COST Action FP1301 EuroCoppice

Innovative management and multifunctional utilisation of traditional coppice forests –
an answer to future ecological, economic and social challenges in the European forestry sector

National Perspectives on Coppice from 35 EuroCoppice Member Countries

Editors Valeriu-Norocel Nicolescu, Debbie Bartlett, Peter Buckley, David Rossney, Patrick Pyttel and Alicia Unrau

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Foreword

Coppicing is a very old and traditional form of sustainable forest management that can provide an array of products and services for households, industry and society. The coppice concept employs short utilization cycles (rotations) to take advantage of the vigorous growth in the early years of certain tree species that are able to naturally (vegetatively) regenerate by shoots or root suckers. Depending on the ecological situation and the actual needs of society, various types of coppice forest management with different tree species and rotation periods were developed throughout Europe.

The COST Action FP 1301 EuroCoppice began its activities in 2014. Its main objectives are to collect, exchange, analyse and disseminate coppice-related scientific knowledge. Given the variety and complexity of forests and their management throughout Europe in general, as well as the even greater differences in perception and management of coppice forests in particular, a detailed exploration of the current situation is the first important and necessary step. Further aims are then to raise awareness and provide recommendations to practitioners, experts and politicians regarding the future management of coppice forests in Europe.

The Action comprises 32 COST Member States, two Near Neighbour Countries and one International Partner Country. Members from all 35 countries actively cooperate and network within the framework of the Action's five Working Groups (WG). Each WG examines coppicing from a different angle, while cross-sectional tasks add a further element of complexity.

Within Working Group 2 "Ecology and Silviculture of Coppice Forests", the initiative was taken to ask experts from participating EuroCoppice countries to draft "Coppice Forest Country Reports". These reports provide basic information on the status and management of coppice forests, based on the available sources in their respective country.

Now, as COST Action FP1301 is coming to an end, reports from all the 35 countries involved have been submitted and reviewed by experts from WG 2. These reports give an overview on coppice forests in the respective EuroCoppice countries, and represent a unique and valuable source of information. They are both a useful tool of dissemination and a basis for further coppice related research activities.

I would like to thank all authors of the reports for their invaluable contributions. My special thanks go to Valeriu-Norocel Nicolescu and his editing team for the initiative and review of the reports.

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Contents

ALBANIA

Abdulla Diku[1] and Vasillaq Mine[1]

As in all other countries, coppice forests in Albania represent a traditional system of forest management. For centuries until the present time, coppice forests have been the model of "coexistence" of forests with local communities. These forests have usually had the same purpose; providing firewood for heating and cooking, supplying materials for construction purposes, agriculture, industry, and livestock grazing, for example.

Prior to 1944 Albania had a forest area of about 1,379,000 hectares; about 300,000 hectares of this were deforested for agriculture during the socialist period. The quantity and quality of coppice forest in Albania is variable. Most of the coppice forest is oak, but shrub species are also managed as coppice across the whole country. Generally, coppice forests are located in close proximity to residential areas. In most of them, coppice forests in Albania are irregularly structured due to their disorganized management. In the last 10 years, there has been a slight increase in the area of coppice forests with coppiced oaks now extending to about 32.5% of the Albanian forest area and comprising 17% of the total volume. The low percentage volume compared to the surface area is attributed to the low quality of these forests and poor management. The average volume per hectare of oak coppice forest is about 43 m^3 ha^{-1}. There is evidence of an increase in volume per hectare of coppice forests in the country, attributed to the use of alternative sources of energy for heating and cooking (electricity). The distribution of coppice forests by age classes is shown in Figure 1 below:

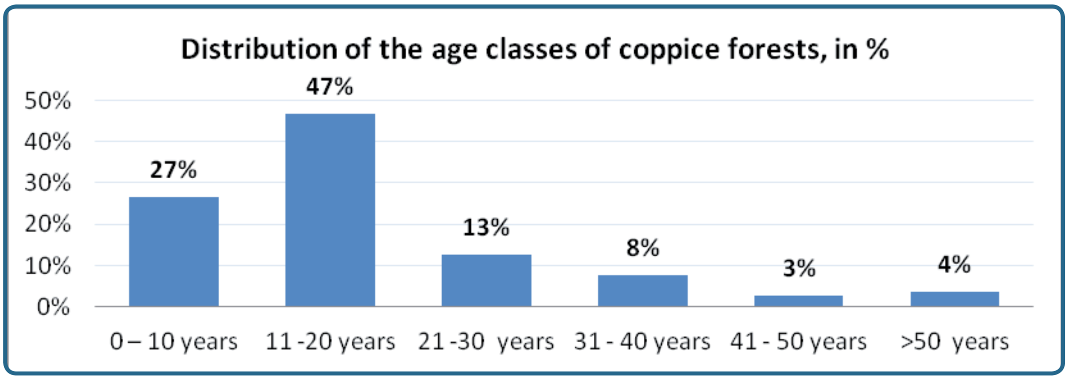

Figure 1. Distribution of the age classes of coppice forests in percent (Source: National Forest Inventory of Albania (2004))

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The chart shows that 70% of coppice is 0-20 years old. Based on inventory data, the average annual growth of coppice forests in Albania is estimated at approximately 2.3 m^3 ha^{-1} yr^{-1}.

Even shrub species are historically treated as coppice forest with this type making up about 25% of the forest area of the country, while in terms of volume; they represent about 10%, with the average volume about 28 m^3 ha^{-1}, again demonstrating the very low quality of these forests.

The main problems of coppice forests in Albania are as follows;

- High demand in the local markets for wood products
- Lack of sustainable management, based on scientific criteria
- Frequent damage due to cutting and fires
- Livestock grazing in the early stages
- Over-use of coppice forests
- Their ineffective use (cutting in short cycles or in breach of technical criteria etc.)
- Unfavourable energy policy in the country (at the expense of forests)
- Forest with poor quality (with low volume/ha)
- Various diseases and pests or harmful agents
- Incorrect data in forest cadastres on area surface and volume

Figure 2. Oak coppice forest in Drini valley.

AUSTRIA

Eduard Hochbichler[1] and Karl Stampfer[1]

At present in Austria coppice forests cover an area of about 100,000 ha or 2.2% of the total forested area. 75,000 ha belong to the "land-coppice system" and 25,000 ha are part of coppice forests in the alluvial plains. 44% of coppice forests are owned by small private farmers, 26 % by private owners with a forested area of 200 to 1,000 ha, 5% by political communities and 51 % by larger private enterprises.

Approximately 90% of the "land-coppice system" area is concentrated in the eastern part of Austria, in the regions of Burgenland and Lower Austria (main growth zone "Sommerwarmer Osten"; oak-hornbeam forest type; average rainfall 450 to 600 mm with dryer periods in spring and autumn; average annual temperature is 9.3 C (Killian et al., 1994). In this region the trees have a high potential for sprouting (Krapfenbauer, 1983).

Due to the site conditions, coppice (15–30 years rotation); coppice with reserves (underwood 20-30 years rotation and reserves 40-60 years) and coppice-with-standards management (underwood 20-30 years, overwood 100-120 years) have been a widespread silvicultural practice in the eastern part of Austria for centuries. Oak and valuable broadleaved trees were/are favoured in overwood. Periodic changes of forest management objectives, influenced by the purpose of optimisation of the performance of forestry systems (coppice system vs. high forest system) and decreasing demand for firewood and/or catastrophic events (*Loranthus europaeus*) have led to different structured stands in the forest enterprises over the last since 40 years (Krissl and Müller, 1989; Tiefenbacher, 1996; Hochbichler, 1997; Hagen, 2005).

This trend caused a decreased relevance of the normal coppice with reserves and coppice-with-standards management systems and fostered promotion of valuable broadleaved trees other than oak. However, ongoing demand for valuable hardwood and for biomass (energy wood) has increased interest in these silvicultural systems once again. Restoration, conversion and transformation strategies are discussed, in order to improve the natural and economic performance (Hochbichler, 1993).

For vigorous coppice sites (top height >24m) a "high forest character" system is now recommended, for moderate sites (top height 18-24 m) coppice with reserves and/or coppice-with-standards system is advised, while for drier, less vigorous sites a coppice system is suggested. Silvicultural recommendations for coppice

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forest management, based on ecological and economic aspects, were developed for various silvicultural strategies (coppice, coppice-with-standards with different percentage canopy cover of the overwood, high forest) and operations (Hochbichler, 2008; Hochbichler et al., 2013).

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BELGIUM

Stefan Vanbeveren[1] and Reinhart Ceulemans[1]

In Belgium, the distinction is made between simple coppice cultures (*hakhout*) and coppice with standards (*middelhout*). Coppice cultures have rotations of 2-30 years and have been the dominant management regime from the middle ages until the start of the 20th century. The earlier and repeat revenues, in comparison to traditional forests, were the main motives for this management regime. The main products extracted from coppice cultures are firewood, oak bark (for tanning), charcoal, pole wood and branches for brooms.

For several years experimental, high density (up to 18,000 trees ha^{-1}), short-rotation (2-4 years) coppice cultures have been established, mainly with *Populus* (Fig. 3) and *Salix* species. These short-rotation coppice cultures are currently grown on 30 ha, an area expected to expand with the predicted increase in demand for second generation biofuels.

Coppice with standards is more typical on rich soils. The coppiced trees were mainly selected for firewood (e.g. *Carpinus betulus, Corylus avellana, Fraxinus excelsior, Castanea sativa* and *Alnus*), while the uneven-aged standards were selected to produce timber (e.g. *Quercus, Populus, Fraxinus excelsior* and *Larix*). From the little available productivity information, 2-7 m^3 ha^{-1} yr^{-1} for stem wood has been calculated.

The use of coppice cultures in Belgium declined in the 20th century as a consequence of the decrease in demand for firewood and oak bark, and the increase in cost of management. Most coppice cultures have been converted to oak high forest or abandoned. Conversion to oak forest involved pruning all but one shoot from each stool but this proved to be an unsuccessful management strategy as it led to poor stem quality. The transformation of coppice cultures usually involved inter-planting with different species such as *Pinus sylvestris, Pseudotsuga menziesii* and/or *Larix*, although old coppice stools can still be found. Recently, coppice cultures have received attention for their nature, cultural and historical value. Re-coppicing old stools is not usually sufficient to re-establish coppices due to the low regeneration capacity of buds. Even if these are still capable of sprouting stem density will be too low, as a consequence of the self-thinning process during past decades. Therefore new planting is often necessary and this requires protection from wildlife and control of competing understorey growth.

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Figure 3. An experimental short-rotation coppice culture in Lochristi (East-Flanders, Belgium) with *Populus* (genotype Bakan, *P. trichocarpa* Torr & Gray (ex Hook) x *P. maximowiczii* Henry).

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BOSNIA AND HERZEGOVINA

Ćemal Višnjić[1], Sead Vojniković[1], Besim Balić[1]

Forests and forest land in Bosnia and Herzegovina occupy an area of 3,231,500 hectares, or 63% of the total area of the country. Of the total 1,252,200 ha of coppice forests in BiH, 34.5% comprises beech, 32.6% thermophilic oak, 22.5% sessile oak, and 10.4% other types of coppice. In terms of ownership, 53% coppice forests is state-owned and 47% private.

In terms of purpose of use, coppice forests in Bosnia and Herzegovina, can be grouped into five classes:

1. productive
2. in very poor management condition
3. special purpose
4. protective
5. inaccessible due to landmines.

Data on areas of coppice forests in Bosnia and Herzegovina, divided into above listed five classes, are shown in Table 1.

Productive coppice forests (class 1) are managed in terms of timber production as the most important function (Fig.4). Other, 2-4 classes of coppice forests have more environmentally and protective functions, while those coppices in class 5 are not subject to any kind of management activity because of the potential dangers of mines from the last war.

The stocking volumes of productive coppice forests in Bosnia and Herzegovina (class 1) by different forest communities are given in Table 2.

In the past, coppice forests in BiH were established as a result of patchy-uncontrolled and unplanned human activity in the forest. As a result, various types of coppice forests, differing widely in structure, quality of stems, and species composition have developed.

Table 1. Areas (ha) all coppice forests in Bosnia and Herzegovina (FBiH- Federation of Bosnia and Herzegovina, RS Republic Srpska)

Class	BiH			FBiH			RS		
	State	Private	Total	State	Private	Total	State	Private	Total
1	438.400	451.300	889.700	217.300	164.000	381.300	221.000	284.900	505.900
2	139.400	80.000	219.400	86.200	52.400	138.600	53.200	27.200	80.400
3	5.200	800	6.000	400	400	800	4.800	400	5.200
4	3.200	2000	5.200	1.200	800	2.000	2.000	1200	3.200
5	75.900	56.000	131.900	52.700	21.200	73.900	23.200	34.800	58.000
Total	662.100	590.100	1.252.200	357.800	238.800	596.600	304.200	348.500	652.700

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Policy now aims to optimise all coppice forests in the productive (class 1) category by using management methods and silvicultural systems to improve the volume of quality stem production and sustainability.

To this end, four categories have been developed to divide coppice forests in terms of the quality of wood and site conditions.

These categories are as follows:

1. good quality coppice forests
2. medium quality coppice forests
3. poor quality coppice forests
4. unknown quality of coppice forests

The Forestry Management Company in Bosnia and Herzegovina pays most attention to good quality coppice forest. These forests, especially coppice forests of beech and sessile oak are managed with coppice selection system. The most frequent rotation is 40-60 years, with felling cycles of 10 years.

In addition to the above types of coppice forests, Bosnia and Herzegovina also has pollards, sometimes as individual trees or in groups. These are evidence of an older heritage where, pollards located near the villages were used by people as a source of small dimension building materials and firewood (Fig. 5).

Table 2. Area and average stocking of large timber of all available coppice forests productive character according coeno-ecological units and entities in Bosnia and Herzegovina (FBiH-Federation of Bosnia and Herzegovina, RS-Republica Srpska)

Coeno-ecological units of coppice forests	FBiH		RS		BiH		
	ha	(m^3/ha)	ha	(m^3/ha)	ha	(m^3/ha)	+-(%)
beech coppice forests	163.500	142,73	189.300	148,99	352.800	146,04	6,49
sessile oak coppice forest	69.300	77,81	160.500	98,42	230.700	92,31	9,93
termopfilic oak forests,	123.500	31,39	85.200	27,90	208.700	29,97	17,17
all other coppice forests	25.000	90,04	70.900	104,15	97.100	100,76	15,18
Total coppice forest	381.300	87,68	505.900	104,46	889.700	97,39	5,27

Figure 4. Productive, well developed coppice beech forest (central Bosnia)

Figure 5. Coppice beech forests with pollards (near Sarajevo)

BULGARIA

Ivailo Markoff[1], Grud Popov[1] and Patrick Pyttel[2]

Bulgarian coppices occupy 1,998,033 ha or 48% of the country's forest area. The oaks dominate (60% of the coppiced area), mainly sessile oak, Hungarian oak and Turkey oak, followed by beech (10%), hornbeam (6%), oriental hornbeam (8%), black locust (9%) and smaller areas of linden, aspen, chestnut, pubescent oak, pedunculate oak, etc. Single trees and groves of the pedunculate oak (*Quercus robur L.*) have survived in the cornfields.

Bulgarian coppices are the result of thousands of years of human pressure – uprooting for cornfields, pasture, and extraction of timber, charcoal and firewood. Usually they issue from an unknown number of coppicing rotations which makes difficult to estimate the age and the vitality of their roots. With some species, a large spacing between the stems in a stool betrays a very old root system. In addition, all Bulgarian coppices have a large or small component of shoots developing from seed which improves their vitality but makes it harder to evaluate them.

The coppices are mainly in the oak forest belt, the most densely populated part of the country. Their altitude is 450 m above sea level on average, and rarely above 1000 m. Coppices are made up of 70% oak and 14% beech. One third (29%) of the coppices are not state-owned, half of these are private (14%) and the rest are community owned. The average slope of the coppice sites is 19°, which is indicative of their protective function.

The average Martonne aridity index for Bulgarian coppices is about 30. By 2050 some 9–10% of them will have developed a steppe climate (aridity below 20) and will be replaced by grasslands and shrubs. By 2080, depending on the climate change scenario, some 16 or 44% of them will be lost in this way. Climatic change is perceived in Bulgaria as increasingly frequent snowless winters and summer droughts. Indirect evidence of this is given by exotic insects previously known only in Mediterranean countries.

Because of their abundance, Bulgarian coppices have never been subject to protection as such. However, in recent times over 60% of Bulgarian forests have been taken into Natura 2000 zones and habitats, including the bulk of the coppices.

Most of the coppices (74%) are in the process of conversion to high forest, with the remaining 26%, called simple forest, maintained as such. Half of the simple forests are plantations of black locust which are really coppiced, the rest are natural stands of Oriental hornbeam (*Carpinus orientalis*

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Mill.) which have been rather abandoned after decades of efforts to replace them with conifers. In Bulgaria there are hardly any coppices with standards. In 1951 there were still 36,000 ha of pollarded high coppices, but since then pollarding has been abandoned. There are no short rotation coppices yet. Unlike Mediterranean countries, in Bulgaria there is no maquis. Deforested and devastated lands were afforested in the post-war years with nearly 1,000,000 ha of pine plantations by which mountain streams and soil erosion were brought under control.

The rotation ages for the conversion forests are: 100 years for the best (site index I and II), 80 for the middle (III) and 60 for the poor (IV and V). Lower rotation ages are set for Turkey oak, with 60, 40 and 40 respectively. The average age of conversion forests is 45 years, i.e. they are already aging. The rotation age for black locust is 20, its average age is 16. It is difficult to set a rotation age for the oriental hornbeam, but its average age is 50 years.

The conversion of coppices to high forest is made in two ways: poor coppices are clear-cut and replaced with conifers (in Bulgaria with pines), otherwise the final cutting is postponed until the reproductive power of stools diminishes and meanwhile they are thinned for pit-poles and firewood. In Bulgaria, the conversion started fairly late and is still going on. The reconstruction with conifers was however abandoned in 2006 because the suppression of viable stools is too expensive.

In Bulgaria, the conversion of coppices to natural stands is a policy dating back to the 1950s, but the main efforts started in the early 60s. This policy aimed to improve both productivity and quality of forests. Indeed, although coppices occupy 50% of the woodland, they produce only 39% of the harvested wood, and at that mainly industrial wood and firewood – the sawlogs make up 5% of the harvested wood, against 23% for the broad-leaved high forest and 36% for the conifers. Nowadays, the rising prices of energy wood gives some cause to reconsider this policy. Firewood prices are also rising in Bulgaria. Nevertheless, firewood is still the cheapest form of energy. All the Bulgarian countryside uses firewood for heating.

Examination of mean increment shows that the optimal rotation time for Bulgarian coppices should be about 20 years if production of biomass is the aim. At that age the stands do not produce seed and should regenerate by re-sprouting. However, resuming coppicing will be a silvicultural challenge because of the aging of the coppices and the oak regeneration problems. Recently, private forest owners often clear-cut their coppices, counting on regeneration by re-sprouting, but the aged coppices re-sprout badly. In addition, Bulgarian coppices are dominated by oak which is more difficult to regenerate because it does not produce suckers (shoots from the roots), unlike beech and the other coppiced species. Another problem is the aging of the root system which is older than the stems in a coppice. After a number of coppice rotations the tap root of the oak starts decaying. Thus the oak coppices become unstable, shallow-rooted forests. Under the lowland conditions, their disappearance is a question of time. A large part of the oak coppices are currently in this threatened condition, especially the Turkey oak (*Quercus cerris L.*). The sustained management of such forests requires making use of the available natural seedlings to renew the root system. Most suitable is the group shelterwood method of cutting with a regeneration period from 15 to 20 years. Where natural regeneration with seedlings is impossible or has failed, acorns have to be sown, in the autumn and after soil preparation to reduce the competing vegetation. Planting of saplings should be avoided because oak develops a deep root while growing in the nursery which is damaged by transplanting. In conclusion, the idea to resume coppicing is very promising but it requires further investigation and experiments.

Figure 7. Oak coppice in Bulgaria

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CROATIA

Tomislav Dubravac[1] and Damir Barčić[2]

The total area of coppice forest in Croatia amounts to 533.828 ha, of which 6.4% has a protective function, for example for soil and watercourses, a designated protected area (e.g. national parks) and has another special purpose. Coppice forests in Croatia represent a significant source of wood products and provides a variety of forest services and functions. There is an almost equal distribution between private and state ownership, at 52% and 48% respectively.

Generally coppice forests in Croatia can be divided between the Continental and Mediterranean parts of the country. In the Continental part the characteristic trees are: European beech, hornbeam, sessile oak, chestnut, alder, acacia, while in the Mediterranean area holm oak, Mediterranean oak and hornbeam coppice are found.

Figure 8. View of the holm oak coppice forest on the Croatian Adriatic coast (photo D. Barcic).

Coppicing is the most convenient form of management for owners of small deciduous forests as this allows them to extract firewood, poles, small-sized industrial wood and fallen leaves. It is also possible to organize grazing in these coppices.

Coppices were created by intentionally or accidentally, curtailing the development of a single-stemmed standard tree. A common feature of most coppices is the absence of any silvicultural work during the early stages and throughout their development. This 'spontaneous' development resulted in a graduation from the best quality, with a relatively high mass of well populated stands to poor quality, with fewer stems and less overall mass.

It should be mentioned that degraded coppice stands often have a high habitat value. Conversion of coppice must retain the existing soil fertility in addition to developing native stands from seed. In accordance with the Forest Act, which applies to all regular forests, including coppice stools, the aim of regeneration must be to produce a high forest stand. Exceptions to this are alder, poplar, willow and acacia stands, which can be renewed by clear cutting, reforestation and shoots (false acacia).

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As with the high forests, silvicultural works in coppice are divided into two basic groups:

1. Silvicultural work on the clearing and thinning of coppice.

2. Silvicultural work on regeneration of coppice.

Coppice forests in Croatia by categories of European forest types:

4 – Acidophilous oak and oak-birch forest;
5 – Mesophytic deciduous forest;
6 – Beech forest;
7 – Mountainous beech forest;
8 – Thermophilous deciduous forest;
9 – Broadleaved evergreen forest;
12 – Floodplain forest.

See Figure 9 below for the distribution of these types by area.

Coppice rotation for species from Forest Management Plan regulations:

Oaks..80 years
(*Quercus pubescens, Q. ilex, Q. petraea*)

Beech...80 years
(*Fagus sylvatica*)

European hornbeam.....................40 years
(*Carpinus betulus*)

False acacia.................................30 years
(*Robinia pseudoacacia*)

Soft deciduous..............................30 years
(*Populus sp., Salix sp., Alnus sp.*)

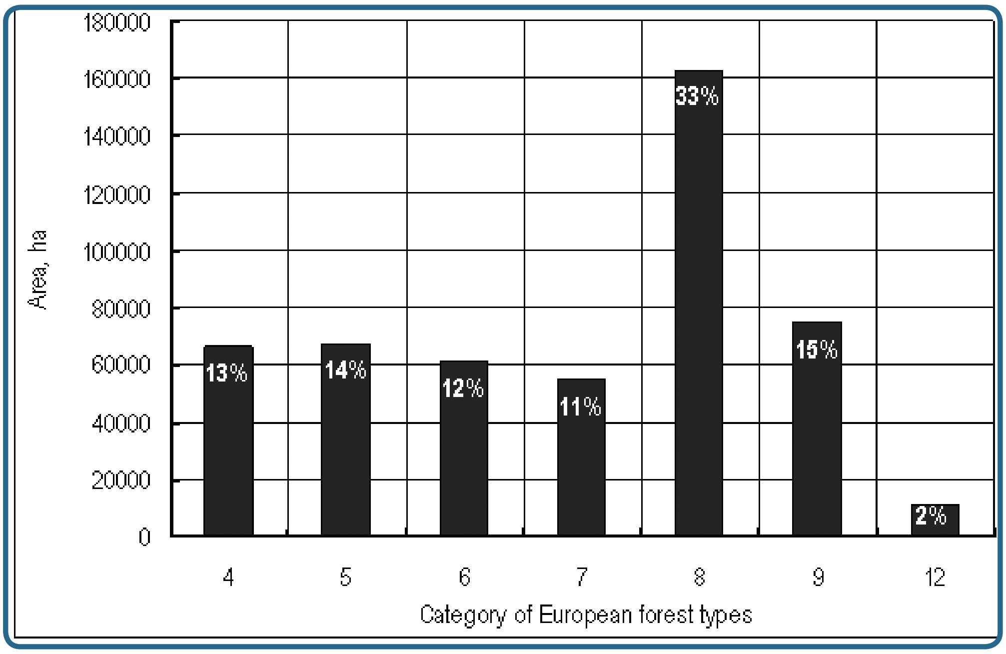

Figure 9. Area of coppice forests in Croatia by European forest types

CZECH REPUBLIC

Petra Stochlová[1]

In the past most forest cover was in the lowlands, the warm hilly areas and highland areas of the Czech Republic, and these were managed as coppice forests to produce firewood. In the 19th century, the decreasing demand for firewood caused coppice forests, including those with standard trees, to begin to be transformed into high forest. The transformation was done in two ways. The direct method was to re-plant using saplings produced from seed after felling coppice. The indirect one was by gradual thinning of the shoots, finally leaving only one. Around 1900, coppices in what is now the Czech Republic covered approximately 95,000 ha, representing 4.1 % of forest cover (Adamec et al., 2014). Since then, the area had been decreasing.

Recently interest in the coppice forests has been increasing in the Czech Republic in order to protect endangered species, enhance biodiversity and obtain a sustainable source of energy. In the last decade, areas of coppice forest have slowly started to increase. Approximately 9,310 ha (0.36 %) of simple coppice forest and 2,393 ha (0.09 %) of coppice with standards can now be found in the Czech Republic (ÚHUL, 2014). Most of the coppice forests are situated in the south-eastern part of the Czech Republic.

According to Czech law, forests cannot be harvested before 80 years growth. Only in six forest management forest types, is it allowed to manage forests as simple coppice forests. Coppice forests predominantly composed of hard wood trees are preferred, with a recommended rotation length of 40 years (although this can range between 30 and 50 years, and in some cases 60 years). Where soft wood trees are in the majority then the recommended rotation is between 20 and 30 years. Recommended rotation length for willow and black locust is 40 and 70 years respectively, in specific forest management stands. Among recommended trees for coppicing in the Czech Republic are alder, oak, hornbeam, maple, ash, elm, lime, poplar and willow; in addition wild cherry, birch and rowan can be also used.

At the present time, the efforts to restore coppice management are viewed circumspectly by some foresters; more information is required in some areas. Although the systems of coppice forest management have been covered extensively in scholarly publications, less is known about the economic effectiveness of coppice forest systems. Recently some research plots were established, converting from quasi-high forest to coppice. Promising results could contribute to positive awareness of coppice forest and this, combined with liberalisation of Czech law, could help with coppice forest renewal.

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DENMARK

Kjell Suadicani[1] and Pieter D. Kofman[2]

Traditional coppice

As in most of Europe, systematic cutting of trees with the purpose of obtaining regrowth from the stumps has been an important part of agriculture and silviculture for thousands of years. Old murals in some Danish churches show the cutting of branches with leaves for fodder.

Coppice forestry was the common silvicultural method in the peasant's forests. The products were fencing, fodder, firewood, charcoal, hoops, shanks, clogs etc. Until wire fencing took over around the 1880s fencing was a quite important product from coppice forestry.

It is assumed that the area of coppice forestry has declined in the period from 1600 to 1800, along with the destruction of the forests in general, but the decline did not happen because there was no need for the products from the coppice forests. That happened later on.

After the law on conservation of the forests in 1805, the land was divided into agricultural land and forests. Before that the two land uses were more mixed. In any case coppicing continued in the forests, because the peasants had the right to cut simple forest and forest in their ownership. Around 1830 the production of agricultural fodder, such as clover and turnips, reduced the need for fodder from the coppice forests, but these survived as a niche silvicultural system at least until the beginning of 1900.

Coppice forestry gradually lost economic importance as other products replaced those from the coppice forests, and many coppice forests grew up to normal high forest. Marks of the old coppice system can still be seen as stumps and crooked growth in stands of old trees.

There is a renewed interest in old silvicultural systems and among these also coppice forestry, because the old systems often create habitats for endangered species.

In the Danish Nature Forest Strategy from 1994 it was stated that the area with old silvicultural systems should be expanded to at least 4000 ha in 2000, and subsidies were introduced in order to reach this goal.

Today there is around 6,000 ha of old coppice forests, but only a few hundred ha is managed as coppice forestry. Especially in state forests, coppice has been reintroduced. Some other coppice forests are conserved by law or because of interest from the land owner.

Coppice forestry is type no. 91 in the Danish system of forest development types. These types describe the long term goal of the desired forest development.

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The Danish system describes four different **coppice forest types**:

1. Oak coppice forests.
Oak, aspen, birch, rowan, hazel.

2. Hazel coppice forests.
Hazel, ash, oak, alder, maple, thorn, elder.

3. Alder coppice forests. Swamp forests
Alder, ash, birch, willow.

4. Energy forests.
Different clones of willow and poplar.

The three upper types are historic types of coppice forests, while the fourth is the modern version introduced in Denmark in the 1980s.

Short Rotation Coppice

Short Rotation Coppice (SRC) is slowly finding its way into Danish agriculture. It is believed that some 2,000 ha of mainly willow plantations exist. There is one main producer of both cuttings, planting as well as harvesting equipment in the North of Jutland. This grower alone owns more than 200 ha of plantations.

The shoots are cut mechanically in the cut and chip method and the chips are delivered to nearby district heating plants. Since normal wood for energy from forests and landscape elements is becoming scarce in Denmark because of the high demand, it is likely that SRC will increase in area in the years to come.

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ESTONIA

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Estonia is located on the border between coniferous taiga forests and broadleaf temperate forest. Hence the number of different forest types here is large and many NATURA 2000 plant community types are represented (Keskkonnaministeerium, 2016). In this boreal zone area almost half of the land, historically, has always been covered with forests (Eesti statistika, 2016) and natural reforestation of agricultural fields has always been more a problem than a wish by the landowners.

Coppicing has never been a cultural tradition in Estonia. Due to the cold climate a lot of firewood has always been needed and typically this was collected manually during wintertime from the low quality forest areas, mainly from wet sites where broadleaf trees (alders, aspens or willows) dominated (RMK, 2016). Usually no clearcut was performed, but older, sick, too densely growing or dead trees were cut out from the area (Valk and Eilart, 1974). The regeneration of trees was natural and the forests contained trees with a large age variability. Such an age distribution of trees in a particular area is also the main aim in the Estonian broadleaf forest protection goals today (Paal, 2000).

Another type of landscape, where coppiced trees can be found, is one specific type of semi-natural grasslands – wooded meadows (NATURA 2000 type 6530*). Here the main aim of management has been historically to provide the cattle of the landowner with grass during grazing period or hay during wintertime (Talvi, 2010). Pruning of bushes and trees has also been an option during years of poor biomass production. The main aim of the trees in an area has been to provide the cattle with shelter and to increase soil fertility and moisture by the deeper root system of trees. The selection of tree species left to the grassland depended on the landowner's ideas but usually broadleaf trees were preferred. Sometimes these trees were coppiced, but the cutting was selective to keep the farming system going. Today the number of trees that can be grown in this type of grassland is very limited.

A little more than 20 years ago we planted the first experimental Short Rotation Coppices (SRC) with different willow species into different parts of Estonia in order to promote the local economy and renewable energy production. Since that period we have performed different studies about usage of SRC for woodchip production (Heinsoo et al., 2002), about the purification efficiency of SRC vegetation filters (Holm and Heinsoo, 2013) and about other ecosystem services that can be provided by SRC (Poplars and willows,

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2016). However, due to legislative limits on the establishment of SRC and lack of any supporting scheme for SRC management, and very volatile wood residue prices the current area of SRC in Estonia is much smaller than in neighbouring countries.

Figure 10. Examples of coppice and short rotation coppice in Estonia

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FINLAND

Jyrki Hytönen[1]

Forests are Finland

Finland is the most extensively forested country in Europe. Finland's forests are mostly northern boreal. Wooded land occupies 26 million ha or 86% of the land area of Finland. This is divided into forest (66% of the land area), scrub and waste land. Of the growing stock volume (2357 million m^3), 50% consists of Scots pine (*Pinus sylvestris*), 30% of Norway spruce (*Picea abies*), 16% of birch (*Betula pendula* and *B. pubescens*) and 4% of other broadleaves.

Traditional coppice forests

Even though coppicing is a traditional silvicultural management system, widely used in Central and Southern Europe, its application in Finland has been very limited. Most of our native deciduous tree species are not considered very suitable for coppice management. In some special cases, such as mountain birch (*Betula pubescens spp. tortuosa*) stands in Lapland, were recommended to be coppiced for firewood. Historically hazel (*Corylus avellana*) and linden (*Tilia cordata*) were grown as coppice for timber and other products in the south of the country. In small areas pollarding was used to produce fodder for cattle.

Today, traditionally managed coppice forests do not exist in Finland. However, in normal forests there are trees of coppice origin, especially birches, but also other species such as rowans. Growing coppiced trees is not encouraged but they may fill up the stand.

Short rotation forests

The use of bioenergy is increasing rapidly due to the need to reduce greenhouse gas emissions. Wood-based fuels are playing a leading role in Finland in attempts to reach national and European Union targets to increase the use of renewable energy. The National Climate and Energy Strategy aims to increase annual woodchip production in Finland to 13.5 million m^3 by the year 2020. Even though woody biomass is mainly harvested from existing forests (small sized trees, slash and stumps), in future growing 'energy forests' may become economically viable. Energy plantations based on fast growing deciduous tree species, grown in dense stands, and renewed by coppicing have been studied in Finland, with the focus on short-rotation willow. This research was begun in Finland in the late 1970s with extensive studies of cultivation methods. However, due to a combination of falling oil prices and the high production costs of willow energy, this practice has not been widely adopted. Currently there are only around 200 ha of willow plantations in Finland. This may increase with the growing demand for energy and increasing prices of other fuel sources.

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Due to Finland's northern location other native deciduous tree species have been the subject of short-rotation forestry (SRC) research. The rotation for coppicing native birches, alders and aspens is, at between 20 and 30 years, considerable longer than for willow. Downy birch (*Betula pubescens*) growing on peatlands (of which there are 572,000 ha) is receiving increasing interest. The grey alder (*Alnus incana*) also has several good qualities, such as a capacity for binding atmospheric nitrogen, good coppicing ability and fast growth. These characteristics are appreciated as they directly affect the economics of biomass production. A further advantage of alder is that it is not susceptible to insect damage and is not as palatable to mammals (vole, moose, hare) as birches, willows, aspen and poplar. Aspen (*Populus tremula*) and hybrid aspen are also subject for research for SRC potential.

Future challenges

The future expansion of wood biomass production systems has many challenges and depends on economical, ecological and policy matters. As well as producing bioenergy cost-effectively and in an environmentally sustainable way, SRC is also expected to provide employment opportunities and support the cultural landscape. Research and development investment is needed to promote the expansion of new renewable energy systems.

Figure 11. One-year growth of energy willow in south Finland (left) and four years old downy birch coppice in northern Finland (right).

FRANCE

Philippe Ruch[1]

Until the industrial era, coppice and coppice with standards were the dominant silvicultural systems in French hardwood forests. The main function of coppice was to supply wood fuel (as logs, bundles or charcoal) for domestic or industrial consumption (forges, glassware, etc.). In some regions, the bark from chestnut and holm oak was also an important resource for tanning. A great conversion campaign towards high forest management started in the middle of the 19th century in public forests. This was connected to the utilization of coal and the depletion of forests. This trend has continued up to the present.

Furthermore, the rural exodus of the 20th century and the attractiveness of fossil fuels have led to the abandonment of coppice management after the 2nd World War. Thus, a significant part of the coppice has been converted by planting coniferous species, which was strongly encouraged through subsidies. Nowadays, there is a renewed interest for firewood due to the rising energy costs and the development of the bioenergy economy.

Compared to the overall 15.7 million ha forest production area, simple coppice forest structures represent 1.7 million ha (11% of the forests) and coppice with standards, 4.7 million ha (30%).

France has a great diversity of forest environments and species linked to diverse geological contexts (acid soils and calcareous soils) and climates (Mediterranean, oceanic, continental and mountain). Thus, the main types of coppice in France, also a result of human choices, are:

- Mediterranean coppices of holm oaks (*Quercus ilex*) and pubescent oaks (*Quercus pubescens*) which represent 52% of the simple coppice area; coppicing is still the main silvicultural system with firewood as principal product;
- Chestnut coppice (*Castenea sativa*), 13% of simple coppice, whose main products are industrial timber, stakes and parquet. Thinning-driven conversion to high forest is sometimes undertaken by owners of land with rich soil. Conversion by plantation is an alternative option often chosen for declining stands;
- More locally, there are also coppice of beech (*Fagus sylvatica*) in the mountains. Common oaks (*Quercus robur* and *Quercus petraea*) and more marginally black alder (*Alnus glutinosa*) or black locust (*Robinia pseudoacacia*) can also be found as coppice;
- Mixed forest structures, composed of coppice with standards. Industrial wood (for the pulp and panelboard mills) and wood energy (logs and more recently wood chips) are the two main value chains

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for the coppice products. In these stands, forest management is mainly focused on the standards in order to produce timber, which is more valuable. Two main types are represented:

- hornbeam (*Carpinus betulus*) or common oaks (*Quercus robur* and *Quercus petraea*) coppice and standards of common oaks on clayey loam soils in central and northeastern France. Other species such as birch (*Betula verrucosa*), beech (*Fagus sylvatica*) and aspen (*Populus tremula*) can also be found in such situations;

- common oaks, chestnut or birch coppice and sessile oak standards on poorer siliceous soils in central and western France.

Although this diversity highlights that coppice structures are still widely present in French forests, their forest management and utilization tend to be taken for granted.

Short-Rotation Coppice (SRC) and Very Short Rotation Coppice (VSRC) cover merely a few thousand ha in France and are therefore quite marginal. The first poplars and eucalyptus SRC plantations for pulp wood purposes date back to the 1980's. More recently (2008 to 2012), it has been attempted to introduce VSRC and SRC on agricultural land for energy purposes, mainly with black locust, poplar and willow. However, this trend has not been pursued due to low profitability. Currently, only eucalyptus SCR continues to be planted in the southwest of France.

Figure 12. Hornbeam coppice with pedunculate oak standard in north-eastern France

Figure 13. Chestnut coppice in western France

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GERMANY

Patrick Pyttel[1] and Achim Dohrenbusch[2]

Coppicing is a traditional silvicultural management system applied all over the world. Until recently coppice stands often represented important elements of the cultural landscapes in rural environments of Central Europe. These forests were traditionally used for the production of firewood and various non-timber forest products. Across Central Europe this practice was largely abandoned in the first half of the last century due to socio-economic changes and this absence of periodic coppicing led to the passive transformation of the remaining stands. In this process the stands lose their typical coppice characteristics and increasingly resemble high forest. Subsequently the specific ecological values of coppice forests decreases and this important element of the cultural landscape gradually disappears.

Today managed coppiced forests (i.e. younger than 40 years) only cover 75,000 ha of Germany which represents 0.7% of the total forest area (BMELV, 2004), while the forest assessment of 1961 reported 3.5% of German forests as coppice. One way of preserving the ecological, cultural and historical value of coppice forests would be to resume coppicing in overstood, formerly coppiced forests with the additional benefits of promoting light and warmth demanding species. This could also increase biodiversity.

Ongoing initiatives by the European Union (EU) call for a substantial increase in the use of renewable energy sources. The objective is to provide one fifth of European energy consumption from renewable sources by 2020. Currently 47% of the renewable energy consumed in the EU is generated from forest biomass (i.e. wood and wood waste). This demand for biomass as energy source has stimulated interest in resuming coppicing of forests that had undergone this management in the past.

Coppice forests are now regarded as cultural heritage features, and with potential as a source of fuel wood as well as being recognised as valuable habitat for many plant and animal species. Despite this restoration by coppicing, particularly of aged, overstood, coppice forests, it has proceeded slowly for various reasons. There are broad public concerns over the ecological sustainability fostered by the media's focus on perceived environmental damage through clear felling. The fact that remnant coppice forests are often found on sites with low growth potential, such as steep slopes, makes economic justification difficult. The potential to convert overstood coppice stands into high forest has contributed to the current situation. One obstacle to resuming coppicing is the belief, held by some forest managers that

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overstood oak coppice will not re-sprout vigorously enough from the stump to ensure successful regeneration, combined with the view that coppicing causes a reduction in soil fertility.

Although most of these assumptions lack scientific evidence, some doubts are certainly justified. However, the fact that coppicing is the oldest type of regulated forest management can be considered as a clear indicator of its environmental sustainability. Recent research has shown that aged, overstood coppice forest can generally be managed in accordance with the pan-European criteria for sustainable forest management and that careful coppice management can preserve valuable and rare tree species such as *Sorbus torminalis* and *Sorbus domestica*. For all forest managers it is necessary to identify the basic situation, from stand to landscape level, at which coppicing is economically justified and needed in order to meet nature conservation goals. It is therefore important to conserve the remaining coppice forests and to continue their sustainable use and management.

Figure 14. Aged coppice forests still dominate the landscape along the large Rhine and Moselle waterways

GREECE

Gavriil Spyroglou[1]

Coppice forests in Greece make up 65% of the forested area and 12% of the whole country (13,200,000 ha). The main species are oaks (*Quercus spp.*) followed by chestnut (*Castanea sativa*), beech (*Fagus sp*) and the evergreen broadleaves that make up the maquis. Other than chestnut, which can produce good quality wood in coppice rotations, the coppiced forests are characterized by very low growth rates producing very low-value products such as firewood and charcoal. Most are grazed, either legally or illegally, and trees are still being pollarded by farmers and residents who keep a few domestic livestock animals. The aesthetic value is small because of the large clear cut areas created by this management. As a result many of these forests are not serving their required purpose, providing economic (wood production), protective (protection of soil erosion), and aesthetic benefits. However the great contribution of these forests is in mitigating climate change and the fight against global warming.

Coppice silviculture is a purely man-made management system that has been implemented in Europe since Roman times, based on the re-sprouting ability of broadleaf tree species. Coppice management was, in the past, the "child of necessity and an easy management solution" but today it presents numerous ecological and environmental problems which, in the context of sustainable, multifunctional, forest management should be directly addressed by a wide program of conversion to high forest. In Mediterranean environments, coppicing remains important because, despite the exhaustive logging, uncontrolled grazing and fires, intact ecosystems have been preserved in the coppice forests. Where forests are degraded this is not necessarily linked to coppice management and this practice can contribute to improving both habitats and biodiversity with appropriate management. Other species such as conifers or fast growing species can co-exist in coppices, combining a mixture of trees regenerating from seed and those sprouting from coppice stools.

Conversion of coppice into high forests represents a change in management and can be achieved in two ways. Indirectly, by extending the rotation time so it equates with that of a high forest and managing the coppice stand as if it was of seedling origin. Alternatively this can be achieved directly by changing the species, which usually takes place on very degraded sites, and is achieved by planting conifers (pines). Coppice conversion in Greece has been going on for more than 90 years with many fluctuations. The current coppice regime is based on the views of the 1950s and earlier. It is therefore appropriate to reconsider it under the current legislative framework,

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and to develop a new strategic plan for a modern holistic approach that will meet today's challenges.

Mediterranean ecosystems in general and coppice forests in particular, have been used through time not for woody products alone. Non-timber forest products such as bark, forage, soil protection, mushrooms, fruits, honey and recreation are important. A critical evaluation of the whole spectrum of uses gives the real value of coppice forests. In this context, the Mediterranean coppice forests contribute to rural development, contribute value with respect to maintaining biodiversity and the economic values associated with this, contribute to ecosystem functions and services and last – but not least – are of considerable cultural importance.

Figure 15. Typical coppice forest in Taxiarchis, Chalkidiki

HUNGARY

Norbert Frank[1], Ádám Folcz[1] and Dénes Molnár[1]

Hungary is situated in the middle of Europe at the Central and Western part of the Carpathian Basin. Due to the characteristics of the Basin the majority of the area of the country is flat, only one third exceeds 200 m elevation, with merely 2% above 400m sea-level. The extensive lower parts are characterized by small amounts of precipitation and extreme temperature changes. The naturally forest-covered areas are the Western part of the Trans-Danubian region and the mountains – generally higher than 400m above sea level. Here the annual precipitation generally exceeds the 600 mm required for the maintenance of forests. In the lower regions, forests could only develop where the water level is not too high, but within reach of the tree roots, or on flood plains.

In 1920, on account of the Treaty of Trianon, the forested area fell from 7.4 million hectares to 1.2 million hectares. This radical reduction was accompanied by the fact that predominantly low productivity areas remained within the new borders, which had provided fuelwood for local inhabitants – most of these forests were coppice forests.

After the Second World War, natural regeneration by coppicing was mostly from stumps with coppice shoots (alder, willow), and to a lesser degree with root suckers (black locust, native poplar).

The new forest act – Act 2009 XXXVII on Forest Conservation and Forest management – enables coppicing of alder, native poplar (stumps coppice) and black locust (root suckers).

Table 3. Comprehensive facts on Hungary and Hungarian Forests

Forest land area	1,000 ha	1,933.6
Forest share	%	20.8
Forest area per 1,000 inhabitants	ha	195.1
Area of land in forestry use	1,000 ha	2055.6
Growing stock	million m^3	366
Gross annual increment	million m^3 yr^1	13
Total felling	million m^3	7.7
Final cuts	million m^3	5.6
Regeneration per year	1,000 ha	15
Afforestation per year	1,000 ha	4.5

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As black locust is one of the most important species in Hungary, we will briefly summarize the most important knowledge about its regeneration by coppicing.

Black locust was introduced in Hungary between 1710 and 1720. The first large black locust forests were established at the beginning of the 19th century on the Great Hungarian Plain, stabilizing the wind-blown sandy soil. In the country, black locust occupied 37,000 ha in 1885, 109,000 ha in 1911, 186,000 ha in 1938 and 4,000,000 ha in 2005. At present, it is the most widely planted species in Hungary, covering 24 % of the country's total forest area. One-third of these stands are high forests and two-thirds are of coppice origin. In the 1960s, Hungary had more black locust forests than the rest of all other European countries together. Black locust afforestation and artificial regeneration may utilize seedlings. The average per hectare volume in all black locust forests is 125 m^3 ha^{-1}, with an average volume of 190 m^3 ha^{-1} at harvest at an average harvest age of 31 years. Black locust forests in Hungary have been established on a range of sites; however only sites with an adequate moisture supply and a well-aerated and loose-structured soil, rich in nutrients and humus can produce good quality timber. Black locust stands are often regenerated by coppice (from root suckers) as well. In young stands of coppice origin, a cleaning operation should be carried out to adjust spacing when the stands are 3-6 years old and should reduce stocking to less than 5000 stems ha^{-1}.

Black locust can be regenerated naturally, from root suckers, or artificially, i.e., with seedlings. For the establishment of new black locust plantations (stands), seedlings are also used. There are some favorable plant characteristics of black locust which make both regeneration methods possible. For seedlings, growing seeds are produced in a wide range of conditions, germinate rapidly, and preserve their germination capacity for a long time. Black locust cannot be regenerated by seed in a natural way due to its very hard seed-coat. On the other hand the root system is very plastic, its vegetative growth from fragments is intensive and it is hard to uproot (Führer and Rédei, 2003).

When making semi-natural or man-made afforestation or reforestation with black locust the following basic technologies and operation groups are:

- Black locust afforestation *with deep loosening*: soil preparation (without trenching) by deep loosening of soil, planting by planting-machine or a tractor-drawn pit-drilling machine, manual soil cultivation in the rows, in inter-rows by machine.
- Black locust afforestation *with trenching or deep ploughing*: planting by planting machine or a tractor-drawn pit-drilling machine, manual soil cultivation in the rows, in the inter-rows by machine.
- *Semi-natural reforestation by root-suckers*: slash removal from the cut-area, bush-cutting, root-ripping, knocking down of coppice shoots, singling of clumps of shoots.

- *Man-made reforestation* of black locust stand *by deep loosening*: slash removal, bush cutting, chemical treatment against sprouting, deep loosening, planting by machine or tractor drawn pit-borer, knocking down of coppice shoots, manual soil cultivation in the row and mechanized in the inter-row.
- *Man-made reforestation* of black locust stands *by complete soil preparation*: slash removal, bush cutting, stump removal (stump-lifting, removal and terrain leveling), trenching, planting by machine or tractor-mounted pit-borer, manual soil cultivation in the rows and mechanized in the inter-row.

The best time for planting is in the spring. The most popular spacing for planting is 2.4 m between rows and 0.8-1.0 m within rows (4,000-5,000 seedlings ha^{-1}), age of planting stock: 1 year, of seedbed quality. Planting may be by machine into a slit or in a pit manually prepared or by tractor-mounted borer. Coppicing by root ripping provides abundant root suckers, when the roots have been wounded. This operation is made with a winged deep-loosening machine working at a depth of 35-40 cm.

Criteria for successful afforestation: at least 3,500 viable plants ha^{-1} when planting with seedlings, in young coppiced stands at least 5,000 suckers ha^{-1} which must be of not less than 3 m in height and consist of non-forked healthy trees, regularly distributed (Führer and Rédei, 2003)

Figure 16. Old black alder forest (*Alnus glutinosa*) of coppice origin in Hungary

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IRELAND

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This report is regarding coppicing in Ireland and excludes short-rotation coppice of willow (*Salix spp.*) for biomass.

It is unclear whether coppicing and coppice-with-standards were historically important in Ireland. All the known ironmasters in Ireland were Englishmen and were likely familiar with coppicing, which was practiced to ensure a continuous supply of the best charcoal (Neeson, 1991) derived from twenty-five-year-old oak coppice. McCracken (1971) argues that, except in Wicklow County, no such management was carried out in Ireland and that, if it had, the woods could have been preserved. This resulted in ironworks moving from place to place as local fuel supplies became exhausted. However, Rackham (2010) posits that coppice woods could have been present in a large scale at one time because Viking buildings in Dublin were made extensively of wattle and daub. House walls, wooden pathways and property fences would all have been made of woven hurdle panels and would have required vast quantities of long, straight hazel (*Corylus avellana L.*), willow (*Salix spp.*) and ash (*Fraxinus excelsior L.*) rods or underwood (O'Sullivan, 1994). The Civil Survey (1654-6) records "underwood" and "copps" (Tomlinson, 1997), indicating that some form of coppice management was being carried out. The earliest record of coppice management (i.e. rotational felling of underwood in fenced woods) from the Watson-Wentworth estate in County Wicklow was 1698 (Jones, 1986). Young (1780) also mentions coppicing in the accounts of his travels around Ireland in the 18th century, some with forty-year rotations. The coppice-with-standards system was also being employed on some Kilkenny estates early in the 19th century (Tighe, 1802), though this appeared to have decreased in popularity, with some former coppices having been abandoned or neglected by this stage. A survey of County Wicklow woodlands in 1903 demonstrated that the system was still popular there, with almost 60% still being managed as coppice-with-standards (Nisbet, 1904). Attentive landlords would fence copses to protect the regrowth from grazing animals. One of the first laws enacted on forest management was in the 16th century, which required enclosure for four years following coppicing (Bosbeer et al., 2008).

Today there is little coppicing being practiced in Ireland. Anecdotally there are a few owners that have small areas of coppice for household fuelwood production or for producing raw material for crafts and minor products. Some coppicing is also being practiced with biodiversity and conservation objectives in mind. In a survey of native woodlands conducted during the period 2003 - 2008, 18 % of the

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sites surveyed had mature coppice whilst only 1% had recently cut coppice (Cross, 2012). Coppicing is not recorded by the National Forest Inventory (Government of Ireland, 2013)

Coppicing is being investigated by the B-SilvRD project (Broadleaf Silviculture Research and Development project, www.teagasc.ie/forestry/research/B-SilvRD/) as a means to bring poorly-performing pole-stage broadleaf stands into productive use. Coppice-with-standards may also have renewed potential in the current economic climate with high oil prices and increasing demand for fuelwood (Short and Hawe, 2012).

Figure 17. Rehabilitative silviculture coppicing pilot study in pole-stage sycamore (*Acer pseudoplatanus*). The coppice is in its fifth growing season and was initiated when the trees were 15 years old.

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ISRAEL

Orna Reisman-Berman[1]

Israel is characterized by a steep precipitation gradient from North – 1200 mm rainfall to South – less than 60 mm rainfall – along only 600 km. It is an intersect of 3 main climatic and 3 phytogeographic zones i.e. the Mediterranean, the Saharo-Arabian and the Irano-Turanic provinces. The vegetation changes dramatically from North to South – From a typical Mediterranean chaparral and some forest patches in the Mediterranean zone, through a shrubland in the semi-arid zone (which is the transition between the Mediterranean and the arid zone), and a very sparse steppe type shrubland in the desert. In the extreme desert vegetation is distributed only in the dry riverbeds that flood one to several times in winter – only in rainy winters.

Those climatic conditions are not suitable for traditional coppice. Indeed, traditionally there was no coppice in this zone. Although - some man traditional practices are small scale coppice. Some examples are:

The genus *Ficus sycomorus* was first brought to Israel by man during the dawn of history, 6,500 years ago, and perhaps even 10,000 years ago. The species re-sprout and the trunk elongate and thickens very quickly. The wood was used for construction (mainly roofs) and for heating. In ancient Egypt the wood was also used for coffins. In Israel, doors of an ancient synagogue were found that were made from *Ficus sycomorus* wood. About a tenth of all wood pieces that were found at Masada from the Roman period were made of *Ficus sycomorus* wood. The species is found in the coastal plan on sandy dunes on an aquifer. This action is in fact a traditional coppice, as it is assisted species movement and its reuse with resprouting.

Similarly, *Tamarix spp.* is a native species that was used and probably planted, cut and re-cut since ancient times. Remains of *Tamarix* were found in archeological excavations as building material and as burning material beginning from the Upper Paleolithic Period, 25,000 years ago, until today. The Romans used the tree to construct the battery at Masada.

A third example is the *Faidherbia albida* –origin in the sub-tropical savannas, found in Israel in fragmented distribution in the southern sea shore and along ephemeral rivers. Its introduction by man in ancient times and its growing in vicinity of agricultural fields cannot be ruled out. In Israel the species propagates only by clonal means and re-sprouting is vigorous – which makes the species an excellent coppice.

In general, resprouting characterizes all woody species in the Mediterranean zone of Israel – except for *Pinus halepensis*. This

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trait allowed traditional practices such as small scale clear-cutting, grazing and the use of fire to encourage herbaceous species growth. Small scale clear cutting was in a sense similar to traditional coppicing – where clear-cut is selective and is conducted locally. At the time of the Ottoman Empire a massive clear-cut of oak forests was conducted, mainly the forests of *Quercus itaburensis*.

In the modern era, starting around 1950, excluded traditional practices such as small scale clear-cutting and the chaparral expanded, mainly on the individual scale, becoming a dense thicket.

A large scale experiment was conducted along the gradient in LTER stations on the effect of clear-cutting on ecosystem biodiversity and the result demonstrated that patchiness of herbaceous and woody species is of importance, and both small scale clearcutting and grazing, to maintain the ecosystem biodiversity. This implies that the small scale clear-cutting – a form of coppicing – should be integrated in this ecosystem.

As of today it has became clear that traditional practices have a role in shaping an open vegetation form that allows the growth of herbaceous species, increasing the biodiversity and productivity of those systems. This can mean that re-introducing small scale clear-cutting or a form of coppicing can be an appropriate management tool to the Mediterranean chaparral ecosystem in Israel.

There were some trails of true coppicing in Israel with alien species. In the 60's very few plantations of *Populus nigra* were planted for the production of matches. However, in spite of extensive irrigation and fertilization which the saplings received in agricultural soil, they did not yield even one quarter of the expected production in the beginning of the 21st century, there was a nation-wide trail of introducing the *Paulownia* as a logging-coppicing tree species. The *Paulownia* was considered attractive due to its high resistance to drought and its modest living requirements. However, the trail failed and did not reach an industrial capacity.

Figure 18. Resprouting that allowed the production of beams; *Ficus sycomorus* (photo from Neot Kdumin archive)

Figure 19. Resprouting that allowed the production of beams; *Quercus ithaburensis* (photo: Orna Reisman-Berman)

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ITALY

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Coppice management is the most common silvicultural system in Italy. Within the approximately 8,500,000 ha of Italian forests, the forest land classified as coppice currently includes almost 35% of the national forest cover (approximately 36,631 km^2) (INFC 2007), yet its distribution varies between administrative units (INFC 2007). This amount has been almost stable since the 1960s (La Marca & Bernetti 2011). Some stands, still regularly coppiced, have been managed this way for several centuries (Piussi 1979, Amorini & Fabbio 2009, Piussi & Redon 2001). However, some stands are relatively recent, such as those a) derived from oak high forests exploited during the second half of the XIX[th] century to provide railroad sleepers, b) resulting from salvage operations in sweet chestnut orchards destroyed by chestnut blight (*Cryphonectria parasitica* [Murr.] Barr.) in the 1940s and 1950s, and c) derived from woodlands spontaneously or purposely established on abandoned farmland for fuelwood production during recent decades (Del Favero 2000).

The most important species traditionally managed as coppice are deciduous oaks (*Quercus spp*., 33%), European hop hornbeam (*Ostrya carpinifolia* Scop., 17%), beech (*Fagus sylvatica* L., 13%), sweet chestnut (*Castanea sativa* Miller, 16%), which are usually grown as pure stands, and the evergreen holly oak (*Quercus ilex* L., 10%), which frequently grows in mixed stands. As with most (63.5%) of the forest cover in Italy, coppice woodlands are mainly under private ownership. Nowadays, this silvicultural category is based on stools. Coppice with standards, among the coded coppice silvicultural systems (i.e., simple coppice, coppice with standards – Matthews 1989, Nyland 2002, and compound coppice – Nyland 2002), is typically applied (76% of coppice woodlands - INFC 2007), while simple and compound coppices account for 24% and 16% respectively. Other forms of coppice, e.g., shredded trees and pollards, can be currently found only as relicts and/or in agricultural landscapes.

Italian coppices account for almost 19.2% of the coppices in the whole EU28, which in turn represent 83.3% and 52.1% of the coppices in the whole of Europe and at the global levels, respectively (UN-ECE/FAO 2000).

The negative environmental impacts of coppice were mainly due to how this system was implemented in the past social, technical and economic context. Historically, coppice represents an important source of firewood and until some 50 years ago, management criteria were based on short rotations (8-12 years), removal of all biomass, including deadwood and litter, with the occasional introduction of agricultural crops following coppice harvesting and grazing (Piussi et al. 2006). Nutrient losses were quite high and erosion was unavoidable, often resulting in forest degradation. These adverse effects are not necessarily the result of coppicing as such, but mainly of poor management practices dictated by need and various physiographic, economic and social constraints (Fabbio 2010). Regulations

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have been issued over time to limit activities and disturbances, which would otherwise reduce the benefits derived from the coppice system and hinder what had been conceived of, and empirically demonstrated through the centuries, as a sustainable wood production system (Mairota et al. 2016a). This more conservative use of coppice woodlands is considered effective in reducing impacts on ecosystem characteristics and processes such as the water cycle, humus loss and nutrient removal (Piussi & Alberti 2015), particularly when carried out within the limits of the optimal ecological conditions of the dominant tree species (Del Favero 2000) and coupled with planning and implementation of appropriate harvesting systems and sustainable mechanization levels (Pentek et al. 2008; Marchi et al. 2016; Venanzi et al. 2016). In both coppices and coppices thinned when converted to high forests the main harvesting methods for wood extraction (Cut-To-Length, C.T.L. or Tree-Length-System, T.L.S.) use tractors with winches (winching and skidding), tractors and trailers or tractors with bins (Picchio et al. 2009, Laschi et al. 2016). Mules and chutes are used in particular contexts (e.g., protected areas, steep terrain). Firewood bundling machines are considered in flat areas to improve safety during loading operations onto trucks before transportation. The main wood products from coppice are: firewood, poles, sawlogs (chestnut and black locust) and woodchips (also produced from logging residues).

However, a negative attitude (mainly on the part of academics, controlling authorities and conservationists) towards coppice still persists both in the criteria applied to current coppices and in the recommendations for protected area management (Mairota et al. 2016b), as well as in guidelines for the monitoring of Natura 2000 habitats and species (cf. Angelini et al 2016). Criteria for current coppice include higher than traditional densities of standards, which have crept into regulations at different administrative levels without precise scientific support (cf. Zanzi Sulli 1995, Fiorucci 2009, Mairota et al. 2016a). Their implementation has resulted in the transformation of many original Italian coppices-with-standards into stands with a high density of overstood and declining populations of stools (Becchetti & Giovannini 1998, Del Favero 2000, Piussi 2007).

Other management options frequently applied to coppice woodlands, particularly in marginal or protected areas, are non-intervention and conversion to high forest.

The abandonment of coppice silviculture, however, is likely to hamper the ecological functionality of woodlands, dampen tree species diversity at the patch level in mixed woodlands and in beech woodlands (Garadnai et al. 2010), disrupt hydrological regimes and increase wildfire risks at the landscape level (Conedera et al. 2010, Piussi & Puglisi 2013). For most species, it is also likely to thwart the eventual reinstatement of the coppice silvicultural system as shading depresses the vigour of stools (e.g., oaks – Bianchi & Giovannini 2006, beech – Terzuolo et al. 2012). Yet, the demise of silvicultural interventions may be a necessary choice for sites of low fertility in economically marginal areas or stands degraded by fire, grazing or other disturbances.

In a similar way, the conversion from coppice to high forest is not always feasible, but rather is contingent on species composition and site fertility, and might pose future regeneration problems. It may also cause biotic homogenization at the stand level (Van Calster et al. 2007). Conversion to high forest is often a long-term process requiring relatively intensive interventions and may not always be economically sustainable for the owner (Motta et al. 2015). Yet, conversion to high forest, where the ecological, technical (e.g. gentle terrains and accessibility) and socio-economic conditions allow, might trigger functional and structural complexity. It would also add value to timber products in certain forest types (e.g., sweet chestnut coppices) which are currently not fully exploited.

A range of modern approaches to coppice silviculture have been tested in Italy for more than a decade within the framework of several EU- and nationally/regionally-funded pilot projects (e.g., CHESUD, TraSFoRM, SUMMACOP, RECOFORME, ForClimadapt, SELVARBO and PProSpoT). Most of these approaches are related to the modes of standard selection (Mairota et al. 2016a), with reference to the number of trees selected as standards, the density and the spatial arrangement as well as the age/size distribution of standards within the stand, guided by informed silvicultural choices (Bastien & Wilhelm 2000, Sansone et al. 2012, Manetti et al. 2014, Motta et al. 2015, Manetti et al. 2016). All these approaches, capable of enhancing stand stability, soil protection and biodiversity, can be combined at the landscape level thus introducing as wider space-time perspective into this silvicultural system and ultimately contributing to the improvement of the rural economy while reducing the ecological costs of timber importation (Manetti et al. 2006).

Although coppicing promotes simplified compositions and structures and vegetative propagation causes a 'genetic stagnation' in the tree component of the stands (Piussi 2006), a number of studies now indicate that active coppice management can improve forest biodiversity at both local and landscape levels and that it does not negatively affect decomposition rate and the transport of nutrients (Holscher et al. 2001, Bruckman et al. 2011).

In addition, woodlands managed as coppice over the centuries show a high level of resilience (Piussi & Redon 2001, Mei 2015), owing to the capacity of the stumps of various species (particularly oaks and sweet chestnut) to expand radially forming new stumps from shoots which develop an independent root system (cf. Piussi & Alberti 2015, Vrska et al. 2016). This should not be overlooked when compared to the uncertainties in the response of reproductive regeneration of tree species comprising current stands under changing climate conditions and the forecasted increase of disturbances (e.g. wild fires, heat or frost waves, pest outbreaks), suggests that coppice silviculture should be reconsidered (cf. Zanzi Sulli, 1995) within the framework of balanced forest management strategies.

Such strategies should combine traditional (e.g., coppice selection system in beech forests, Coppini & Hermanin 2007) modern approaches to coppice, conversion to high forest and non-intervention, as most appropriate to specific forest habitats and site conditions at the stand/landscape level and be based on appropriate exploitation criteria. In such a way, they would most likely revitalise local economies and cultural landscapes, while being compliant with the Framework Program for the Forestry Sector – Horizon 2020, the EU 995/2010 Timber Regulation and the Habitats Directive.

Moreover, as standard trees in coppice woodlands can nowadays provide new services related to biodiversity maintenance and aesthetics, the mode of standard selection still represents a distinctive (indeed crucial and challenging) issue for coppice silviculture in Italy. This not only refers to the number of trees selected as standards, but also concerns the density and the spatial arrangement as well as the age/size distribution of standards within the stand, which should be guided by informed silvicultural choices. The ecological and hydrological effects of spatial arrangement of standards within the stand (i.e. uniform vs group distribution, both envisaged in the technical prescriptions of the majority of regions, the Prescrizioni di Massima e Polizia Forestale; Annex on legislation framework), in particular, although considered in European forestry literature (e.g., Perona 1891, Huffel 1927, Perrin 1954, Cantiani et al. 2006, Fiorucci 2009, Piussi & Alberti 2015), deserve further investigation.

Finally, the great heterogeneity of prescriptions across species and forest types in Italy (see Annex on Legislation framework), further exacerbated by prescriptions for coppicing in Natura 2000 sites, has led to a great variety of woodland structural types most of which do not correspond to any of the coded coppice silvicultural systems (i.e., simple coppice and coppice-with-standards – Matthews 1989, Nyland 2002, compound coppice – Nyland 2002) nor to high forest. This calls for an effort coordinated at the national level to define ecologically and socially sound a) criteria to reduce discrepancies and b) principles to harmonise prescriptions concerning the same habitat types of the Habitats Directive in Natura 2000 sites in different (often neighbouring) regions.


Figure 20. Abandoned beech coppice in Pollino national Park, Southern Italy – landscape and stand views. (Photo: P. Mairota)

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LATVIA

Dagnija Lazdina[1]

Coppice as a forest management system is not separated from normal forestry. However, short rotation coppice (SRC) is separately defined as “areas planted with certain tree species, where the tree roots and stumps are left in the soil after harvesting and in the next vegetation season gives new shoots”. The rotation period of SRC is normally five years in order to receive common agriculture payments. However, it is allowed to keep up to 15 year rotation periods for poplars, willows and Grey alder and still be considered an agricultural crop. In 2016, 174 ha of aspens, 14 ha of grey alder and 516 ha of willows received common agriculture payments. Willow, osier and aspen are the most common coppice species in Latvia. Hazel, linden, alder, ash and also birches are partly naturally regenerated as coppice and some old wetlands (Fig. 21).

No statistics about coppice forests in Latvia are available. However, it is estimated that birch, aspen and alder are common coppice species in naturally regenerated as well as planted forest areas where they have naturally sprouted from former forest stand tree stumps or root suckers.

Coppice is more common in privately owned forests, which have a greater proportion of broadleaves than the state forests (Fig. 22). The proportion of private and state forests is close to 50:50. In all forests aspen is the main coppice species.

Both grey and black alder are widely spread in the Latvian landscape. Grey alder is a pioneer species on abandoned former agriculture land, but black alder contributes to the biodiversity of old forests in wetlands providing habitat for living organisms.

Willow on road sides | Hybrid aspen stands | Black alder wetlands

Figure 21. Coppice in Latvia landscape and forests

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Black alder also grows on the banks of small forest rivers and ditches.

Willows are mainly distributed near water reservoir banks, protected areas – wetlands and "poorly managed" forest properties (Fig. 23).

In addition to their use in short rotation coppice, willows, including decorative varieties, are also used in flower gardens and industrial parks. Coppice forest products are becoming fashionable as interest increases in the centuries-old traditions of using willows and osiers materials for different craft work, fences and apiculture as early flowering trees.

Poplars are still used as excellent windbreaks, shelterbelts and fast growing landscaping trees, commonly planted along roads and on borders between properties.

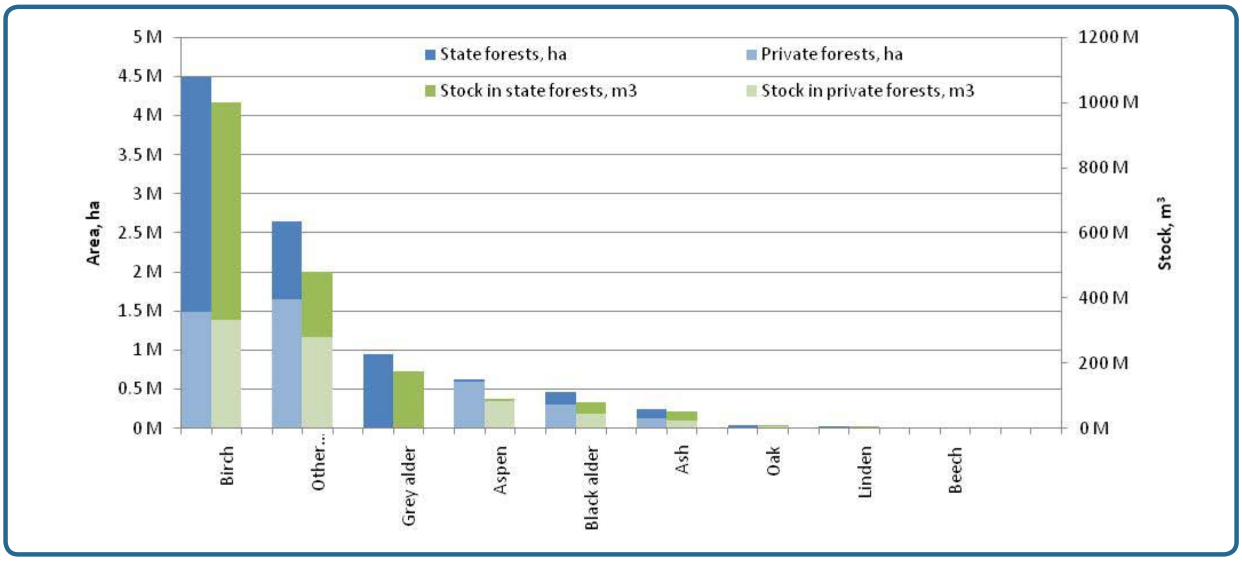

Figure 22. Growing stock (in millions – M) of traditional coppice forest species and area in Latvia forests (Source: VMD CD2016)

Figure 23. Coppice on abandoned agriculture land

LITHUANIA

Mindaugas Škema[1], Marius Aleinikovas[1] and Julija Konstantinavičiene[1]

In Lithuania, coppice with standards does not exist and the national forest inventory authority of Lithuania (State Forest Service) does not even register this type of forest. Short rotation coppice system research in Lithuania was established 20 years ago.

The most common coppice is a willow (Salix sp.) short rotation coppice system, used to produce biomass for energy. In Lithuania, the short rotation woody crop area is 3,027 ha with a willow plantation area of 2,477 ha (NMA, 2014). Compared with some other countries, in terms of the country's area, Lithuania has a relatively large area of woody energy plantations. However, in Lithuania to date, 66 percent of willow plantation owners have not harvested their first rotation crop (Konstantinavičienė and Stakėnas, 2015).

The first commercial short rotation energy plantations (SREP) were planted in 2003 in Lithuania, however statistical data could be found only from 2007 (see Table 4: 2007 = 260 ha), later yearly increasing from 13 to 60% (NMA, 2014).

A mathematical model for the determination of the dry above-ground biomass of energy willow plantations grown in Lithuania using a non-destructive method has been prepared (Konstantinavičienė et al., 2014).

Another coppice culture in Lithuania is hybrid aspen. Breeding and selection work on hybrid aspen started in 1965. It was reactivated in 1982, and then again in 2007 (A. Pliūra, personal communication). Until 2007, approximately 50 ha were cultivated both on forest and abandoned agricultural lands.

During the last decade, up to 400 ha of hybrid aspen short rotation plantations have been planted annually in Lithuania (Fig. 24) (Tullus et al., 2011; A. Pliūra, personal communication).

Breeding of hybrid poplars has also been started and clones best adapted to Lithuanian climatic conditions will be used to establish short rotation plantations, a portion of which will also be managed as coppice forest without replanting after the first and second rotations (Pliūra et al., 2014).

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Table 4. Statistics on short rotation energy plantations (SREP) and willow energy plantations (WEP)

Year	Total SREP area (ha)	SREP increase (%)	Total WEP area (ha)	WEP increase, (%)
2007	260	–	–	–
2008	375	44	–	–
2009	492	31	–	–
2010	556	13	–	–
2011	891	60	109	–
2012	1106	24	252	131
2013	1768	60	1196	375
2014	2493	41	1823	52
2015	3027	21	2477	36

Figure 24. Short rotation plantation of hybrid aspen in Dubrava Forest Enterprise, Lithuania, which will become coppice forest in one rotation (after clear cut at 20 years age) (photo: V. Suchockas and A. Pliura)

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REPUBLIC OF MACEDONIA

Pande Trajkov[1]

As a result of traditional forest management, combined with the extensive cattle breeding practiced until the middle of the 20th century and cruel environmental and climatic conditions, large areas of the forests in the Republic of Macedonia are coppiced and degraded. In previous times the landscape in the lower and middle parts of the mountains mainly comprised coppiced forests. In order to improve their condition and prevent further degradation of forests, an Act was introduced in 1948 prohibiting the breeding of goats (Nikolovski, 1955). The result was a rapid reduction in the goat population of about 1.2 million. During the second half of the 20th century the recommendation was for coppice to be transformed into high forest (Nikolovski, 1955, 1958 1960, 1964, 1966; Mircevski, 1977, 1989). Direct conversion, combined with replacement of tree species, was recommended for degraded coppice forests, while the preserved stands were subjected to indirect conversion. The most common species used for re-forestation was black pine. This has a low growth rate on poor sites and suffers damage from frequently occurring forest fires and pests (Trajkov, 2007). This, combined with lack of knowledge about the growth of other species has resulted in the transformation of coppice forests over recent decades being applied only in restricted areas.

Today the total area of managed coppice forests is about 618,000 hectares or about 68.5% of the total managed forest. 54,000 hectares of this are shrubs and pseudo-maquis. The coppice forests consist mainly of beech (*Fagus moesiaca*) and several species of oak: sessile (*Quercus petraea*), Hungarian (*Q. conferta*), Turkey (*Q. cerris*), Macedonian (*Q. trojana*), downy (*Q. pubescens*) and kermes (*Q. coccifera*). There are several types of hornbeam: the European (*Carpinus betulus*), Oriental (*C. orientalis*) and hop hornbeam (*Ostrya carpinifolia*) as well as maples (*Acer campestre, A. monspessulanum, A. obtusatum*), manna ash (*Fraxinus ornus*) and aspen (*Populus tremula*), are also found. Oak coppice forests cover a wide range across the vertical distribution of vegetation. As a result of human influence almost all the oak forests occurring up to an altitude of 1100 meters are coppiced, except for small areas around religious objects or deep in the mountains, far from human settlements. Both beech and oaks stands re-spout well from coppiced stools until they are very old; these are managed on a rotation of 50 years. The wood from the coppice forests is mainly used as firewood.

As a result of the large coppice resource and despite the continuation of coppicing, there are now over-aged stands, older than 50 years, whose regeneration is debatable.

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In privately owned coppiced oak forests, thinning has been practised in order to provide continuous annual yield. This approach has led to a reduction in the canopy and the emergence of a vigorous understorey that now obstructs its transformation to high forest. On the other hand, the reduced number of stools in these stands means that the classic coppice system cannot be applied and economics prevents owners from performing direct transformation. As a result of all these factors oak coppice stands are being quietly transformed into hornbeam and ash stands.

Environmental and political development in the country is increasingly threatening the existence of the coppice system. The public comment negatively on large areas of clear cut near settlements, close to recreation centers or along roads.

Figure 25. Oak coppice stands at the regeneration stage

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NETHERLANDS

Patrick Jansen[1]

Large parts of the Dutch forests were coppice woodlands up to around 1850. Approximately 57% of the forests were coppice woodlands. Oak coppice was dominant due to the use of its bark for leather production. The most common production cycle was 8-10 years for bark production. For fuelwood longer production cycles were used, up to 25 years. Coppice with standards was rather rare in the Netherlands.

Some beech and birch coppice existed on the drier lands and ash and alder coppice in wetter conditions. Due to the rise of cheaper tanning and fuel products and rising labour costs the management of coppice woodlands declined in the second half of the nineteenth century. Thereafter, only a small proportion of the coppice woodlands were managed in the traditional way. In the two World Wars some coppice woodlands were harvested for fuel wood, and in many cases this was the last time they were coppiced. Coppice woodland on the more fertile soils was converted to agricultural land. In drier, not so fertile grounds the coppice woodlands were converted to high forest. Between 1955 and 1965 there was even a subsidy scheme available for this aim. High forests were seen as a better economic alternative. Stools were cut down and species such as Douglas-fir or spruce were planted, but many oak coppice woodlands were also 'singled'. In this strategy only one sprout was saved on every stool. These shoots formed the basis of a new high forest of oak.

Already in 1964 two prominent ecologists published an article on the nature conservation values of traditional coppice woodlands. Some nature conservation organisations saved a small area of coppice woodlands for this reason, but most was converted to high forest of agricultural land or simply abandoned.

Currently only approximately 1,500 ha of actively managed coppice woodlands remain managed mainly for biodiversity and cultural heritage. Old stools form an interesting habitat for certain species, for example some rare mosses. Coppice woodlands are also a suitable habitat for a large number of species because of the quick shift between sunny and shaded conditions. Both light demanding and shade tolerant species can find a suitable habitat in actively managed and therefore ever-changing coppice woodlands.

One of the main challenges in restoring coppice woodlands is to rejuvenate old stools. Many old stools died back after coppicing. This is also due to the large number of deer, but research has shown that the main reason is the time that has passed since the last coppicing. Even if the old stools resprout successfully, the number

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of stools is very low compared to historic densities. The low number of stools in old coppice woodlands is due to self thinning in the last decades. Restoring coppice woodlands therefore also involves planting new trees with the aim of forming new stools.

The wood from these coppice woodlands is mainly use as industrial biomass chips or domestic fire wood. The rise of the biomass market has had some positive impacts on the management of coppice woodlands, but the cost of coppicing and restoring coppice woodlands is still much higher than the income from the wood and biomass sales. Coppice woodlands are also subsidised. For coppice woodlands on wet soils the management subsidy is currently 2,563 euro per hectare per year. On dry lands it is 394 euro per hectare per year. These subsidies have been crucial in protecting the small remaining area of coppice woodlands in The Netherlands.

Since the nineties, high density short rotation coppice with poplar and willow has been promoted, but due to the high prices for land it has only been a success in areas where dual goals could be achieved. A good example is the establishment of short rotation coppice on biological chicken farms. The chickens use the available land better through the short rotation coppice and the farmer has biomass to sell.

Figure 26. Coppice management in alder coppice in The Netherlands (photo Patrick Jansen)

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NORWAY

Giovanna Ottaviani Aalmo[1]

Standard coppice does not exist in Norway as the Norwegian forestry sector is essentially dominated by conifers, though, on the other hand, deciduous trees represent a very important part of the culture and a substrate for biodiversity.

Coppicing in Norway is a traditional farming practice, which was extensively used in the West Coast area. This type of practice was relevant to slightly beyond the 1900s, nowadays it is still minimally used for feeding goats.

By means of this old traditional technique, farmers were cutting the main branches of the tree to form several new shoots so to increase the production of leaves used for feeding sheep and goat in winter and supplementing their diet.

To prevent grazing animals the cutting was performed up to two or three meters from the ground (Fig. 27).

The most common types of wood were ash, linden, elm, rowan and birch. Not all had equally good nutritive value or tasted as good as the other.

The harvest in western farms was frequently executed in spring before the leaves were starting to grow bigger. The branches were cut down and either left on site, stored or given directly to the animals. Elm and ash represented the best fodder. Leaves and thin branches were therefore cut and dried. The good quality fodder “Godlauv” from elm and ash was bundled, transported and dried on the farm ground (Fig. 28).

The other types were instead dried in outlying areas bundled and hung up on the trees.

Once dried the bundles were either put in stacks or stored in an outer storage until they were fetched home during winter.

In many localities, linden production was commonly used for the production of ropes and binding cords while other species were more commonly used as fences and along streams.

Figure 27. Coppice managed tree: 1989 and 2009; Photo by Leif Hauge and Oskar Puschmann; location: Arnafjord, Vik Sogn og Fjordane Norway

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Nowadays coppicing is still performed in several counties, i.e. Akershus, Rogaland, Sogn og Fjordane and Nord-Trondelag (Fig. 29).

This practice is maintained essentially to keep the historical value of this tradition and protect the biodiversity.

Norwegian farmers can in fact apply for a specific subsidy, which amount at about 50 Euros/tree from the Regional Environmental Program for Agriculture (RMP) for keeping and managing as coppice the deciduous trees on their properties.

Figure 28. Year 1903; Photo taken by Anders Beer Wilse; copy - of the original belonging to Norsk Folkemuseum, Hardanger, Hordaland, Norway

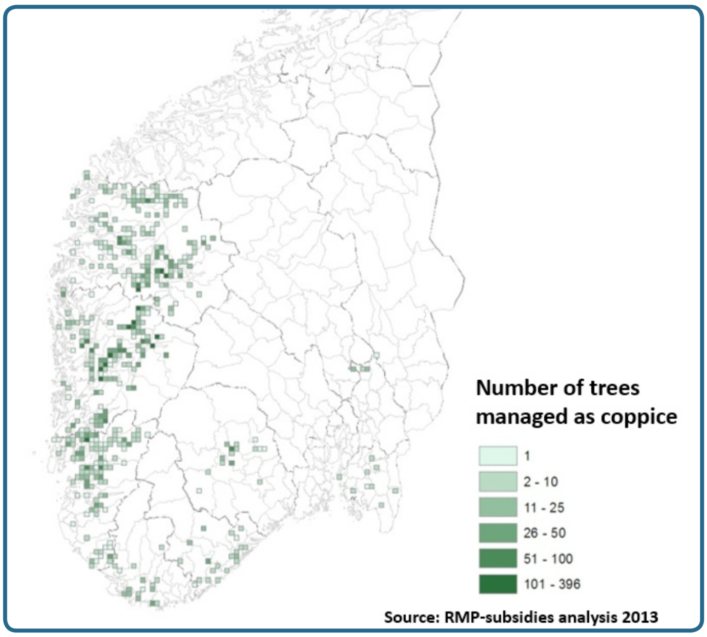

Figure 29. Map of coppice management in Norway

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POLAND

Martyna Rosińska[1], Mariusz Bembenek[1], Zbigniew Karaszewski[2] and Piotr S. Mederski[1]

Forest management in Poland is focused on a high forest system. Stands of seed origin provide timber of high quality, which corresponds with current demand from the timber sector. Forests cover almost one third of Poland, of which 7,094,696 ha is under the State Forest National Forest Holding management. Coppice forests occur in Poland very occasionally; coppice is considered a less important forest management type. The total area of coppice in Poland amounts to 21,477.57 ha and almost 89% belongs to the State Forest (Fig. 30).

Coppice forests grow very often on areas of low access and are considered to be water and soil-protecting forests. A main coppice-forming species in Poland is black alder (*Alnus glutinosa* Geartn., Fig. 31), which is able to vegetatively regenerate well.

However, coppice trees are characterised by lower height, high tapering trunk, unilaterally formed crown and being vulnerable to rotting. Due to these factors, the final felling age for vegetative alder stands was reduced from 80 to 60 years in current forest management (Maciejowski, 1953). Despite all the silviculture treatments, alder coppices are still economically less attractive and their functions are limited to forest protection and biodiversity.

The other coppice-forming species are oaks (*Quercus spp.*) and silver birch (*Betula pendula* Roth). Additionally, European beech (*Fagus sylvatica* L.), lime (*Tilia spp.*) and hornbeam (*Carpinus betulus* L.) are also used as mixed species in coppice.

Oak is the subject of special type of coppice

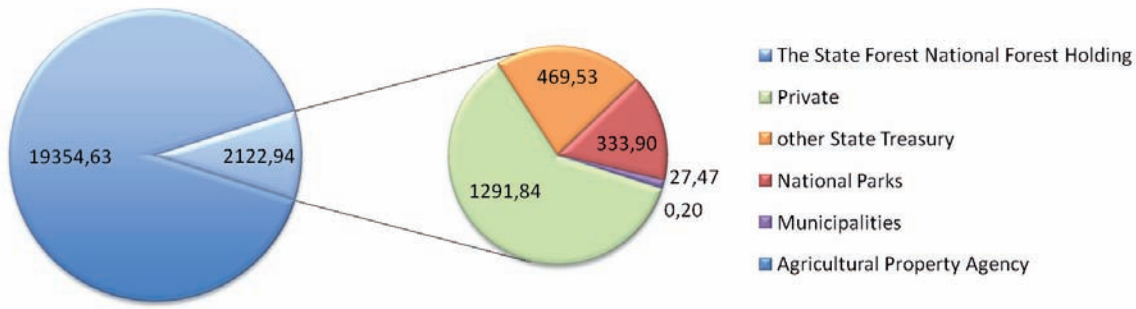

Figure 30. Coppice area (ha) in Poland by coppice owners (Bureau for Forest Management and Geodesy, 2016)

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in the State Forest, which is formed after cutting browsed seedlings (mostly *Quercus petraea* and *Quercus robur*). The low cutting is performed 3-8 years after planting the unsuccessful, browsed crop. The damaged plantation is fenced one year prior to the intervention. This low cut results in a rapid growth of coppice shoots, which reach about 1 m height within 1 year.

The oldest and the largest coppice area (about 3,000 ha) is located in the South of Poland, Pogórze Kaczawskie (Sudety Mountains). These *Quercus petraea* coppices were created before the Second World War. The trees were cut in a 14-year rotation period, mainly to obtain material known as mirror bark. Remaining stands create one of the rarest forest areas in Poland and are now excluded from utilisation (Szymura, 2010).

Currently, due to increased demand for renewable energy sources, short-rotation plantations of fast growing trees such as willow or poplar are being established. These plantations could be recognised as expanding coppice utilisation for energy purposes in Poland, together with a share of other (coppice) species.

Figure 31. Black alder coppice in Pułtusk Forest District (Photo M. Rosinska, 2015)

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PORTUGAL

João P. F. Carvalho[1], Helder Viana[2] and Abel Rodrigues[3]

Coppice is a silvicultural system that has been commonly used in Portugal for decades. This produces a range of small and medium sized materials, such as firewood, poles, charcoal, raw material for basketry and cooperage, on short (10 to 30 year) rotations. It is one of the oldest forms of management in semi-natural forests.

Different types of coppicing, with regeneration by stool shoots, has been practiced for many species such as common oak (*Quercus robur*), Pyrenean oak (*Quercus pyrenaica*), Portuguese oak (*Quercus faginea*), holm-oak (*Quercus rotundifolia*), chestnut (*Castanea sativa*), ash (*Fraxinus spp.*), poplar (*Populus spp.*), willow (*Salix spp.*) and eucalyptus (mainly *Eucalyptus globulus*).

While coppicing of some species has declined over the years, eucalyptus coppice has expanded enormously in recent decades, grown on 10 to 12 year rotations for pulpwood production. *Eucalyptus globulus* (Fig. 32) is now dominant over approximately 812,000ha (National Forest Inventory, 2013) and, as this is 23% of the total forested area of the country, it is currently the main Portuguese species. Eucalyptus makes up nearly 94 % of the total area in coppice management.

Most of the other formerly coppiced species have been converted into high forest. Most Common oak (*Q. robur*) occurs as high-forest with coppice retained only in small patches. Pyrenean oak (*Q. pyrenaica*) forests have been improved to high-forest for quality timber production and conservation purposes (Carvalho and Loureiro, 1996). Oak forests are very rich ecosystems and in some regions are important for the survival of rare and threatened plants. Silvicultural practices have been used to improve tree growth and so the production of better quality, larger dimension wood. Portuguese oak (*Q. faginea*) was previously coppiced for firewood and charcoal but nowadays coppicing this species is not common. There are residual patches of holm oak (*Q. rotundifolia*) in the north and center of Portugal, maintained to produce firewood and charcoal. The southernmost holm oak areas are now part of a silvo-pastoral system known as montado, where trees and livestock husbandry activities are combined. The majority of chestnut (*Castanea sativa*) is in orchards for nut production. Only small areas exist for wood production and there is little coppice.

Coppice rotation for oaks (*Q. faginea, Q. pyrenaica* and *Q. robur*) varies between 10 and 30 years, depending on the species, site quality and final tree diameter. Previously coppice had many uses but during

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recent decades much has been abandoned and converted into high-forest (Carvalho and Loureiro, 1996). Nowadays, only a few oak coppices are maintained for firewood production. In certain areas, it is common to find oaks as small groups and at the edges of fields. Generally they have a secondary production role, forming a reserve to meet occasional needs (e.g., firewood, poles). Some of these areas are also managed for biodiversity, conservation and soil protection.

Pollarding may be found in some areas. Traditionally oak (*Quercus spp.*) and ash (*Fraxinus angustifolia*) foliage was cut for cattle feed, in rotations of 2 to 4 years; this is not common nowadays.

As result of the strategy for climate change mitigation and for secure energy supply (European Commission, 2014) European Union members have been implementing projects for energy production from biomass (e.g. Viana et al., 2010). The biomass needed by the power plants will generally be supplied from forest residual biomass, but this can be complemented by short rotation woody crops, specifically grown for their energy value. Coppice systems work well with short rotations to produce wood for energy from species such as willows, poplars, and Eucalyptus; as well as lignocellulosic crops such as reed canary grass (*Miscanthus*) and switch grass. Currently, short-rotation coppices (SRC) to produce raw material for energy purposes are very scarce, but several studies are in progress. According to some evaluations there is a potential for these to be used in Portugal, primarily on abandoned, previously agricultural land, (Abel, 2012). These SRC plantations would involve eucalyptus (mostly *E. globulus, E. maideni* and *E. camaldulensis*) and poplar (*Populus x euroamericana* clones) in rotations of 3 to 5 and 2 to 3 years, respectively. Yield may range between 8 and 40 tons dry weight ha^{-1} $year^{-1}$ for eucalyptus (85% stands between 8 and 30) and 8 to 20 ton dry weight ha^{-1} $year^{-1}$ for poplar.

Figure 32. Eucalyptus (*E. globulus*) coppice stand in Portugal

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ROMANIA

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Coppice forests have always been a major component of Romanian forest land as:

- it is a ”country” of broadleaved tree species, dominated by oaks (e.g., sessile, pedunculate, Turkey, Hungarian, pubescent) and European beech but also including maples, ash, hornbeam, lindens, alders, poplars, willows, etc. Ever decreasing in the last two millennia as a result of major human transformations, the share of broadleaves in the national forest land still reaches over 70%.
- the size of the rural population of Romania, decreasing strongly since mid-19th century (over 89%) down to about 46% at present, is still one of the highest in Europe.

Before the nationalization of all forests at the end of the Second World War and beginning of the Communist period, coppice forests covered important areas in Romania: 1.9 million ha (30 % of forest land) of simple coppice in 1948 (Costea, 1989), over 0.229 million ha (3.5 % of forest land) of coppice-with-standards in 1928 (Ionescu, 1930). In 1948, the application of coppice-with-standards was completely forbidden, all coppice forests of this kind being converted towards high forests. Owing to the same process of conversion, the share of simple coppice in Romanian forests has continuously decreased so that they currently cover only 5 % of national forest land. According to the current Forest Law (2015), the simple coppice system can be applied only to native poplars (i.e. black, white) and willows in floodplain areas, and black locust forests. Yearly, about 3,500-4,500 ha of simple coppice stands are harvested in Romania (www.insse.ro); the maximum size of coppice areas is 3 ha.

The application of coppice forest management in Romania is also possible in the floodplain willow forests, which are pollarded (high coppiced) with a rotation of (15) 20 to 30 (35) years when targeting the production of sawn timber. Logging areas in pollard stands are located perpendicular to the watercourses (Fig. 33), with a size of maximum 10 ha. Rotation of cutting in pollarding: annual.

Since 2005, the application of short rotation coppice management has started in Romania exclusively on agricultural, non-forest land; currently over 800 ha of willow cultures, as well as ca. 1,000 ha of poplar cultures are established.

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Coppice forests, mostly of black locust (the species covers over 250,000 ha) are a major supplier of firewood in many rural areas of Romania. They are also important for the protection of river banks (poplars and willows), on sandy soils (black locust), in the honey-related industry, etc.

As about 800,000 ha of Romanian forests, consisting mostly of broadleaved tree species with a high potential for vegetation reproduction, are owned by over 700,000 small forest owners (average size of forest estate 1.1 ha), the management of such lands as high forests as practiced currently owing to the legal requirements is a major challenge in technical and economic terms. Unfortunately there is no political commitment for re-defining their economic/ ecological targets and re-converting these forests into simple coppices or coppice-with-standards, which affects the ownership rights as well as the freedom to manage them in a more dynamic and profitable way.

Figure 33. Pollards of white willow are a characteristic feature along the banks of Danube River.

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SERBIA

Milun Krstic[1]

The dominant form of silviculture in Serbia is coppice forests and they make up 1,456,400 ha, or 64.7% of the country's land area, and 50.0% of the forest volume. Most of the coppice forests, 61.4%, are in private ownership. 48% have oak dominant and 25% beech as the principle species. The distribution of coppice forests by surface area is as follows: preserved coppice stands 76.3%, under-stocked coppice stands 21.3% and devastated coppice stands 2.4% (NFI 2009). Volume per hectare in preserved coppice forests is 133.0 m^3 ha^{-1}; under-stocked 102.7 m^3 ha^{-1}; devastated 42.5 m^3 ha^{-1}. The age structure in the coppice forests is not favourable with the proportion of young, middle-aged and mature being 10:78:12. Coppice forests classified as energy coppice forests are not recorded as such in Serbia. Coppice forests produce a variety of products from small poles, used for fuel, to larger timber, etc.

The forestry silvicultural methods used are those considered close to nature, in other words promoting permanently sustainable and economically justified activities, limited and conditioned by natural processes. Selection and application of suitable silvicultural or ameliorative methods depend on the precise degree of forest degradation (production, quality, condition, composition, origin, etc.) and the habitat and site conditions (the degree of degradation of soil, etc.), based on scientific criteria.

Precise silvicultural measures appropriate for application to coppice are divided into the following basic groups:

- Quality coppice forests of valuable tree species and preserved habitat: *Indirect conversion* into high forest. Young stands are extensively cultivated in the respective stages of development; at maturity they shall be naturally regenerated. According to Forest Law harvesting cannot take place before the trees are 80 years old.
- Where forests have been degraded then *direct conversion* processes should be applied, with the land preserved and the degraded forests removed. Amelioration is carried out either by artificial restoration of the same species (restitution) or, where stands and habitats are degraded, then appropriate species of trees that can grow successfully in such habitat conditions are planted (substitution).

Where stands are unequally degraded over the site area then the amelioration procedures of indirect methods of conversion, restitution and substitution, can be combined.

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Figure 34. A typical coppice situation in Serbia

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SLOVAKIA

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The extent of coppice forests in Slovakia is 34,463 ha (1.8 %), in addition to 76,216 ha (3.9 %) in the first generation on conversion to high forest (according to the Country Act nr. 453/2006, § 19). The area of traditional coppice is decreasing due to conversion to high forest (in 1920 there was 208,438 ha).

Species used in different types of coppice are *Quercus cerris, Quercus petraea* agg., *Carpinus betulus, Fagus sylvatica* and *Robinia pseudoacacia*. The most accepted coppice management is coppice-with-standards. Rotations of *Quercus* coppice stands are 20 to 40 years, with the cutting season in winter. Pollarding was historically common, but is now only carried out by individuals and this is usually illegal and mostly practiced with *Salix*, although previously both *Morus* and *Robinia* were pollarded. In the 19th century oaks were pollarded in the Upper Nitra region.

Short rotation coppice (SRC) is a new challenge. The total area of SRC on Slovakian forest land is 520 ha, although the potential area is 15,000 ha. The anticipated annual production is 10 t per ha dry matter. According to estimates by the National Forest Centre the theoretical potential for SRC on agricultural land is 45,000 ha, although currently there is only about 150 ha on agricultural land. The main tree species used in SRC are *Salix* and *Populus*. Rotation time is three (*Salix*) to twenty (*Populus*) years, with expected annual yields of 12 to 18 t fresh biomass per hectare (6 to 10 t dry matter under good conditions and management).

The Slovak legislation does not include coppicing in future plans but there is no clear regulation of coppice management.

After beech, oaks are the most important deciduous woodland trees in Slovakia but restoring oak stands is more difficult than restoring beech forests. Oak forests are unstable and the abundance fluctuates depending on human activities. Coppicing usually increases plant diversity. Oak stands are light-demanding (if there are no clearings created, the oak seedlings die in the shade) and without traditional coppicing, which prevented full canopy closure and so the dominance of shade-demanding species, the oaks decline. Hornbeam, which is more shade tolerant, can proliferate creating a shrub layer under the oak overstorey that suppresses oak seedlings. In places where foresters removed hornbeam as a ‘weed’ tree, forests were light and this led to a vigorous herb layer with weeds, grasses and shrubs, and these also prevented effective natural regeneration of oak from seed. Therefore, the best way to support the oak is by coppicing, but this requires further study

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to provide evidence to counteract currently fashionable views and opinions that are not always based on facts. Reduction of oak cover was also caused historically by the planting or spontaneous growth of other, often invasive species, especially *Robinia pseudoacacia*.

Coppice forests are considered an important part of the landscape pattern, require protection and the NATURA 2000 areas include 10 coppice forest types (91G0*, 91H0*, 91I0*, 91M0, 9170, 9180*, 9110, 9130, 9140, 9150) although the 'best practice' manuals do not recommend future coppicing, except for habitat 9180*. In the context of nature conservation, decision making is a challenge. It is unclear whether forests should be preserved by less intensive management, although this risks oak decline as well as the light demanding components of the herbaceous layer or, alternatively, whether forests should be managed more intensively, even in protected areas, so there would be more light and so the rare (and often protected) species would be retained. Drier areas require simple management with thinning, wetter forests require more frequent management.

Planting new black locust (*Robinia pseudoacacia*) forests is prohibited. This plant was registered on the official list of invasive plant species in 2011 but has now been has now been removed from the list (Announcement of the Ministry of Environment SR Nr. 158/2014).

Figure 35. Coppice forest: *Quercus petraea* and *Q. dalechampii* at Nitra (SW Slovakia) (photo: Alexander Feher)

SLOVENIA

Nike Krajnc[1] and Matevž Mihelič[2]

Traditional coppice forests in Slovenia

According to official data from the Slovenian Forest Service, coppice forests in Slovenia are present only on 18,810 ha, which is less than 2 % of total forest area. These forests are present in the west, south-west, and south-east parts of the country. Coppice production in the country uses distinctively short rotations of 12-30 years.

The traditional coppice forests in Slovenia can be divided into several types:

1. In the western part of the country the coppices were used mostly for production of poles and firewood. The main tree species used were *Robinia pseudoacacia, Quercus spp.* and to a lesser extent also *Castanea sativa*.

2. In the south eastern part of the country the beech coppice forest was mostly used for production of charcoal. The coppice forests in this part of the country are mostly dominated by beech, and the large demand for charcoal was initiated by the new ironworks and glass production at the end of the 18th century. But this use of forests declined in the last century which is why the share of beech coppice forest is decreasing; they were mainly transformed into high forests.

3. There is some recent evidence indicating that coppice use was heavily interconnected with the use of land for animal grazing (Panjek, 2015) however this use of land in the alpine region has been changing during the last 50 years and many grazing areas in mountain areas were overgrown by natural vegetation (high forests).

4. In the eastern part of the country chestnut coppice was also used for poles in vineyards and for other mostly agricultural purposes. In the 1950s a new and very massive production of tannin started, which intensified coppicing (Wraber, 1955). The tannin industry and production of parquet from chestnut is still very much alive today. The company producing tannin in Slovenia TANIN Sevnica needs more than 50.000 m^3 of chestnut wood per year.

Short rotation plantations

Besides traditional coppice forests there was also a strong initiative to start short rotation plantations with willow in an area affected by mining activities. The mining company established 4 ha of test plantation measurements and measured the production potential of two different clones of willow (*Salix sp.*, clones *Tordis* and *Inger*) as an alternative energy source. The measurements were performed each year for four years.

The quantity of produced biomass (absolutely dry) is calculated as a product

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of mean volume of the coppice, number of coppices per hectare (where mortality is also considered) and mean basic density of the shoots. The quantity of wood biomass produced in the first year of coppice growth was 0.88 dry tons ha^{-1}, in the second year 4.58 dry tons ha^{-1} and 27.29 dry tons ha^{-1} in the third year in the case of *Tordis* clone. The equivalent for *Inger* clone gave lower values of 0.63, 3.49 and 9.17 dry tons ha^{-1}. The results are presented in Table 5.

Table 5. Results of the analysis of short rotation plantation in Velenje (Pilar et al., 2014)

Willow (*Salix sp.*) clones	*Tordis*			*Inger*		
Year	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
Survival of plants (%)	87	85	84	85	81	75
Mean number of shoots in a tuft	2.3	2.1	2.2	2.2	2.6	2.6
Mean height of the plant (cm)	147	319	624	136	290	403
Diameter at 1 m height (mm)	8.15	14.5	28.4	7.6	13.5	16.7
Mean volume of the shoot (cm^3)	95	559	2955	90	416	1000
Yield (t atro/ha)	0.88	4.58	27.29	0.63	3.49	9.17


Figure 36. Coppice forests in Slovenia (Photos N. Krajnc)

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SOUTH AFRICA

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Within South Africa, the forestry sector contributes 1.2% to the Gross Domestic Product of the country. Of the total land area, about 1.1% (1.275 million ha) is planted as exotic plantation forests, with less than 0.9% occupied by indigenous forests. The main tree species planted for commercial purposes include pines (51%), eucalypts (42%) and wattle (7%) which supply timber products (sawlogs, veneer, pulpwood, mining timber, poles, matchwood, charcoal and firewood) to both the local and export markets.

Most of the plantation forests are located along the eastern seaboard of South Africa, where various eucalypts and/or their hybrid combinations are matched to the site conditions (Fig. 37). *Eucalyptus nitens, E. macarthurii* and *E. smithii* are planted in the cooler temperate regions, *E. grandis, E. dunnii* and *E. grandis x E. nitens* in the warmer temperate regions and *E. grandis x E. urophylla* in the sub-tropical regions. These eucalypts are grown over short rotations (typically 8 to 10 years), predominantly for pulpwood production, and to a lesser extent mining timber. Intensive silvicultural regimes are practised to maximise production volume, with mean annual increments ranging from 15 to 60 m^3 ha^{-1} $annum^{-1}$, dependent on site quality. Although eucalypts are planted at various inter- and intra-row distances, the target density at felling age is 1,300 to 1,600 stools per hectare.

One of the notable attributes of eucalypt species is their ability to survive and produce new growth following adverse environmental conditions, and this is largely a function of their bud systems being able to coppice. This survival mechanism is exploited in commercial plantations for re-establishment following felling, where the coppice shoots are selectively thinned over time and managed as a coppice stand for the production of pulpwood.

Previous research on coppice management in South Africa focused primarily on optimising the number of stems remaining on the stump, and on the effects of frequency and timing of reduction (or thinning) of the shoots on timber volume and properties. This produced robust recommendations which are still used today, and state that coppice should be reduced in two operations: first to two or three stems per stump when the dominant shoot height is 3-4 m, and later to the original stocking when the dominant shoot height is 7-8 m.

Dependent on a number of factors, eucalypt stands may be coppiced once, or a maximum of twice, before being replanted.

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Decisions on whether to replant or coppice include determining whether the:

- correct species is growing on the site (for example is the species the best in terms of potential yield, genetic improvement, disease resistance, drought tolerance, frost and snow tolerance?),
- trees were planted at the correct spacing (matching stand density to site productivity),
- stocking of the originally planted stand when harvested is adequate, or if there is high tree mortality?
- planted species have the ability to coppice?

Current challenges in terms of coppice management centre mainly around issues associated with increased mechanisation of forest operations, and the incidence of pests and disease. Until recently, South Africa made extensive use of manual labour for both silvicultural and motor-manual harvesting operations. Planting densities (especially between tree spatial arrangements), thinning (reduction) operations, and the remaining number of stems per hectare (based on manual operations), will need to be optimised for mechanisation. This will ensure that the currently higher harvesting costs associated with felling coppiced stands is optimised. The impact of recently introduced pests and disease into South Africa has meant many susceptible eucalypts have been replaced with more resistant, alternative eucalypts and/or hybrid combinations. The coppicing potential and subsequent silvicultural management of these eucalypts will need to be tested.

Figure 37. A coppiced stand of six-year-old *Eucalyptus grandis x E. camaldulensis* clones in the sub-tropical region of Zululand, South Africa.

SPAIN

Míriam Piqué[1] and Pau Vericat[1]

Coppicing has been widely applied for centuries to almost all hardwood species with re-sprouting ability in Spain. Several coppice methods and rotations have been used in order to obtain a wide range of products, depending on the species. Coppice was the most usual management to obtain fuelwood, charcoal and tannins, medium sized saw wood (e.g. staves, poles, stakes) or rods for basketry. Pollarding was also applied to some species in order to combine grazing with fuelwood production, and to obtain fodder from the branches.

The rotation length used for coppices in Spain varies widely depending on geographic areas, dominant species, type of coppice, site quality and desired characteristics of the products. The most common rotation is around 30 years (between 20 and 40), but shorter rotations were not unusual, especially for pollards.

Coppice forests in Spain cover around 4 million ha, which constitutes around 50% of the total area covered by spontaneous hardwood, and more than 20% of the total forest area. The most important species are *Quercus*, mainly *Quercus ilex* (Fig. 38) and *Quercus pyrenaica*. Since 1950 coppice forest management has been gradually abandoned all across Spain and, at present, only particular species and regions still maintain a significant use of coppices (e.g. *Quercus ilex* in the North East, *Quercus pyrenaica* in the North West and *Castanea sativa* in the North of Spain).

Because of this general abandonment, all current coppices have exceeded the usual age of rotation, most of them doubling that age. The excessive density of these abandoned coppices, combined with much of the photosynthetically derived energy being used to maintain the significant underground biomass, has caused a reduction in growth and loss of vitality.

The main emerging risks are related to global change. In this context, abandoned coppices are very vulnerable to water stress and forest fires, both great threats to Mediterranean forests. In addition, low seed production and reduced gene flow can compromise the ability to adapt to new scenarios. Furthermore, the dense and homogeneous stands resulting from abandonment become simplified in terms of structure and specific composition, and so tend to be very unfavourable from the viewpoint of biodiversity.

Finally, some specific types of coppice, such as pollarding of beech or ash, are very interesting from their historical, social and environmental values, and are at risk of disappearing.

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Therefore, in general, the priority is to recover the management of the large area of abandoned coppice in order to ensure the provision of economic, environmental and social services. For this, it will be necessary to reintroduce the traditional management, enhancing this when necessary, or using other silvicultural approaches such as conversion, where it is economically, environmentally, and socially sustainable. Integrating fire prevention and improved habitat conditions is an imperative in all cases.

A major challenge is to improve the profitability of management and exploitation. The current scenario of increased demand for biomass as an energy source is favourable in this respect. Finally, social awareness is also needed to facilitate the acceptance of coppice management, which involves clear felling in many cases.

Major areas of research on Mediterranean coppices in Spain are:

- Silviculture: developing, assessing and transferring new management alternatives is a priority to achieve a real multi-functional management. Improving harvesting techniques;
- Ecology and dynamics of Mediterranean coppice forests;
- Eco-physiology of coppiced species and the relationship of this to silvicultural practices and ecological conditions (carbon balance, stump lifespan, re-sprouting ability in relation with age/size of regrowth);
- Seedling regeneration and genetics of coppice systems, in order to understand the effects and the long term sustainability of the coppice system.

Figure 38. *Quercus ilex* and *Quercus suber* uneven-aged coppice with standards in Catalonia, Spain.

SWEDEN

Ioannis Dimitriou[1], Magnus Löf[2], Tomas Nordfjell[3] and Martin Weih[4]

In Sweden there are limited areas where traditional coppice forest management has been applied. Coppice with standards does not exist in Sweden and the national statistical authority of Sweden (Forest Statistics - Riksskogstaxeringen) does not even register these types of forest. The same concern regarding recording applies to pollards, although there are several sites in Sweden, and recent restoration of pasture with pollarded trees of *Tilia cordata*, *Sorbus aucuparia* (mountain ash), *Fraxinus excelsior*, alder (*Alnus spp.*), aspen (*Populus tremula*), willow (*Salix sp.*), poplar (*Populus spp.*).

There are a number of sites of simple (low) coppice managed forest in the South (Scania) and in the mountainous areas of Sweden, however these are not very extensive (as compared to 'conventional' forestry). The species used for simple coppice are alder (*Alnus sp.*), birch (*Betula sp.*), aspen (*Populus tremula*), willow (*Salix sp.*), and poplar (*Populus sp.*). Forest statistics (Riksskogstaxeringen) do not record these types of forests, which is indicative of the status and condition of coppice forest management in the country.

The most common coppice system in Sweden is willow (*Salix sp.*) short rotation coppice (SRC) system used to produce biomass for energy. Today, approximately 11,500 ha of this are being grown. Willow cultivation is fully mechanized, from planting to harvest. In the initial phase approximately 12,000 cuttings per hectare are planted in double rows, to facilitate future weeding, fertilization and harvesting. Conventional inorganic fertilizers have commonly been applied in the years following planting. The willows are harvested every three to five years, during winter when the soil is frozen, using specially designed machines. The above-ground biomass is chipped on-site, and then stored or directly burned in combined heat and power plants. After harvest, the plants re-sprout vigorously, and replanting is not therefore necessary. The estimated economic lifespan of a short-rotation willow coppice stand is between 20 and 25 years. Average yields from commercial SRC willow plantations in Sweden are between 6-10 tons dry matter per hectare each year.

There is an increased interest in using willow SRC in phyto-remediation systems

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to clean soils from, for example heavy metals, especially Cadmium, and waste water that is nutrient-rich. Several plantations have been established specifically for these purposes. At the same time, there is an interest in coppice plantations designed to promote biodiversity (such as birds and wild game) and this can also be a reason for implementing willow coppice systems.

The ambition for future coppice sites in Sweden is to consider how new forms of production can be designed to produce biomass for energy and also enhance biodiversity, landscape diversity and cultural values. It is important to incorporate new ideas on modifying coppiced stands to meet current needs and designing systems that will satisfy society's requirements in an economic, environmental and energy efficient way. Trees in, for example, urban forests, urban environments, under power line corridors as well as strips within 5 to 7 meters of forest roads and agricultural fields, should all be seen as a resource. Production systems could be designed so that they fulfill the requirements mentioned above. Some specific thinning regimes of dense young stands, around 5 to 7 m in height, might be considered as a relevant 'coppice approach' to forestry.

SWITZERLAND

Josephine Cueni[1] and Patrick Pyttel[2]

As in many other European countries, coppice forests with and without standards were brought to Switzerland by the Romans around four centuries B.C. Both forest types have been characteristic elements of the Swiss landscape for centuries. Due to socio-economic changes most coppice forests, with and without standards, were abandoned or converted into high forests during the 19th century (Schuler et al., 2000; Meier, 2007; Imesch et al., 2015).

Today coppice forests (excluding coppice with standards) cover 35,000 ha and 2.8% of the total Swiss forest area (Abegg et al., 2014). The majority of the remaining coppice forests were last harvested between 1959 and 1963. These forests currently show slow growth (ca. 5.6 m^3 ha^{-1} a^{-1}), low mean annual harvesting rates (0.5 m^3 ha^{-1} a^{-1}) and increasing dead wood volumes (ca. 1/3 of the annual increment; Abegg et al., 2014; Häfner et al., 2011). They occur in all regions of Switzerland (Jura, Midland, Pre-Alps, Alps, South), although the majority are located south of the Alps (20% of total regional forest area; Abegg et al., 2014). Most are found on fertile sites and at elevations ranging from <600 m to 1000 m. Coppice forests in and to the north of the Swiss Alps are dominated by beech, oak, ash and alder. In southern Switzerland, sweet chestnut is the main tree species (Bachofen et al., 1988).

Due to the prevailing orography, protection is a key role of Swiss forests. Around 16.900 ha or 66% of all coppice forests in Switzerland are located in the area of protection forests. In the Alps and in southern Switzerland, 71% and 86% respectively of all coppice forests serve as protection forests (Abegg et al., 2014). This management type is thought to be suitable for this function under only for certain circumstances, i.e. only: where slopes are short (<75 m), and rocks likely to fall are less than 40 cms diameter (Frehner et al., 2005; Gerber and Elsner, 1998). Consequently, coppicing is not suitable in the majority of protection forests and (the naturally occurring) conversion of coppice stands into high forest is welcomed (Frehner et al., 2005).

Since 1991 the Swiss Government has offered monetary incentives for the supply and use of fuel wood (BUWAL, 2005). Within this context the resumption of coppicing and the need for short rotation plantations has been the subject of controversy (Schmidt et al., 2008; Zimmermann, 2010). Since regional fuel wood needs can be satisfied by day-to-day forest management and because of concerns regarding landscape esthetics, coppice forests and short rotation plantations are not considered important for fuel wood (Oettli et al., 2004; Meier, 2007; Ansprach

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and Roesch, 2014). The Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) has investigated the economic potential of chestnut coppice forests for valuable wood production (e.g. Zingg and Giudici, 2006) and there are some innovative enterprises that are trying to market assorted products from over-aged coppice forests (Castagnostyle 2015, online).

The Swiss Ministry of Environment (BAFU) considers coppice forests (with and without standards) as valuable forest types important for biodiversity, culture and history. The Ministry promotes the preservation of these by paying subsidies for restoration and tending of coppice forest with and without standards (4000 CHF ha^{-1} per intervention; Imesch et al., 2015; BAFU, 2011). Between 2004/06 and 2009/13 re-coppicing occurred on 400 ha (Abegg et al., 2014). To date between 600 and 700 ha of simple coppice and 400 to 800 ha of coppice with standards were designated parts of forest reserves (WSL, 2015). It can be assumed that these forests are being - or will be - managed traditionally (WSL, 2015). Some of them also serve as study sites for the WSL (e.g. Rothenfluh BL; WSL, online).

To conclude, few previously coppiced forests continue to be managed in this way. The exceptions are some study sides and as parts of some forest reserves. The unsuitability of coppice for protection forest and the production of enough fuel wood as a byproduct of day-to-day forest management do not encourage the continuation of this ancient management system. There is probably more managed coppice, both simple and with standards, in the context of nature conservation and the preservation of cultural historical land-scapes. It is possible that increasing fuel wood prices will encourage more coppicing in the future.

Figure 39. Aged coppice forest on steep slopes in the Untersiggenthal, canton of Aargau - first view (Photo: Pro Natura, Christoph Oeschger)

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Figure 40. Aged coppice forest on steep slopes in the Untersiggenthal, canton of Aargau - second view (Photo: Pro Natura, Christoph Oeschger)

TURKEY

Halil Barış Özel[1]

There are 21.7 million hectares of forest in Turkey, 20.4% of which is coppice. These coppice forests are distributed in the Marmara, Aegean, and the Western and Eastern Black Sea Regions of Turkey. They have an estimated total volume of 69.9 million m^3 and a mean annual increment of 3.4 million m^3. The main coppice product is firewood in Turkey, especially in rural villages. The coppice forests are damaged by fire, storm and snow but there are no risk assessments for them. The coppice forests are comprised of *Fagus orientalis, Sorbus torminalis, Sorbus domestica, Alnus glutinosa, Acer pseudo-platanus, Robinia pseudoacacia, Carpinus orientalis, Carpinus betulus, Platanus orientalis, Quercus petraea, Quercus robur* and *Castanea sativa* (Fig. 41).

There are coppice forests on the north and northwest slopes and on the 500-650m altitude gradient level. Productivity is generally very low but the highest volume increment is found for *Fagus orientalis, Alnus, Salix, Platanus* and *Populus* coppice near rivers as a gallery forest type. *Buxus* coppice is used for hand-made kitchen-ware, but this coppice type is currently in a degraded state.

There is no breeding programme for coppice forests undertaken by the General Directorate of Forests in Turkey. The public forest service strives to convert all current coppice to high forests. But this is not a successful conservation measure and is adding to the area of degraded coppice forest annually. There is potential for coppice forests to be used for energy but there have not been any studies on this subject; specific clones would be required. Coppice forests near rivers are damaged because of water pollution in Turkey. This caused the destruction of about 500 hectares of Platanus coppice forest between 2008 and 2014.

Coppice forest vegetation is continually being destroyed. Research has shown that about 130 plant species have been lost from the coppice forest resource in Turkey. Coppice is necessary for the long-term productivity of the forest but breeding and silviculture planning is required. Protected stands to be converted to coppice forests should be properly identified in Turkey. Coppice forests should be protected for ecology as the ecological balance has been damaged over a long period of both legal and illegal harvesting.

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Figure 41. *Castanea sativa* coppice in Turkey

UKRAINE

Ivan Sopushynskyy[1] and Vasyl Zayachuk[1]

In the Ukraine, 9.7 million ha are covered by forests; approximately 10% of this is coppice forest. Most of the coppices are oak forests (5.1 %). There are differentiated natural coppices with rotations up to 60 years and coppices with rotations of 2-5 years. The latter ones are called wood energy plantations, which have been initiated during the past two decades. The revenues are the main reasons for this forest management regime. The density (up to 20,000 trees ha^{-1}) of coppice plantations has been established mainly with *Populus* and *Salix* species. These short-rotation coppices are expected to expand with the predicted increase in demand for second generation biofuels. The main products extracted from natural coppice forests are firewood, charcoal, pole wood and branches for brooms. The coppiced trees were mainly selected for firewood (e.g. *Carpinus betulus, Robinia pseudoacacia, Fagus sylvatica, Betula verrucosa, Salix alba, Salix capraea, Alnus glutinosa, Alnus incana, Sorbus aucuparia, Malus sylvestris, Populus tremula,* and *Corylus avellana*), while the uneven-aged standards were selected to produce timbers (e.g. *Quercus robur, Quercus rubra, Fraxinus excelsior, Fagus sylvatica*, and *Alnus glutinosa*).

Generally, coppice forests are located in poor rural communities. In most of them, coppice forests are irregularly structured due to the disorganized forestry.

There are some problems with coppice forests in the rural communities:

(a) the lack of forest management plans,

(b) frequent damage due to illegal cutting and random fires,

(c) over-use of coppice forests,

(d) unfavourable national energy policy,

(e) no real data on coppice in cadastres.

Natural coppice forests in Ukraine occupy significant ecological niches that are of great social and economic value. They are mostly divided into two types regarding the site conditions and biotopes:

(1) along small rivers with temporarily wet soils and

(2) on poor forest soils with low fertility and moisture content.

In both coppice forest types there is no regular forest management planning in the rural areas. The silvicultural treatments are mostly linked to the demands of the rural community for wood as raw materials and as non-wood forest products.

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Figure 42. Natural mixed broadleaved coppice forests in the Ukrainian Subcarpathians

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UNITED KINGDOM

Debbie Bartlett[1]

Coppice management has been practiced since the earliest times with archaeological evidence including the remains of trackways laid across boggy ground showing the marks of felling axes. The composition of the woods has varied over time as particular tree species were preferentially encouraged to meet the demands of markets. Similarly, rotational cycles were developed to provide roundwood of the required dimensions.

Forestry as a whole has undergone dramatic changes in recent centuries. The demands of oak for ship building, particularly in the 17th and 18th centuries, led to the development of the coppice with standards system. In this, oaks were grown over coppice, encouraging branching and the development of the 'crooks' or angled branches required by the master ship wrights.

In the immediate aftermath of the First World War the Forestry Commission was set up in response to the shortages of timber and this Government organisation, which still exists today, set about increasing self-sufficiency in timber. This was done by buying woodland, planting conifers and providing financial incentives for private woodland owners to do the same. In many cases this led to previously coppiced native broadleaved woods being cleared and over-planted with fast growing conifers.

After the Second World War, which again had a major impact on woodlands, particularly coppice, there was a period of agricultural intensification, driven by the food shortages. This led to a reduction in the woodland area as land was cleared for agriculture. The rise of the environmental movement and increasing awareness of the effect on native flora and fauna led to a change in forestry policy with a move from coniferisation to encouraging native broadleaves in the mid - 1980s.

So how has this affected coppice woodland management? The area managed as coppice has risen and fallen with changes in market demand, policy and overall woodland area. By the turn of the century it had virtually died out in most parts of the UK as an economic activity and was practised, primarily by nature conservation organisations, to maintain specific habitats. The exception to this trend was the chestnut industry, concentrated in the south eastern counties, and producing fencing materials. This has remained largely 'hidden' as there is no legislation affecting it (i.e. no permissions are required for harvesting roundwood of small diameter). There has been continuity with coppice workers often working in family groups and with skills and knowledge passed from father to sons.

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There has been a revival in hazel coppice crafts apparent in the last decades of the 20th century with some choosing to take up this livelihood, often after becoming disillusioned by working in more high powered careers. These tend to sell products directly to their customers, as opposed to feeding produce into 'coppice merchants' as is the case for the chestnut industry, and supplement this by demonstrating at craft fairs and country shows.

In addition to these two sectors, based on specific tree species, woods are coppiced for firewood.

Figure 43. An example of coppice in the United Kingdom

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EuroCoppice - COST Action FP1301 2013 - 2017

Over 150 experts, researchers and practitioners from **35 European and partner countries** came together to collect and analyse information on coppice forests and their management. A broad range of topics were addressed in five **Working Groups**: (1) Definitions, History and Typology, (2) Ecology and Silvicultural Management, (3) Utilisation and Products, (4) Services, Protection and Nature Conservation, and (5) Ownership and Governance.

Action Members have produced reports and publications for science, policy and practice, raised awareness for important coppice-related issues, highlighted findings at numerous conferences and supported the careers of young researchers. Further information can be found at: www.eurocoppice.uni-freiburg.de

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