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CONVERSION OF INSTABLE PRIMARY FORESTS IN THE LUSATIAN POST-MINING LANDSCAPE

Key words: forest reclamation, forest conversion, under planting, height growth, mortality, vitality indicator

S u m m a r y

In the federal state Brandenburg in Germany about 464 000 ha of mainly middle aged Scots pine stands are planned to be converted. In addition, instable broad leaved forests like disintegrating monocultural birch and poplar stands on dumps of lignite mining need conversion. Forest owners feel unsure regarding the silvicultural treatment in these stands. Therefore, research is needed to develop strategies for a forest conversion practice in primary forests on dumps within the mining landscape. The urgency of conversion of primary dump stands with regard to the tree species exists in the decreasing order: poplar, birch and Scots pine. While conversion of young primary pine forests into mixed broad-leaved forests is not advisable because of unfavourable site conditions, suitable timber stands on dumps represent favourable pioneer crops appropriate for conversion. Derived from investigations practical advises are given about kind, strength and time of preparatory thinning for under planting and ongoing thinning. The nutrition potential of the soil substrate has to be considered. Furthermore, height growth and leave mass of under planted oaks are indicators for the forest treatment.

Introduction / objectives

As main commercial tree species Scots pine covers over two thirds of the forest area in the eastern German lowland. The often not site-adapted stocking situation leads to increased susceptibility to damage by biotic and a biotic stress factors. Therefore, forest ecosystems are characterized by loss of vitality and ongoing destabilization, so that forest functions cannot be achieved best. Because of this, during the next decades forestry will focus on a large scale conversion of instable stockings into semi-natural stands which are oriented on the natural forest community [Kätzel 2003; Stähr 2003; Ertle 2003].

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In the federal state Brandenburg in Germany about 464 000 ha of mainly middle aged Scots pine stands are planned to be converted. So, the extent of conifer forest types shall be reduced from 75% to 42 % [Mlur 2003]. In addition, instable broad leaved forests like disintegrating monocultural birch and poplar stands on dumps of brown coal mining need conversion [Bartelt 2003; Ertle et al. 2004].

Forest owners feel unsure regarding the silvicultural treatment in these stands. Therefore, research is necessary to develop strategies for a forest conversion practice in primary forests on dumps within the mining landscape.

One objective of ongoing investigations is to clear up if very young primary forest stages can be used as pioneer crop to cope with the large potential conversion area over a longer period of time. Furthermore, analysis and evaluation of the under planted conversion trees within the establishing stage have been other questions of research. In conclusion strategic advices concerning forest conversion practice should be derived for forest owners.

Investigation sites / methods / climate

Because of the dominance of young forests (most stands are younger than 35 years) the chosen sample-plot system for conversion tests integrated young pine growths (height range 3-5 m) and pole pine stands (height range 10-12 m) as well as converted Silver birch-, Poplar- and Scots pine timber stands (height range 20 m) – Table 1. A similar investigation design to distribute the under planted tree species was set up in all sample plots. Mixed stands containing the major tree species *Quercus petraea* (Sessile), *Fagus sylvatica* (Beech) and *Acer plantanoides* (Maple) as well as the admixed tree species Tilia cordata (lime) and Carpinus betulus (hornbeam) were planted under pine-, birch- and poplar canopy. In addition open space was integrated to investigate natural regeneration. The choice of investigation sites took into account a gradient of increasing site quality, which is influenced by nutrition potential, available water storing capacity and dump specifics like silt- and clay fragments or lignite admixtures.

Table 1. Overview about the sample plots including characteristics of the initial stand

Sample Stage	Tree species Primary stand	Age (Jan/ 2001)	Yield class	Degree of density	Conversion time	Conversion (under planted) Tree species
Young growth (N=2)	Pine	14	I,0-I,6	0,3-0,4	2001	Oak, Maple, Beech, Hornbeam, Lime
Pole stand (N=2)	Pine	27-29	0,9-I,8	0,3-0,4	2001	Oak, Maple, Beech, Hornbeam, Lime
Timber stand (N=8)	Pine	48-65	0,9-I,2	0,7	1997	Oak, Maple, Beech, Hornbeam, Lime
	Birch	47-53	III,2-III,7	0,7	1997	
	Poplar	44	V,1-V,3	0,6	1997	

Determination of the yield class for pine by Lembcke et al. [1975], for birch by Lockow [2004], for poplar by Knapp [1973].

Long-standing averages show a yearly precipitation of 527 to 564 mm and a temperature of 9 °C for the investigation area. In comparison to Kopp et al. [1994] an increase of temperature and a decrease of precipitation is recognised analysing the 60-years standing average up to present time. The distance between the temperature curve and the precipitation curve decreased within the last 11 years. Very dry conditions during the vegetation period are typical for the Lusatian mining district.

The classification of site quality was carried out using the SEA 95 and the soil survey instruction AG Boden [2005]. Height increment and mortality of the under planted trees as well as structure and quality parameters were measured to analyse the establishing stage. From the same forest layer folia samples were taken to determine the nutrition status and folia weight was finally used to examine the vitality of planted trees.

Results

Site conditions

The investigation stages can be divided into two groups regarding their age. Young pine growths and pole pine stands belong to the first group. In terms of soil formation, humus genesis and stability these stands are at the beginning of their development. Therefore, the soils can be classified as syrosem with a very thin humus layer and they show no or a very low deposition of fly ash (Table 2).

The second group contains the oldest pine-, birch- and poplar timber stands on dumps on the soil type regosol. Under the pine canopy a thick humus layer has built containing high amounts of fly ash. This fly ash mainly consists of alkaline compartments and therefore has a positive effect on the nutrition potential of the sites.

Table 2. Overview about the sample plots including site characteristics

Sample Stage	Tree species Primary stand	Soil form [AG Boden 2005 and Wünsche et al. 1981]	Humus-form	Fly ash-deposition (By Tölle 1993)	Dump specifics (% Vol.)		aWSC	Site quality
					Silt-, clay fragments	Lignite-admixture		
Young growth (N=2)	Pine	oj-(k)ss-xss (q/t)	Rohhumus	No	5	0.7-4.3	low to medium	Z-M
Pole stand (N=2)	Pine	oj-(x)ls (q/t)	Rohhumus - Rohhumuslike Moder	No-low	3	0.2-1.5	low to medium	M
Timber stand (N=8)	Pine	oj-(k)ss-ls (q)	Rohhumuslike Moder	Medium-high	5	0.2-0.8	low to medium	Z-M
	Birch	oj-(x)ls (t/q)	Moder	Medium-high	5-10	1.0-2.1	medium	M-K
	Poplar	oj-xls-xll (t/q)	Moderlike Mull	Low	5-10	1.5-5.9	high	R

aWSC-available water storing capacity, Z-rather poor, M-medium, K-strong, R-rich
oj – dumped material, ss – pure sand, ls - loamy sand, ll – loam, k – gravel, x - lignite

Mortality

In all investigation stages all tree species showed with 62-100% high accretion success (Table 3). Within the first three years the mortality rate is slightly higher in the timber stages than in younger stages. One reason for this higher mortality is the high competitive strength of the soil vegetation on the rich sites under poplar canopy.

It is interesting, that neither different light condition in several thinning variants had an effect on the mortality nor differences could be found between the tree species.

Table 3. Relative accretion of the under planted tree species in the conversion sample stages after 3 years

Sample Stage	Tree species Primary stand	Oak	Beech	Maple	Lime	Hornbeam
		%				
Young growth (N=2)	Pine	86-100	79-100	100	82-100	96-100
Pole stand (N=2)	Pine	98-100	92-96	100	97-100	98-100
Timber stand (N=8)	Pine	83-95	76-78	62-99	79-98	75-97
	Birch	80-97	95-100	72-100	98-100	70-100
	Poplar	83-100	89	85	76	65

Kätzel [2003] showed similar good accretion success for oak in older pine timber stands on natural sites in the south of Brandenburg. But he could find a correlation between higher light condition in a stronger thinned variant and the mortality rate of oak. Also Kriegel [2000] found out that young beeches in young spruce growths had a lower mortality in comparison to open space conditions during the first three years. Obviously under planted trees do not need higher light conditions during the first three years after planting.

This situation is changed during the following years in the young sample stages. So mortality increased significantly in the darker thinning variant in the young pine growth in the fifth year for all tree species accept beech. In the pole and timber stands the difference was not significant. In the timber stands no considerable mortality was found from the 3. to 10. year.

Growth behaviour of under planted trees

In comparison between the sample stages all tree species show the lowest height growth in the young growths (Fig. 1, left). Regarding to different thinning variants during the first three years no proved height differences are rec-

ognisable between the shade tolerant species lime and beech towards the light species oak. Hornbeam has the highest increment rates in all investigation plots and reacts under lighter canopy with better growth. In the pole stage height growth of all tree species shows a middle position, the highest increment rates are visible in the timber stages. During the first three years effects caused by site quality could only be found in poplar stands, where oak showed a considerable height increment of 70 cm.

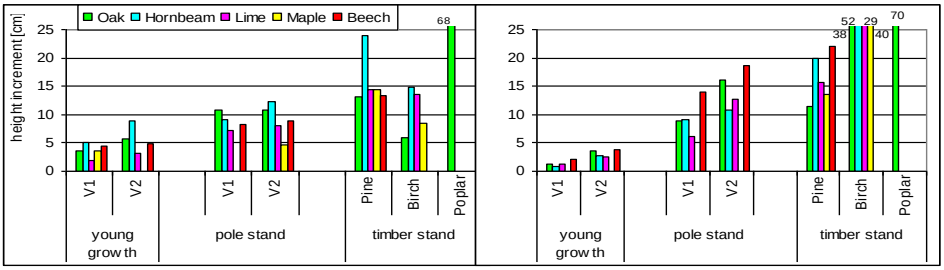

Fig. 1. Average height increment of under planted tree species from 1. to 3. year (left) and from 3. to 5. year (right) in the sample stages, V1-closer canopy than V2

Analysis of the height growth from the third to the fifth year (Fig. 1, right) showed another situation. Height growth of all under planted tree species was significantly higher in the thinner variants of the two younger sample stages. This was not the case in the timber stage. In comparison to other species beech had higher increment values also in the darker variant on the younger sites, so its competitive strength towards the light indigent oak was then higher.

The height development of under planted trees in the young growth is still unacceptable low. Especially unfavourable site conditions like an insufficient internal nutrition cycle within the young forest ecosystem, missing fly ash deposition and low soil biological activity cause low growth. Therefore, low values of nitrogen in the foliage as well as a very low leaf mass was analysed too. Furthermore, growth dynamics of the primary pine stand is higher than in all older stages. Five years after thinning pine canopy has already closed in the darker variant where every second row was removed. Site conditions and growth dynamics of the primary forest stand are reasons to decide against conversion at this early stage.

After the first three years under planted tree species in timber stands showed a better height growth than assumed. Light conditions had less effect on the growth behaviour than site quality. Even under dark canopies of birch, oak has high increment values of almost 40 cm due to dump specifics in the soil as silt

and clay fragments as well as lignite admixtures. Special soil conditions can obviously balance a limiting light situation up to a certain level.

All under planted tree species in the timber stands have an optimal vitality analysed by the nutrient content in the foliage and by the leaf mass. In this connection, the investigation found out, that there is a significant correlation between height growth of under planted oak and maple to their leaf mass. Trees with a 100 leaf-mass of 32 g showed a very good height growth even under almost closed birch canopy.

A comparison of the development of under planted oaks in timber stands on dump sites with oaks after the same treatment on natural sites illustrates a surpassing height growth on dump sites (Fig. 2). Here the yield classes determined according to Noack [2005] are clearly higher.

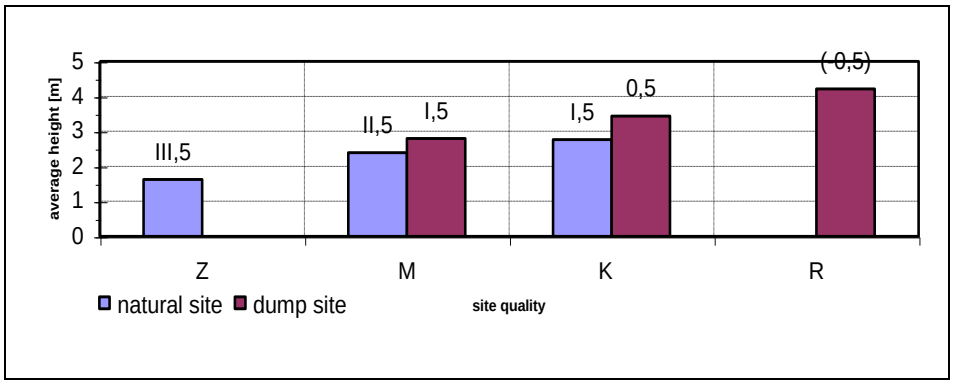

Fig. 2. Comparison of average heights of 9-years old under planted oaks on natural site (by Noack, 2005) and on dump sites for different site qualities; yield classes by Noack [2005] and Muchin [2004]

Quality of the under planted trees in timber stands

During the establishing stage height growth of admixed tree species increases stronger with rising site quality. As a result, admixed tree species can overgrow principal species, which leads to competition actions at mixture distribution by rows (Table 4). The portion of desirable growth habits of oak decreased by the competition action of particularly lime regarding a rising site quality. In consequence intensified formatting of twin stems was determined. Oaks with desirable growth habit had higher height increments than with undesirable WF.

On one hand, this means that desirable WF had asserted against undesirable WF, called auto selection. On the other hand, competition action of admixed tree species had not only led to twin stem formation of oak but also lower height growth occurred. On dump sites characterised by strong and rich site

quality it is necessary to implement mixture regulation thinning in the under planting layer. Therefore, mixture distribution by rows on sites with strong and rich site quality can be evaluated as problematic. Height rates of desirable WF (> 70%) were found on beech where it was under planted without admixed species by rows. On rich sites beech with desirable WF had a 0.57 m higher average height than such without desirable WF, so that auto selection is manifested. Using the example of beech it is clear that the development of quality of under planted deciduous trees is assisted by using group- and cluster mixture distribution on rich sites. In this case there is no need for young growth thinning. Therefore the choice of mixture distribution can reduce the maintenance expenditure.

Table 4. Average heights in 2006, portion of desirable growth habits (WF) and difference of average height between desirable and undesirable growth habit (auto selection)

Site quality			Oak	Beech	Lime	Hornbeam	Maple
M	average height	[m]	2.79	3.50	2.70	2.34	2.37
	portion of desirable WF	[%]	55	78	46	34	62
	auto selection Diff. H	[m]	0.45	0.01	0.45	0.66	0.01
K	average height	[m]	3.44	-	4.70	4.73	4.49
	portion of desirable WF	[%]	46	-	56	56	64
	auto selection Diff. H	[m]	0.10	-	0.80	-0.13	0.77
R	average height	[m]	4.21	4.57	5.65	5.46	7.62
	portion of desirable WF	[%]	44	74	42	70	54
	auto selection Diff. H	[m]	0.29	0.57	-0.15	0.06	0.12

The distribution of stem- and crown forms of under planted oak demonstrate a better quality on dump sites than on old natural sites. Here. relative parts of oak showing straightness of the stem and ambition to treetop stems were higher without distinction of site quality. An appreciable difference was found according to high portion of oak forming multiple twin stems (crown form 4 by Gockel [1994]) on old natural forest sites.

Conclusions

The urgency of conversion of primary dump stands with regard to the tree species exists in the decreasing order: poplar, birch and Scots pine. Relating to the stand age a different practice is useful for young stands than for middle

aged stands. Conversion of young primary pine forestation sites within the developing stages young growth and pole stand into mixed broad-leaved forests is not advisable because of the unfavourable site conditions (nutrient cycle still in constitution) as well as the growth dynamics of the stocking forest system. Exceptions are forest stands showing mortality gaps and heavy stability problems in the stocking. Apart from mortality gaps where under planting can be started directly, light constituting thinning is required before conversion. Because of the strong growth dynamics of the young stocking forest, group and cluster as mixture distribution should be chosen but no row form. Depressing of the volume density up to 50% of the primary stocking can be necessary before planting. Nevertheless, maintenance thinning should already be taken into account after 3 to 5 years.

In older timber stands on dump sites conversion can be started if the volume density is between 80-70%. In contrast to the young stands light conditions are adequate for establishing under planted broad-leaved tree layers. Over a period of up to 10 years maintenance thinning can be depended on the economic situation of the primary stocking. The time period can enhance with rising site quality which can balance the limiting light conditions partially. On rather poor (Z) dump sites with only low admixtures of silt, clay and lignite in the soil thinning has to be done at least up to a density rate of 70 %. Beside the height increment the foliage mass is a useful indicator on oak and maple to decide about evaluation of growth development and the time period of maintenance thinning.

As appropriate tree species to be used for under planting on dump sites with at least rather poor site quality oak, beech, hornbeam and lime can be recommended. Maple should be taken into account on sites with medium site quality and better. Good experience was made with two years old bare root plants.

Because of a very good height growth and good stem- and crown quality parameters of under planted conversion trees on dump sites in comparison to old natural sites in the north eastern lowland, suitable timber stands on dumps represent favourable pioneer crops appropriate for conversion.

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