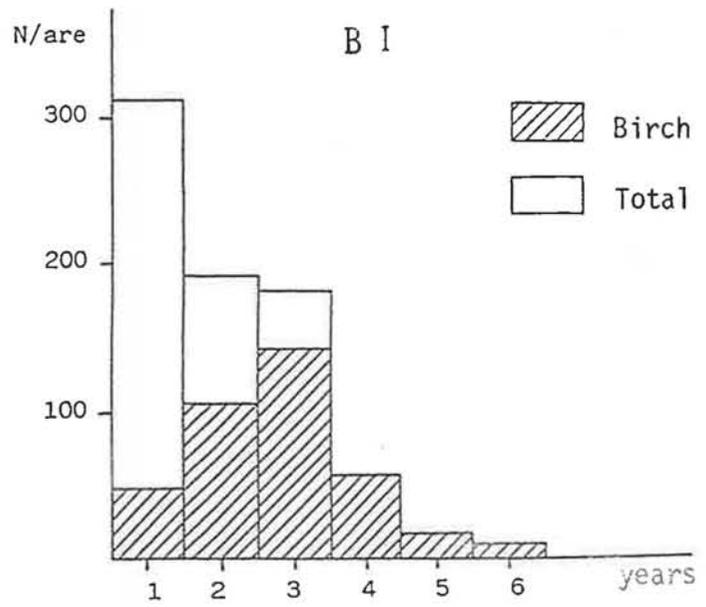
Figures 2 : Age-class distribution of the main species of the regeneration types
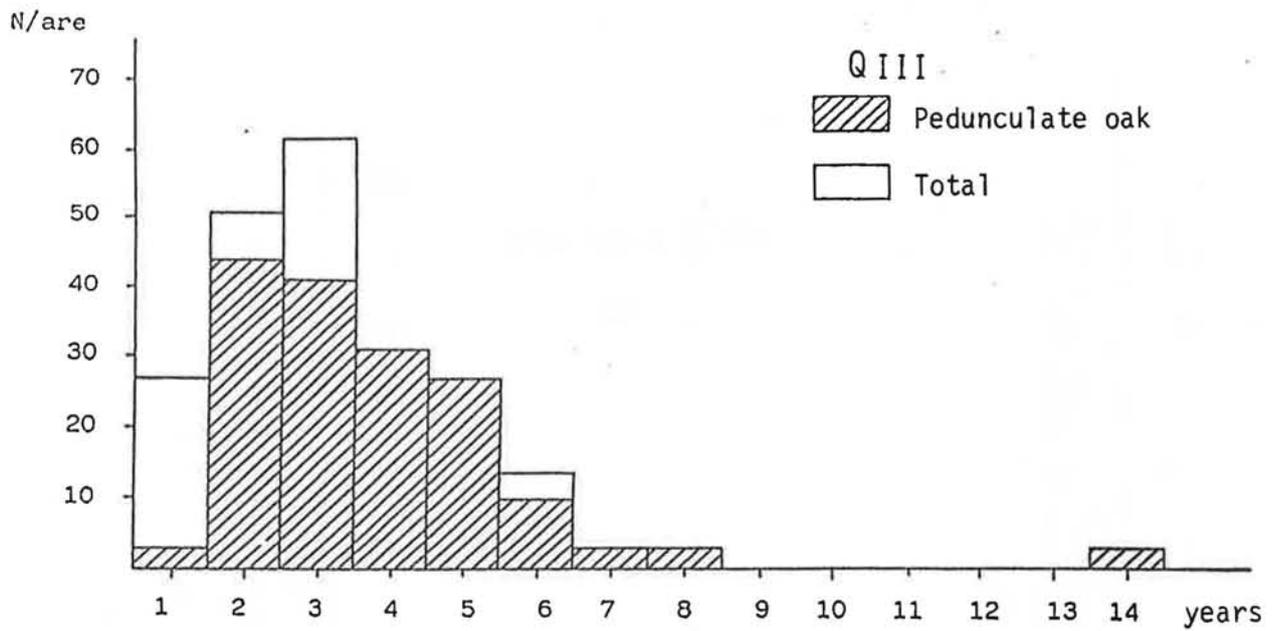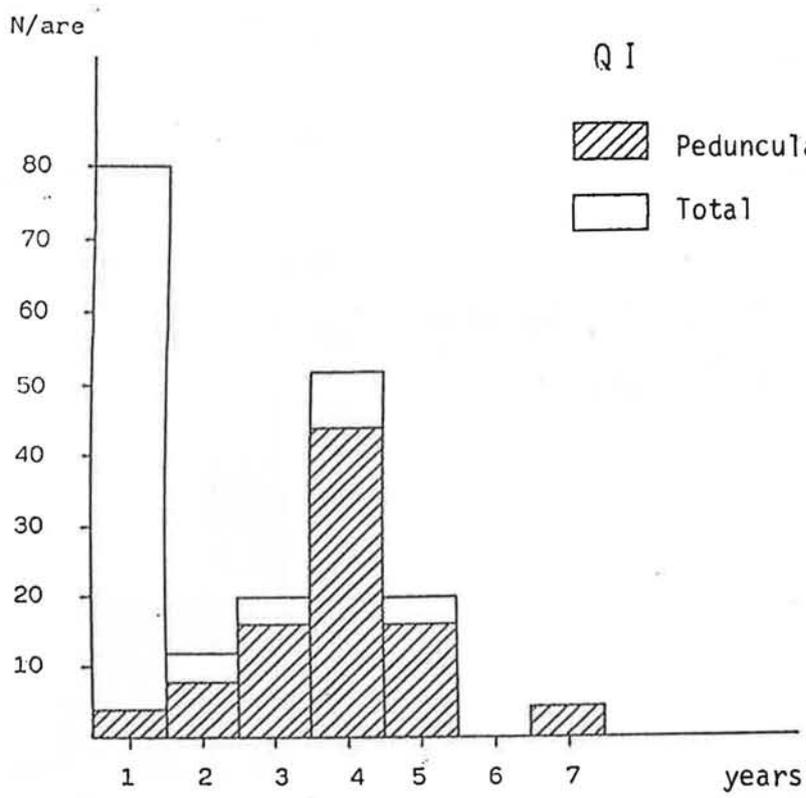
Figures 2
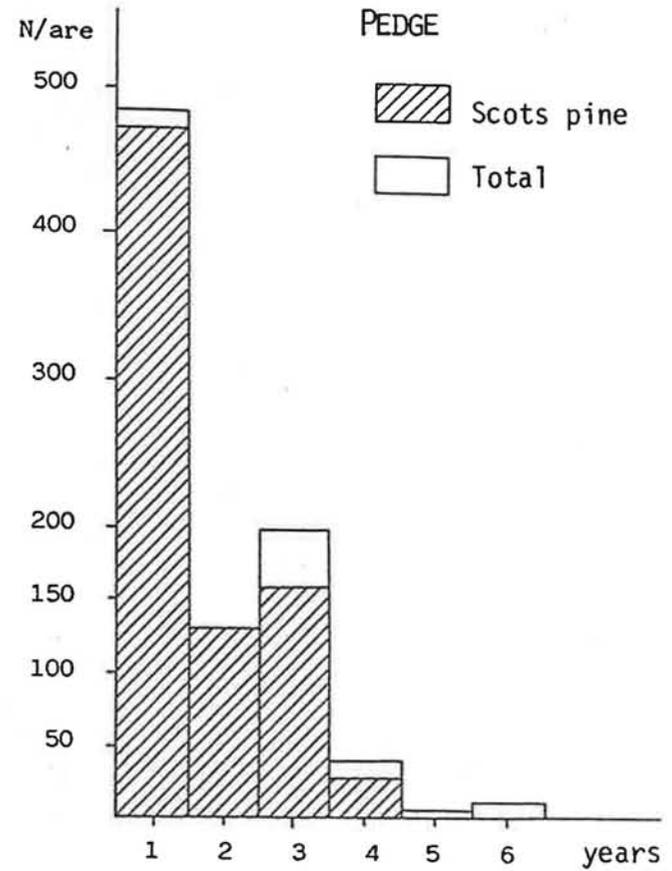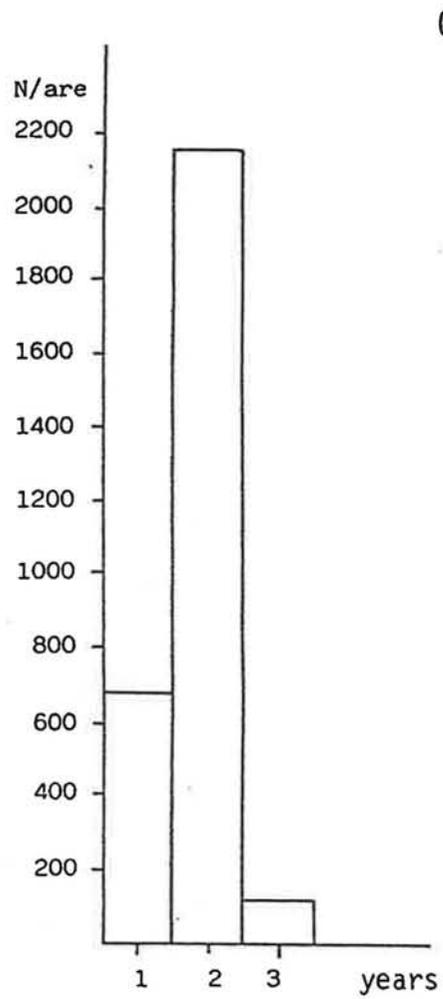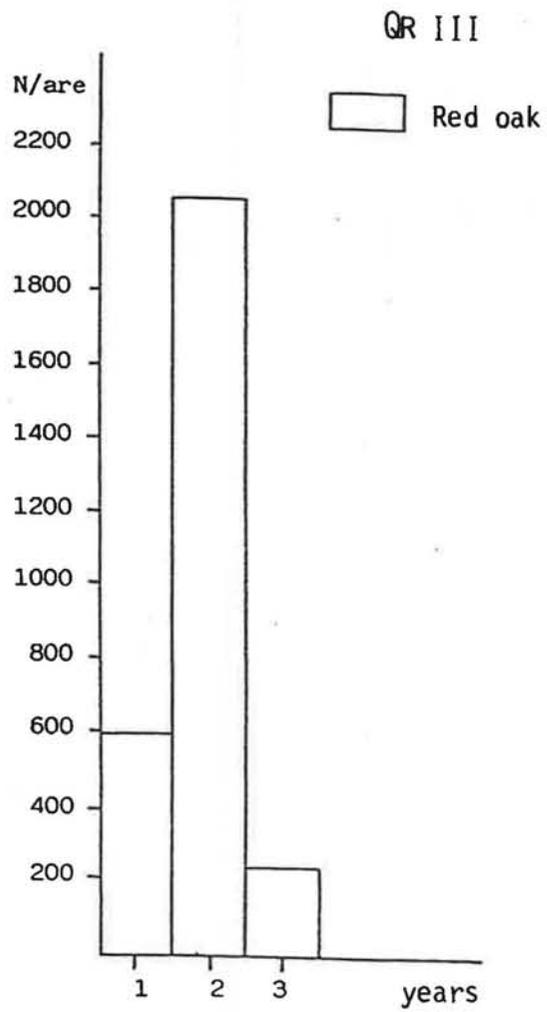
Figures 2

Figures 2

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