Renaissance and global utilisation of the coppice system

- Is the historical silvicultural system „coppice forest“ topical again? -

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Introduction

The silvicultural system „coppice forest“ is a cultivation system seeming to be antiquated. On the one hand, the coppice forest experiences a sort of worldwide revival, because of reasons that are closely connected with the topic of energy production based on biomass or energy wood. On the other hand, it is necessary to give this silvicultural system serious thoughts. That requires an integrated examination of the nature, the advantages and disadvantages of this system.

The article has got following structure:

1. Explanation of the concept: silvicultural system „coppice forest“
2. Specific characteristics of the worldwide coppice forests concerning to assortments, stand structure, and forest management
3. The global utilisation of the coppice forest system today and in the future
4. Modern forms of the coppice forest system
5. Conclusions
6. Summary

1. Explanation of the concept: silvicultural system „coppice forest“

The applied silviculture uses forest-economic criteria to define different silvicultural systems in the production forest. Classification in silvicultural systems and management systems is made according to:

- the sort of regeneration (natural or artificial regeneration, reproduction period),
- the type of silvicultural treatment (type of thinning, thinning intensity, tree species),
- the production period (period from the plantation establishment until the timber harvest),
- the production target (assortments, management goals).

Coppice forest is an old silvicultural system that is based on the ability of (leaf)trees to sprout, in other words, the ability of vegetative regeneration and reproduction. For that reason these forest crops are often called sprout forest management. Vegetative regeneration occurs from roots (as root shoot), from stumps (as „stump [coppice] shoot“), from pollards (= pollarding system) and branches (lopping method) or as propagation by cuttings.

In Europe, only hardwood has been cultivated with the coppice forest system, on other continents it has been used partially also with conifers, as for example bald cypress (*Taxodium distichum L.*), grand fir (*Abies grandis Lindl.*), and mammoth tree (*Sequoia giganzea Lindl.*) in North America (SIEDER 2003).

The ability of vegetative reproduction of the diverse tree species is very different (Table 1). Particularly poplar, willow, robinia, and alder have a distinct ability to coppice. Root shoot appears particularly intensively with poplar, aspen, mountain ash, and robinia. Species of poplar, willow, and aspen are mostly used for propagation by cuttings.

Table 1: Ability of vegetative reproduction of deciduous trees (following HAMM 1896)

	ability of vegetative reproduction	
	coppice shoots (length of annual shoot [cm])	**root shoots** + very low +++ strong [1)]
balsam poplar (Populus balsamifera)	150	+++
black poplar-hybrides (Populus nigra)	150	++
white poplar (Populus alba)	100	++
asp (Populus tremula)	-	+++
willow (Salix spec.)	150	+
mountain ash (Sorbus aucuparia)	-	+++
robinia (Robinia pseudoacacia)	150	+++
elm (Ulmus spec.)	100	++
grey alder (Alnus incana)	120	++
common alder (Alnus glutinosa)	120	+
horse-chestnut (Aesculus hippocastanum)	-	++
chestnut (Castanea sativa)	100	++
lime (Tilia platyphyllos/cordata)	-	++
whitebeam (Sorbus aria)	-	++
birch (Betula pendula)	150	++
common/sessile oak (Querc. robur/petraea)	60	+
European beech (Fagus sylvatica)	40	+
hornbeam (Carpinus betulus)	60	+
ash (Fraxinus excelsior)	150	+
sycamore maple (Acer pseudoplatanus)	150	+
plane maple (Acer platanoides)	120	+

note 1) + very low – even after cutting or damage
++ middle
+++ strong – also in case stem and root are healthy

The geographical distribution of the silvicultural systems coppice forest and middle forest is uneven. In Germany 6 % of the forest area were managed by coppice forests or middle forests in 1982 (Table 2). This share of area was in France and Italy clear higher with 50 % and 57 %. At present coppice forest and middle forest have in Germany a secondary importance. In 1999 they occupy each only 1 % of forest area of the country.

Table 2: Share of coppice and middle forests of the forest area some european countries in 1982 (BMELF 1982)

country	Germany	France	Italy	Belgium
area [tsd ha]				
coppice forest	315		2685	55
middle forest	78		730	119
area total [tsd ha]	393	4714	3714	174
share on the forest area [%]	**6**	**50**	**57**	**30**

2. Specific characteristics of the worldwide coppice forests concerning to assortments, stand structure, and forest management

The ability to reproduce vegetatively decreases with advancing age. Therefore, the cultivation of diverse tree and shrub species in the coppice system was realised mostly in short **rotation cycles**. Moreover, the length of the rotation was based on the production target. As an example, the productive time of firewood is much longer than that of wickerwood.

With softwood species like birch, aspen, willow, and hazel, rotation cycles of 10 to 25 years have turned out to be favourable. With hardwood species, the rotation cycle was between 25 and 45 years. This is true for instance for oak with ancillary tree species as hornbeam, lime, ash, elm, maple and wildfruit trees. For willow plantation, for example with basket willow (*Salix viminalis L.*), rotation cycles of 1 year, occasionally up to 8 years were sufficient.

There are two forms of coppice forest with longer rotation cycles:

1st Alder coppice forest:

This tree species is able to coppice and root shooting up to the age of 50 to 70 years.

2nd Oak bark forest:

This form was used not only for the production of firewood and charcoal but also for the extraction of oak tanbark. Its importance decreased when tree species of a much higher content of tanning agent were found overseas, like quebracho species in South America and acacia species in Africa.

Other common forms of coppice forests are firewood, robinia, and sweet chestnut coppice forest. The energy forest can be seen as a bridge between history and prospect.

Primary assortments were firewood, charcoal, oak-tanbark, grape stakes and small-sized structural timber.

The **stand structure** of coppice forests is mostly single-storied and hold-over trees are rare. Hold-over trees can improve the frost protection, but they lead to yield reduction owing to the encroachment of the main stocking. In addition hold-over trees frequently have stagheadeness and the “old” stumps recoppice badly.

The utilisation of the forest products of the coppice forest was mostly realised as a complete use by clear felling, rarely as selective removal of the largest poles of a stump. With this, it is of particular importance that first basic rules of a forest management were developed with the coppice forest. At the beginning, the utilisation was realised by yield regulation by area. Later, yield regulation by volume was established. In this way, 3 to 5 solid cubic metres/hectare*year of small commercial timber could be extracted sustainably. For this reason, the coppice forest system is the most original and most simple sustained yield forest of the forestry.

The cutting was realised in the winter half year when stump and rootage were well provided with reserve substances. However, there were two disadvantages:

1st After several cycles, the stumps were of reduced vitality and productivity and had to be replaced by seedlings.

2nd The soil is subject to a high nutrient removal because the stocking is constantly in the juvenile stage with high increment. On the other hand, the nutrient input into the ecosystem is low. Soil degradation, grassiness, and unproductive shrubb-rich softwood stocking are the effects. Particularly with willow plantation management, fertilisation is necessary.

The **productivity** of the coppice forest is an essencial parameter (Table 3).

Table 3: Productivity of the coppice forest

product-yield	**typical coppice forest tree species**	**productivity**
yield of wood	• poplar, willow • common alder, lime, ash, maple • grey alder, elm, oak, birch • hornbeam, wild fruit, hazel • European beech	> 10 m^3 / ha*year > 10 m^3 / ha*year > 8 m^3 / ha*year > 6 m^3 / ha*year > 4 m^3 / ha*year
yield of tan bark	common/sessile oak (Quercus robur/petraea)	250 – 500 kg / ha*year
yield of dry matter	• willow (Salix spec.) • eucalyptus (Eualyptus spec.)	20 t / ha*year = 40 m^3 / ha*year

The data of the mean total increment are up to 10 cubic metres per hectare*year, the yield of dry matter is up to 40 solid cubic metres per hectare*year. In case the stumps are vital, the yield is at least so high than in high-forest systems of this tree species on the same sites (BURSCHEL und HUSS 1987). These facts demonstrate that the importance of the coppice forest does not depend on its productivity but on the utility and monetary value of the product „timber“.

3. The global utilisation of the coppice forest system today and in the future

A silvicultural system gains importance when it meets specific demands of the human society on the forest. These demands are in flux continuously and have to be analysed.

The **historic importance** of the coppice forest consisted in the production of commercial timber and sweet chestnuts as well as in utilisation by agriculture and livestock farming. The **current and future importance** of the coppice forest system results mainly from two aspects – the utilisation and the conservation aspect:

1st Utilisation aspects:

- In the European forestry, the producing coppice forest system in historical sense exists now only as a minor forest management system. Particularly in times of war and need, the coppice forest system was established consistently. The targets were mainly production of tanbark and firewood as well as willow plantation. In Europe, forms of coppice forest are of importance especially in the field of rural natural economic utilisation. Their relevance in Eastern Europe (for example production of wickerswood, firewood, and pasture stakes) and in Southern Europe (production of grape stakes and firewood) is to be pointed out.
- In tropical and subtropical regions, coppice forest crops are of considerable importance, in particular for firewood production. In addition, forest crops similar to coppice forest systems as well as hedges serve as forage in times of need. In this context, pruning is often practised. Mainly in the Sahel and the Sudan, foliate branches are cut in order to rescue cattle in times of need. In the Sahel, for example, acacia is taken. In doing so, there is a risk that the already loose and overexploited forests and bush formations will be destroyed completely. So a very important task of forest development assistance is the laying out of hedges as forage reserves for times of need. For this, extensive and successful projects were realised on Haiti. Because of the regional socio-economical characteristics, methods of a combined agrar-forest-cattle economic system are often reasonable.
- One of the globally important utilisation aspects - currently and in the future - is the production of biomass in order to extract energetically utilisable wood and pulpwood. More about that in the following article “Modern forms of the coppice forest system”.

2nd Conservation aspects:

- *Soil conservation:*

Prevention of deflation by intensive root penetration and soil cover is a function of the forest that is of continuously increasing importance, particularly in regions with low precipitation. In order to guarantee erosion control, deviation from the principle of extensive utilisation is necessary. This applies to the soil conservation on places with steep escarpments or the risk of strong drifts in particular. Falling of forest litter supports the creation of humus cover and – at the same time – the supply with nutrients. Thereby, the productive efficiency of the soil is conserved.

But: In case of full utilisation, coppice system can remove high amounts of nutrients from the soil. Admittedly the European soil sorts should be estimated in another way than the poor, geologically old tropical soils. European soils are able to keep their productivity in spite of high removal of nutrients – according to information in literature, sometimes up to 100 and more years (DENGLER 1935, DOHRENBUSCH 1982). Tropical soils, on the other hand, impoverish dramatically fast.

An Example:

In order to supply the needs of firewood in sparsely wooded regions and to counteract the destruction of forests, broadleaved tree species - not-autochthonal, but with sprouting capacity - were often planted on large areas on tropical soils (for example *Azadirachta indica* and *Gmelia arborea* from Asia or eucalyptus species from Australia). The targets are the extraction of firewood and charcoal and the saving of seeding costs for the following forest generation by coppice shoot (economic significance). However, the third generation showed already stunted growth and larger failures. The productivity of the soil had been reduced as a result of wood harvest by large-scale clear cutting system and utilisation of all branches.

- *Conservation of resources:*

Forest areas of intensive, large wood production can avoid or at least reduce the overcutting of semi-natural forests on large areas. So they contribute to the sustainable utilisation of wood as an important natural ressource. In addition, a specific form of conservation of ressources in tropical and subtropical regions is the conservation of characteristic and rare forest-ecological biocoenosisses. Again, that applies particularly to the sensible ecosystems of the regions of low precipitation.

- *Nature conservation:*

The best known example of the conservation of a historical utilisation system because of ecological and nature conservation reasons is probably the alder coppice forest in the area of the „Spreewald“. Recently, historical forms of forest utilisation have become a new significance from the point of view of nature conservation, mainly because of the rare mixtures of tree and shrub species and the valuable natural habitats for fauna and flora. They often serve as a reserve for endangered species. Because of the world-wide continuously decreasing forest area and the extinction of species, the conservative significance of coppice forest increases.

- *Climate protection:*

The world-wide steadily rising of CO_2-emission affects the global alteration of temperature. That is why the forecasted global warming runs unnaturally fast. Productive forest crop assimilates large amounts of CO_2, so that high-capacity plantations that are run coppice forest-alike can have a share in climate protection.

Following reasons militate for and accordingly against the suitability of the coppice forest system for performing the mentioned functions and social expectations:

Reasons for the coppice system:

- The coppice forest is a simple management system, the qualification level is low.
- No costly facilities are necessary.
- The timber yield is relatively high and not inferior to the high forest system.
- The conservative significance of historical forms of forest management is highly prized.

Reasons against the coppice system:

- Clear cutting situations appear more often than with the high forest system, though the vegetative reforesting runs fast.
- The complete utilisation of the biomass is followed by considerable nutrient leaching, partly increased by pasturage and litter utilisation. These processes can lead to strong strains of the soil productivity and to degradation. Coppice forest is an unnatural form of forest management with high site requirements.
- The poor timber assortments limit the usage considerably. Because of that, there is a strong dependence of the takings from the local and seasonal market situation.

4. Modern forms of the coppice forest system

In connection with the probably in future world-wide most significant functions of the coppice forest, the production of biomass and climate conservation, the idea of the coppice forest experiences kind of renaissance.

This connection is based on following **initial situation:**

⇨ The air pollution by fossil fuels like coal and petroleum attained a high level.

⇨ Ecology groups and parties demanded „life-cycle assessments“ for industrial production processes. Within this, energy balances and cycles of resources are in the focus. Renewable energy sources like wood or reed are evaluated favourably in life-cycle assessments. They ensure cycles of resources instead of pure use/wastage of resources.

⇨ The continuous CO_2-emission accelerate the imminent global alteration of temperature and with that the global climate change. Wood as a CO_2-neutral energy source acts as a regulator in this process.

- ⇨ The steadily rising costs of the conventional energy sources (most notably petroleum) provoke a search for more cost-efficient energy sources.
- ⇨ The evaluation of the situation by the conference in Rio de Janeiro in 1992 led to stricter conventions regarding the climatic protection.

From these factors, the basic idea of searching for alternative energy sources and materials that lower the amount of CO_2 was developed. The production of **energy timber** as fuel or as a source for the production of electrical energy came to the focus of the energy users.
There are two possible methods of reasonable extraction of energy timber:
1st method: Use of small-sized timber and waste timber from the thinnings:
That way, on the one hand, tending arrears can be made up fast. On the other hand, the economically little attractive small timber sector could be appreciated and the increment-exploitation-deficit in the forest reduced. For example, only about 70 % of the realised increment is used at present in european forests.
2nd method: Reflections about other management systems:
These reflections result in the development of new economic strategies according to coppice forest principle. Today, the most distinct form of the coppice forest system is in practical application with the cultivation of energy timber plantations. Modern energy timber plantations are managed mechanically and very efficiently according to typical features of the coppice forest. They use the high volume production of rapid growing tree species as well as their sprouting capacity. The realisation of cuttage is the most common form of reproduction.
Most suitable are mainly all sorts of populus and salix as well as their hybrids, hybrids of the tacamahaca section (balsam poplar) and robinia.

Research programmes in Sweden showed that plantations on low-yielding agricultural sites after fertilizer application became interesting from the business management point of view, despite the hard climatic conditions. For instance, willow plantation with poplar and willow produced attractive yield after application of fertilizers.
In the future, mainly disused, former agricultural areas seem to be suitable as main sites for the creation of energy timber coppice forests. In order to support these activities, there are programmes of the European Union as well as of the Federation and the Federal States.

Currently, timber plantations are particularly common and developed in South Africa, Brazil, New Zealand, Chile and Australia, mostly with rotation periods between 7 and 15 years.

Nevertheless, it is necessary to point out some **special features**:

- The designation of energy timber plantations with rapid growing tree and shrub species of short rotation periods is no forest utilisation in the sense of forest right and is not considered

to be an afforestation. Thereby, a rapid retransformation into agricultural or other systems of utilisation is possible.

- The cultivation of energy timber plantations is incompatible with the existing certification indicators. Fertilization, driving on the entire area, and clear cutting unapproved on certificated areas. But certification takes place only on forest areas according to forest right.
- Energy timber plantations are highly productive but unnatural forms of stocking.

The creating of energy timber coppice forests aspires to **three targets**:

1) Reaction on the forecasted effects of the Global Warming by application of CO_2-neutral, alternative, environmentally friendly energy sources. All in all, the need of CO_2-reducing landusing systems is rising. Possibly, even infrastructural forest functions like the storage of CO_2 will be appreciated monetarily in future.
2) Reaction on the global change of the economic environment by efficient extraction of alternative energy sources.
3) Reaction on the global change of the barter economic utilisation demands, for example reasonable use of agriculturally disused areas.

5. Conclusions

[1] Global changing is an integral process that results from the changing of ecological (nature, soil, climate conservation), economic (efficient extraction of raw materials, substitution of fossil fuels), and social factors (work, solid social structures).

[2] It is not the historic significance of the coppice forest that has been focussed recently by barter economic utilisation strategies but the coppice forest principle.

[3] Following main features of the coppice forest principle are acted on: vegetative reproduction, rapid growth, single-storied stand structure, early use by clear cutting system (usually after max. 20 years).

[4] Central targets are the quick production of biomass for energetic purposes, the agro-forestry sector (forage, soil conservation), and climate protection (CO_2-neutral extraction of resources).

[5] Currently, more and more highly efficient technologies of timber production that have been derived from the coppice forest system are applied. Primarily, they are based on the cultivation of pioneer tree species such as eucalyptus species, *Pinus radiata (D.Don.)*, poplar and willow species.

[6] The coppice system is unnatural and concentrated on productive sites. For this reason, it can be only part of barter economic utilisation. Forestry has to focus mainly on natural, steady,

multifunctionally effective afforestation systems. Perspectively, they are adapted at best to global changings.

6. Summary

The global reorientation of the using demands on the forest, the advanced demands of the society on forest utilisation, and the effort to sustainable protection of resources as well as environmental prevention are reasons for the current revival of the historic silvicultural system coppice forest and its practical application as utilisation strategy worldwide.

For special ecological and socio-economic needs as for instance soil conservation and production of energy wood, cultivation strategies that are similar to the coppice system can be regionally a reasonable supplement to the „traditional“ silviculture. The significance of the coppice system has to be seen mainly in the aspects of production of energy wood – particularly as a substitute for fossil fuels – and the providing of resources for the worldwide rising demand on cellulose. Thereby, single storied forest crops as well as different agroforestry systems can be applied.

The coppice forest system is to evaluate as a highly productive but unnatural form of forest management.

Bundesministerium für Ernährung, Landwirtschaft und Forsten (BMELF) 1982: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland 1982 Abt. 2 „Planungskoordination und Wirtschaftsbeobachtung“. Deutscher Landwirtschaftsverlag, Münster-Hiltrup

BURSCHEL, P. und HUSS, J. 1987: Grundriß des Waldbaus – Ein Leitfaden für die Praxis. Verlag Paul Parey, Hamburg und Berlin

HAMM, J. 1896: Der Ausschlagwald. Verlag Paul Parey, Berlin

DENGLER, A. 1935: Waldbau auf ökologischer Grundlage. 2. Aufl., Verlag Julius Springer, Berlin

DOHRENBUSCH, A. 1982: Waldbauliche Untersuchungen in Eichen-Niederwäldern des Siegerlandes. Diss. Forstl. Fak. Univ. Göttingen

SIEDER, P. 2003: Angewandter Waldbau, Waldbausysteme und -strategien. Waldbau zur Jahrtausendwende, Bd. 4, Shaker Verlag, Aachen