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COPPICE-WITH-STANDARDS: MANAGEMENT OPTIONS FOR AN ANCIENT FOREST SYSTEM

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Abstract

Coppice-with-standards (CWS) is an ancient forest system in Europe which served for centuries to provide timber and a number of other goods, like firewood, poles and fodder to the society while maintaining a continuous forest cover. Since the dawn of modern forestry the area of coppice and CWS forest in Germany has constantly decreased. With the recent rise of energy prices and of wood as a renewable source interest in this system aroused again. Also it was found that CWS forests because of their diversity in structure are a precious habitat for rare and endangered animal and plant species in comparison with high forests. We present two management options in one of the biggest remaining forests of this type in Germany, in Lower Frankonia, Bavaria. The first management option is directed to increase the value of the remaining trees (standards) in the coppice stands in order to cope with timber trees from high forests. The second management option includes an agro-silvopastoral component: in a pilot project we use coppice-with-standards forests as a pasture for Swabian-Hall swines, which are famous for their superior meat quality. The integrative character of this project may support the conservation of the Swabian-Hall swine, which remains an endangered race on the red list of the Society for the Conservation of Old and Endangered Livestock Breeds.

Key words: forest reared Swabian-Hall swine, oaks, silvopastoral system, uneven coppice.

Introduction

Coppice-with-standard (CWS) forests are two-storey forests, where simple coppice is forming the underwood and scattered trees (standards) are building the upper-storey component (Buckley 1992). Indeed CWS forests are a combination of simple coppice and high forest on the same area (Vlad 1940). While in the simple coppice compartment firewood is the main product, in the high forest compartment timber production is in the focus. Until the 18th century many regions in Germany were characterised by this type of forest management. In the course of switching from firewood to fossil fuels, e.g. petroleum and natural gas, the production of firewood increasingly lost its importance.

At the same time the demands on quality of big timber arose, an assortment, which can be produced only in a limited amount in CWS forests (Hochbichler 2005). As a consequence CWS ceased in many regions and those forests subsequently have been converted into high forests. Nowadays the area of CWS forests in Germany is only 0.7% of the total forest area, more than half of these forests is located in Bavaria and Rhineland-Palatinate (BMVEL 2002).

Within Bavaria this type of forestry nowadays is still practised in parts of Franconia. One of the prominent examples is the community forest of Iphofen in Lower Franconia. To keep those remnant forests alive they often have received state subsidies in the past. After a reform of the funding criteria in 2004 by the Bavarian government, a drastic cutting of funding took place. As a consequence many communities planned to convert the remnant CWS forests into high forests.

A conservation of this ancient type of forestry seems possible only, if the financial returns from CWS can compete with the expected financial return from high forests. Interestingly a renaissance of firewood use – especially in rural areas – in combination with a significant increase in market prices for firewood has taken place recently and give reason for hope.

So as not to become dependent on the firewood market a crucial factor will be whether it is possible to produce also highly valued oak timber under a CWS management system, too. Within the framework of a project the TUM Institute of Silviculture (Summa 2007) tried to evaluate what potential oaks from CWS forests have and whether this potential can be improved[1].

An alternative management option for former CWS forests includes an agrosilvopastoral component. In 2005 a pilot project[2] was initiated with the aim to conserve the CWS forest in its structure and use it as a pasture for Swabian-Hall swines, an endangered breed, which hopefully may support the efforts on the conservation of the Swabian-Hall swine. In that project we focus on the quantity and quality of acorn production, which is one of the major components of fodder of swine, but also on the impacts of pig herding on the composition of ground vegetation, tree regeneration, and soil fauna. The study took place in an ancient CWS forest, which is quite similar to the forests where we tested silvicultural optimization.

Increasing the value of standards

Object of our research were typical CWS stands in Lower and Middle Franconia, where we established a set of experimental plots to study the following objectives:

1. Evaluation of current quality potential of valuable timber candidate trees (standards) in CWS

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2. Improvement of quality potential by silvicultural means

3. Comparison of the potential with corresponding results from high forests

We established permanent sample plots in two CWS forests, one in Iphofen (county of Kitzingen) second in Weigenheim (County Neustadt an der Aisch). The CWS forest of Iphofen is a mixed Oak-Hardwood forest on moderately dry sand beds, whose upper canopy layer is dominated by Sessile Oak (*Quercus petraea*), associated with Pedunculate Oak (*Quercus robur*) and some single specimens of Common Beech (*Fagus sylvatica*), Lime tree (*Tilia cordata*), and Wild Service Tree (*Sorbus torminalis/ domestica*). The sparsly existent understory is made up mainly of regeneration of the two Oak species as well as coppice of Lime Tree and Common Beech. The Weigenheim forest is a mixed Oak-Hardwood forest, too, which grows on moderately dry loam beds. The upper canopy layer is also dominated by Sessile Oak and Pedunculate Oak, accompanied by some single specimens of Silver Birch (*Betula pendula*), Aspen (*Populus tremula*), Hornbeam (*Carpinus betulus*) and Lime Tree (*Tilia cordata*). The understory is composed of saplings of Oak and coppice of Silver Birch, Lime Tree and Field Maple (*Acer campestre*). We subjected the sample plots to three different silvicultural treatments:

Treatment A: Control plots without any quality improving silvicultural management prescription. Stand should be converted passively in high forests, a usual practice applied in many locations in Germany.

Treatment B: On these plots the traditional way of management of CWS has been continued.

Treatment C: On these plots we tried to improve the quality of timber by various silvicultural means. For this reason a number of 60 candidate trees was selected and subsequently pruned.

In total we established in the two forests of Iphofen and Weigenheim 12 experimental plots with an area of 0.25 ha each. On each of the two locations we performed two replications of the three treatments (2 locations x 3 treatments x 2 replications = 12 plots). Apart from an inventory of the remaining stand, an evaluation of the thinning and an inventory of the advanced regeneration a quality monitoring of the standards on each plot took place. These data provided insight in the age structure, stand structure and quality structure of the stands and gave chance for comparison with data from high forests.

All experimental plots should carry at least 15 standards each (i.e. 60 standards per ha) and should be comparable with each other. The modified type of CWS silvicultural system (treatment C) aimed to build up an uneven-aged stand structure in the standards of the remaining stand, as it was suggested already by Cotta (1835, cited in Hamm 1896). Following Cotta the optimum stocking of the plots with standards should be 30 (or 120 standards per ha) exhibiting a specific distribution in various age classes (Table 1).

Thinning treatments in each of the age classes reduce the number of trees to half of the number, i.e. that the density will be reduced on a plot with each

Table 1. Optimum density of maiden trees on Treatment C experimental plots.

Age class	Labelling	Age	N per plot	N per ha
1	Maiden (Lassreitel)	< 30	15	60
2	Oberständer	30 – 60	8	32
3	Angehende Bäume	60 – 90	4	16
4	Bäume	90 – 120	2	8
5	Hauptbaum	> 120	1	4
$\sum$ 1–5	Standards (Kernwüchse)	< 30 ≥ 120	30	120

thinning by 15 trees (60 per ha). Because 15 new maidens will be selected in each thinning the total number of standards will remain constant and supports the sustainability of this type of forest management.

Quality parameters

Standards tree quality parameters were monitored according to the methodology of Sliwa (1988):

– DBH.

– Tree height.

– Position where crown of tree commences (i.e. position of large vital branches; no epicormics or water sprouts).

– Position and diameter of the largest living branch of the crown.

– Position and diameter of the largest dead branch beneath the living crown.

– Position and width of stem crookedness (highest deviation of the stem from plumb line and its distance to the midpoint of stem at root collar).

– Position of forks.

– Number of epicormic sprouts (up to a height of 10 m; in three classes: single < five per trunk; several = 5 to 20 per trunk; many > 20 per trunk);

– Number of wounds (distinguishing between the following wound types: mechanical wounds, cancer, fungal disease).

In addition another quality criterion, the length of clear bole was determined, which has not been monitored and analysed in the studies of Sliwa (1988) and Mosandl and Kleinert (1998). It is defined as the length of bole from the lower end to the position of the lowest vital branch with a minimum diameter of 1 cm. At least a pruning of standards was applied on all C plots, where branches and epicormics have been removed up to a height of 7 m.

Comparison with oaks from high forests

Data for comparison originated from studies of Sliwa (1988) on the quality of young sessile oaks from mixed Oak-Beech-Hardwood forests on red sandstone soils from Lower Franconia

Table 2. Comparison of maiden trees from CWS forests with oaks from high forests of Rohrbrunn and Weisswasser.

Parameters	Weigenheim		Iphofen		Rohr-brunn[1)]	Weiss-wasser[2)]
	A+B	C	A+B	C		
Age, years	30	30	30	30	49	50
Height h_g, m	14.5	12.9	13.3	14.1	16.0	14.5
DBH d_g, cm	15.4	10.5	13.5	15.1	15.6	14.2
Position where crown commences, m	7.8	6.3	6.6	7.7	9.7	6.2
Length of crown, m	7.3	5.3	6.0	7.3	6.3	8.4
Position of the largest living branch, m	9.0	7.2	7.7	8.9	10.5	7.8
Position of the largest dead branch, m	6.2	5.6	6.7	8.0	7.6	5.1
Diameter of the largest living branch, cm	5.7	4.1	4.5	4.5	5.0	5.2
Diameter of the largest dead branch, cm	2.4	2.0	2.2	3.3	3.8	3.6
Percentage of trees with stem crookedness, %	28	27	27	23	72	61
Mean width of stem crookedness, cm	22	38	21	17	52	33
Percentage of trees with forks, %	18	27	21	39	22	39
Percentage of trees with epicormic sprouts, %	69	0	66	0	32	39
Percentage of trees with wounds at bole, %	13	23	25	35	0	6

[1)] from Sliwa (1988) [2)] from Mosandl and Kleinert (1998)

as well as from studies of Mosandl and Kleinert (1998) on the quality of oaks resulting from dispersal by jays in mixed Oak-Pine forests on sandy brown soils and podsols in Weisswasser/Saxonia.

For the comparison between trees from CWS forests and high forests oaks have been selected from high forests which have had an individual age of about 20 years older. The reason was that oaks from high forests ranked significantly in height and diameter behind those from CWS forests. For a qualitative comparison it seems reasonable to compare individuals with a similar developmental stage, although of uneven age. Hence the data from a 49 year old stand from the Rohrbrunn forest district (Sliwa 1988) and those from a 50 year old stand from Weisswasser (Mosandl and Kleinert 1998) have been selected. In the following Table 2 the quality characteristics of the maiden trees from the CWS forests are shown in comparison with the oak trees from the two high forests. In addition the Weigenheim and Iphofen data have been subdivided according to treatments 'A+B' (= unpruned) and 'C' (= pruned).

Regarding height of maiden trees in comparison with oaks from high forests we observed, that the height of CWS trees, although distinctively younger in age, was nearly similar to that of the high forest oaks. The height of oaks from Rohrbrunn (16.0 m) was slightly higher than that from CWS (heights between 12.9 and 14.5 m). Oaks dispersed by jays from Weisswasser exhibited a height of 14.5 m – the same height as maiden oaks from CWS.

DBH from maiden oaks and jays' oaks showed values between 10.5 und 15.4 cm. Oaks from Rohrbrunn (Spessart) were slightly wider (DBH 15.6 cm). One of the main reasons for this result could be an enhanced diameter growth rate of CWS trees as a result of the periodical removal of the underwood.

The position, where crown commences, was 9.7 m in oaks from Rohrbrunn, and hence considerably higher than that from CWS (6.3 and 7.8 m, respectively). Jays' oaks from Weisswasser showed the lowest mean value (6.2 m). Mean crown length in CWS was between 5.3 and 7.3 m; this is very similar to oaks from Rohrbrunn (6.3 m). Jays' oaks from Weisswasser had considerably longer crowns (8.4 m).

An important quality criterion is the branchlessness of the bole. The smaller the branches and the higher their insertion on the bole, the higher is the value of the bole. The mean position of the largest living branch in CWS oaks was up to 3.5 m lower than that from oaks from Rohrbrunn. Jays' oaks from Weisswasser showed similar positions as those from CWS.

Concerning the mean position of the largest dead branch we found comparable results. CWS oaks exhibited values of 5.6 m and 8.0, respectively, which is up to 2 m less than oak forests from Rohrbrunn (7.6 m). Jays' oaks from Weisswasser showed the lowest insertion height with 5.1 m.

Oaks from the high forests of Rohrrunn and Weisswasser revealed a stem crookedness of 72% and 61% of the trees, respectively, whereas CWS oaks revealed only a maximum of 38% in Iphofen. Sliwa (1988) supposed that the high percentage of crooked oaks in high forests may be a result of the high stem density, which leads to enhanced phototropic reactions.

In many cases forking is matter of genetic disposition, and seldom a result of management. Between 18 and 39% of oaks exhibited forking.

Epicormic shoots were detected in a considerable amount in maiden trees from CWS. In the sub-category of unpruned CWS stands 69% and 66%, respectively, of the monitored maiden trees have some to many epicormic shoots at the bole and result in a decrease of wood quality. On the other hand oaks from high forests also display epicormic shoots, with about 32% in Rohrbrunn and 39% in Weisswasser. In treatment C all the epicormic shoots have been removed.

The percentage of trees with wounds on the bole was relatively high in CWS trees between 13% and 35%. In comparison oaks from high forests perform much better with a very little amount of wounds, e.g. in Weisswasser only 6% of the trees monitored. Reason for the high number of wounds in CWS are mechanical injuries as a result of logging and extraction due to improper handling by private persons.

Definition of quality categories

The solely description of quality criteria in the previous chapter give no information about the percentage of "very good", "good" or "worse" maiden trees. Only the correct classification of individual trees into categories helps to quantify the latter (Table 3).

Figure 1 give an overview of the quality performance of maiden trees from CWS versus oaks from high forests in Rohrbrunn and Weisswasser. As expected plus trees from oak high forests of Rohrbrunn performed best in the high quality categories. In the maiden trees from CWS the percentage of worse qualities was relatively high (in Weigenheim > 40%, in Iphofen > 60%), but in comparison with jays' oaks from Weisswasser the maidens exhibited a high share of very good individual specimens. In addition there is higher share of very good maidens in pruned plots (treatment C), which is nearly double in percentage to that in the unpruned stands.

Conclusions from the experiments on increasing the value of standards

While comparing DBH and height data of maiden trees from CWS with data of oaks from high forests there is a great evidence of better growth performance of oaks in the CWS stands in the juvenile age phase. This observation can encourage forest managers to produce highly valuable timber in CWS stands in a shorter rotation period than in high forests.

On the other hand quality of oaks from CWS is poorer than from high forests. So some efforts should be undertaken to improve quality of standards in CWS stands. Quality improvement of standards is feasible by three measurements:

– New standards must be carefully selected with regard to timber quality within the coppice system.

– Harvests in CWS stands should be carried out in a way to avoid wounds at the bole of the standards.

– Pruning of epicormic shoots seems to be an appropriate means to produce valuable timber (the long term effect has still to be investigated).

Pig Herding in the CWS Forest

Pig herding took place in an ancient CWS forest near Possenheim (Huss

Table 3. Categories of quality for the evaluation of maiden trees (Sliwa 1988).

Quality of maidens	Factor	Thresholds
Worse	Wounds on the bole	all
	Width of crookedness over	80 cm
	At a height lower than	7 m
	Height of forking lower than	10 m
	Epicormic shoots	many
Satisfactory – good	Width of crookedness over	80 cm
	At a height more than	7 m
	Otherwise below	40–80 cm
	Height of forking higher than	10 m
	Epicormic shoots	some
	Diameter of biggest living branch higher than	5 cm
	At a height of lower than	10 m
	Diameter of biggest dead branch higher than	4 cm
	At a height lower than	8 m
Very good	Without defects or max. width of crookedness lower	40 cm
	Epicormic shoots	single
	Diameter of biggest living branch lower than	5 cm
	Diameter of biggest dead branch higher than	4 cm
	At a height higher than	8 m
	Otherwise below	4 cm

2006), which is quite close and very similar to the forest of Iphofen, where we tested silvicultural optimization. The Possenheim forest is a mixed Oak-Hardwood forest, which was actively managed as a CWS until the late eighties of the last century. The upper canopy layer is dominated by Sessile Oak (*Quercus petraea*) accompanied by Pedunculate Oak (*Quercus robur*) and also harbours single specimens of *Acer pseudoplantanus* and *A. platanoides*, *Populus tremula, Betula pendula, Fraxinus excelsior, Sorbus domestica* and *S. aria, Malus sylvestris*, and *Pyrus pyraster*. The mid- and understorey is characterized by numerous young hornbeam (*Carpinus betulus*) trees, mostly from resprouts, together with an extensive regeneration consisting of a fine grained mixture of saplings of the already mentioned canopy species.

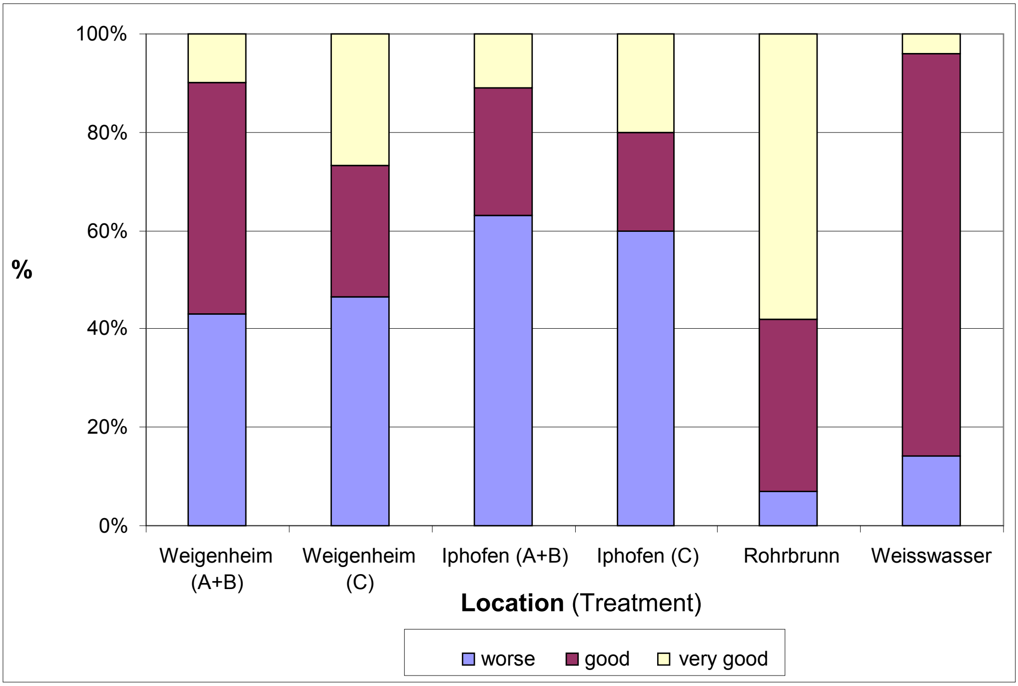

Fig. 1. Quality performance of maiden trees from CWS in comparison with oaks from high forests.

Acorn production was monitored quantitatively and qualitatively for a period of four years with a variety of methods, including Unmanned Aerial Vehicle (UAV) which carried a camera (Hofmann et al. 2009). In addition the impacts of swine on the composition of ground vegetation, tree regeneration, and soil fauna were examined.

Substantial fluctuations in acorn production occur from year to year. We observed a good mast in 2006 with an acorn production of 1154 $kg.ha^{-1}$ that allowed for herding of up to 171 pigs on an area of 20 ha for a fattening period of 90 days or allowed for herding 150 pigs for a fattening period of 103 days, respectively (Table 4). In the two following years 2007 and 2008 acorn production was only a fraction of the 2006 production (~ 28%), and in 2009 was nearly zero. Although acorns are an important staple pigs obviously find suitable substitute feed (e.g. roots, bulbs, herbs, mushrooms, insects, beetles, caterpillars, earthworms and mice). This has been demonstrated in studies with domestic and feral pigs (Genov 1981, Matthes et al. 1997, Schley and Roper 2003). Severe feed shortage can be alleviated by complementary feeding of acorns (collected in other stands and/or purchased), alternatively herd size can be adapted to the mast conditions.

Table 4. Evaluation of acorn production, herd size and fattening period.

Year	Acorn production, kg.ha^{-1}	Carrying capacity (on 20 ha for 90 days)	Calculated fattening period (on 20 ha for 150 pigs)
2006	1154	171 pigs	103 days
2007	315	47 pigs	28 days
2008	321	48 pigs	29 days
2009	26	4 pigs	2 days

Conclusions from pig herding

Yearly acorn production in oaks stands is highly variable. Unfortunately there are only few data series on the periodicity of mast. Local and regional data series are needed as a basis for evaluation, planning and model building for an alternative use like pig herding in CWS. Basic methodology of forecasting is already available but relatively imprecisely and hence has to be improved considerably. Pig herding in CWS with Swabian-Hall swine supports the conservation of the endangered race and also supports the conservation of CWS forests, because the potential use of underwood and/or standards is not affected by herding. First investigations demonstrate that in mast years (e.g. 2006) pigs leave over a considerable number of acorns, which may give raise to a sufficient amount of oak regeneration.

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