APPENDIX

A. Forest nature reserve in Białowieża National Park, Poland

This description corresponds to the best preserved fragment of forest in Białowieża National Park in North-Eastern Poland, which is under strict protection. The beginning of Białowieża National Park can be traced back to 1921, when the "Reserve" forest was created at the place currently occupied by the Park. In 1932, this „Reserve" was transformed into „National Park in Białowieża" and in 1947 this unit was reinstated as Białowieża National Park by an ordinance of the Cabinet [1].

The Białowieża National Park covers the last natural forest in the European lowlands which retains a primeval character, with stands characterized by large amounts of deadwood at various stages of disintegration and very high biodiversity of plants and animals.

According to the "Ordinance of the Cabinet about Establishment of Białowieża National Park, 1947", the main objective of an unmanaged forest nature reserve is to allow natural processes and natural disturbance regimes to develop without management intervention to create natural ecological valuable habitats and biodiversity, in the last primeval forest in lowland Europe. Furthermore it serves as a field laboratory for basic and applied research.

Tree species selection, genetic engineering, regeneration type, and succession elements
According to the "Ordinance of the Cabinet about Establishment of Białowieża National Park, 1947" in an unmanaged forest nature reserve under strict protection no management to favour particular tree species takes place. The forest is naturally regenerated.

Machine operation, soil preparation, fertilisation and liming
There is no machine operation, soil preparation, fertilisation and liming.

Application of chemicals or protective agents, integration of nature protection
There is no application of chemicals or protective agents. Maintenance of undisturbed nature has the highest priority.

Tree removals, final harvesting system, and maturity
There are also no tree removals.

According to the strict protection by the ordinance of the Cabinet Białowieża National Park is to be classified as an unmanaged forest nature reserve (see Figure 1.a).

B. European beech management in Baden-Württemberg, Germany

The following description of current management of European beech refers to the forest type "European beech forest with coniferous admixture" of the corresponding regional directive (Landesforstverwaltung Baden-Württemberg 1999) in Germany. This forest type is widely distributed in the sub-mountainous temperate zone of Baden-Württemberg. European beech (*Fagus sylvatica*) grows naturally on most sites in the region, except on organic or heavy clayish soils, sites with highly fluctuating water availability, wet sites, floodplains and steep sites with moving rocks. Current beech forests are said to represent the natural forest

[1] Rozporządzenie Rady Ministrów z dnia 21 listopada 1947 r. o utworzeniu Białowieskiego Parku Narodowego (Dziennik Ustaw Nr 74, pozycja 469) - (Ordinance of the Cabinet of 21. November 1947 establishing the Białowieża National Park (Official Gazette No. 74, item 469))

vegetation and can be assigned to the climax forest communities of Galio- and Lonicera-Fagetum (Ellenberg 1996). Here, beech is highly competitive, thus admixed tree species only compete outside the natural range of beech.

The long term forest development objective is semi-natural, well structured European beech stands with significant admixtures of conifers (20-50 %) and limited amounts of other broadleaved species (0-20 %). The admixed tree species are distributed either as single trees or in small groups. On small areas the stand structure is multi-storied during the regeneration phase. Apart from this, where not dominant itself, beech can form an understory under the conifer admixture. Beech trees and the partly pruned conifers produce valuable stem wood. The target diameter for European beech is 60cm or more depending on stem quality and the risk of economic losses through red heartwood formation.

Tree species selection, genetic engineering, regeneration type, and succession elements
European beech is only favoured on adequate sites where it generally is part of the potential natural vegetation. Most European beech stands are naturally regenerated with planting on spots where no sufficient regeneration is available. If there is insufficient natural regeneration, beech is planted at a spacing of approximately 2 x 1 m (~5000 seedlings/ha) with additional planting of site adapted mixed species in patches (~20%). The planted material may originate from seed stands. Currently no genetically improved material is being used. Admixed tree species and especially light demanding ones are to be maintained in the stand.

Machine operation, soil preparation, fertilisation and liming
The directive does not discuss site cultivation, fertilization or liming. However, it is mentioned that soil fertility is well preserved under mixed beech stands. Again, machine operation is not directly addressed in the directive. Vehicle movement is restricted to racks with a minimum distance apart of 20 or 40 m depending on soil vulnerability.

Application of chemicals or protective agents, integration of nature protection
Forest protection is regulated by the forest law and plant protection act and not by the directive itself. Within the rationale of integrated plant protection approach the application of protective chemical agents is seen as a last resort. The directive requires maintenance of the forest community with site adopted flora and fauna.

Tree removals, final harvesting system, and maturity
After selection of 60 – 80 future crop trees per hectare, when natural pruning reaches 25-35% of expected final tree height, the main competitors (1-3) for these trees are removed in 5-10 year intervals with no more than 80 $m^3 ha^{-1}$ removed per thinning. Even though this is not stated in the directive, generally only solid wood is removed. The rotation length is chosen according to target diameter and is not defined by age. According to the growth dynamics and the risk of red heartwood formation, production time might be in the range of 80 to 150 years. The final felling system is mostly harvesting trees that have reached the target diameter, or uses group cuttings in order to promote natural regeneration.

Given the statements made in the directive the management recommendation for European beech can be classified as “low intensity category” with some “medium intensity” measures (see Figure 1.b).

C. Norway spruce management in the county of Västerbotten in Sweden

The following description of Norway spruce management refers to the forest type "Mixed forests dominated by Norway spruce," i.e. where more than 70% of growing stock consists of Norway spruce (*Picea abies* [L.] Karst.). Other common tree species in the mixed forest are birch (*Betula pubescens* or *B. pendula*) and Scots pine (*Pinus sylvestris*). About 22% of the forest area corresponds to this type. Norway spruce grows naturally on most sites except on dry soils dominated by lichens and on mires.

The main objective is to produce wood to obtain a good profit. Additional objectives are typically water protection, habitat protection, nature protection, and recreation. The magnitude and importance of additional objectives depends on the local situation.

Tree species selection, genetic engineering, regeneration type, and succession elements
The preferred methods of regeneration are planting of Norway spruce after clear-cut or natural regeneration with a shelterwood system. Normally, the planting material is genetically improved but not genetically modified. The number of plants depends on site index but on average about 2000- 2500 per ha. Birch and/or pine seedlings almost always occur on the regeneration sites. Biological legacies and natural biotopes should be promoted inside the stands. If necessary, pre-commercial thinning is carried out to reduce the number of trees at 1.5 – 4 m medium height.

Machine operation, soil preparation, fertilisation and liming
Machine operations are not limited, as long as they do not harm the environment. Site cultivation is applied to sites when necessary. Fertilization can be an option, but is not widespread.

Tree removals, final harvesting system, and maturity
The rotation period of a stand is chosen by the potential natural vegetation as well as economic interests. Additional to this, the Swedish Forestry Act (Skogsstyrelsen 2010) has a lowest allowable clear-cut age depending on site index and geographical location. The final harvest system is preferably clear-cut or a combination of shelterwood and clear-cut if natural regeneration is preferred to reduce the costs of reforestation.

Summarizing the management recommendations result in "medium intensity" measures (see Figure 1.c).

D. Sitka spruce management in Scotland

The forest area of Scotland comprises about 1.4 M ha of which some 530,000 ha is composed of forests of Sitka spruce (*Picea sitchensis* (Bong.) Carr.). These plantation forests are fast growing in European terms with an average productivity of 14 m^3 ha^{-1} $yr^{-1}$and better sites yielding more than 20 m^3 ha^{-1} yr^{-1}. All forests are managed to conform to principles of sustainable forest management with a commitment to meeting multi-purpose objectives (McIntosh 1995). In practice, the balance between timber production, conservation, recreation and amenity will depend upon local conditions. Stands are generally managed so that pulpwood and small roundwood is produced in early thinnings while sawtimber is provided by later thinnings and final fellings.

Tree species selection, genetic engineering, regeneration type, and succession elements
The commonest method of regeneration is by planting at density of 2500-2700 trees ha^{-1}. About 20 per cent of other species are planted along with Sitka spruce to increase diversity (Mason 2007). Genetically improved material derived either from seed orchards or from propagation of controlled cross mixtures, is widely planted and is expected to give increased timber yields over first generation stands (Moore et al. 2009). No genetically modified material is planted. Natural regeneration of spruce, pine, larch and various broadleaves is accepted when it occurs but the other species rarely survive beyond canopy closure because of the fast growth of the spruce stands. Respacing (precommercial thinning) is carried out in dense natural regeneration when trees are 2-3 m tall.

Machine operation, soil preparation, fertilisation and liming
Machine operation is not limited provided the guidance on soil conservation and maintaining water quality is observed. Site cultivation is standard practice when replanting occurs while fertilisation is much reduced compared to the earlier afforestation phase (Mason 2007). No liming is carried out.

Application of chemicals or protective agents, integration of nature protection.
Under the certification process, there is an aim to reduce levels of chemical input to the forest system but the use of chemical herbicides and pesticides is permitted where no practical cost-effective alternatives exist (Willoughby et al. 2004). Conservation considerations are incorporated through the forest design process (McIntosh 1995).

Tree removals, final harvesting system, and maturity
The customary rotation period is between 35 and 50 years depending upon site productivity and the risk of windthrow. A non-thin regime is used on more exposed sites: elsewhere 3-4 intermediate thinnings are carried out on a 5 year cycle followed by clear felling. In some locations of high amenity or recreational value, attempts are being made to introduce continuous cover forestry into the management of Sitka spruce forests.
Summarizing the management measures (see Figure 1.d) suggests that most are of high-moderate intensity although there are current tends to reduce the intensity.

E. Eucalyptus management in Portugal

Eucalyptus (*Eucalyptus globulus)* is an exotic species that grows exceptionally well in Portugal. Eucalyptus is a fast growing species for which the maximum net increment occurs before the age of 5, although high productivities do not persist for a long time (Soares et al. 2007). Most of the stands are planted and plantations are mainly managed as short rotation coppice systems, with an average cutting cycle of 10-12 years to benefit from its productivity. The main objective is to produce high quality wood for pulp and paper production.

Tree species selection, genetic engineering, regeneration type, and succession elements
Eucalyptus first rotation stands are usually planted with a density of 1250 seedlings per ha. A beating up operation is performed 6 months after planting to replace dead trees (15%). Its fast growth rate makes this species quite competitive and intolerant to succession elements, which reduces the regeneration of natural vegetation resulting in pure even-aged stands. Due to this species high coppicing ability, a first cycle of planted seedlings is usually followed by 2 to 3 cycles of coppiced stands. To increase productivity, improved genotypes resulting from tree breeding can be used and genetically modified material may be used in the future.

Machine operation, soil preparation, fertilisation and liming
There is a set of mechanised silvicultural operations that are performed. Whenever replanting is considered, stump removal and harrowing for woody debris incorporation are performed. Site preparation can be carried out through harrowing, ploughing or ripping operations. It is common to fertilize at planting with a NPK slow release fertilizer plus a phosphorus fertilizer. Additional mechanical fertilizations with NPK fertilizer can take place when the soil proves to be deficient in some specific nutrient(s). One or more mechanical weed control operations can be done in order to eliminate competition and decrease the risk of fire. Usually, weed control and mechanical fertilizations are done at the same time in a single operation reducing costs and compaction problems caused by machine movement on forest soil. In high fire risk areas weed control can be more frequent and/or more intense forest and building of forest roads' conducted to improve access.

Tree removals, final harvesting system, and maturity
In coppice stands, the number of sprouts per stool is reduced down to 1.2 to 1.6 by motor-manual cutting of shoots selected according to the intensity of mortality occurred in the transition from planted to coppice stands. Management is conducted in order to minimize the effects of natural hazards: stands showing any sign of being infected with any pest or disease may be submitted to chemical/biological control, pruning (after intense night frosts and/or *Botrytis cinerea* attacks) or even pre-commercial thinning (after insects or fungi attacks), Normally, only cut stems are removed from the stand although the extent of components extracted in thinning and final harvest operations can go up to the whole tree. A clear-cut is carried out at the age of 12 years producing 400-600 m^3 ha^{-1}. The size of the clear felling area depends upon the landscape.

The basic principles behind the current forest management of planted and coppice Eucalypt stands are very similar, differing only in the type of regeneration, and in specific silvicultural operations associated with it such as soil preparation and tree removals (see Figure 1.e).