Silviculture of Scots pine in Belgium

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1. Position of Scots pine in Belgium

Scots pine is not considered to be a native species in Belgium. Nevertheless Scots pine was, together with birch, the first tree species, to occupy many sites after the last ice ages. On sandy soils, this boreal pine-birch forest was later replaced by forests of oak (*Quercion*) accompanied by birch on the poorer sites and beech on the richer.

The most common type, the Birch-Pedunculate oak forest (*Betulo-Quercetum roboris*), is a low dense forest formation. Sessile oak (*Quercus petraea* LIEB), European aspen (*Populus tremula* L.) and Beech (*Fagus sylvatica* L.) are scarcely dispersed. Rowan (*Sorbus aucuparia* L.) and Alder buckthorn (*Frangula alnus* MILL.) are well represented shrubs.

The herbal layer is relatively poor and often dominated by *Deschampsia flexuosa* and to a less extent by *Vaccinium myrtillus*. *Molinea caerulea* indicates higher moisture levels or a form of disturbance.

During the last millennia and especially with the great reclamation wave of the 12th - 13th century this natural oak-birch forest has been almost completely replaced by heathlands and drift sands. Since 1850, these sites have been (re)afforestated almost exclusively by means of Scots pine. In this way monocultures over large areas were established (Lust & Muys, 1995). The present Scots pine area in Belgium covers some 60,000 ha, about 10% of the total forest area. About 60% of them are private ownership.

2. Some Characteristics of the present Scots pine forests

Scots pine was formerly planted at relatively narrow plant distances, 0.80 m to 1.00 m, in evenaged monocultures with as major objective the production of mining products. The tending was based on a weak to moderate low thinning with a rotation of 40-45 years.

The increment of Scots pine stands ranges around 5 m³/y/ha. Due to stagnating timber prices along with rising costs, Scots pine stands were no longer attractive and many of them were replaced after World war II by Corsican pine (*Pinus nigra var. corsicana*), which yields increments over 10 m³/y/ha on the same poor sites.

Many Scots pine plantations are surrounded by a narrow hardwood firebelt with a/o Black cherry (*Prunus serotina EHRH.)* and Red American oak (*Quercus rubra L.*). The former is very aggressive and competitive and the latter is growing quite well, but also very competitive, especially against the indigenous oaks. These two species spontaneously settled under the cover of the maturing Scots pine trees, influencing very strongly the ecological conditions of the forests.

As a result of it, total above ground biomass of a representative 75 year old first generation Scots pine stand on former heathland can be described as in table 1 (Maddelein, 1993).
The above ground tree biomass was estimated at 120,000 kg/ha. Scots pine holds 77% of total above ground tree biomass. Forest floor biomass is almost as high with 105,000 kg/ha. The herb layer only represents a biomass of 1,200 kg/ha.
The nutrient distribution in tree compartment, forest floor and mineral soil (0-100 cm) is presented in table 2 (Maddelein, 1993).

Table1. Above ground stand biomass of a 75 year old Scots pine stand (kg dry mass/ha)

Species	Trees (dbh >8cm)	Under-storey
Scots pine	84,300	/
Red oak	22,100	6,500
Black cherry	3,000	3,400
Total	109,400	9,900

Table 2. Nutrient distribution in a Scots pine stand (in kg/ha)

	N	K	Ca	Mg	Fe	Al	P
Trees	241	114	152	21	10	7	20
Litter layer	1475	32	100	34	194	219	75
Mineral soil							
- total	7927	2977	258	3658	56659	48223	1888
- exchangeable	7927	58	62	24	1862	3868	168

The largest proportion of all nutrients is stored in the mineral soil. For the base cations K, Mg and Ca however these quantities are comparatively low. For Ca the total available quantity in mineral soil is about equal to that in trees and litter layer combined.
An important part of the total nutrient pool is stored in trees and forest floor. Clearcutting the stand, with removal of all wood and bark, would result in the export of 53 kg K, 107 kg Ca, 13 kg Mg, 9 kg P and 79 kg N per ha. For Mg, Ca and K, this would mean a loss of 16.5, 34.2 and 26.0% respectively of the available amounts in the stand. These losses can be reduced significantly by debarking within the stand.
The removal of litter, a major nutrient sink, should be prevented in any case.
Recently there is a kind of revival of the Scots pine. The species is partially reappreciated, due to its capacity to reach longer rotations and to the appearance of some nice natural regeneration. Moreover, Scots pine, as an exotic tree species, is not considered by nature conservationists to be a serious threat to indigenous species.
The silvicultural system in the pine forests is shifting from the clearcut system towards progressive selective thinnings, resulting in a high forest with standards at a stand age between 70 and 100 years. Natural regeneration, formerly considered to be impossible, becomes more and more a normal process, both on clearcuts and under shelter. At the same time, natural ingrowth of all kind of hardwoods regularly occurs in the maturing stands.

3. Future objectives : Increase of naturalness and biodiversity

The period of the traditional monocultures of Scots pine stands, with short rotations and high stand density, is completely over. Nowadays it is, mainly in public forests, aimed at the conversion of such like stands towards a kind of mixed, unevenaged and irregular stands, with a various share of Scots pine. It should be aimed at a closer to nature forestry, with more attention to biodiversity and stressing more stand quality instead of wood production.
To achieve this new challenges a lot of principles can be applied, which are reflecting on the one hand to the fundamentals of forest conservation and on the other hand to the basic ideas of the Pro Silva movement (Peterken, 1981; Lust & Muys, 1995; Van Boghout 1991; Van den Berge, 1994).

1. Minimise the rate of change The transformation period should be long enough and indirect conversion methods should be used. Clearcuts must be avoided and regeneration under cover must be applied.

2. Use of native tree species Conversion of Scots pine stands must be based on the use of native hardwood species. Especially native oaks and birch are strongly recommended. Scots pine itself, although not native, must be maintained, but a compromise must be sought between native broadleafs and Scots pine. Black cherry must be eliminated completely, unlike red American oak, Corsican pine and Douglas fir, which must be controlled.

3. Avoid clearcut Instead of clearcuts, several alternative silvicultural systems are possible, such as group cutting, regeneration under cover, strip cutting and even some forms of selection cutting.

4. Encourage natural regeneration Natural regeneration favours native species, it minimises changes, it tends to generate mixed stands with a more irregular structure, natural genetic variety can be better maintained and the natural distribution of tree species in relation to soil types in favoured.

5. Lengthening of rotation period Stands should have the occasion to reach the mature phase of their life cycle, in which biodiversity is increasing spontaneously. Trees must have the occasion to get old. Observations indicate that, even on the poor sites in the Campine region, rotation periods of more than 120 year are feasible, especially with Scots pine.

6. Development of a complex structure Instead of the poor regular structure of the monocultures, it should be aimed at a complex stand structure, both in the horizontal and vertical sense, and at a mosaic forest structure. Small scale forestry is a good instrument to reach this goal. Due attention should also be paid to the forest edges, which are very valuable biotopes. Well structured edges, gradually built up by native herbs, shrubs and trees, are highly appreciated.

7. Use of self regulating processes Artificial measures, such as draining of wet sites, soil preparation, burning of slash wood, fertilisation, soil preparation and use of biocides should be very restricted. Infrastructure works for harvesting and disturbances during the operations should be reduced to a minimum. Afforestation techniques with low impact should be stimulated. Game density should be controlled.

8. Attention for specific habitats Protection of small habitats, valuable for the conservation of endangered species, can often be taken without significant impact on the overall economic result (fens, dishes, roads, etc.)

9. Dead wood The amount of dead wood should be increased. Old big tree bodies should be left standing or lying in the forest. Crown wood and bark should be left and decomposed on the spot.

10. Monitoring Records are necessary to evaluate the effect of management on biodiversity, naturalness or sustainability. Control ecosystems should be maintained free from any human influence.

With respect to biodiversity, it can be accepted that, notwithstanding the poor quality and variation of the sites, the diversity of the primary birch-oak forest was relatively high. Biodiversity, however, strongly decreased due to all kinds of cuttings and the appearance of large heathlands. It still diminished by the establishment of Scots pine monocultures, to reach a minimum in the dense middle-aged stands. Currently, however, all kind of processes occur in maturing stands, leading to a significant increase of biodiversity. Among others, this can be observed on three important parameters, quite relevant for silvicultural aspects: herbal layer diversity, natural regeneration and stand structure. Concerning these indicators the following results were obtained in typical Campine Scots pine forests.

- Current herbal species presence is very limited. In all only nine herbal species were counted. The dominating herb is presently *Deschampsia flexuosa,* sometimes covering over 80% of the soil. Beside this species, only three herbal species (*Vaccinium myrtillus, Epilobium angustifolium* and *Dryopteris sp.*) are present in more than 50% of all plots.

- A fair natural regeneration of deciduous trees is established under pine canopies of 70 year old, with an average density of 7,000 saplings/ha. In all 10 tree species are found, but 80% of the regeneration is black cherry. Regeneration of Scots pine itself is very limited and restricted to the stands where black cherry was regularly cut or uprooted.

- As a result of spontaneous ingrowth of hardwoods, the original homogeneous Scots pine stands are currently slowly but steadily transformed into heterogeneous mixed stands, as shown by two vertical projections of a 75 year old Scots pine stand (Fig.1).

Discussion remains on the significance and the meaning of clearcuts. On one hand the advantages of a forestry without clearcuts, as mentioned by von Lüpke (1992), cannot be denied: less export of nutrients, a higher supply of seed, less competition from herbs, less frost damage, no problems wit regeneration of light demanding species provided a light intensity of 40-50% of normal, much better quality of saplings. On the other hand, however, the effects of clearcutting are highly variable. Indeed the system regenerates a new juvenile phase, promoting the development of a rich herbal layer and favourable life conditions for all kind of mammals and songbirds. On large afforestated areas, featured by mosaic structures, clearcuts are not absolutely negative for biodiversity. Moreover the scale and pattern of clearcuts are also vitally important in determing the response of different species to disturbances.
In the Campine region (clear)cuts are usually made on a small area, e.g. 0.50 hectares. But clearcuts are likely to be necessary in the case of bad parent stands. In that way, however, it is tried to restrict the cut to an area of 3 hectares or at the most to 5 hectares.

More attention should also be paid to the choice of tree species (Lust & Muys, 1995). This is likely to be the most important measure in relation to biodiversity. Scots pine, although it cannot be considered as a native species, is certainly a species which is appropriate to the site and which enables a high degree of diversity, especially in older stands with a long rotation. Therefore Scots pine must not disappear, but should be used in a more environmentally friendly way.

Among native species, especially oak and birch come into consideration. Both species, however, are able to eliminate Scots pine. Therefore an appropriate tending should be applied, ensuring the regeneration and development of Scots pine. It means that the stand density must be controlled and that the mixture pattern should pay due attention to the site quality. Indeed within the sandy soils of the Campine the differences in soil fertility are still great. Establishment of hardwood is recommended on the better soils, with a higher loam and clay content and belonging to the c or d drainage class.
Not at all clear is the position of birch, still generally considered in that region as a weed tree. Therefore it is combated almost completely. It must be stressed, however, that birch is a tree species, which must be strongly favoured in future stands.
Indeed as well from the silvicultural as from the biodiversity point of view it is a very valuable tree species. It improves degraded sites, it enables a mixture with other light demanding tree species, provided an appropriate tending takes place, it regenerates spontaneously and abundantly on open areas and its production is fair.

The following observations were noted after establishment of birch (Muys, 1991): more earthworms, faster litter decomposition, deeper action of the organic matter with the soil, higher soil pH, more roots and an increasing density of the herbaceous layer. Unfortunately, the timber market for birch is not developed.

4. Conversion of Scots pine monocultures into mixed stands

Natural regeneration of hardwoods and conifers under the cover of ageing pine stands is nowadays a widespread phenomenon. There is, however, little experience with the management of such forests and several questions still arise.

A major question deals with the techniques, which should be used with the conversion of the formerly pure evenaged Scots pine monocultures into unevenaged mixed stands (Maddelein, 1993). This conversion, based on oaks, occurs by preference under cover (Ebeling & Hanstein, 1988; von Lüpke, 1992). Artificial regeneration as well as natural regeneration can produce satisfactory results (Kuper, 1989).

Unfortunately, in order to reach this goal it is often necessary to carry out a preparatory measure: the integral control of black cherry. If the control is postponed until the maturity of the trees or until the clearcut, a massive regeneration of Scots pine is likely to establish (Lust,1987; Maddelein et al., 1990).

Spontaneous establishment of oak already occurs in 40-50 year old, normally closed Scots pine stands. However, due to a lack of seed trees, the regeneration capacities are often insufficient. Therefore it is desirable to start planting small groups of broadleafs (oaks and other species) in 40-50 year old stands of Scots pine.

To avoid a too fast conversion, the number of groups and the area of the individual groups in the first phase may not be too great. It is proposed to create groups with a size from 2-10 are, over a maximal area of 20-25 are. Herewith it is possible to make use of already existing gaps. As an unevenaged stand with several diameter classes is aimed at, the stem number of the regeneration should not be to great in the beginning. Some hundreds of seedlings per ha of oak or other broadleafs are enough. Unevenaged structures suppose an almost permanent regeneration.

Soil injury during thinning operations will promote the settlement of additional regeneration. Not only main tree species, but also secondary species such as Rowan, Alder buckthorn and Trembling aspen are to be expected. These mainly culturally useful tree species should be protected by the management, instead of removed.

With regeneration under cover it is traditional to warn for the danger of exploitation damage. Numerous observations, however, have shown already that careful thinning and harvest hardly damages the regeneration (Maddelein, 1993; Van Boghout,1991).

At the age of 80-90 years, the stand consists of an irregular, slight cover of ageing pine standards, with an ingrowing generation of several species, reaching already the middle-storey and even the upper storey (see Fig.1). Since the closure is also irregular in the regenerated layer, new seedlings can always settle.

In such forests the notion 'rotation' declines. Tree maturity is determined in function of the stand structure (cf. selection forest or Plenterwald). The mixture is individual or by small groups. The management of these forests is on the one hand extensive and on the other hand small scaled. Thinning rotation is 8-10 years, whereas the management is based upon individual treatment. A small number of future trees are individually promoted, by giving them optimal development

possibilities. At the same time pruning and protection of the selected trees against exploitation damage is often very useful. Selection of new trees out of the regeneration can happen every 20-30 years.

Productivity and profitability of such forests can be discussed. The value of the harvested timber will likely be less than that of evenaged clearcut stands. Since reafforestation of clearcuts is very expensive, any direct financial profitability is practically excluded. On the contrary, in unevenaged, mixed forest types, based upon natural regeneration with an extensive management, costs are very low, leading finally to a much greater profitability, despite the lower financial return (Kuper,1989).

Summarising, the main attention should be paid to the following topics:

- creation of seed trees, of various species, in each stand;
- avoidance of clearcuts : regeneration under cover which is cut in successive thinnings and conservation of standards;
- regular selection of future trees in the regeneration, with individual treatment;
- promotion of permanent regeneration by creation of gaps, followed by natural regeneration or artificial plantings;
- attention to aesthetical and natural values.

5. References

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