ROLE OF COPPICE FORESTS IN MAINTAINING FOREST BIODIVERSITY

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Abstract

This contribution gives an overview about forest diversity of coppice forests in general and describes the plant species richness, stand structure and protection status by means of examples from Austria, Bulgaria, Croatia and Macedonia. There is a trend of decreasing tree species richness observed in coppice forests in several countries in Central and South Eastern Europe, which is considered as one of the main shortcomings of this management approach, both historically as well as in recent years. On the other hand coppice forest management can maintain and improve the characteristic habitats and levels of forest diversity. In this context the overall conversion of coppice forests to high forests and/or the strict protection of sites could lead to a loss of forest diversity in the long run. The authors conclude that there is still lack of information and knowledge regarding the importance of coppice forests in maintaining forest diversity at various levels.

Key words: Coppice forests, species richness, conservation management, Natura 2000, conversion

INTRODUCTION

Forest ecosystems are characterized by a complex of various elementary factors: plant, animal and microorganism communities, abiotic factors (climate, abiotic soil substance) and humanity as an integral component of ecosystems. Natural disturbances are inherent key processes of forest ecosystems and a major driver of forest development in various forest biomes (Peltzer et al., 2000, Gromtsev, 2002, Payette, Delwaide, 2003, Lorimer, White, 2003, Harcombe et al., 2004, Splechtna, Gratzer, 2005). Disturbances are important in determining the structure of biological communities and in maintaining species diversity. In the absence of natural or man made disturbances, such communities may move towards climax forest associations with competitively dominant species (Levin, Paine, 1974) and lower species density. Besides evolutionary processes it has been human use and management which has considerably influenced landscapes and (forest) ecosystems. Due to increasing human use there has been an ongoing trend to a shift from natural landscapes to land developed and cultivated by man. In most European countries
there has been intense human pressure on forests and correspondingly an alteration of forest structure and composition. Losses of forested area to settlement and urbanization and transport infrastructure are compensated by afforestation of agricultural and other land, which leads to slow expansion of forests. Consequently, in most European forest ecosystems changes of nutrient, water and energy cycles, genetic diversity, species composition, habitats and landscape structures can be observed (Schimel et al., 1997 Sirami et al., 2008). The combination of direct and indirect uses of forest ecosystems by man, disturbance agents and the impacts of climate change lead to changes in species composition, species diversity and ecosystem variety (Araujo et al., 2008).

Restoration of cultural landscapes and traditional forest management practices can have an important role in nature conservation and sustainable forest management (Strandberg et al., 2005, Rotherham, 2006), and for maintaining forest diversity (Bengtsson et al., 2000) and historical characteristics of ancient woods (Peterken, 1999). Coppice forestry in general, including all its variants, is a silvicultural system that is still widespread over many European countries where it covers an area of about 23 million hectares (UN/ECE-FAO, 2000). While in Western, Central and Northern Europe coppice forests comprise a relatively small share of total forest area, in South and South Eastern Europe (SEE) coppice forests make up major parts of the forest resource. This partly reflects the greater share of deciduous tree species in South and SEE forests which are more diverse in terms of tree species richness compared to Central and Northern Europe (EEA, 2007). Because the last glaciation led to massive extinction of forest communities, thermophilic and temperate tree species survived only locally in refuge areas that were primarily located in South and SEE (Petit et al., 2002).

In regions where coppice forests have already been largely converted into high forest and where current policies favour the continued conversion of coppice forests into relatively homogeneous and more productive stands of seed origin, the revival of coppice management could contribute to landscape diversity (Rackham, 1976) and help to maintain biodiversity by providing important habitat for those plant and animal species typically found in coppice forests which would otherwise not survive in high stands. Restoration of such management systems can be considered an improvement in the context of environmental-biological stability (Andreatta, 2006; Joys et al., 2004; Niemela et al., 1996).

In that context, the existing forest management policies and measures need to be reconsidered. According to the protocols of UNCD Earth Summit at Rio de Janeiro and the Conferences on Protection of European Forests at Helsinki (1993) and Lisbon (1998) biodiversity has been identified as a key issue for sustainable use of forest resources. The aim of Natura 2000 network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. The legal basis for the network comes from Birds Directive which dates back to 1979 and Habitats Directive from 1991. The ecosystem approach (FAO, 2003, MCPFE 2004) recognizes that humans are an integral component of ecosystems and the parties to Convention on Biological Diversity (CBD) committed themselves to achieve by 2010 a significant reduction of the current rate of biodiversity.
loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth.

Therefore in the context of a sustainable forest management approach (MCPFE, 1997) forest management planning needs to focus not only on timber production but also on the maintenance of biodiversity. However, science based evidence on likely impacts of direct and indirect influence by man, disturbance agents and climate change on forest biodiversity of coppice forests is still under debate.

In this context this paper (i) provides an overview about selected aspects of forest diversity in coppice forests, (ii) compares plant species richness, stand structure and protection status of coppice forests in selected countries in SEE and Central Europe, and (iii) discusses the effects of coppice forest management on forest diversity.

**Diversity in coppice forests**

Exploitation of forests in SEE gradually increased with the development of human civilization. Mediterranean forests were first to experience pressure of wood demand, due to the very early settlement of the Mediterranean area. Population increase combined with scarcity of forests in harsh Mediterranean climate led to the introduction of forest protection into contemporary legislation. First written regulations concerning forest management appeared in Croatia as early as in the XII century in the statutes of coastal towns like Nin (1103 A.D.) and Korcula (1214 A.D.) (Dubravac et al., 2008). In continental parts of SEE lowland forests were most severely affected, extensive areas being cut for both timber production and obtaining new agricultural and pasture lands. Evidence and literature sources from XVI and XVII centuries suggest that some mountain regions were partially deforested due to production of charcoal for heating and to support the iron industry. Other mountainous forests were burned down to open new pasture lands (Stoyanov, 1968). Forests over extended areas were converted into coppices after several rotations of clearcutting and vegetative reproduction. As a consequence the resulting coppice stands were generally characterised by less diverse spatial structure, tree species composition and gene pool in comparison with the primary high forests (Nedyalkov et al., 1961). However, in the middle of XIX century the importance of coppicing began to decline as other energy sources substituted the use of wood from coppice forests.

**Different levels of diversity**

In considering forest diversity at different levels, the various ecosystem functions, the composition and structural elements have to be discussed. According to the spatial context diversity at the level of the individual tree, the forest stand, forest ecosystems as well as the landscape level could be considered (compare Bachmann et al., 1998; Noss, 1999). According to structural aspects the genetic variation at the level of an individual, the vertical and horizontal structure within a coppice stand and the patchiness in the landscape are to be considered.

Forest management causes the most important impacts on forest diversity in general (Vacik et al., 2001). On sites were the conversion of high forests to coppice
forests has taken place in former centuries, the resulting coppice forests often had a changed tree species composition. In contrast, several studies have shown that at comparable sites coppice and coppice with standards systems could result in increased species richness compared to high forests with more closed canopies (Ciancio et al. 2006). As a consequence the higher variety of plant species allows high abundance of various bird species, insects and butterflies as well (Deconchat, Balent, 2001; Campodron, Brotons, 2006; Floren, Schmidl, 2008; Benes et al., 2006). Some authors describe that the management of coppice forests helps to maintain a landscape mosaic and enhances regional plant diversity (Gondard et al. 2006). Regular coppicing within short rotation periods allow maintaining of an even higher landscape and temporal pattern of forest diversity then patch cutting approaches in high forests. Despite the decline of the area of coppice forests, depicted in historical and recent records, they still host a big number of species, including endangered ones. Therefore coppice forests are considered as a rare and relevant element in terms of forest diversity nowadays (Fuller, 1992; Gonzalez et al. 2008; Rahman et al., 2008, Vacik et al., 2008). Beside the high variety of plants, shrubs and tree species the most important tree species in coppice forests in SEE and Central Europe are *Quercus petraea* L. and *Fagus sylvatica* L. (Table 1).

There is a trend of decreasing tree species richness observed in coppice forests in several countries in SEE and Central Europe. In Austria the tree species composition in many coppice forests has changed due to non-regular management, prolongation of rotation period and increased cuttings of the over wood in coppice with standards. *Fraxinus excelsior* L., *Ailanthus altissima* L. and *Robinia pseudacacia* L. have gained higher shares as a consequence. In case of Bulgaria, the reasons for changes in tree species composition are related to (i) selective cutting of tree species with valuable wood, (ii) better vegetative regeneration of species like *Quercus cerris* L., *Carpinus orientalis* L., *Carpinus betulus* L., *Tilia tomentosa* L. by coppice/sucker shoots, and (iii) destruction of autochthonous tree and shrub communities during reconstruction activities. As a result, considerable areas of coppice forests at low elevation sites, which used to be dominated by oak species, are now edified by *Q. cerris*, *C. orientalis* and *T. tomentosa*. The situation in the mountain vegetation zone is similar. *C. betulus* has significantly increased its share in the mixed *Q. petraea* L./*F. sylvatica*/*C. betulus* stands. Toward 2005 more than 50% of coppice forest area in Bulgaria was covered by *Q. petraea*, *Quercus frainetto* L., *Quercus pubescens* Willd. and *F. sylvatica*. The area of *C. orientalis* was also considerable with 11%. *Quercus* sp., *F. sylvatica* and *C. betulus* formed 89% of the total coppice forests growing stock (SFA, 2005).

**Conservation management**

Coppice forests are considered as highly important habitat for many breeding birds (Fuller, 1992), small mammals (Gurnell et al., 1992) and invertebrates (Greatorex-Davies, Marrs, 1992; Spitzer et al., 2008). In the context of conservation management it is important to consider that in certain cases management has to take place in order to maintain the characteristic habitat attributes. If the conservation status of a protected forest does not allow management activities, it is likely that the diversity of coppice
Forests will be negatively affected. For example, in one of Croatia’s national parks, Brijuni islands, a strict nature-protection regime does not allow any management in holm oak coppices nor regulation of deer populations. As a consequence, a highly overstocked deer population has destroyed ground vegetation by browsing, and prevented any kind of regeneration establishment in coppices of holm oak that have very high landscape value (Krejči, Dubravac, 2001).

Currently the total percentage of protected coppice forests in the studied region is highest in Bulgaria, which is mainly due to significant areas put in Natura 2000 status (compare Table 2).

In accordance with current forest management plans, the total area of coppice forests in Macedonia is approximately 0.5 mill. ha (compare Table 2). The area of

<table>
<thead>
<tr>
<th>Country</th>
<th>Most important species (&gt;15% share)</th>
<th>Other important tree species</th>
<th>Ground vegetation and shrub species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td><em>Quercus petraea</em> Liebl.; <em>Fagus sylvatica</em> L.; <em>Carpinus betulus</em> L.; <em>Tilia cordata</em> L.</td>
<td><em>Fraxinus excelsior</em> L.; <em>Acer campestre</em> L.; <em>Ulmus glabrae</em> L.; <em>Robinia pseudoacacia</em> L.</td>
<td><em>Corlylus avellana</em> L.; <em>Cornus sanguinea</em> L.; <em>Ligustrum vulgare</em> L.; <em>Euonymus europaeus</em> L.; <em>Sambucus nigra</em></td>
</tr>
<tr>
<td>Bulgaria</td>
<td><em>Quercus petraea</em> Liebl.; <em>Q. frainetto</em> Ten.; <em>Q. cerris</em> L.; <em>Fagus sylvatica</em> L.</td>
<td><em>Carpinus betulus</em> L.; <em>Carpinus orientalis</em> Mill.; <em>Tilia tomentosa Moench</em>; <em>Robinia pseudoacacia</em> L.; <em>Quercus pubescens</em> Willd.; <em>Acer campestre</em> L.; <em>Fraxinus ornus</em> L.; <em>Quercus robur</em> L.</td>
<td><em>Crataegus monogyna</em> Jacq., <em>Cornus mas</em> L.; <em>Cornus sanguinea</em> L.; <em>Catinus coggygia Scop.</em>, <em>Euonymus europaeus</em> L.; <em>Corylus avellana</em> L.; <em>Cytisus sp.</em>; <em>Rubus caesius</em> L.; <em>Rhododendron myrtifolium Schott et Kotschy</em></td>
</tr>
<tr>
<td>Croatia</td>
<td><em>Quercus pubescens</em> Willd.; <em>Fagus sylvatica</em> L.; <em>Quercus ilex</em> L.</td>
<td><em>Carpinus betulus</em> L.; <em>Quercus petraea</em> Liebl.; <em>Quercus cerris</em> L.; <em>Robinia pseudoacacia</em> L.; <em>Castanea sativa</em> L.</td>
<td>N/A</td>
</tr>
<tr>
<td>Macedonia</td>
<td><em>Quercus petraea</em> Liebl.; <em>Fagus sylvatica</em> L.; <em>Quercus frainetto</em> L.; <em>Quercus pubescens</em> W.</td>
<td><em>Carpinus betulus</em> L.; <em>C. orientalis</em> L.; <em>Ostrya carpinifolia</em> L.; <em>Quercus coccifera</em> L.; <em>Quercus macedonica</em> L.; <em>Quercus cerris</em> L.; <em>Tilia tomentosa</em> L.; <em>Platanus orientalis</em> L.; <em>Robinia pseudoacacia</em> L.; <em>Acer campestre</em> L.; <em>Fraxinus ornus</em> L.</td>
<td><em>Phillyrea media</em> L.; <em>Crataegus heidreichii</em> L.; <em>Cornus mas</em> L.; <em>Paliurus spina Christi</em> L.; <em>Pistacia terebinthus</em> L.; <em>Coronilla emeroides</em> L.; <em>Colutea arborescens</em> L.; <em>Lonicera etrusca</em> L.; <em>Pistacia mutica</em> L.; <em>Jasminum fruticans</em> L.; <em>Asparagus acutifolius</em> L.; <em>Rubus aculeatus</em> L.; <em>Rosa gallica</em> L.; <em>Rubus canescens</em> L.; <em>Rosa arvensis</em> L.</td>
</tr>
</tbody>
</table>

Table 1
Important tree and shrub species in coppice forests in selected regions
protected coppice forests (reserves, national parks) is about 43.170 ha (7.6%). No management activities are allowed in core areas of these protection zones. Forests in buffer zones are managed by a single tree selection system. The implementation of Natura 2000 regulations has not started yet in Macedonia despite the current pressure on faunal diversity exerted by direct and indirect anthropogenic impacts. In coppice forests many vertebrate species are included in the category of threatened species, where about 21.1% of the entire vertebrate fauna is listed (17 are Macedonian endemic species) (Anonymous, 2004).

Austria launched ‘Natural Forest Reserves Program’ in 1995 which is in compliance with the H2 Resolution (General Guidelines for the Conservation of the Biodiversity of European Forests – Helsinki 1993) and ‘Mountain Forest Protocol’ to ‘Alpine Convention’, which includes the legally binding objective to establish natural forest reserves (Schärer, Zürcher, 1997) in Austria. Natural Forest Reserves program supports the in situ conservation of rare and endangered forest types and the study of the natural dynamic processes, including the effect of natural disturbances and catastrophes. On the other hand, natural forest reserves serve as reference for biodiversity assessments and ecological monitoring as the forests are not subject to any direct human activities (Frank, Müller 2003). In that context some oak dominated forests in Eastern Austria were included within this program. These forests had been managed under coppice systems in the past but there have been only minimum human interventions in the forests for up to 60 years (Vacik et al., 2008). Within Natura 2000 network some coppice forests are included as well. However, these are not strictly protected forests and forest management in a sustainable way is still possible.

In Croatia, a very small portion of coppice forests is under strict protection regime like National parks and forest Reserves. This is due to the selection of area for protection where lack of human influences was one of the most important criteria. However, much greater share of coppice area is under at least some kind of protection, or under

<table>
<thead>
<tr>
<th>Country</th>
<th>Area of coppice forests (ha)</th>
<th>Coppice forests protected (ha)</th>
<th>Percentage (%)</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>70 000</td>
<td>140</td>
<td>2.0</td>
<td>Natural forest reserves, Natura 2000</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1 750 000</td>
<td>17 500</td>
<td>1.0*</td>
<td>Forest reserves, national and nature parks Natura 2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>700.000</td>
<td>appr. 40.0**</td>
<td></td>
</tr>
<tr>
<td>Croatia</td>
<td>533 828</td>
<td>4254</td>
<td>0.8</td>
<td>National parks, Park-forests, Forest reserves</td>
</tr>
<tr>
<td>Macedonia</td>
<td>565 047</td>
<td>43 170</td>
<td>7.6</td>
<td>Forest reserves, national and nature parks</td>
</tr>
</tbody>
</table>

* in forest reserves and national parks; ** in NATURA 2000 sites
a management regime which incorporates some of the nature protection measures. For example, around 28 000 ha of coppices in state ownership are managed for protection against erosion on steep slopes, or for protection of water courses (Anonymous, 2006). In addition, in Nature parks, management plans for all forests including coppices, have to satisfy basic measures of nature protection. Areas of coppices under protection are expected to increase soon in Croatia with the establishment of Natura 2000 network.

**Conversion of coppice forests**

Conversion of coppice forests to high ones by means of natural regeneration has been a well recognized practice in Europe. In many countries the motivation for this well-grounded type of conversion was the chance to move from low-productive coppice stands to forests producing higher shares of round wood. However, another conversion strategy in coppice forests was also wide spread. It was based on clearcutting and substitution of the tree species by means of artificial regeneration (Zerbe, 2002; Zlatanov, 2005). In most cases coniferous species such as European spruce (*Picea abies* (L.) Karst.), Scots pine (*Pinus silvestris* L.) or Austrian pine (*Pinus nigra* Arn.) were used for afforestation. In some cases the introduction of fast growing non-native deciduous tree species into coppice forests was tested in an effort to increase productivity, e.g. introduction of Euro-American poplar clones into alder coppice stands (Glavač, 1962). In contrast to these intensive forest operations several studies have shown that coppicing and coppice with standards helps to maintain species richness (Benes et al., 2006) and regional plant diversity (Gondard et al. 2006). Recent findings suggest that intense thinning practices are unadvisable in the conversion of coppices into high forest due to the significant losses of genetic diversity when removing unique genotypes (Valbuena-Carabana et al., 2008).

In Bulgaria the conversion of coppice forests to high ones by means of natural regeneration was officially introduced in 1956. Stands on productive sites in good health condition were included in this strategy. The area of coppice forests scheduled for conversion gradually increased from 0.67 mill ha in 1965 up to 1.08 mill ha in 2005 (Fig. 1), and only a few stands have been successfully converted (Nedyalkov, 1961; SFA, 2005). The least productive tree and shrub communities on poor and degraded sites, mainly in the lowest vegetation zone, were set aside for reconstruction by clear cutting and substitution of the main tree species. Again, lack of success of the silvicultural strategy has to be admitted. Despite cleaning activities, planted seedlings were suppressed by coppice/sacker shoots of the local tree and shrub vegetation. Currently this practice is abolished in Bulgaria. So it might be hypothesized that with the ongoing trend of conversion a big loss of species is going herewith, unless specific silvicultural measures are taken.

Some restoration activities in coppice forests in Macedonia have been accomplished until the middle of 90s (Mircevski, 1998). Around 379 000 ha were considered as degraded coppice forests according to Program for Development of Forestry (1971-1990). A small part (20 000 ha) of these degraded forests were treated melioratively, a bigger share of them, mostly beech and sessile oak coppice stands were designated for
conversion (by means of artificial regeneration) and reconstruction (by means of natural regeneration). However, the low financial power of the forestry sector in Macedonia is an important reason for the low realisation rate of these measures. At that end government had shown greater interest to establish new forests on bare land.

**CONCLUSIONS**

The general idea about a partial conservation of highly artificial and partly non-natural forest types discussed in this contribution might lead to some misunderstandings. There is a trend of a decreasing number of tree species richness observed in coppice forests in several countries in Central Europe and SEE which is considered as one of the main shortcomings of this management approach, both historically and in the recent years. According to international regulations there is a clear indication to maintain traditional forest management systems like coppice forests (MCPFE, 1999). From an anthropogenic as well as from a biogenic perspective it seems important to partially maintain these historical land use systems which led to a high variety in plant and animal species. Consequently, the overall conversion of coppice forests to high ones and as well as the strict protection of sites could lead to a loss of diversity in the long run. At some places, conservation management has to consider proper coppice management in order to maintain the characteristic habitats and levels of forest diversity caused by man. In order to support initiatives in the conservation of traditional forest management systems more emphasis has to be placed on financial incentives for forest owners. With an increasing

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Fig. 1. Dynamics of the coppice forests area in Bulgaria by management types for the period 1960-2005
interest in forest resources for bioenergy production and ongoing conversions to high forests forest owners will often need financial support in order to maintain coppice forests. In that context the collaboration across national boundaries is very important also. Initiatives like CForSEE can help to contribute to the conservation and sustainable use forest diversity including the cooperation between research and forest management.

Do we have already gathered enough information to identify the key threats to forest biodiversity in coppice forests? From the scientific literature it can be concluded that there is still lack of information regarding the importance of coppice forests in maintaining species richness at various levels. Additionally, there are hardly any mechanisms developed in this aspect to monitor the impact of climate change, local and long-range pollution, changing land-use management practices, and tourism as well. Some coppice areas of particular importance to forest biodiversity are protected through protected area networks, but the measures that have been put in place to identify, prevent and/or mitigate the negative impacts of those threats are not well studied. In comparing different aspects and scales of forest diversity in coppice forests in different countries it is important to consider that the level of importance is different according to the amount of coppice forests in relation to high forests.

The validity and use of the indicator species concept, the need for long-term monitoring programs and clarification of how they might be designed, and trade-offs between conservation strategies and economic costs are critical for future biological conservation activities in coppice forestry. The indicator species concept can make an important contribution to biodiversity conservation because of the impossibility of monitoring all taxa in species-rich forest environments like coppice forests. The results of such investigations must be communicated to, and adopted by, forest managers, an exchange that can only occur if linkages are established between research and management (Lindenmayer, 1999).

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