CHAPTER 16

CONCEPTIONS FOR CONVERTING THE FORESTS IN THE ORE MTS. INTO ECOLOGICALLY MANAGED ECOSYSTEMS

RALF KÜBNER[1], REINHARD MOSANDL[2]
[1]*Institut für Waldbau und Forstschutz, Postfach 10, D-01737 Tharandt, Germany, kuessner@trh.thueringen.de*
[2]*Lehrstuhl für Waldbau und Forsteinrichtung, Hohenbachernstr. 22, 85354 Freising, Germany*

16.1. The development of forests and forestry in the Ore Mts. since the 12th century

Early in the 12th century the forest stock of the Ore Mts. was still in a largely undisturbed condition. It was only when mining and, subsequently, metallurgical refining, started in this region that the forests were subjected to serious changes.

Due to widespread forest devastation resulting from the huge demand on timber by the mining and steel industry and the clear-cutting of forests for agricultural land use, the forest area of the Ore Mts. had been reduced by 30 to 40% (Thomasius 1994). Irregular selective utilization and excess game density as well as intensive grazing on forestland caused some more damage to the species and structure of the residual forests.

At the beginning of the 18th century, the forests of the Ore Mts. were in a desolate condition. It was at this time when the practice of scientific forestry developed, which aimed at a regeneration of the overexploited and exhausted forest stands as well as foster a sustainable utilization of the available resources (Carlowitz 1713; Cotta 1817).

To establish productive forests over a wide range of land proved to be extremely difficult on devastated sites and in light of the extreme climatic conditions of frost and drought.

Demanding climax tree species such as beech (*Fagus sylvatica*) or silver fir (*Abies alba*) were found to be unsuitable for this purpose. A less sensitive and more productive tree species had to be found for afforestation and forest construction, as well as to meet the rapidly increasing demand for forest products by the developing industries of the region. The solution of this problem was seemingly found by widespread intensive management of Norway spruce (*Picea abies*) in even-aged monocultures. Such forests have been subject to continuous management mostly through even-aged area regulation of the high forest via clearcutting - until recently the model of forestry in the Ore Mts..

Gradually, the ecological disadvantages of this monotonous forest regeneration and management system became more and more obvious: excessive insect multiplication, wind damage and the increased susceptibility to air pollution. Such factors suggested that these forest ecosystems, which bore little resemblance to the natural forest dynamics, were of questionable vigour. The advantages and disadvantages of this intensive silvicultural system have been repeatedly debated. In this century, both Graser (1928) and Krutzsch (1952), inspired by the advocacy for permanent forest (Möller 1922), attempted to pursue forest management planning with ecological aspects.

However, social and economic factors, such as timber harvesting for reparations and lack of funding for forest infrastructure, the heavy weight of tradition in silvicultural thought and excessive game density, repeatedly frustrated efforts toward more ecological forestry.

Only now, late in the 20th century, do the ecological and social conditions exist to reconstruct the spruce forests of the Ore Mts. in the framework of an ecologically oriented silviculture (Thomasius 1992, Mosandl 1993).

16.2. Reasons for a forest conversion in the Ore Mts. on a long-term basis

There are three principal reasons that the long-term conversion of Saxon forests, particularly the spruce forests of the Ore Mts., should be undertaken:

1. risks to the economic production of pure, even-aged stands of spruce,
2. ecological risks of the management of pure stands of spruce, and
3. changes in the social and political environment regarding forest management.

Regarding the first reason, risk to economic production - Faced with the indisputable advantages of spruce as a source of universally utilizable timber that grows at relatively high rates of increment, over the past few decades foresters have been widely concerned with the economic production risks of the management of pure stands of spruce. In his experimental investigations on working circles of spruce, Strütt (1991) assumes profit reductions between 12% and 80% as a result of production risks, primarily wind breakage. Therefore, objectives regarding stability should be given preference. Pure stands of spruce are subject to a particularly high production risk due to high stem number in the sapling and pole stages. And that kind of stands is typical in the Ore Mts.. According to investigations conducted by Kurth et al. (1987) in Saxony, only 40% of all spruce stands reach the desired rotation age of 100 years.

Thomasius (1980) estimated that only 40% to 80% of the pure stands of spruce growing in the highlands and in the colline belt of eastern Germany would reach the production target unimpaired. In comparison, close-to-nature stands of broadleaved trees are estimated to have survival probabilities ranging from 80% to 100%, a distinctly lower production risk.

Concerning the second reason, ecological risks - Even-aged pure stands of spruce belonging to a low structural class imply the ecological risk that they will be subject to widespread and long-term damage caused by abiotic (e.g., snow breakage, storm) and biotic (e.g. excessive insect damage) influences. Such impacts, which generally occur on a small scale in natural forests, are magnified by the presence of dense, pure stands of spruce. Such widespread losses may result in irreversible damage to the nutrient cycle, the water balance and pattern of landscape. Most recently, the declining health of forests in the Ore Mts. has resulted mainly from the high rates of atmospheric pollution, which have severely damaged up to 59% of all spruce over 60 years in age (SML 1994).

Regarding the final reason, changes in social and forest policy objectives - The transition from an industrial society to a service-oriented society has led to a decrease of the role of wood as a primary product. Conversely, the social and non-timber demands on the forest have risen (e.g., recreation, nature conservation). In consequence, the majority of state forest services have put the management regulations for forests on an ecological basis and have declared that the structured, close-to-nature forest that allows for optimum fulfilment of the forest functions be the new model of forestry.

16.3. Natural forest associations and actual stocking in the Ore Mts.

The forest law of the Land of Saxony (SächsWaldG 1992) requires a close-to-nature stocking for all Saxon forests. Close-to-nature forests comprise elements of the potential natural vegetation. Therefore, the natural forests of the Ore Mts. are presented below and compared with the actual species composition and stocking. From these presentations the first assumptions as for a forest conversion in the Ore Mts. may be made.

16.3.1. (Potential) natural forest associations

The growth district „the Ore Mts." comprises a forest area of about 128,000 ha. The morphology of this growth district is characterized by a constant increase of altitude from the lowlands (< 350 m a.s.l.) in the north to the ridge regions in the south near the boarder to the Czech Republic (fig. 16.1). The highest elevation in this growth district is the Fichtelberg (1,214 m a.s.l.).

In this forest area five altitudinal zones are differentiated as for the climate: the lowlands, the lower altitudinal belts (350 - 450 m a.s.l.), the medium (450 - 680 m a.s.l.) and the higher montane belts (680 - 800 m a.s.l.) as well as the ridge regions (> 800 m a.s.l.). The number of days with a mean daily temperature of above 10 °C declines from 140 - 160 in the lowlands and lower altitudinal belts to less than 100 days in the moist and cool ridge regions.

In the lowlands - favoured by higher temperatures - oak-hornbeam forests are prevailing in the natural forest associations. In the lower altitudinal belts the (potential) natural forest association is dominated by beech (oak-beech forests). Other forest types of the lower altitudinal belts, mainly composed of oak and pine, are restricted to specific site conditions. (Silver fir-) beech forests - with a considerable proportion of spruce - are prevailing in the medium and the higher montane belts of heavy precipitation and on soils with rather low to medium nutrient supply, respectively. Natural spruce forests - mixed with Mountain ash (*Sorbus aucuparia*) - are restricted to the climatically extreme ridge regions.

16.3.2. Actual forest composition in the Ore Mts.

The actual tree species composition in the Ore Mts. is coined by a high proportion of coniferous tree species (cf. tab. 16.1, fig. 16.2). Their percentages increase from 79% in the lowlands to almost 100% in the ridge regions. Conversely, the proportion of deciduous tree species drops from 21% or 25%, respectively, in the lowlands and lower belts to merely 1% in the ridge regions.

In the Ore Mts. spruce is the dominant tree species (tab. 16.1). In contrast to this, beech and oak (*Quercus spec.*) as leading tree species of the natural forest associations are only represented in noteworthy proportions in the lowlands and the lower altitudinal belts. In the ridge regions substitute tree species (*Pinus spec.* et al..) that were grown there to a greater extent occur in addition to spruce.

Tab. 16.1 refers to stand level whereas map (fig. 16.2) is referring to a higher level (forest compartment) - this may explain differing proportions of tree species.

An analysis of the inventory data as for the tree species spruce shows that unfavourable climate conditions and high levels of air pollution have caused spruce stands to partly disintegrate: in the higher montane belts and ridge regions the mean degrees of stocking and stand volumes lie clearly below the stand parameters of spruce found in the lower-altitude zones and the medium montane belts (tab. 16.2).

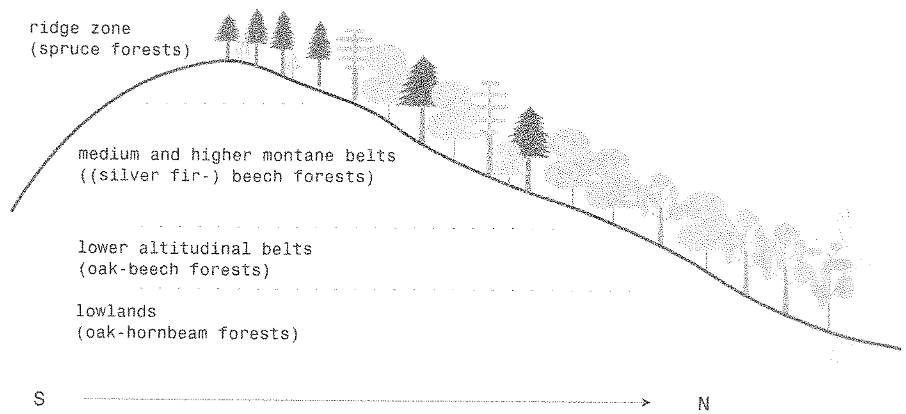

Fig. 16.1: Simplified figure of the (potential) natural forest associations of the Saxon Ore Mountains

Tab. 16.1: Percentages of tree species of the actual stocking in the Ore Mts. for different altitudes (total area of 127,716 ha = 100%)[a]

Tree species	Altitudinal zone					Total
	Lowlands	Lower altitudinal belts	Medium montane belts	Higher montane belts	Ridge regions	
Fagus sylvatica	16	5	4	3	0	4
Quercus sp.	0	7	0	0	0	1
Picea abies	77	56	86	90	89	82
Pinus sp.	1	13	2	2	7	4
Other species [b]	6	19	8	5	4	9
Percentage of altitudinal zone	< 1	18	48	31	3	

[a] tab. 16.1 refers to stand level whereas map 1 is referring to a higher level (forest compartment - thus may explain differing proportions of tree species),
[b] Other species, e.g. Larix decidua, Picea omorica, Betula pendula

Tab. 16.2: Characteristics of tree species spruce in the Ore Mts. according to different altitudinal zones

Index	Altitudinal zone				
	Lowlands altitudinal belts	Lower montane belts	Medium montane belts	Higher montane belts	Ridge regions
Average stand density [a]	0.82	0.91	0.87	0.86	0.76
Average stand volume [b]	188	204	204	179	140

[a] stand density = relation of actual stand volume (m^3/ha) to volume (m^3/ha) of a closed stand referring to a yield table
[b] stand volume in m^3/ha

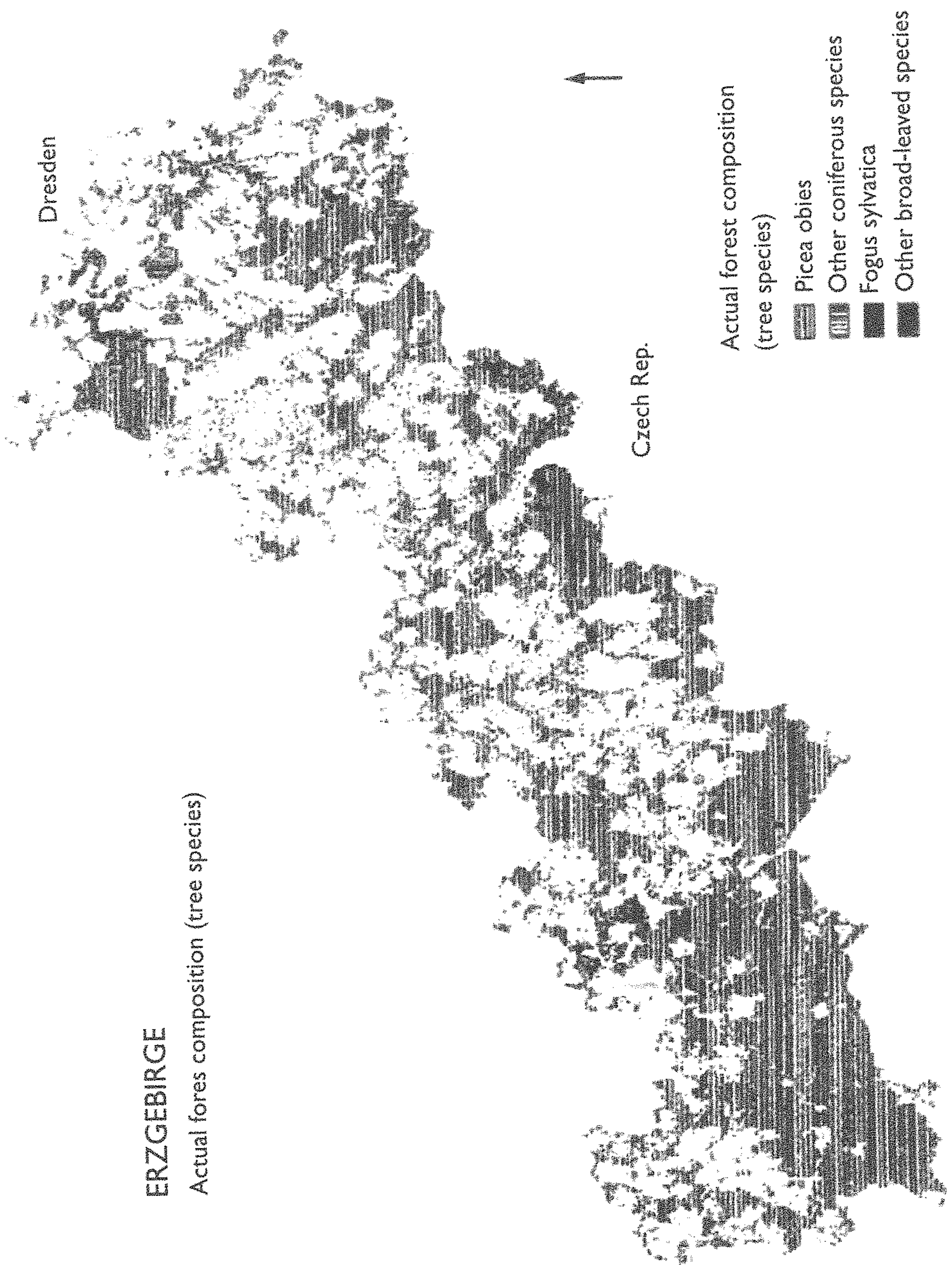

Fig. 16.2: Actual tree species composition in the Ore Mts. on the basis of data of forest compartment level

When comparing the tree species composition of the (potentially) natural vegetation (chapter 16.3.1) with the actual tree species composition it becomes obvious, that the forests of the Ore Mts. are largely in a far-from-nature state. The natural (silver fir)-beech forests have been replaced by single-stratum pure spruce stands (chapter 16.1). A forest conversion aims at creating close-to-nature permanent stockings. This will result e.g. in a future decrease of the proportion of the tree species spruce in favour of a higher share of beech and fir.

Age class distribution of a tree species is an important criterion for determination of the urgency of forest conversion. Forest conversion concentrates mainly on the old stands. In this connection an alternation of tree species or an admixture of suitable tree species in the course of forest regeneration presents itself.

To assess the urgency of a forest conversion, the percentage of stands exceeding the age of 80 years is crucial for spruce; the areal proportion of these mature timber stands informs about the mature spruce stands that have to be converted on a short and medium-term basis. As a whole, the proportion of old spruce stands in the Ore Mts. urgently requiring conversion accounts for 25,000 ha (except for ridge regions), with about 3,300 ha lying in the lower altitudinal zones, 13,500 ha in the medium and 8,300 ha in the higher-altitude montane belts.

Especially the conversion in the drier lower altitude zones seems to be very urgent: This is due, in part, by the expected climate changes - higher temperatures in combination with fluctuating amounts of seasonal precipitation. This will certainly create a particularly critical (phytosanitary) situation for spruce with high mortality rates expected.

Summed up, the following points are significant as to the Ore Mts. forest conversion:

a) Spruce is the dominant tree species in the actual forest composition whereas beech is the prevailing tree species in natural forest associations. With the dedication to a „close to nature"-forestry the percentage of the tree species spruce is to be reduced, whereas the proportion of beech and silver fir has to be increased.

b) A change in tree species composition is only feasible in the regeneration phase of a stand. About 25,000 ha of spruce stands in the Ore Mts. are in this regeneration phase and could be converted within a short- and medium-term period.

c) In the air pollution stressed higher montane belts and in the ridge regions spruce is particularly stricken by disintegration and decline. Therefore, there is an additional urgency in these regions to convert the pure spruce stands into mixed stands.

d) The spruce-stands of the lower-altitude zones are subject to a higher forest conservation risk (drought, phytophages) due to the prospective changes in climate and have to be converted likewise on a short- and medium-term basis.

e) In the medium montane belt, where most of the spruce stands are located, no additional severe risks (e.g. drought, air pollution, etc.) to cause intensive forest decline occur. The conversion of these spruce stands is less urgent compared to the stands in the ridge region or in the lower altitude zones. Therefore it should be achieved within a long-term period.

16.4. Principles and strategies for attaining the objective

A forest conversion in the Ore Mts. firstly requires the readiness of society to accept such an objective. In Saxony this was achieved by integrating this objective into the forest law of the Land of Saxony (SächsWaldG 1992). The second step is to develop a program for the realization of this objective. The realization should rest on some ecological principles as well as on adapted silvicultural strategies.

16.4.1. Principles for a forest conversion by ecological criteria

The supreme principle of an ecologically oriented silviculture is to ensure ecological sustainability, which guarantees on the individual plot a permanent functioning of the forest ecosystem as well as the continuity of its effects (Thomasius 1992).

From this it may be seen that externally caused systems interferences (e.g., extensive mortality phenomena due to atmospheric agencies) and the lasting disengagement of the processes of composition and decomposition (e.g., by extensive clear-felling) affect this ecological sustainability. The forest conversion must be based on ecological principles, which take into account global aspects as well as local ones that relate to the individual stands.

One such principle that aims to reconstruct the forests by ecologically substantiated criteria refers to the potential threat by a global climate change and thus also to the principle of a CO_2-compatible forest management. The forests bearing worldwide importance as CO_2-sinks and CO_2-sources should be managed in a manner by which their function as storage for greenhouse gases is intensified. This may be achieved by increasing the timber supply (CO_2-fixation); at the same time caution must be taken as to the tending of the large-scale standing volume in order to increase the forests´ stability (Irslinger 1995). This idea is put into practice by an ecological forest conversion through extended regenerative periods comprising measures of advance planting, with the overstory cover continuing to exist.

Other principles to be taken into account are mainly characterized by their risk-minimizing function. For example, methods for selecting tree species as regenerative stock appropriate to the site should consider possible changes of the site (climate) and include recommendations for tree species selection, as well as striving for a greater extent of biological diversity guided by the potential natural forest vegetation.

A strategy of harvesting considering the initial condition of the respective site should prevent a destabilization of forests with age class composition, based on considerations as of the existing spatial arrangement as well as correctly planned and cautiously taken silvicultural measures.

In this context, the task of forest protection is to create a system for prognosis of biotic and abiotic hazards related to defined types of forest stands on certain sites as well as to facilitate regeneration measures by systematic game management without the expense of costly fencing.

An appropriate method to minimize risks connected with extremely damaged sites consists in compensatory liming as well as measures for soil rehabilitation. The impacts of forestry on soil-chemical processes (e.g. nitrification) should be considered in the selection of silvicultural strategies.

Applied Genetics - Through the proper application of forest-genetic principles (provenance selection, use of autochthonous seed and plant material), the genetic adaptation of forest trees to the site is largely ensured and excessive risks (e.g., snow breakage hazard) avoided. Effective Silviculture - The generally accepted silvicultural principles for regeneration, improvement and tending of forest stands are to be taken into account (Thomasius 1992).

In summary, a conversion of the forests in the Ore Mts. designed with the long term in mind should be rooted in these principles, which govern the practical operations.

16.4.2. Silvicultural strategies to convert the forests in the Ore Mts.

Forest managers considering forest conversion are confronted with widely varied conditions in the Ore Mts., due to different climatic characteristics in the individual altitudinal zones as well as a multitude of geological parent materials. Also, the growing stock presents a heterogeneous pattern. In greatly simplified terms, several structural types ("types of the initial condition") may be identified (fig. 16.3).

Adapted to the specific starting situation, silvicultural strategies are applied in order to establish or to preserve a vigorous, close-to-nature and structured permanent stocking.

Denuded areas overgrown with grass (type I of initial condition)

Several areas of the close-to-nature spruce forests in the ridge zones of the Ore Mts. (>800 m a.s.l.) died off during the past decades. The denuded areas that resulted have been left to natural succession to a large extent.

These denuded areas are distinguished by the dominance of grasses in the ground vegetation. An example of this type is a trial plot for reforestation near Lugstein (eastern parts of the Ore Mts., Forest district of Altenberg, 880 m a.s.l). The grasses *Avenella flexuosa* and *Calamagrostis villosa* are highly stable species that reach a degree of coverage as high as 81% in the ground vegetation. Their above-ground phytomass attains a proportion of 79% of the total dry mass of ground vegetation, accounting for a total of 4.3 t/ha (Mosandl et al. 1994).

The grass ecosystems in the high-altitude and ridge sites may be assumed to continue to exist at a very stable level after the decline of the forest stands. They do not indicate any elastic behaviour under the present conditions of air pollution. Obviously, they are able to persist in their present condition over decades without unleashing a secondary succession and thus a return to a forested condition as in the original vegetation.

To facilitate a succession, intensive anthropogenic measures such as soil tillage in conjunction with liming, seeding in conjunction with tillage, or planting operations are required.

Nebe (1994) referred to the favourable effects of a program of combined tillage comprising liming of self-regenerating pioneer crops (mountain ash, sallow, aspen) in the ridge sites of the Ore Mts..

Investigations of reforestation by seeding on the trial plot near Lugstein (Benabdellah 1996) detailed the impact of competition by grasses upon seedling germination. In tilled areas where competition by grasses could be reduced as a result of partial exposure of the mineral soil, levels of mountain ashes (*Sorbus aucuparia*) and birches (*Betula pubescens*) successfully germinated reached 8% or 2%, respectively, of the seeds sown. These results were distinctly higher than was evident from the untilled areas with a dense grass cover on which not a single seedling could grow. The sown seeds were prevented from germination by the dense grass cover - as was a natural seed fall in the course of a secondary succession.

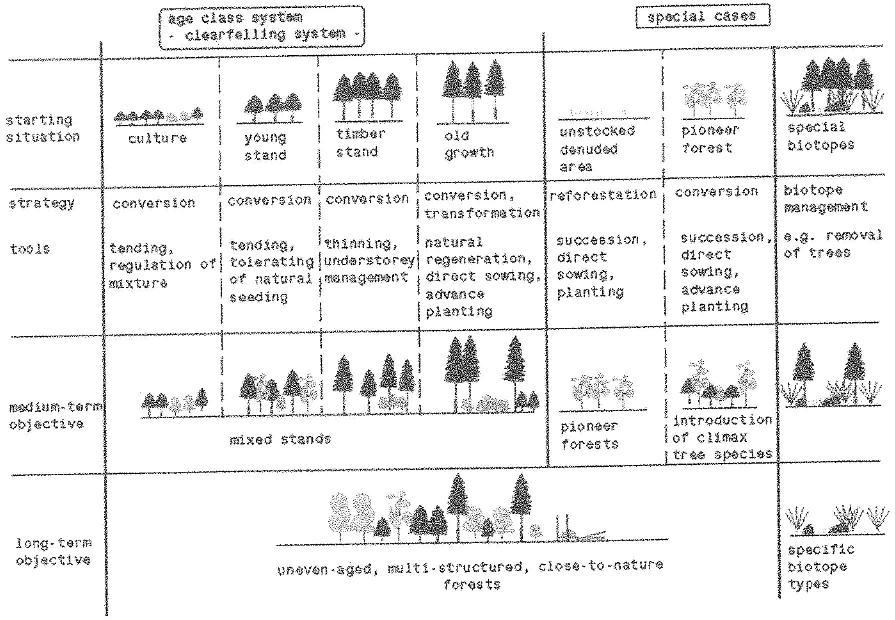

Fig. 16.3: The initial silvicultural condition and suitable silvicultural strategies for establishing close-to-nature permanent stockings

Tab. 16.3: Frequencies (pcs/ha) of trees growing in the shrub layer (height > 50 cm) and in the regeneration (year of germination 1993 - 95)[a]

Tree species	Shrub layer	Natural regeneration
Spruce (*Picea abies*)	0	19,400
Birch (*Betula pendula*)	5,238	11,600
Mountain ash (*Sorbus aucuparia*)	1,429	9,500
Other broadleaved tree species [b]	448	7,600
Other coniferous tree species [c]	327	6,000
Total	7,442	228,700

a) triual ap Ladenmuehle district of Altenberg, medium montane belt, rather poor soil site productivity, medium fresh soil moisture content
b) e.g. Salix sp., Fagus sylvatica
c) e.g. Larix decidua, Pinus sylvestris

The reforestation experiments conducted near Lugstein show planting to be a proven tool for reforestation of the pioneer tree species birch and mountain ash as well as of the climax tree species spruce under the most adverse climatic conditions, provided that vigorous plant material is used (Mosandl et al. 1994).

The long-term objective of reforestation of these denuded areas consists of creating a permanent forest in the form of a pioneer forest developing from seeding or planting, which later will be converted into a climax forest.

Disintegrating mature spruce stands (type II of initial condition)

The spruce stands occurring on large areas in the Ore Mts. are characterized by a high degree of damage due to atmospheric pollution occurring over many years (chapter 16.2). Because of the decline of individual trees and the high needle loss, mature spruce stands are subject to disintegration of the forest canopy.

The silvicultural strategy envisions conversion of these disintegrating spruce stands, i.e. contrary to clear-cutting the mature stand being involved in a conception of silvicultural treatment. Proceeding from the mature spruce stand, a conversion takes place in the course of the regeneration of the stand: reasonable utilization of natural regeneration processes, seeding under canopy, planting of admixture tree species under canopy (= advance planting) or a combination of these regeneration strategies should lead to the desired species mix and forest structure.

Processes of natural regeneration in opened-up mature spruce stands are obviously not considerably affected by air pollution impact. Küßner (1996) investigated the tree species composition of the shrub layer and the regeneration in an opened-up mature spruce stand on a trial plot in the eastern parts of the Ore Mts. (tab. 16.3).

Under the mature spruce stand a second stand layer („shrub layer") composed of a great number of trees, primarily birch and mountain ash, has emerged via natural regeneration. Spruce emerges in high number within the regeneration. Other tree species of the climax forest phase (beech, silver fir) occur only among the regeneration, if seed-producing mature trees grow in the vicinity and if favourable types of ground vegetation prevail.

The urgency to reconstruct the disintegrating mature spruce stands is reduced by the multistoried stand structures developing via natural regeneration. Presupposing suitable genetic constitution, spruce may be included in the regeneration strategy. As a rule, admixture tree species have to be introduced via seeding or advance planting due to the lack of nearby seed-producing individuals in the overstory.

Scientific investigations on seeding under canopy (Littek 1993, Leder, Wagner 1996) as well as experience gained from forestry practice (Gommel 1994) show seeding to be an appropriate strategy for the conversion of mature spruce stands. Additional measures such as tillage and liming may favourably influence the development of young seedlings (Weber 1967, Gehrmann 1983).

The ecologically advantageous characteristics of the mature spruce canopies (such as the amelioration of the extreme weather conditions present in the open fields like early season frost, or the suppression of competing vegetation, mainly grasses (Weihs 1993)) can be taken advantage of by regeneration through advance planting.

However, the light and temperature demands of the advance plantings have to be taken into account in the regulation of canopy density. In the Saxon highlands, as elevation increases, the light and temperature conditions have to be more and more controlled by opening up the mature overstory to ensure the success of the regeneration.

Thus, beeches planted in advance in mature spruce stands which are opened up to a greater extent show distinctly more favourable assimilation balances than those placed under closed canopies with low light. Contrary to this, water availability is no point of concern for the success of advance planting measures, owing to the favourable soil moisture storage capacities and precipitation patterns in the Saxon Ore Mts. (SML 1995).

Young spruce stand (type III of initial condition)

Long-term conversion of the forests of the Ore Mts. requires vigorous stands to withstand the harsh conditions of the environment. Necessarily, a coordinated strategy of thinning or tending must be undertaken to ensure such vigour. In this connection objectives for attaining stability have to be given preference over quality objectives (see chapter 16.2).

Schmitt (1994) concludes from investigations conducted in a 115-year-old spruce-pine stand that a stabilization of young spruce stands will be a decisive factor affecting future conversions of pure coniferous stands. This can only be achieved through a strategy of tending aimed at stability, which starts as early as in the young growth phase and lasts over decades.

An efficient management as to the density of deer populations to avoid stability losses due to red rot in spruce boles is especially important according to Schmitt (1994) - in particular in view of the long-term (stability) objectives in the conversion of pure stands of spruce.

Associated tree species developing from natural seeding such as birch or mountain ash may be included in a strategy of tending (to support the establishment of admixture tree species) with the target of improving the soil productivity via build-up of humus as well as improving the stand structure (Lange 1995).

Intermediate crop and pioneer forests (types IV and V of initial condition)

Larch (*Larix decidua, Larix kaempferi*), blue spruce (*Picea pungens*), lodgepole pine (*Pinus contorta*) and Serbian spruce (*Picea omorica*) form intermediate crops that were originally planted as pollution-tolerant substitute tree species from about 1960 to 1990 and that are not indigenous. The intermediate crop is intended to preserve the forest as a form of vegetation during the period of most severe air pollution impact as well as protect the soil from erosion until a tangible reduction of the input of toxic substances occurs.

Despite the fact that these original objectives could be achieved, biotic damage to the substitute tree species became, however, apparent within a rather short period (Feiler et al. 1992, Hering 1993, Roloff et al. 1995), requiring a conversion of the intermediate stocking earlier than planned.

Considerations of any future inclusion of these tree species in successive regeneration efforts will focus on the larch stands, provided they are vigorous, of high quality and do not adversely impact site quality or other forest functions. As concerns the other introduced intermediate tree species a successive conversion into close-to-nature stands presents itself without any further usage of these tree species in the succeeding crop.

From the silvicultural point of view, pioneer forests form a „nurse crop" which ensures climatic protection of the subsequently grown main tree species (of the intermediate or climax forest phase).

On areas in the Ore Mts. denuded by decline, pioneer forests developed through natural succession, seeding or planting, and consisted chiefly of birch and mountain ash. Due to their age and exposure to extreme climatic conditions, some pioneer forests are entering a phase of disintegration, a circumstance that makes conversion of those forests a high priority.

An inner forest climate could develop within the intermediate crops and pioneer forests, and the competition by ground vegetation of grasses could be diminished, which is an immense advantage for a regeneration consisting of exacting, susceptible climax tree species that might respond with high rates of decline to unfavourable open-field relations (glazed frost, frost hazard, ground vegetation) (Hering 1995).

Because of the thus obtained silvicultural flexibility intermediate stockings and pioneer forests may be further stabilized by tending operations in order to be reorganized at a later point of time through conversion (natural regeneration, seeding, advance planting) into stands, the major proportion of which being composed of tree species which represent the respective potential natural forest association.

Stable stockings adequate to the site (type VI of initial condition)

Stable stocking of trees appropriate to the site largely correspond to the desired objective, i.e., a stable close-to-nature and structured permanent crop. Under such conditions conversion measures are not necessary. An ecologically oriented forestry program pursues a sustainable ecosystem management.

16.5 Acknowledgements

The authors thank Prof. Andreas Bitter, Frank Eilermann and Carsten Schnell of the Institute for Forest Management in Tharandt for their assistance in data collection and mapping. We also thank Dr. W. Keith Moser, Tall Timbers Research, Inc., for reviewing our manuscript and for his helpful comments.

16.6 References

Benabdellah, B. (1996): Untersuchungen zur Wiederbewaldung kahlgefallener Flächen in den Kammlagen des Ost Erzgebirge. Verband Deutscher Forstlicher Versuchsanstalten, Sektion Waldbau. Tagungsbericht Göttingen 1995: 11 - 18.

Carlowitz, H. C. (1713): Sylvicultura oeconomica , oder hausswirtliche Nachricht und naturmässige Anweisung zur wilden Baum-Zucht... Leipzig. 432 pp.

Cotta, H. (1817): Anweisung zum Waldbau. 2. Auflage. Dresden. 209 pp.

Feiler, S., Tesche, M., Zentsch, W., Schmidt, P. A., Bellmann, C. (1992): Untersuchungen zum Wasserhaushalt der Fichte bei Befall durch Armillaria sp. Eur J For Path 22: 329 – 336.

Gehrmann, J. (1983): Untersuchungen zum Wachstum von Buchenkeimlingen in Luzulo-Fageten und Möglichkeiten ihrer Förderung durch Bodenmelioration. AFZ 38: 689 - 692.

Gommel, H. J. (1994): Umbau von Fichten-Beständen durch Buchen-Saat. AFZ 49: 516 - 518.

Graser, H. (1928): Die Bewirtschaftung des erzgebirgischen Fichtenwaldes. 1. Band. Dresden. 98 pp.

Hering, S. (1993): Waldbau im SO_2-Immissionsschadgebiet der sächsischen Mittelgebirge. AFZ 48: 1300 – 1303.

Hering, S. (1995): Die Lärche in Sächsischen Mittelgebirgen. Nur eine Übergangsbaumart im Immissionsschadgebiet? AFZ 50: 1126 – 1132.

Irslinger, R. (1995): Waldbewirtschaftung unter Treibhausgesichtspunkten. AFZ 50: 303 - 305.

Krutzsch, H. (1952): Waldaufbau. Deutscher Bauernverlag, Berlin. 159 pp.

Küßner, R. (1996): Natürliche Verjüngungsprozesse in Fichtenbeständen des Ost Erzgebirges. Verband Deutscher Forstlicher Versuchsanstalten, Sektion Waldbau. Tagungsbericht Göttingen 1995: 120 - 128.

Kurth, H., Gerold, D., Dittrich, K. (1987): Reale Waldentwicklung und Zielwald - Grundlagen nachhaltiger Systemregelung des Waldes. Wiss Z TU Dresden, Heft 5: 121 – 137.

Lange, C. (1995): Untersuchungen zum Einfluß von Birke (Betula pendula ROTH.) auf Fichte (Picea abies L.) an ausgewählten Mischbestockungen des Tharandter Waldes. Unveröffentl. Diplomarbeit, Fakultät für Forst-, Geo- und Hydrowissenschaften der TU Dresden. 88 pp.

Leder, B., Wagner, S. (1996): Bucheckern/Streu-Voraussaat als Alternative beim Umbau von Nadelholzreinbeständen in Mischbestände. Forstarchiv 67: 7 - 13.

Littek, T. (1993): Die Abhängigkeit des Verjüngungserfolges vom Oberbodenzustand und Säuregrad in geschädigten Waldbeständen des Schwarzwaldes. Forschungsbericht KfK-PEF 106. 240 pp.

Möller, A. (1922): Der Dauerwaldgedanke. Sein Sinn und seine Bedeutung. Berlin. 84 pp.

Mosandl, R. (1993): Ökologischer Waldbau. Zur Neuorientierung des Waldbaus. AFZ 48: 1122 - 1127.

Mosandl, R., Küßner R, Benabdellah B (1994): Waldbauliche Untersuchungen in den Hoch- und Kammlagen des Erzgebirges. XI. Gemeinsames Kolloquium „Brno - Tharandt“. Tagungsbericht. Karsdorf. pp 76 - 101.

Nebe, W. (1994): Zur Ernährung von Umwandlungsbaumarten auf immissionsbelasteten Standorten des Erzgebirges. Forstw Cbl 113: 291 - 301.

Roloff, A., Schulze, S., Zentsch, W., Feiler, S., Heinzel, F. (1995): Ökophysiologisch-biochemische Untersuchungen zu Wirt-Parasit-Beziehungen zwischen Waldbäumen und Hallimasch (Armillaria spp.) unter den spezifischen Immissionsbedingungen des Erzgebirges. In: Untersuchung von Waldökosystemen im Ore Mts. als Grundlage für einen ökologisch begründeten Waldumbau. Forschungsbericht TU Dresden Tharandt. pp 68 - 74.

SächsWaldG (1992): Waldgesetz für den Freistaat Sachsen vom 10.04.1992. SächsGVBl, p. 137.

Schmitt, M. (1994): Waldwachstumskundliche Untersuchungen zur Überführung fichtenreicher Baumhölzer in naturnahe Mischbestände mit Dauerwaldcharakter. Forstl Forschungsberichte München, Band 144. 223 pp.

Chapter 16, Conceptions for converting the forests in the Ore Mts., R. Küßner, R. Mosandl

SML (1994): Sächsisches Staatsministerium für Landwirtschaft, Ernährung und Forsten. Waldschadensbericht. 78 pp.

SML (1995): Sächsisches Staatsministerium für Landwirtschaft, Ernährung und Forsten. Jahresbericht 1994 der Sächsischen Landesanstalt für Forsten. 179 pp.

Strütt, M. (1991): Betriebswirtschaftliche Modelluntersuchungen zu Z-Baum orientierten Produktionsstrategien in der Fichtenwirtschaft. Mitt Forstl Versuchs- und Forschungsanstalt Bad-Württ. Heft 156. 221 pp.

Thomasius, H. (1980): Produktivität und Stabilität von Waldökosystemen. Sitzungberichte der Akademie der Wissenschaften der DDR. Akademie-Verlag, Berlin. 55 pp.

Thomasius, H. (1992): Prinzipien eines ökologisch orientierten Waldbaus. Forstw Cbl 111: 141 – 155.

Thomasius, H. (1994): Der Einfluss des Bergbaus auf Wald und Forstwirtschaft im sächsischen Ore Mts. bis zum Beginn des 19. Jahrhunderts. Mitt Chemnitzer Geschichtsverein, Neue Folge III 64: 39 – 70.

Weber, E. (1967): Versuche zur Naturverjüngung der Weißtanne (Abies alba MILL.) im Bereich der Oberforstdirektion Regensburg. FwCbl 86: 221 - 238.

Weihs, U. (1993): Versuchsergebnisse aus dem niedersächsischen Harz. Waldschäden - Walderneuerung. AFZ 48: 1304 - 1312.