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

Coppice Forests in Europe

Editors

Alicia Unrau, Gero Becker, Raffaele Spinelli, Dagnija Lazdina, Natascia Magagnotti, Valeriu-Norocel Nicolescu, Peter Buckley, Debbie Bartlett and Pieter D. Kofman

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the Horizon 2020 Framework Programme of the European Union

UNI FREIBURG

COST EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the Horizon 2020 Framework Programme of the European Union

www.cost.eu

COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

Published by:
Albert Ludwig University Freiburg
Chair of Forest Utilization
Werthmannstr. 6
D-79085 Freiburg
Germany
www.uni-freiburg.de

Printed by: Albert Ludwig University Freiburg Printing Press

Contact:
www.eurocoppice.uni-freiburg.de
eurocoppice@fob.uni-freiburg.de
0049 (0)761 203 3789

Coppice Forests in Europe

Editors: Alicia Unrau, Gero Becker, Raffaele Spinelli, Dagnija Lazdina, Natascia Magagnotti, Valeriu-Norocel Nicolescu, Peter Buckley, Debbie Bartlett and Pieter D. Kofman

ISBN 978-3-9817340-2-7

Recommended citations:

For the full volume: Unrau, A., Becker, G., Spinelli, R., Lazdina, D., Magagnotti, N., Nicolescu, V.N., Buckley, P., Bartlett, D., Kofman, P.D. (Eds.) (2018). *Coppice Forests in Europe*. Freiburg i. Br., Germany: Albert Ludwig University of Freiburg.

For individual chapters/articles: List of author(s) with surname(s) and initial(s). (2018). Chapter/article title. In A. Unrau, G. Becker, R. Spinelli, D. Lazdina, N. Magagnotti, V.N. Nicolescu, P. Buckley, D. Bartlett, P.D. Kofman (Eds.), *Coppice Forests in Europe* (pp. xx-xx). Freiburg i. Br., Germany: Albert Ludwig University of Freiburg.

The articles in this volume were developed within the context of COST Action FP1301 EuroCoppice (2013-2017). Numerous contributions were published as single, independent booklets during the course of the Action; they were subsequently reviewed and updated for this volume. A digital version of this volume, further results and more are available on the website: www.eurocoppice.uni-freiburg.de

Design, layout & formatting: Alicia Unrau

Coppice image acknowledgements: Simple coppice (grey) based on a drawing by João Carvalho (pp. 46); Leaf vector originals designed by www.freepik.com (modified)

Coppice Forests in Europe

Editors

Alicia Unrau
Gero Becker
Raffaele Spinelli
Dagnija Lazdina
Natascia Magagnotti
Valeriu-Norocel Nicolescu
Peter Buckley
Debbie Bartlett
Pieter D. Kofman

Albert Ludwig University of Freiburg

Freiburg im Breisgau, Germany

2018

Foreword

Coppicing represents the oldest form of systematic and sustainable management and utilization of forests. It is a very flexible management system that requires a low input and has been adapted and modified throughout Europe and beyond according to the needs of rural societies, to whom coppice forests deliver small size wood primarily for energy, agriculture and small scale businesses. Despite the reduction of coppice forest area, there are still over 20 million hectare of forests throughout Europe that originate from coppice. They characterize our landscapes, especially in mountainous areas of central, east and southern of Europe. Due to rural migration and technical and economic restrictions, most of these coppice forests are today neglected or even abandoned, representing a significantly underused natural resource.

Furthermore, current European ecological research reveals that coppice forests protect and stabilize critical slopes and contribute in a unique way to biodiversity conservation. Due to their inherent ecological features they are appreciated as resilient ecosystems, also in the context of climate change adaptation.

The COST Action FP1301 EuroCoppice was set up in 2013 to explore options and to propose practical ways and means to make better use of existing European coppice forest resources for the economy, environment and society. More than 150 scientists and experts from 35 COST Member Countries addressed in five Working Groups a wide array of coppice-related issues ranging from history and ecology to harvesting and utilization techniques, environmental protection and rural employment. During four years of activities, national and regional knowledge from both literature and collective sources was compiled, analyzed, documented and published. Research gaps were identified and cooperative strategies to close them were developed. A number of congresses and workshops were organized to discuss and share the common findings and views with the scientific community and with practitioners from forestry, wood industry and environmental agencies. Five COST Training Schools and 42 Short Term Scientific Missions were organized in different member countries, primarily for young researchers to increase their knowledge and expertise on several coppice related issues, as well as to promote personal networking. Major results of the Action and a call to take action were communicated to national and European actors and stakeholders. To facilitate further scientific activities after the lifetime of the Action, material, results and databases were transferred to the International Organization of Forest Research Institutions (IUFRO), where a permanent Unit dedicated to traditional coppice forestry was established.

With all of these activities and achievements, EuroCoppice is an excellent example showing that substantial added value for science, economy and policy can be achieved by bringing together the expertise and views from various European regions and institutions. The coordinators together with the great number of participating scientists have used the EU format COST effectively to enhance knowledge and to raise attention of the multiple benefits and future opportunities of traditional coppicing.

The results of this COST Action are also highly relevant in the context of the EU Forest Strategy and the growing recognition of the importance of forests for several EU policies and initiatives, such as energy and climate, rural development, environment and bioeconomy.

As former research programme officer in the European Commission responsible for COST forestry actions, I want to express my recognition and warmest thanks for the excellent work of all persons involved, and I strongly recommend this book to all people interested and involved in forest and nature conservation issues throughout Europe.

Ignacio Seoane

DG Agriculture and Rural Development

European Commission

Table of Contents

4 Conservation *109*

5 Governance *157*

6 Thirty-Five Countries *183*

List of Authors

Marius Aleinikovas
marius.aleinikovas@mi.lt
Institute of Forestry,
Lithuanian Research Centre for Agriculture and Forestry,
Lithuania

Besim Balić
balicbesim@yahoo.com
Faculty of Forestry,
University of Sarajevo,
Bosnia & Herzegovina

Damir Barčić
damir.barcic@zg.htnet.hr
Department of Forest Ecology and Silviculture, Faculty of Forestry,
University of Zagreb,
Croatia

Debbie Bartlett
d.bartlett@gre.ac.uk
Faculty of Engineering & Science,
University of Greenwich,
United Kingdom

Gero Becker
gero.becker@fob.uni-freiburg.de
Chair of Forest Utilization,
Albert Ludwig University of Freiburg,
Germany

Mario Beltrán
mario.beltran@ctfc.es
Multifunctional Forest Management Programme,
Forest Science and Technology Centre of Catalonia,
Spain

Mariusz Bembenek
mariusz.bembenek@up.poznan.pl
Department of Forest Utilisation,
Poznan University of Life Sciences,
Poland

Gheorghe F. Borlea
fborlea@yahoo.com
Department of Sustainable Development, Banat University of Agriculture and Veterinary Medicine “King Michael I of Romania” from Timisoara,
Romania

Viktor J. Bruckman
viktor.bruckman@oeaw.ac.at
Austrian Academy of Sciences,
Austria

Peter Buckley
peterbuckleyassociates@gmail.com
United Kingdom

Eduard Busquets
eduard.busquets@ctfc.cat
Multifunctional Forest Management Programme,
Forest Science and Technology Centre of Catalonia,
Spain

João Carvalho
jpfc@utad.pt
Department of Forest Sciences and Landscape Architecture,
University Tras-os-Montes Alto Douro (UTAD) / Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB),
Portugal

Santa Celma
santa.celma@silava.lv
Latvian State Forest Research Institute “Silava”,
Latvia

Reinhart Ceulemans
reinhart.ceulemans@uantwerp.be
Research Centre of Excellence PLECO, Department of Biology,
University of Antwerp,
Belgium

Marco Conedera
marco.conedera@wsl.ch
Insubric Ecosystems Research Group, Swiss Federal Research Institute WSL,
Switzerland

Mário Costa
mcosta@ist.utl.pt
Mechanical Engineering Department, Instituto Superior Técnico, Universidade de Lisboa,
Portugal

Josephine Cueni
josephine.cueni@pronatura.ch
Pro Natura,
Switzerland

Imre Czupy
czupy.imre@uni-sopron.hu
Institute of Forest and Environmental Techniques,
University of Sopron,
Hungary

Abdulla Diku
adiku@hotmail.com
Diava Consulting shk,
Albania

Ioannis Dimitriou
ioannis.dimitriou@slu.se
Department of Crop Production Ecology, Swedish University of Agricultural Sciences,
Sweden

Martina Đodan
martinat@sumins.hr
Division for Silviculture,
Croatian Forest Research Institute,
Croatia

Achim Dohrenbusch
adohren@gwdg.de
Chair of Silviculture and Forest Ecology of the Temperate Zones,
Georg-August University of Göttingen,
Germany

Tomislav Dubravac
tomod@sumins.hr
Division for Silviculture,
Croatian Forest Research Institute,
Croatia

Murat Ertekin
muratertekin@hotmail.com
Faculty of Fine Arts,
Necmettin Erbakan University,
Turkey

Alexander Fehér
alexander.feher@uniag.sk
Dept. of Sustainable Development,
Slovak University of Agriculture,
Slovakia

Norbert Frank
frank.norbert@uni-sopron.hu
Institute of Silviculture and Forest Protection, University of Sopron, Hungary

Eulalia Gómez Martín
eugomar1990@gmail.com,
Climate Service Center Germany (GERICS),
Germany

Radim Hédl
radim.hedl@ibot.cas.cz
Institute of Botany,
Czech Academy of Sciences,
Czech Republic

Katrin Heinsoo
katrin.heinsoo@emu.ee
Institute of Agricultural and Environmental Sciences,
Estonian University of Life Sciences,
Estonia

Cornelia Hernea
corneliahernea@yahoo.com
Department of Forestry, Banat University of Agriculture and Veterinary Medicine "King Michael I of Romania" from Timisoara,
Romania

Eduard Hochbichler
eduard.hochbichler@boku.ac.at
Institute of Silviculture,
Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences Vienna (BOKU),
Austria

Jyrki Hytönen
jyrki.hytonen@luke.fi
Natural Resources,
Natural Resources Institute Finland (Luke),
Finland

Indrek Jakobson
indrek.jakobson@eramets.ee
Estonian Private Forest Centre,
Estonia

Patrick Jansen
patrick@bosmeester.com
Bosmeester,
Netherlands

Rob Jarman
robinajarman@gmail.com
Centre for Environmental Change and Quaternary Research,
University of Gloucestershire,
United Kingdom

Paula Jylhä
paula.jylha@luke.fi
Production Systems,
Natural Resources Institute Finland (Luke),
Finland

Zbigniew Karaszewski
z_karaszewski@itd.poznan.pl
Wood Investigation and Application Department,
Wood Technology Institute,
Poland

Pieter D. Kofman
pdkofman@gmail.com
Danish Forestry Extension,
Denmark

Julija Konstantinavičienė
julija.konstant@gmail.com
Institute of Forestry,
Lithuanian Research Centre for Agriculture and Forestry,
Lithuania

Nike Krajnc
nike.krajnc@gozdis.si
Slovenian Forestry Institute,
Slovenia

Volodymyr Kramarets
v_kramarets@ukr.net
Institute of Forestry and Park Gardening, Ukrainian National Forestry University,
Ukraine

Milun Krstić
milun.krstic@sfb.bg.ac.rs
Faculty of Forestry,
University of Belgrade,
Serbia

Martin Kühmaier
martin.kuehmaier@boku.ac.at
Department of Forest and Soil Sciences, Institute of Forest Engineering, University of Natural Resources and Life Sciences Vienna (BOKU),
Austria

Rubén Laina
ruben.laina@upm.es
Technical University of Madrid,
Spain

Dagnija Lazdiņa
dagnija.lazdina@silava.lv
Latvian State Forest Research Institute "Silava",
Latvia

Hugues Lecomte
hugues.lecomte@spw.wallonie.be
Direction des Ressources Forestières, Département de la Nature et des Forêts (DNF),
Belgium

Keith M. Little
keith.little@mandela.ac.za
School of Natural Resource Management (Forestry Programme), Nelson Mandela University,
South Africa

Magnus Löf
magnus.lof@slu.se
Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences,
Sweden

Irene Luchenti
ireneluchenti@hotmail.it
DAFNE, University of Tuscia,
Italy

Natascia Magagnotti
magagnotti@ivalsa.cnr.it
CNR IVALSA,
Italy

Paola Mairota
paola.mairota@uniba.it
Department of Agro-Environmental and Territorial Sciences, University of Bari Aldo Moro,
Italy

Kristaps Makovskis
kristaps.makovskis@silava.lv
Latvian State Forest Research Institute "Silava",
Latvia

Giorgos Mallinis
gmallin@fmenr.duth.gr
Department of Forestry and Management of the Environment and Natural Resources, Democritus University of Thrace (DUTH), Greece

Didier Marchal
didier.marchal@spw.wallonie.be
Direction des Ressources Forestières, Département de la Nature et des Forêts (DNF), Belgium

Enrico Marchi
enrico.marchi@unifi.it
Department of Agriculture, Food and Forestry Systems, University of Florence, Italy

Ivailo Markoff
imarkoff@abv.bg
Forest Research Institute, Bulgarian Academy of Sciences, Bulgaria

Iryna Matsiakh
iramatsah@ukr.net
Institute of Forestry and Park Gardening, Ukrainian National Forestry University, Ukraine

Andrew McEwan
andrew.mcewan@nmmu.ac.za
Forestry and Wood Technology, Nelson Mandela University, South Africa

Piotr Mederski
piotr.mederski@up.poznan.pl
Department of Forest Utilisation, Poznan University of Life Sciences, Poland

Matevž Mihelič
matevz.mihelic@bf.uni-lj.si
Dept. of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana, Slovenia

Jenny Mills
jennymills48@gmail.com
United Kingdom

Vasillaq Mine
vasillaqmine@yahoo.com, vmine@ubt.edu.al
Department of Forestry, Agricultural University of Tirana, Albania

Luljeta Mine
luljetamine@yahoo.com
Faculty of Economy and Agribusiness, Agricultural University of Tirana, Albania

Ioannis Mitsopoulos
i.mitsopoulos@prv.ypeka.gr, ioanmits@gmail.com
General Directorate of Environmental Policy, Ministry of Environment & Energy, Greece

Christine Moos
christine.moos@bfh.ch
School for Agricultural, Forest and Food Sciences HAFL, Bern University of Applied Sciences, Switzerland

Francesco Neri
francesco.neri@unifi.it
Department of Agricultural and Forest Economics, Engineering, Sciences and Technologies, University of Florence, Italy

Ljupco Nestorovski
nestorovski@sf.ukim.edu.mk
Faculty of Forestry, Ss. Cyril and Methodius University of Skopje, Macedonia

Valeriu-Norocel Nicolescu
nvnicolescu@unitbv.ro
Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, Romania

Tomas Nordfjell
tomas.nordfjell@slu.se
Department of Forest Biomaterials and Technology, Swedish University of Agricultural Sciences, Sweden

Pavol Otepka
pavol.otepka@uniag.sk
Department of Sustainable Development, Slovak University of Agriculture, Slovakia

Giovanna Ottaviani Aalmo
gio@nibio.no
Department of Economics and Society, Food Production and Society Division, Norwegian Institute of Bioeconomy Research, Norway

Halil Bariş Özel
halilbarisozel@yahoo.com
Department of Silviculture, Faculty of Forestry, University of Bartın, Turkey

Thomas Papachristou
thomas.papachristou@fri.gr
Forest Research Institute, Hellenic Agricultural Organization, Greece

Nenad Petrović
nenad.petrovic@sfb.bg.ac.rs
Chair of Forest Management Planning, Faculty of Forestry, University of Belgrade, Serbia

Rodolfo Picchio
r.picchio@unitus.it
DAFNE, University of Tuscia, Italy

Míriam Piqué
miriam.pique@ctfc.es
Multifunctional Forest Management Program, Forest Science and Technology Centre of Catalonia (CTFC), Spain

Pietro Piussi
pietro.piussi@gmail.com
University of Florence (retired), Italy

Anton Poje
anton.poje@bf.uni-lj.si
Department of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana, Slovenia

Grud Popov
gr_popov@abv.bg
Forest Research Institute, Bulgarian Academy of Sciences, Bulgaria

Patrick Pyttel
patrick.pyttel@waldbau.uni-freiburg.de
Chair of Silviculture, Albert Ludwig University of Freiburg, Germany

Orna Reisman-Berman
oreisman@bgu.ac.il
French Associates Institute for Agriculture and Biotechnology of Drylands, Blaustein Institutes for Desert Research, Ben-Gurion University, Israel

Abel Rodrigues
abel.rodrigues@iniav.pt
Unidade de Tecnologia e Inovação, INRB, IP, Portugal

Martyna Rosińska
martyna.rosinska@up.poznan.pl
Department of Forest Utilisation, Faculty of Forestry, Poznan University of Life Sciences, Poland

David Rossney
esusforestry@btinternet.com
Esus Forestry & Woodlands, United Kingdom

Philippe Ruch
philippe.ruch@fcba.fr
Technology Institute FCBA, France

Janine Schweier
janine.schweier@foresteng.uni-freiburg.de
Chair of Forest Operations, Albert Ludwig University of Freiburg, Germany

Marco Senfett
marcosenfett@gmail.com
Dipartimento di Scienze Agrarie e Forestali, University of Tuscia, Italy

Ian Short
ian.short@teagasc.ie
Forestry Development Department, Teagasc, Ireland

Mindaugas Škema
skeminis@yahoo.com
Institute of Forestry, Lithuanian Research Centre for Agriculture and Forestry, Lithuania

Ivan Sopushynskyy
sopushynskyy@nltu.edu.ua
Department of Botany, Wood Science & Non-Wood Forest Products, Ukrainian National Forestry University, Ukraine

Giulio Sperandio
giulio.sperandio@crea.gov.it
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA), Italy

Raffaele Spinelli
spinelli@ivalsa.cnr.it
CNR IVALSA, Italy

Gavriil Spyroglou
spyroglou@fri.gr
Forest Research Institute, Hellenic Agricultural Organization - Demeter, Greece

Karl Stampfer
karl.stampfer@boku.ac.at
Institute of Forest Engineering, University of Natural Resources and Life Sciences Vienna (BOKU), Austria

Kristīne Štikāne
kristine.stikanek@gmail.com
Metsa Forest Latvia SIA, Latvia

Petra Štochlová
stochlova@vukoz.cz
Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst., Czech Republic

Kjell Suadicani
manne.suadicani@gmail.com
Section of Forest Nature and Biomass, University of Copenhagen, Denmark

Christian Suchomel
christian.suchomel@landespflege-freiburg.de
Chair of Forest Operations, Albert Ludwig University of Freiburg, Germany

Pier Giorgio Terzuolo
terzuolo@ipla.org
Institute for Timber Plants and the Environment (IPLA), Italy

Eduardo Tolosana
eduardo.tolosana@upm.es
Technical University of Madrid, Spain

Elvin Toromani
etoromani@ubt.edu.al
Department of Forestry, Agricultural University of Tirana, Albania

Pande Trajkov
ptrajkov@sf.ukim.edu.mk
Faculty of Forestry, Ss. Cyril and Methodius University of Skopje, Macedonia

Davide Travaglini
davide.travaglini@unifi.it
Department of Agricultural, Food and Forestry Systems, University of Florence, Italy

Petros Tsioras
ptsioras@for.auth.gr
School of Forestry and Natural Environment, Aristotle University of Thessaloniki (AUTH), Greece

Alicia Unrau
eurocoppice@fob.uni-freiburg.de
Chair of Forest Utilization,
Albert Ludwig University of Freiburg,
Germany

Stefan P. P. Vanbeveren
stefan.vanbeveren@uantwerp.be
Department of Biology,
University of Antwerp,
Belgium

Kris Vandekerkhove
kris.vandekerkhove@inbo.be
Research Institute for Nature and Forest (INBO),
Belgium

Rachele Venanzi
venanzi@unitus.it
DAFNE, University of Tuscia & University of Padova,
Italy

Pau Vericat
pau.vericat@ctfc.es
Multifunctional Forest Management Program,
Forest Science and Technology Centre of Catalonia (CTFC),
Spain

Helder Viana
hviana@esav.ipv.pt
Agrarian Superior School,
Polytechnic Institute of Viseu / Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), UTAD
Portugal

Ćemal Višnjić
c.visnjic@sfsa.unsa.ba
Faculty of Forestry,
University of Sarajevo,
Bosnia & Herzegovina

Sead Vojniković
s.vojnikovic@sfsa.unsa.ba
Forest Ecology and Ecology of Urban Greenery, University of Sarajevo,
Bosnia & Herzegovina

Martin Weih
martin.weih@slu.se
Dept. of Crop Production Ecology,
Swedish University of Agricultural Sciences,
Sweden

Vasyl Zayachuk
Zayachuk_vsim@lviv.farlep.net
Institute of Forestry and Horticulture, Ukrainian National Forestry University,
Ukraine

Miljenko Županić
zupanicm@sumins.hr
Research Centre for Private and Urban Forests, Croatian Forest Research Institute,
Croatia

Preface

The work on this volume first began in 2012 with the preparation of a project proposal on coppice forest management to the EU-funded organisation COST (European Cooperation in Science and Technology). The idea for such a European project came to one of the editors, Gero Becker, in the years prior to his (semi-) retirement as Professor of the Chair of Forest Utilization, Faculty of Environment and Natural Resources, Albert Ludwig University of Freiburg. Along with a group of professors and researchers at the faculty, he had already explored the subject on a national level in the state of Rhineland-Palatinate from 2008-2012 with much success and recognised the need and potential for collaboration following a similar angle, but on a much wider, international scale.

Having connected with many of the leading international experts on the topic, his idea became reality in November of 2013 with the kick-off of 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", of which he became Chair. Within months, the number of countries grew to 35 from within Europe and beyond, involving 150 researchers and practitioners, a testimony to the timeliness and demand for such an undertaking. Action Members came from a large variety of fields, from history and ecology, to conservation, protection, governance and, particularly, silviculture and utilisation, so that cooperation in and between five Working Groups ensured a broad perspective on the topic of coppice forest management.

During the four years of the Action, from 2013-2017, Action Members collected, analysed and harmonised data and information, in addition to supporting and implementing numerous events for young researchers, the scientific community and policy makers. A list of the main EuroCoppice activities and all of its members can be found in the Annex of this volume, while a wealth of further information and details can be accessed on the website (www.eurocoppice.uni-freiburg.de).

The articles in this volume are the fruits of extensive efforts over the course of those years, involving experts from both within and outside of EuroCoppice. Although the COST framework offers optimal assistance for activities such as scientific exchanges, training and conferences, it does not provide compensation for labour, which means that much of this work has been done in the authors' own time – a sign of their dedication to the topic and vision of the EuroCoppice. Many of the articles were first published as single booklets in 2017. Following the end of the Action, the articles went through a thorough review and were harmonised to achieve the volume's current form; the publication is supported by COST in the form of a "Final Action Dissemination".

For this first attempt at gathering a truly European-wide group of researchers on coppice forests, COST was the perfect vehicle to build a network of experts, explore such a relatively under-reported field and lay the foundation for further cooperation. Within this context, we are pleased to highlight the new IUFRO Unit 1.03.01 on traditional coppice, which provides a global scientific platform for coppice topics and is open to any interested parties; please see the Annex for details.

Although this volume is quite comprehensive and provides a strong basis for information and knowledge on coppice forests in Europe, it is only a beginning: We hope to look forward to a future full of collaborations and knowledge-exchange on coppice forest management.

Freiburg, August 2018,

Alicia Unrau, *on behalf of all editors*

Acknowledgements

This publication is based upon work from COST Action FP1301 EuroCoppice, supported by COST (European Cooperation in Science and Technology). We are particularly grateful to the Scientific Officer of the Action, Federica Ortelli, as well as the Administrative Officers Cassia Azevedo and Andrea Tortajada for their friendly assistance throughout the four years.

COST Action FP1301 was provided with additional funds by the Eva Mayr-Stihl Stiftung, which greatly improved the quality of the outputs; we very appreciative of this kind support.

Countless researchers, practitioners and administrative staff, from within and outside of the Action, engaged in the many, many COST Action FP1301 activities, providing valuable time and further resources.

Funded by the Horizon 2020 Framework Programme of the European Union

Summary for Policy Makers

Coppice forests in Europe: A valuable and sustainable natural resource

Executive Summary

Coppice is the oldest form of sustainable forest management and is still abundant throughout Europe today. Its unique characteristics contribute to rural livelihoods, the bio-economy, environment and cultural heritage. Coppice forests have become neglected in recent history, leaving an enormous untapped potential. Experts from 35 countries, involved in COST Action FP1301 "EuroCoppice", urge EU policy-makers to seize this opportunity by specifically addressing and supporting coppice within EU strategy, policy, R&D programmes, and structural funds.

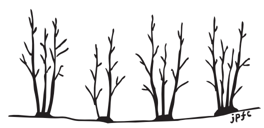
Coppice Forests in Europe

Over 20 million hectares across Europe are managed as coppice, while a much larger area originates from past coppice management. It is the **oldest form of systematic and sustainable forest management** and was developed to supply rural communities and early industries with wood, **mainly for fuel**.

In the early 20th century the prevailing concept for the management of forests **shifted to "high forest"**. This was mainly due to a rise in the use of fossil energies, through which fuelwood became less important. Another factor was an increased need for large dimension construction wood, which is more easily produced in high forests. Consequently, many coppice forests were **converted to high forests or abandoned**. The rate and intensity of these changes depended on the local conditions of industrial development and market demand.

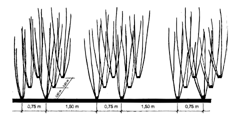
Thus, today a **large regional variation** of coppice forests exists in terms of distribution, structure, legal status and management. Likewise, **diverse products and services** are supplied by coppice.

High forest consists of trees that are left to grow a long time; they originate from seed



Simple coppice is harvested frequently on rotation; shoots regrow from the stump

Coppice with standards is a mix between simple coppice and high forest



Short Rotation Coppice (SRC) is harvested more frequently; it is an agricultural crop

Coppice is harvested at **frequent intervals** and **sustainably supplies wood** at a **low cost**. This management is **highly efficient** at producing large amounts of wood in a short time. Coppice forests provide **unique habitat features** that benefit a large variety of vegetation and wildlife, thus contributing to biodiversity. The existence of coppice forest and its future **depends on human management**.

What are the Benefits of Coppice?

Coppice forests have unique characteristics that make a valuable contribution to society, economy and the environment:

- **Rural livelihoods** – regular income, sustainable employment and resources
- **Low-carbon bioeconomy** – renewable, sustainable, environmentally friendly biomaterials & fuels
- **Protective function** – mitigates soil erosion, rockfall, landslides and avalanches
- **Sharing economy** – community use & recreation
- **Provision** – timber and non-timber forest products
- **Enrichment** – biodiversity and cultural landscapes

What is the Issue?

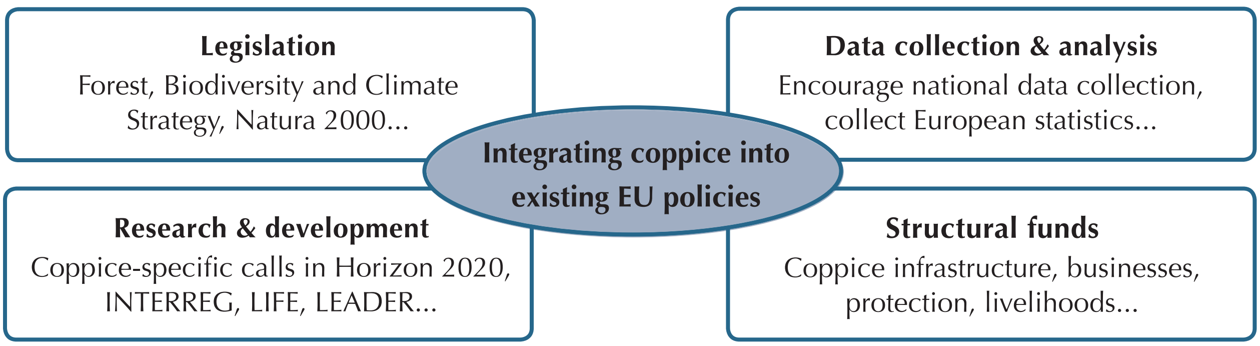
Coppice is hardly recognised or addressed in EU policy. It is also neglected and even opposed in many national policies. In consequence, reliable data on coppice is scarce and knowledge on coppice is diminishing in both science and practice.

The continued neglect of the coppice resource is a lost opportunity for European development.

Policy Recommendations

A European approach and harmonised action is essential to unlock this potential!

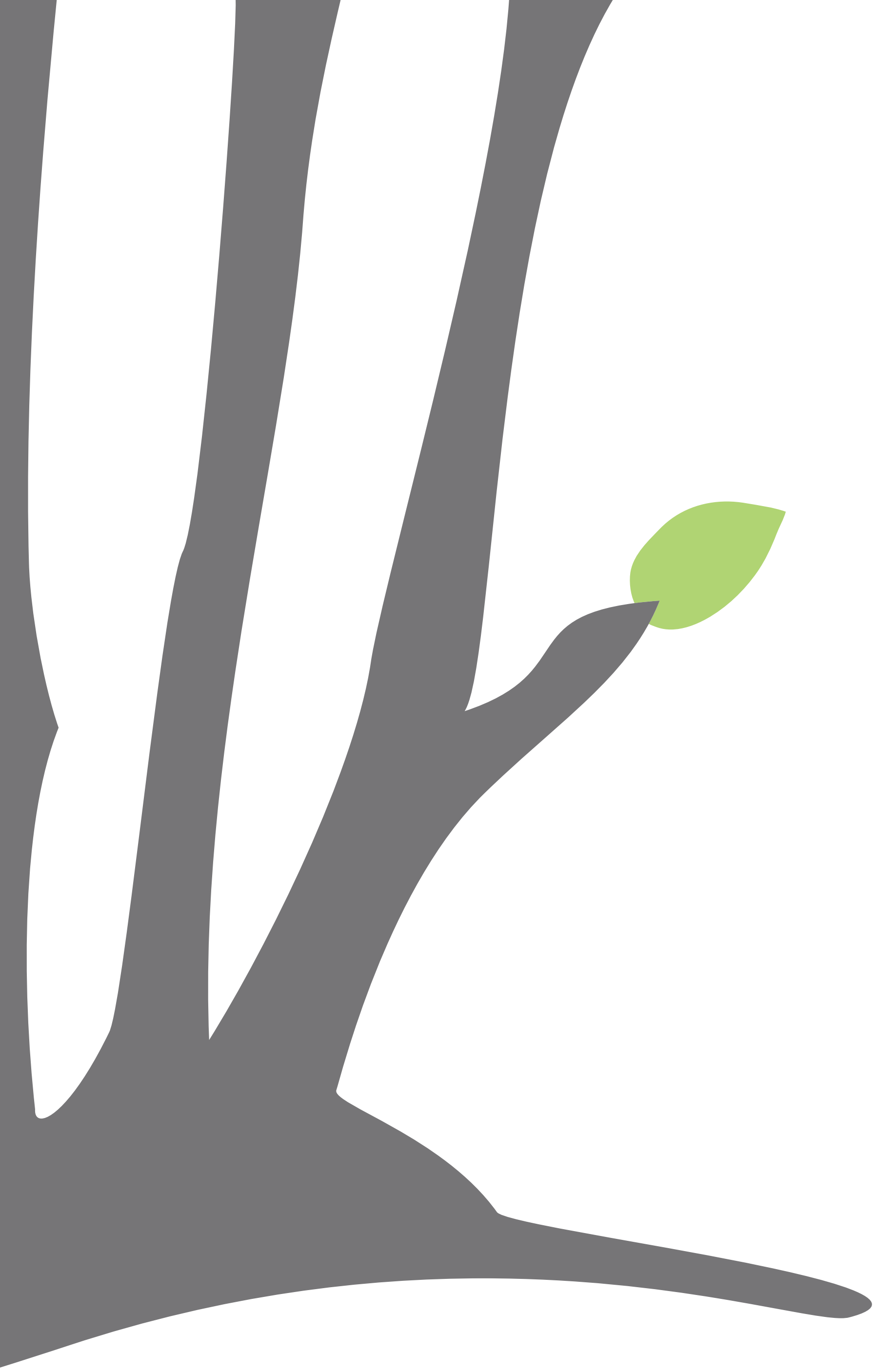
To achieve this aim, coppice must be reinstated at an EU level:



Awareness for and implementation of the policies **are the responsibility of EU Officials, national forest-related organisations and NGOs**; particularly those related to the following European Commission DGs:

- Agriculture and Rural Development
- Employment, Social Affairs and Inclusion
- Environment
- Climate Action
- Energy
- Eurostat – European statistics

Policy makers and environmental professionals are urged to seize this opportunity and reinstate coppice forest management at both national and European level.



1 Overview

What is coppice?

History & what to expect from this edited collection.

The most important characteristics of coppice, as well as the different types.

Help?! Reference the glossary for guidance on the meanings of terms related to coppice.

Visit this chapter for:

Coppice forests in Europe: a traditional landuse with a new perspective

Coppice in brief

Typology of European coppice forests

Glossary of terms and definitions related to coppice

Coppice Forests in Europe - A Traditional Landuse with New Perspectives

Gero Becker and Alicia Unrau

For many people in Europe, the image that comes to mind when thinking or speaking of forests is a landscape with an extensive area of woodland that is permanently stocked with tall trees of medium to large diameter. Depending on the region, these forests may be coniferous or broadleaved, or a mixture of both. When trees are cut, it is done selectively, or in clearcuts, and regeneration occurs either naturally by seed, or through artificial re-planting. Long rotation cycles (often between 50 and 100 years) lead to harvested trees of large dimensions, which are used in sawmilling and for other high-end wood products. All of these traits are typical of the "high forest" management regime.

When traveling across the continent, especially in the middle, south, east and Mediterranean regions, vast areas of the landscape are covered with a completely different type of forest: The broadleaved trees of these regions are often short, crooked, of small diameter and can be quite dense. Many stems originate from the same stump, giving the forest a bush-like appearance. This more or less uniform picture is occasionally interrupted by smaller clearcut patches, where trees have been recently cut and very young shoots are now sprouting again from the old stumps. Short rotation cycles, resulting in harvested trees of smaller sizes, are typical for this "coppice forest" regime.

The origin of coppice management

Historically, coppicing is the oldest form of forest management and utilisation to take place in a systematic and, in many cases, sustainable way. Our ancestors, mostly self-sufficient farmers that settled in small and isolated villages, depended on forest resources for their survival: They used the wood for cooking and heating, fencing, building houses and for all kinds of furniture and tools. They collected the foliage of the trees to feed their animals, used bark for tanning and insulation, and collected fruits, berries and mushrooms from the forest to complement their diet. They did not have the technical means to transport heavy logs over long distances, so trees were harvested close to home, at a younger age and smaller size, using hand tools and transported by hand or draft animals to the nearby settlements.

The people of those times knew very well -and made use of- the natural capability of some tree species to sprout vigorously and repeatedly from the stump that remains after being cut, as is the case with oak, hornbeam, linden, black locust, willows, poplars and others. They deliberately cultivated these species in the vicinity of their villages and developed increasingly sophisticated management rules and techniques to optimise the outputs of coppice forests over generations. It can be observed that the coppice techniques sometimes developed in parallel to specific socio-cultural arrangements, such as common ownership or cooperatives. Thus, rural societies managed and utilised their forests in a way that made the best "sustainable" use of their natural resources.

Corresponding Author: Gero Becker, gero.becker@fob.uni-freiburg.de

It can be stated that throughout Europe, until the end of the medieval period, the majority of accessible forests were very intensively used and managed as coppice forests. The only exceptions were woodlands claimed by kings and other nobles for exclusive use, most often for hunting purposes; these forests were managed by trained forester-hunters. Their utilisation by the local subjects for wood procurement and cattle grazing was strictly limited and controlled, resulting in less pressure on the resource and, as a consequence, in a different type of management.

The influence of the industrial revolution

With the development of early industry in some regions of Europe, technology, markets and social structures changed. Industrial activities such as mining, steel, glass, pottery and textiles appeared, generally close to the places where the respective commodities were found. Wood was the only available source of energy for processing and still the preferred material for building. As a result, the demand for wood increased dramatically. Coppice forests were an appropriate and established way to supply these industries with large quantities of wood in short time and at low costs. Thus, large coppice forest areas were actively managed surrounding those centres of early industries (good examples are the regions of Sauerland, Tuscany, Limoges and England). They were often owned by noble families acting as entrepreneurs and were managed intensively, providing not only wood products, but also labour and income for rural inhabitants. In some cases, forests were over-used beyond their natural capacity, leaving devastated and poorly stocked woodlands.

Coal mining activities began in the middle of the 18th century, prompting industries, as well as the urban households, to meet their growing energy demands by gradually replacing wood with coal. Moreover, once water, road and railroad infrastructure had been improved, it was feasible and economical to transport fossil energy to much more remote areas. In consequence, the demand for energy wood decreased, while that for rural and urban construction wood, along with technical uses of wood, such as mining or paper, increased. Man-made plantation forests were established by planting or seeding, often with relatively fast-growing conifer species, and managed as high forest, applying selective thinning and longer cutting cycles to meet the industrial demand for long and straight trees of larger dimension. Forest science was developed to study and to implement modern silvicultural methods in order to increase the productivity and to guarantee a sustainable use of these high forest systems.

These trends have continued until recent times, leading to the current situation around industrial and urban centres, where coppice forests have either been replaced by high forests or abandoned, depending on the owner and the prevailing socio-economic conditions of the respective region. In rural areas, inhabitants long relied on wood for their daily lives and coppicing was still actively practiced for many decades - in many places it still is today.

Recent developments

All in all, it is estimated that there are currently well over 20 million hectares of European woodlands that are mostly managed as coppice, while many more are of coppice origin. Although the figure is difficult to assess, it comprises over 10 % of the total European forest area. The national and geographic variation is great, ranging from a negligible amount in northern countries, such as Finland and Sweden, to over 50 % of the total forest area in Serbia and Bosnia & Herzegovina.

Despite this relative importance, there is actually quite sparse grey and scientific literature on coppice and it is still stigmatised on many societal levels. Due to the historical development described above, coppice forest management has been somewhat "out of fashion" or even "forgotten" during the past decades. It was rarely discussed or even recognised in forest science and in national and EU-forest policies and the main emphasis of professional activities is still on high forest management.

Only recently has the idea and concept of coppice forest management gained attention once more. The main reasons behind this new interest have been: (1) the debate on climate change and a CO_2 neutral economy: fast growing, easy to manage and cheap to harvest dendrobiomass from coppice forests are being recognised as a valuable and abundant, but underused natural resource to provide feedstock for green energy and the bioeconomy; (2) new research results on biodiversity and nature protection have identified coppice forests as resilient ecosystems that give shelter to a unique composition of species and are less vulnerable to certain types of biotic and abiotic risks; (3) efforts are being made to acknowledge and improve the situation of those in in rural areas, as it is (re-) discovered that coppice forests and the related wood and non-wood products can be a source of rural employment and income.

Into the spotlight with COST Action FP1301 EuroCoppice

This was the starting point from which FP1301 EuroCoppice, an "Action" within the framework of COST (European Cooperation in Science and Technology), was launched. It brought together researchers and experts from 35 countries together for four years of cooperation on a broad range of themes related to coppice forests.

Action members recognised the pitfalls and opportunities of the topic, such as:

- The geophysical situation, but also the socio-economic backgound in Europe are so diverse, that many different ways and means to practice coppice forestry developed over time at the regional and national level. Thus, there is no common European understanding between officials, scientists and stakeholders, on the role and the future potential of coppice forest management.
- Much coppice-related knowledge exists, but it is regionally/locally scattered and rarely communicated amongst the European scientific and professional community.
- This lack of consistent and common knowledge base prevents the exchange of lessons learned and of new ideas, prohibiting an effective handling and use and further development of this interesting and trendsetting management concept.

EuroCoppice was the first major international cooperation to focus on coppice forest management. Besides many on-site activities and events to collect and exchange coppice related information, the efforts of the members resulted in quite a number of written documents, which have been edited and are communicated in this volume, "Coppice Forests in Europe".

Contents of this edited collection

The volume begins with very broad, general information on coppice, before diving into the details of different coppice themes, related to ecology, management and policy. The second half is then focussed on the situation in different countries, before giving a short summary and conclusion.

(1) The articles in the rest of this chapter, **Overview**, give brief descriptions of the different types of forest, first in a mainly text-based format, then the typology in a table format. Finally, for those unfamiliar with certain terms, the Glossary provides a first point of reference that can be accessed as necessary.

(2) The second chapter on **Silviculture** features comprehensive guidelines on coppice forests in Europe, compiled by a large number of experts

from across Europe, making it a key document for further cooperation and development in both science and practice. The focus then narrows to the role of two particular invasive species, before the final article transitions to the coming chapter by linking silviculture with utilisation.

(3) Having already touched on the topic of **Utilisation** in the previous article, this chapter begins with an overview about the various products from coppice forests, both wood and non-wood. This illustrates that coppice management is a very flexible production system that can be adapted to the actual needs of the population. After this, a second set of comprehensive guideline presents the different possibilities of coppice harvesting. The next contribution is devoted to the interaction between harvesting systems and their impacts to the soil, with recommendations for low impact systems.

(4) Moving on from the products-focussed research, the fourth chapter on **Conservation** encompasses articles on subjects such as the biodiversity, protective function and cultural heritage of coppice forests and their ecosystems. While the first two contributions highlight coppice in Natura 2000, the third is an extensive review of literature related to erosion and rockfall. A case study from the Czech Republic illustrates the effects of changing socio-political frame conditions on coppice in that country.

(5) Continuing on the societal theme, the next chapter on **Governance** outlines the influence of socio-economic aspects on the management of coppice forests in several European regions, then touches on the barriers that prevent small scale landowners from successfully managing their coppice forests. The picture is completed with an example of a community-owned and managed coppice forest in Serbia.

(6) Having finished with theme-related contributions, the sixth Chapter comprises reports on the **Thirty-Five Countries** that were involved in EuroCoppice, nearly all of which are in Europe. They include facts and figures, maps, descriptions and forestry regulations, as well as a summary of a selection of the main data. These contributions are a valuable source of detailed, country-specific information on coppice forests in Europe, which has never before been presented so comprehensively.

(7) After these many theme and country related articles, the **Outlook** summarises the consequences of all the facts and findings that have been gathered throughout the four years of COST Action FP1301 EuroCoppice. Conclusions are drawn and recommendations are given for decisions and activities on EU and national level with the aim to conserve, further develop and promote coppice forests in Europe.

(8) Finally, those interested in the activities and members of the Action should visit the **Annex**. Of particular interest could be the final article on the newly-formed IUFRO Unit on traditional coppice; it is open to any researcher worldwide who has a special interest in coppice forests.

Despite being comprehensive, this volume is not able to address all aspects of coppice in the same depth and it reflects the interests of the contributors. It will hopefully stimulate and encourage further research on the subject.

Closing remarks

Coppice has been –and in many cases still is– an important traditional forest land use across Europe. Its development is closely related to human efforts to establish a sustainable management of forests with a minimal input of scarce resources, such as energy, capital and land. It's still unclear whether this type of forest will again become a recognised, perhaps even prominent, element of European landscapes in the near future… For the time being, read on to discover and explore the many faucets of this fascinating, but half-forgotten land use system and let yourself be inspired, be it on a practical, scientific or political level.

Coppice in Brief

Rob Jarman and Pieter D. Kofman

Introduction

***Coppice** (noun): An area of [wood]land (on forest or agricultural land) that has been regenerated from shoots and/or root suckers formed at the stumps of previously felled trees or shrubs.*

[Adapted from IUFRO Silva Term Database 1995]

Coppice is a word that is used to cover many things, including: a type of woodland consisting of trees that are periodically cut; the multi-stemmed trees that occur in such woodlands; the process of felling (i.e. coppicing) the trees; and the production of new shoots by recently-cut stools. The principle of coppicing is simple: it is the ability of many woody plants (trees and shrubs) to regrow from cut or damaged stems or roots. At its simplest, a single-stemmed tree that has grown from a seed or a sucker is cut down and allowed to regrow: several shoots will then sprout. Repeated felling at multi-annual intervals will produce a multi-stemmed tree, growing from a base called a stool. A group of such multi-stemmed stools in one site are what then form a coppice, i.e. 'coppice woodland', or 'coppice forest'.

In some regions/countries, elaborate forms of coppice management have evolved over centuries, designed to produce specific resources from coppice systems of selected species cut on strict rotational cycles. Sweet chestnut (*Castanea sativa*) has been managed in single species coppices for poles; likewise sessile oak (*Quercus petraea*) for tanbark and charcoal; and hazel (*Corylus avellana*) for poles and split-wood products. Coppice woodlands supplied the needs of rural and urban communities for millennia, in a relatively sustainable way, until the Industrial Revolution, at which time the growing population and the demand for fuels and materials exceeded the capacities of the coppices to supply, requiring the importation of fossil fuels and wood products. 'Traditional' coppice management declined during the past century and many coppices were abandoned or converted to high forest, plantations or other land uses.

There is currently a resurgence of interest in coppicing for intensive production of wood for energy or manufactured products, as well as for ecological and cultural objectives. Newly planted short rotation coppices (SRCs) typically rely on species such as *Eucalyptus* or *Robinia*, or vigorous hybrids of poplar, willow or alder; they may be classed as an agricultural land use rather than as forestry.

Restoration of former coppice woodlands may attempt to replicate a traditional system, or adapt management to meet modern requirements for wood production and other societal and environmental benefits. Food production from coppices can be locally important (e.g. fungi, nuts, berries, honey) and artisanal products can also be of local economic interest (e.g. hazel thatching spars, chestnut fencing, limewood turnery, willow basketry).

Corresponding Author: Rob Jarman, robinajarman@gmail.com

Silviculture and Tree Management Systems

Two basic systems of coppice woodland management are recognised: **simple coppice**; and **coppice with standards**. A third, rarer system is **selection coppice**. In addition, there are two management systems that apply coppicing principles of vegetative regrowth to individual trees, rather than to woods: these are termed **pollarding** and **shredding**. Finally, there is a new system of coppice that is often considered a type of agriculture: **short rotation coppice**.

Figure 1 illustrates five applications of coppicing (excluding selection coppice) and the typical landscapes that result from them; each application is described in the following sections.

Simple coppice

This is woodland managed as an even-aged, single-storey structure, typically producing small/medium-sized roundwood for poles or fuelwood. The coppice is cut on a regular rotation, the length of which depends on the product required and also on species, location, rate of growth and environmental/societal interests (though usually between 15 and 30 years). Theoretically, the coppice is managed by sequential cutting of 'coupes' (= compartments) throughout the woodland, with the woodland divided into the number of 'coupes' equal to the number of years in the planned rotation: one coupe is then cut each year. Coppice woodlands managed in this way, are described as 'in-cycle', or 'in-rotation'.

Coppice with standards

In this method, the woodland is multi-storied, with an understorey of coppice underwood cut regularly to produce small material, as well as a partial overstorey of standard trees that can be grown from seed or from selected stems on stools and allowed to grow to a sufficient size for timber or tree products. Coppice with standards is more difficult to manage than simple coppice as it is necessary to manage the species, number, age and location of the large overstorey trees, as they will affect the growth of the understorey crop. The underwood is managed as simple coppice: after cutting each coupe, the number and distribution of the standards is adjusted. Over time, some of the oldest trees may be retained for veteran tree interests, whilst younger generations of standards need to be recruited, but at a density that avoids over-shading that would degrade the coppice.

Selection coppice

Two or three age classes of stems are rotated on the same coppice stool, to provide specific sizes or shapes of poles for particular purposes. They can be found, for example, in some of the mountain beechwoods and holm oaks of Europe. Hazel coppice is sometimes cut in this way, to provide thin straight rods for thatching spars and, later, larger poles for fence hurdles or building.

Pollarding

A pollard is a tree that is cut like a coppice stool, but at a height above the ground intended to be out of reach of browsing animals (typically more than one to two metres). New shoots grow from the decapitated trunk and can be harvested periodically in just the same way as from a coppice stool, whilst grazing animals can use the land beneath the tree – multi-purpose land use. Willow and poplar pollards are also widely used to stabilise banks of water courses.

Pollards can grow for centuries whilst being repeatedly cropped for shoots, used for livestock fodder, for poles, firewood or even for small timber. Some of the most ancient trees in

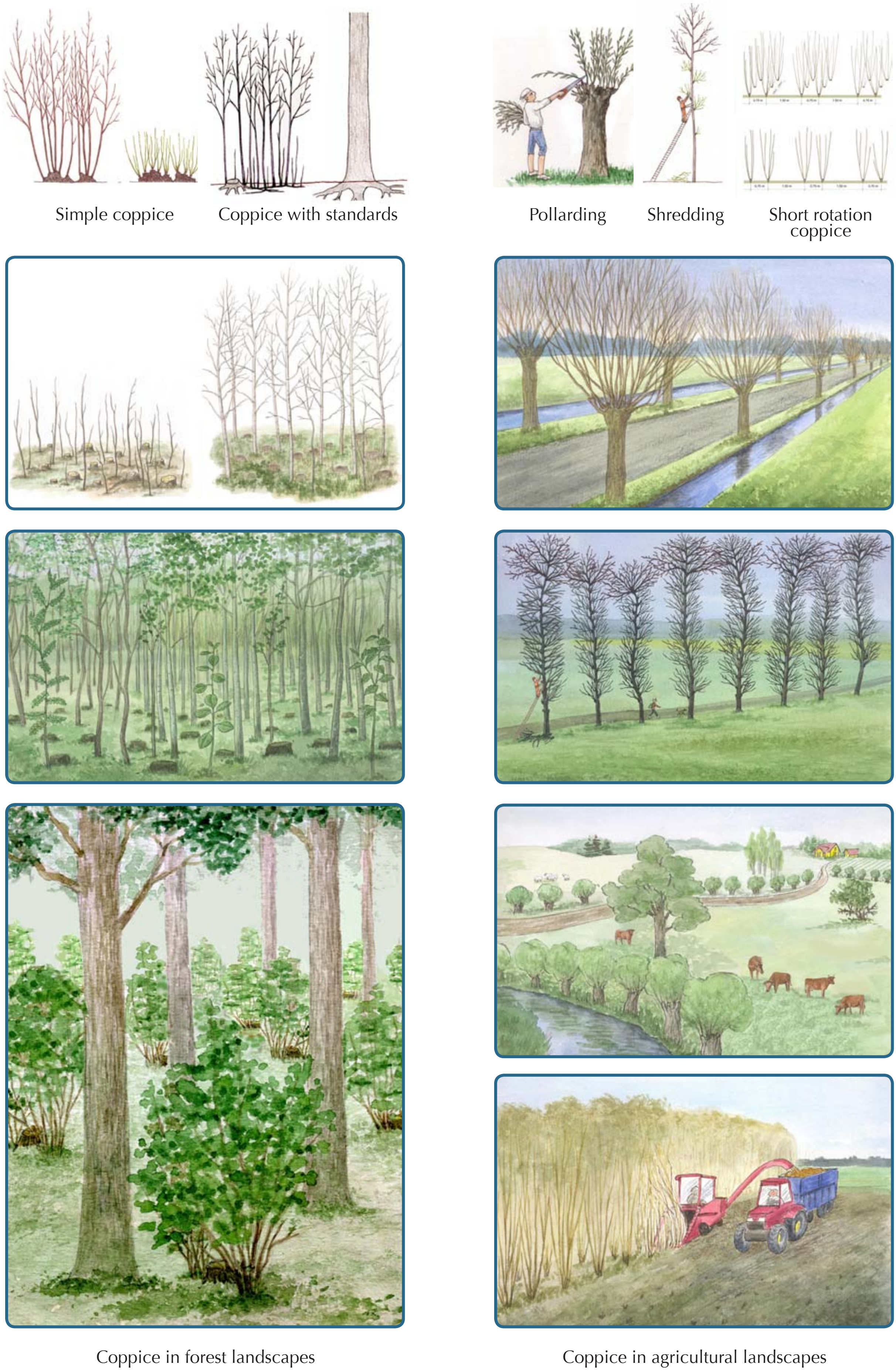


Figure 1. Types of coppice management and typical landscapes that result from them (Illustrations: Ruta Kazaka)

Europe are pollards. In many regions, pollarding for production purposes has died out, but may be continued for ancient tree management objectives or for landscaping reasons. In some regions, pollarding for firewood and fodder is still practised e.g. on Ash (*Fraxinus*), Lime (*Tilia*) and Elm (*Ulmus*).

Shredding

This is the practice of cutting side branches from the main trunk of a tree while retaining the crown, typically to provide wood and fodder for livestock. Unlike pollarding, the tree is not decapitated and continues to grow upwards as a single stem tree, ultimately able to provide large dimension timber. Shredded trees are typically found alongside tracks or field boundaries and also in some pasture-woodland systems.

Short rotation coppice (SRC)

This is a special example of 'simple coppice' that is mainly on agricultural land. The lifespan of any shoots is short compared with those of traditional coppice woodlands (typically between 1 and 3 years): the stools may need to be replanted after only 5 to 7 rotations to maintain site productivity.

Biology of Coppice Shoots

The ability of woody plants to re-sprout is a natural adaptation that enables survival after damage to the tree/shrub from animals, fire, storm or pathogens. Not all tree species can produce coppice shoots – most conifers (gymnosperms) cannot, whilst most broadleaved trees (angiosperms) can. Some species regenerate more readily from stumps, some from root suckers; over centuries, some individual plants can spread to a considerable area in their above ground stool or underground root structures, creating clonal structures covering hundreds of square metres.

Origins of coppice shoots

There are three ways in which coppice shoots form (see box on following page for details):

- **'Stump shoots'** that originate from dormant buds suppressed in the bark;
- **'Stool shoots'** that originate from adventitious buds in callus tissue following cutting or wounding;
- **'Suckers'** that originate from adventitious buds along a tree's roots.

Regeneration of coppice shoots and longevity of stools

The probable number of shoots that will be produced from any one species of tree when coppiced depends on many factors, including stump size, age, condition, site parameters, competition from other plants. It is certainly possible for coppice stools several hundred years old to continue to produce abundant shoots when routinely coppiced, even though the centre of the stool may have completely died out leaving a ring of productive stems several metres in circumference.

It is quite possible that some stools of long-lived species such as *Tilia* and *Castanea* are more than a thousand years old. These species are particularly successful at vegetative reproduction through layering, which is the rooting of branches that are in direct contact with the soil. Layering to produce genetically identical clonal offspring may take place either naturally following collapse of a tree's stem, or as part of a deliberate management procedure to generate new stools within a coppice.

'Stump shoots' are the usual response of a broadleaved tree to cutting, when dormant buds buried in the bark are stimulated to break dormancy and sprout. Dormant buds are the primary source of most coppice (and pollard) shoots and they should be favoured after cutting, as they will form the strongest shoots.

'Stool shoots' grow from adventitious buds that develop from plant tissue growing in the callus wound at the cut wood surface. These buds develop into shoots in the same season as the cut but, unlike dormant buds, they are not directly connected to the plant's vascular system, so have to make a new vascular link. As a result these shoots are often short-lived; and if they survive, they only form weakly attached shoots, so are not desired as coppice shoots.

'Suckers' grow from adventitious buds on the roots. They may be stimulated to sprout from below ground by the cutting of the above ground plant, or by disturbance of the ground, or simply as a natural vegetative reproduction process.

If the rotational cutting of coppice is neglected for a long period, then it is possible that the sprouting response to the next cutting will be poor. Neglected stools can survive for many years, attaining large dimension stems, but they can become increasingly unstable and vulnerable to windthrow, when entire root plates can be uplifted due to the top-heavy growth of stems; or the stool can be destroyed because it is split into many pieces.

Browsing animals

Coppice stools, being close to the ground, are very vulnerable to herbivore damage – new shoots are highly palatable and young bark is easily stripped. Deer, grey squirrels, rabbits, hares and voles can severely restrict coppice regrowth after cutting and also degrade standing coppice: they require strict control. Livestock (cattle, sheep, goats, pigs and horses) should be excluded from coppices, preferably permanently, although some coppice woodlands were traditionally opened for grazing for the final years of the coppice cycle. It is possible for coppices to be managed as a resource for grazing animals and for game, but the strict control of browsing in the first few years after coppicing is crucial and often very costly.

Coppice management

Most coppice woodlands have been intensively managed over several centuries to achieve a high density of stools and a few selected species. Typical coppices are monocultures of hazel, oak, lime, sweet chestnut, or black locust, which are specially selected to meet industrial needs such as bark for tanning, wood for charcoal, poles for fencing and building. Ageing stools would be cut back and replaced with a new plant, by layering from an adjacent stool or by seeding or planting. Deadwood would be cut out and only the favoured species retained. The method of cutting the stool, the type of tool/machine used and the height, angle and season of cut are all factors influencing stool vitality and ecological interest.

Coppices that have been neglected or their rotation cycles abandoned are termed 'overstood', 'stored coppice' or 'over-aged coppice'. This cannot be a long-term strategy for coppice – such woods will inevitably become high forest. There is also a risk of damage to any archaeological features present by stems and root plates being thrown over in high winds. Today, after perhaps decades of neglect, reinstating a coppice management rotation can be difficult, especially in view of the modern requirement for larger dimension poles for fuelwood.

One aspect of modern management that should be given more attention is the effect of mechanised cutting and harvesting on the woodland soil and its essential life-support role for the ecosystem. Compaction of soil is highly damaging to root systems and to the mycorrhizal fungi that are essential in nutrient transport for the trees and shrubs. It is also very damaging to surface and buried archaeology. Timing of operations and selection of appropriate machinery are crucial in the management of sensitive sites (see Chapter 3 'Utilisation' of this volume).

In modern short rotation coppice, stool management might be very different, with the need to maintain production and tree vigour. Mechanically harvested short rotation coppice may require more frequent replanting, at intervals of 12-20 years.

Biodiversity and Cultural Heritage

Coppices of all kinds and ages are of interest for their associated wildlife and for their cultural heritage. The management system of rotational cutting creates structural heterogeneity across a woodland area, providing a range of age-classes and space for a high diversity of plants and animals that prefer open spaces and edge habitats and alternate light and shade conditions. Continuation of coppicing is essential for many species – they cannot tolerate the denser shade of high forest or the lack of spatial diversity therein. Ecological management of coppice can increase the extent of old trees and deadwood habitats beyond that normally found in intensive coppice systems, for example by retaining some trees and shrubs beyond their normal rotation and broadening the diversity of tree/shrub species. Retaining ancient trees in the landscape, as coppice stools (especially the high-cut stools known as 'stubs') in the forest and as pollards and shreds in pasture-woodlands and along watercourses and roads, adds considerably to the flora and fauna.

Cultural heritage interests are found in ancient coppices, where thousands of years of woodland management have created features such as banks and ditches, hollow ways, timber slides, boundary markers, charcoal-making platforms, pollards and veteran trees, often with archaeological artefacts dating back to the prehistoric period. More recent coppice woods may contain pre-woodland features of field systems, habitation sites and other archaeological structures. Both old and new coppices require sensitive management to protect these cultural and ecological interests.

Other aspects of cultural heritage associated with coppices include the food and artisanal products mentioned in the introduction, as well as the social history and art/literature and language so inextricably tied up with coppicing as a long-established practice in most rural communities. The evident popular interest across many European regions in community woodlands, woodland crafts, use of wood instead of artificial materials, switching to woodfuel, and local food festivals is highly encouraging – woods will survive if their products are in demand.

Conclusions

Coppicing is a venerable practice – it can, when practised ecologically, be a very effective way of managing trees and shrubs to produce wood and food required by society, in a repetitive manner without undue depletion of natural resources. It creates valuable habitats for many species of plants, fungi and animals and also safeguards and perpetuates landscapes and aspects of high cultural importance.

The long-established coppices hold some of Europe's most ancient trees and archaeology. Conservation of semi-natural ancient woodland by the continuation of coppicing is one way to protect and promote these assets, provided that management objectives are widened to encompass these less-productive features.

Traditional coppicing can be promoted for multi-purpose production and conservation objectives, whilst new wooded areas on agricultural land managed as short rotation coppices can be designed and managed to replicate some of the most important elements of traditional coppice. They have the potential to produce large volumes of wood for energy in a short time, whilst diversifying the landscape and creating habitats that support wildlife and game.

Conversion of ancient coppices to high forest or non-wooded land should be avoided wherever possible. The task for all of us is to ensure that we can manage woodlands (old and new) to integrate all of society's needs, within the capacity of the environment (economical, natural and cultural) to supply them.

Acknowledgements

This text is based on the Harmer (2004) text and has been modified to suit the context of COST Action FP1301 EuroCoppice. We are grateful to Ralph Harmer for allowing the use of the text and for the constructive comments on an early draft of this document.

References

Harmer, R. (2004). Coppice silviculture practiced in temperate regions. In Burley, J., Evans, J., Youngquist, J.A., (Ed.), *Encyclopaedia of Forest Sciences*. Academic Press, Elsevier Ltd., Oxford.

IUFRO (2005). *Multilingual pocket glossary of forest terms and definitions.* IUFRO SilvaVoc terminology project.

Nieuwenhuis, M. (2000). *Terminology of Forest Management.* IUFRO World Series Vol. 9-en. IUFRO 4.04.07 SilvaPlan and SilvaVoc.

Typology of European Coppice Forests

Valeriu-Norocel Nicolescu, Debbie Bartlett, Gero Becker, Gheorghe F. Borlea, Peter Buckley, Pieter D. Kofman, Dagnija Lazdiņa, Natascia Magagnotti, David Rossney, Raffaele Spinelli and Alicia Unrau

Coppice forests are an important component of European woodlands, with over 20 million ha of the productive forests in Europe being managed as coppice (UN/ECE-FAO, 2000, cited in Zlatanov and Lexer, 2009). Over millennia, the development of coppice forests has been influenced by many factors, such as regional climate, eco-physical conditions, wood market requirements and owners' interests. This has led to a very large variety of coppice forests in terms of their distribution, structure, legal status and management.

This document describes the basic types of coppice in Europe: simple coppice, coppice with standards, selection coppice, pollarding, and short rotation coppice (Figures 1 to 5), the latter being a more recent phenomenon. It is important to note that the above-mentioned diversity of coppice in Europe can never be captured in a categorisation. In practice, there are no distinct boundaries between types and within each type there are exceptions to each described element. Nevertheless, *coppice* is a common denominator of all these types, and there are typical "trends" to be found across Europe.

The five coppice types and their most important characteristics are summarised in the following figures and table.

Figure 1. Simple coppice of sweet chestnut (Photo: D. Rossney)

Figure 2. Coppice with standards (Photo: V.N. Nicolescu)

Corresponding Author: Valeriu-Norocel Nicolescu, nvnicolescu@unitbv.ro

Table 1. Typology of European coppice forests

	Simple coppice (fig. 1)	Coppice with standards (fig. 2)	Coppice selection (fig. 3)	Pollarding (fig. 4)	Short rotation coppice (fig. 5)
Definition	A coppice system in which all shoots in a stand are cut at each felling (Nieuwenhuis 2000)	A coppice system in which selected stems are retained as standards at each felling to form an uneven-aged overstorey which is removed selectively on a rotation constituting some multiple of the coppice rotation (Burley et al. 2004)	A coppice system in which only selected shoots of merchantable size are cut at each felling (Nieuwenhuis 2000)	A coppice system in which the crowns of trees are cut back, in a more or less systematic fashion, with the object of producing close heads of shoots (pollards) (Burley et al. 2004, modified)	Production of woody biomass, generally on agricultural land, by regenerating new stems from the stump or roots after harvesting and relying on rapid growth, generally over a 1 to 5 year cycle (ISO EN 16559)
Regeneration method	Stool shoots, root suckers	Stool shoots and seeds	Stool shoots	Stem shoots (at various heights)	Cuttings (willow, poplar) or seedlings (eucalypt, black locust) followed by stool shoots
Structure	Even-aged	Uneven-aged	Uneven-aged	Even-aged	Even-aged
Species	Most broadleaved species: oaks, sweet chestnut, hornbeam, linden, eucalypts, ash, alders, black locust, poplars, birch, European beech, hazel	*Upper storey* (standards): oaks, elms, ash, sycamore, Norway maple, wild cherry, wild service tree, service tree, black walnut, pines, larches *Lower storey* (coppice): hornbeam, field maple, European beech, linden, sweet chestnut, hazel	European beech, holm oak	Poplars, willows, ash, plane-tree, beech, chestnut, mulberry, oaks, linden, elms, black locust, maples, hornbeam, hazel	Willows, poplars, black locust, eucalypts

(Table 1 continued)

	Simple coppice (fig. 1)	Coppice with standards (fig. 2)	Coppice selection (fig. 3)	Pollarding (fig. 4)	Short rotation coppice (fig. 5)
Typical rotation period	15 – 30 years	15 – 30 years (coppice)	15 – 30 years	1 – 5 years (up to 25)	1 - 5 years
Potentially occurring in the forest vegetation types... (according to EEA, 2007)	4. Acidophilous oak and oak-birch forest (types 4.1 and 4.2) 5. Mesophytic decidous forest (types 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7) 6. Beech forest (types 6.2, 6.5, 6.6, 6.7) 7. Mountainous beech forest (types 7.1 and 7.8) 8. Thermophilous decidous forest (types 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8) 9. Broadleaved evergreen forest (type 9.1), 14. Plantations and self-sown exotic forest (type 14.2)				Not applicable; mostly on agricultural land
Size of product	Small-sized roundwood	Small-sized roundwood and timber	Roundwood of different sizes	Small-sized roundwood	Small-sized (whole) stems
Wood products	Firewood, charcoal, industrial roundwood, basketry, hoops, fascines, pea and bean sticks, fencing, poles, tannin, tool handles...	See simple coppice + timber	See simple coppice + timber	See simple coppice + sometimes timber (historically used as fodder)	Wood chips, pulp, basketry, fencing
Management options	Commercial exploitation Conversion Restoration Maintenance for biodiversity and as an element of landscape and culture				Commercial exploitation

Figure 3. Coppice selection with European beech (Photo: O. Cardoso)

Figure 4. Pollard of white willow (Photo: V.N. Nicolescu)

Figure 5. Willow clone treated as short rotation coppice (Photo: V.N. Nicolescu)

References

Burley, J., Evans, J., Youngquist, J.A. (2004). *Encyclopaedia of forest sciences.* Elsevier and Academic Press, Amsterdam-Boston-Heidelberg, vol. 4, pp. 1873-1928.

ISO EN 16559: *Solid biofuels. Terminology, definitions and descriptions.* International Organization for Standardization, Geneva, Switzerland.

EEA (2007). *European forest types. Categories and types for sustainable forest management reporting and policy.* 2nd edition. EEA Technical report No. 9/2006, European Environment Agency, Copenhagen, 111 pp.

Nieuwenhuis, M. (2000). *Terminology of Forest Management.* IUFRO World Series Vol. 9-en. IUFRO 4.04.07 SilvaPlan and SilvaVoc.

Zlatanov, T., Lexer, M.J. (2009). *Coppice forestry in south-eastern Europe: problems and future prospects.* Silva Balcanica 10(1), pp. 5-8.

Glossary of Terms and Definitions Related to Coppice

Dagnija Lazdiņa, Kristaps Makovskis, Pieter D. Kofman and Alicia Unrau

Term	Synonyms	Definition	Reference
adventitious	adventitious root; adventitious bud; adventitious shoot	1. (of buds) those produced elsewhere than normal, such as leaf axils, shoot apices (e.g. those appearing with wounds). 2. (of roots) lateral roots coming from organs other than main root system, such as the stem.	Beentje & Williamson (2016)
afforestation		Establishment of a forest or stand in an area where the preceding vegetation or land use was not forest.	Ford-Robertson (1971)
bioenergy		Energy derived from biomass.	ISO EN 16559
biological diversity	biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.	UNEP (1992) via SilvaVoc
browsing		Feeding on the buds, shoots and leaves of shrubs and trees by livestock or wild animals.	Kaennel & Schwein-gruber (1995)
bud		A meristem (either apical or lateral) in early development or resting stages, with its protective coverings; immature shoot, usually protected by scales or prophyll(s), or immature flower, protected by bracts, bracteoles and/or perianth segments.	Beentje & Williamson (2016)
canopy		The foliar cover in a forest stand, consisting of its upper layers.	Helms (1998)

Corresponding Author: Dagnija Lazdina, dagnija.lazdina@silava.lv

Term	Synonyms	Definition	Reference
canopy closure	canopy cover	Ground area covered by the crowns of trees or woody vegetation as delimited by the vertical projection of crown perimeters and commonly expressed as a percent of total ground area —note crown cover measures the extent to which the crowns of trees are nearing general contact with each other.	Ford-Robertson (1971)
clones		A group of plants produced from cuttings, stump or root sprouts, tissue culture, or some other method that produces offspring genetically identical to the original plant.	Maynard (1996) in FAO (2002)
conversion		A change from one silvicultural/management system to another, e.g. from clearfell to selection forest. Sometimes also used for a change from one (set of) species to another.	Nieuwenhuis (2000) via SilvaVoc
coppice		1. A plant derived by coppicing. 2. Any shoot arising from an adventitious or dormant bud near the base of a woody plant that has been cut back.	Burley et al. (2004)
coppice conversion by aging		The low coppice is no longer cut so that stands reach a maturity in which they are able to regenerate naturally by seed. During the waiting period, tending operations (e.g., cleaning, thinning) are applied depending on the stage of development. These interventions are halted after 60-80 years, after which silvicultural systems typical to high forests can be applied in order to regenerate the stands naturally by seed.	Nicolescu et al. (2017)
coppice conversion by replacement		The restoration of such coppice stands for their conversion to high forest is done either by (1) Clear-cutting, followed by planting, mostly of conifer tree species such as pines or Norway spruce; (2) Clear-cutting, followed by manual/mechanical seeding of species such as oaks; (3) Use of high forest silvicultural systems, such as uniform shelterwood cutting.	Nicolescu et al. (2017)

Term	Synonyms	Definition	Reference
coppice forest		Forest which has been regenerated by allowing regrowth from cut stumps or root suckers, or both, i.e., by vegetative means. Normally grown on a short rotation for small poles, but sometimes, e.g. some eucalypt species, to a substantial size.	IUFRO (2005)
coppice selection system	coppice selection	A coppice system in which only selected shoots of merchantable size are cut at each felling, giving uneven-aged stands.	Nieuwenhuis (2000) via SilvaVoc
coppice stand		Forest stand composed of stools that produce coppice shoots which form the major part of the crop.	Harmer (1995)
coppice system		Silvicultural system in which crops regenerate vegetatively by stump sprouts and the rotation is comparatively short.	Young (1982)
coppice with standards	compound coppice; coppice with standards system	A coppice system in which selected stems are retained as standards at each felling to form an uneven-aged overstorey which is removed selectively on a rotation constituting some multiple of the coppice rotation; a crop partly of vegetative and partly of seedling origin.	Burley et al. 2004
coppicing		1. The production of new stems from the stump or roots. 2. To cut the main stem (particularly of broadleaved species) at the base to stimulate the production of new shoots for regeneration.	Burley et al. (2004)
cutting(s)		A small shoot taken from near the end of a branch or the stem of a plant. It is placed in the ground and will produce roots and develop into a new plant which will be genetically identical to the original plant.	Nieuwenhuis (2000) via SilvaVoc
dieback		A term often used to mean 'death'. More correctly, it means a progressive death of a tree or a branch from its extremities towards the roots. Dieback can be reversible.	Burley et al. (2004)

Term	Synonyms	Definition	Reference
direct conversion of simple coppice		A transition from low coppice to high forest that does not involve another silvicultural system. The method of direct conversion includes (i) conversion by ageing (conversion by full cessation of low coppice cuttings), (ii) mixed conversion (conversion by partial cessation of low coppice cuttings), and (iii) conversion by replacement/restoration.	Nicolescu et al. (2017)
dormancy	dormant bud; latent bud; preventitious bud; latency	A special condition of arrested growth in which the plant and such plant parts as buds and seeds do not begin to grow without special environmental cues.	Young & Giese (1990)
epicormic growth		Growth of lateral buds after the apical bud is damaged.	Young & Giese (1990)
epicormic shoot	water shoot; water sprout; epicormic branch	A shoot arising spontaneously from an adventitious or dormant bud on the stem or branch of a woody plant often following exposure to increased light levels or fire.	Ford-Robertson (1971)
fodder		Coarse food that is composed of entire plants or the leaves and stalks of a cereal crop, and is fed to cattle and horses.	Park & Allaby (2013)
fuel wood	firewood	Any wood source that is used, without alteration, as a type of fuel for heating, lighting or cooking purposes.	Grebner et al. (2013)
high forest		A stand of trees, generally of seedling origin, that normally develop a high, closed canopy.	Ford-Robertson F.C. (1971)
high forest system		Silvicultural system in which forest is managed on rotation sufficient to produce trees large enough for timber production.	IUFRO (2005)
indigenous		Native to a specified area or region, not introduced.	Ford-Robertson (1971)
indirect conversion of simple coppice		This method removes all current species and introduces new species to the area.	Nicolescu et al. (2017)

Term	Synonyms	Definition	Reference
introduced tree species		An established (not nec…) plant or animal not native to the ecosystem, region, or country.	Ford-Robertson (1971)
invasive tree species		An organism that is non-native (or alien) to an ecosystem and whose introduction causes or is likely to cause economic or environmental harm or harm to human health = invasive pest species.	Ford-Robertson (1971)
lateral shoot		Lateral means 'at the side', 'towards the side', 'from the side', 'axillary', 'farther from the midline of the body', 'situated towards or at the side of the body'. E:... (4) lateral shoot.	Klein (2008)
layering		The rooting of an undetached branch (= a layer) lying on or partially buried in the soil, which is capable of independent growth after separation from the mother plant.	Nieuwenhuis (2000) via SilvaVoc
leading shoot		The leading shoot is the main shoot which develops from the terminal bud at the top of a tree each year.	Klein (2008)
mixed conversion (coppice)		Conversion to high forest by partial cessation of low coppice cuttings. Every 10 years (production of a new management plan), a part of low coppice stands are no longer exploited, while the rest of stands are treated as low coppice. The area of low coppiced stands continuously decreases until they no longer exist, while the area covered with high forests increases and these stands form successive age classes.	Nicolescu et al. (2017)
mixed forest		Forest or woodland consisting of different species either between or within specified areas.	Nieuwenhuis (2000) via SilvaVoc
monoculture	pure stand	A stand of a single species, generally even-aged.	Ford-Robertson (1971)
multi-stemmed tree		"multi-": comb. prefix meaning many.	Gray (1967)

Term	Synonyms	Definition	Reference
over-aged coppice	abandoned coppice; aged stools; derelict coppice; neglected coppice; neglected stools; overstood coppice; stored coppice	Coppice woodlands that have been left to grow substantially beyond the normal rotation and developed stools with stems having the characteristic sizes and lengths of high forest trees.	Harmer & Howe (2003)
overmature stand		1. A tree or even-aged stand that has reached that stage of development when it is declining in vigor and health and reaching the end of its natural life span - not nec end of life... 2. A tree or even-aged stand that has begun to lessen in commercial value because of size, age, decay, or other factors.	Ford-Robertson (1971)
plantation		A stand composed primarily of trees established by planting or artificial seeding —note 1. a plantation may have tree or understory components that have resulted from natural regeneration —note 2. depending on management objectives, a plantation may be pure or mixed species, treated to have uniform or diverse structure and age classes, and have wildlife species commensurate with its stage of development and structure —note 3. plantations may be grown on short rotations for biomass, energy, or fiber production, on rotations of varying length for timber production, or indefinitely for other values.	Ford-Robertson (1971)
pole		A straight, bark-free, tree-length log with one end embedded in the ground that supports power and communication wires, highway sound barriers, and similar structures.	Burley et al. 2004
pole stage	pole phase	Still-young tree larger than 10 cm dbh, up to about 20-23 cm dbh.	Young (1982)

Term	Synonyms	Definition	Reference
pollarding		Cutting back, in a more or less systematic fashion, the crown of a tree, with the object of producing a close head of shoots (a pollard) beyond the reach of browsing animals.	Burley et al. (2004)
provenance	geographic origin	Natural origin of seeds or trees, usually synonymous with "geographic origin", or a plant material having a specific place or origin.	Young & Giese (1990)
pruning		The removal, close to the branch collar or flush with the stem, of side branches (live or dead) and multiple leaders from a standing tree —note 1. pruning is generally done on plantation trees to improve the tree or its timber, or on urban and rural trees to improve their aesthetics or health —note 2. green pruning is the removal of live branches, dry pruning is the removal of dead branches, and chemical pruning is the application of chemicals, e.g., plant-growth regulators, to the living tree to kill, suppress, or inhibit lateral shoots.	Ford-Robertson (1971)
regeneration		The natural or artificial process of re-establishing tree cover on forest land.	Nieuwenhuis (2000) via SilvaVoc
rotation period	rotation age	Period of years required to establish and grow timber crops to a specified condition of maturity. Applies only to even-aged management.	Young (1982)
seed tree		A tree selected and often reserved for the collection of seed or for natural seeding of a (understocked) regeneration area.	Nieuwenhuis (2000) via SilvaVoc
shelterwood system		A harvesting system in which most of the trees are felled but some are left to provide protection for the new forest by providing either shade or wind protection.	Helms (1998)
shoot	coppice shoot; sprout; spring	A shoot arising from an adventitious bud at the base of a woody plant that has been cut near the ground. In the case of a sucker, the shoot arises from the root of the plant.	Nieuwenhuis (2000) via SilvaVoc

Term	Synonyms	Definition	Reference
short rotation coppice		Production of woody biomass, generally on agricultural lands, by regenerating new stems from the stump or roots after harvesting and relying on rapid growth, generally over a 1 to 5 years cycle.	ISO EN 16559
shredding	lopping	The repeated removal of side branches on a short cycle, leaving just a tuft at the top of the tree.	Burley et al. (2004)
shrub		Woody perennial plant, seldom exceeding 3.0 m in height, usually having several persistent woody stem branching from the ground.	Young (1982)
simple coppice	low coppice; simple coppice system	A coppice system in which all shoots in a stand are cut at each felling, giving even-aged shoots and stands.	Nieuwenhuis (2000) via SilvaVoc
singling	stored coppice	To reduce the regrowth from a coppice stool to allow a single pole to grow on to form a standard tree.	Park & Allaby (2013)
site index		A species-specific measure of actual or potential forest productivity (site quality, usually for even-aged stands), expressed in terms of the average height of trees included in a specified stand component (defined as a certain number of dominants, codominants, or the largest and tallest trees per unit area) at a specified index or base age. —note site index is used as an indicator of site quality.	Ford-Robertson (1971)
site quality class		The maximum quantity of material, of given species, that an area is capable of producing under normal conditions, so long as the factors of the locality remain unchanged.	Nieuwenhuis (2000) via SilvaVoc
sprouting		Type of asexual vegetative reproduction in which sprouts arise (i) from the side of a stump (developed from dormant buds) or (ii) between the bark and wood, on the surface of the stump (originated from adventitious buds).	Fujimori (2001)

Term	Synonyms	Definition	Reference
stool	stump	A living stump (capable of) producing coppice shoots.	Burley et al. (2004)
stool shoot	stool sprout; stump shoot; stump sprout	1. A shoot or new stem/branch emerging from (near) the base of the plant, especially when the stem has been cut; 2. Several stems arising from the same root.	Beentje & Williamson (2016)
sucker	root sucker	A shoot arising below group from the roots some distance from the main stem.	Beentje & Williamson (2016)
thinning residues		Woody biomass residues originating from thinning operations.	ISO EN 16559
vegetative regeneration	vegetative propagation; vegetative reproduction	Nonsexual reproduction.	Burley et al. (2004)
veteran tree		1. Trees of interest biologically, aesthetically or culturally because of their great age; 2. Trees in the ancient stage of their life; 3. Trees that are old relative to others of the same species.	Read (2000)
virgin forest	semi-natural forest; semi-natural ancient woodland	Areas (or forests) that have never been disturbed by human intervention, showing natural development in structure and dynamics. The soil, climate, entire flora and fauna and the life processes have not been disturbed or changed by timber management, cattle grazing, or other direct or indirect anthropogenic influences.	Schuck et al. (2002)
windbreak	shelterbelt	A line of trees or shrubbery planted or managed in such a way as to protect a building or crops, or to alter climate or wind.	Helms (1998)

These terms and definitions can be found in the online Multilingual Forestry Glossary, along with illustrations and translations into many European languages.

Visit the EuroCoppice website for details:

www.eurocoppice.uni-freiburg.de

Acknowledgements

We are very grateful to the following COST Action FP1301 EuroCoppice Members for contributing to and reviewing the Glossary: Rob Jarman, Jyrki Hytönen, Valeriu-Norocel Nicolescu, Radomír Klvač, Ivailo Markoff, Enrico Marchi, Gero Becker, David Rossney, Peter Buckley, Debbie Bartlett, Marko Condera and Raffaele Spinelli.

References

Beentje, H. & Williamson, J. (2016). *The Kew plant glossary: an illustrated dictionary of plant terms.* Richmond, Surrey, UK: Kew Publishing.

Burley, J., Evans, J., Youngquist, J.A., (2004). *Encyclopedia of forest sciences.* Elsevier and Academic Press, Amsterdam-Boston-Heidelberg, vol. 4, pp. 1873-1928 (Glossary).

Dublin, R., Manubay, G., (Ed.) (2007). *Glossary of Urban Forestry Terms for Citizen Foresters.* Tree Trust Community Tree Planting Guide ESRI Press Department of Natural Resources, Parks & People Foundation.

FAO (2002). *Glossary on forest genetic resources (English version).* Forest Genetic Resources Working Papers, Working Paper FGR/39E, Forest Resources Development Service, Forest Resources Division. FAO, Rome (unpublished).

Ford-Robertson F.C. (Ed.) (1971). *Terminology of forest science, technology practice and products.* Washington D.C., Society of American Foresters. 370 pp. (2nd printing)

Fujimori, T., (2001). *Ecological and silvicultural strategies for sustainable forest management.* Elsevier, Amsterdam-London-New York-Oxford-Paris-Shannon-Tokyo, 398 p.

Gray, P. (1967). *The Dictionary of the Biological Sciences.* Reinhold, New York.

Grebner, D., Bettinger, P. & Siry, J. (2013). *Introduction to forestry and natural resources.* Amsterdam Boston: Academic Press.

Harmer, R. (1995). *Management of Coppice Stools; Research Information Note 259*. The Forestry Authority, Surrey.

Harmer, R., Howe, J., (2003). *The silviculture and management of coppice woodlands.* Forestry Commission, Edinburgh, 90 p.

Helms, J.A. (ed.), (1998). *The Dictionary of Forestry.* The Society of American Foresters. CABI Publishing, Bethesda & Wallingford, 210 p.

Hocker, H. (1979). *Introduction to forest biology.* New York: Wiley.

ISO EN 16559: *Solid biofuels*. Terminology, definitions and descriptions, International Organization for Standardization, Geneva, Switzerland.

IUFRO (2005). *Multilingual pocket glossary of forest terms and definitions.* IUFRO SilvaVoc terminology project.

Kaennel, M., Schweingruber, F.H. (1995). *Multilingual glossary of dendrochronology: terms and definitions in English, German, French, Spanish, Italian, Portuguese and Russian.* Berne u.a: Haupt.

Klein, E. (2008). *Bilinguales Wörterbuch Biologie.* München: Verb. Biologie, Biowiss. und Biomedizin in Deutschland.

Maynard, C. (1996). *Glossary of forest genetics.* Unpublished.

Nicolescu, V.-N., Carvalho, J., Hochbichler, E., Bruckman, V., Piqué-Nicolau, M., Hernea, C., Viana, H., Štochlová, P., Ertekin, M., Tijardovic, M., Dubravac, T., Vandekerkhove, K., Kofman, P.D., Rossney, D., Unrau, A. (2017). *Silvicultural guidelines for European coppice forests. COST Action FP1301 Reports.* Freiburg, Germany: Albert Ludwig University of Freiburg.

Nieuwenhuis, M., (2000). *Terminology of Forest Management.* IUFRO World Series Vol. 9-en. IUFRO 4.04.07 SilvaPlan and SilvaVoc.

Park, C. & Allaby, M. (2013). *A dictionary of environment and conservation.* Oxford: Oxford University Press.

Read, H. (2000). *Veteran Trees: A guide to good management.* English Nature, 176 p.

Schuck, A., Päivinen, R., Hytönen, T., Pajari, B., (2002). *EFI Internal Report 6: Compilation of Forestry Terms and Definitions.* European Forest Institute, Joensuu.

UNEP (1992). *The Convention on Biological Diversity.* Article 2.

Young, R.A. (ed.) (1982). *Introduction to forest science.* John Wiley & Sons, New York-Chichester-Brisbane-Toronto-Singapore, 554 pp

Young, R. & Giese, R. (1990). *Introduction to forest science.* New York: Wiley.

2 Silviculture

Management matters.

What are the details of shoot production?

What silvicultural options are there for different types of coppice?

Between threat and opportunity – characterising two major invasive species.

How does this connect to the upcoming chapter on the operations of coppice forest management?

Visit this chapter for:

Silvicultural guidelines for European coppice forests

Two potentially invasive tree species of coppice forests: *Ailanthus altissima* and *Robinia pseudoacacia*

Active management of traditional coppice forests: an interface between silviculture and operations

Silvicultural Guidelines for European Coppice Forests

Valeriu-Norocel Nicolescu, João Carvalho, Eduard Hochbichler,
Viktor J. Bruckman, Míriam Piqué, Cornelia Hernea, Helder Viana,
Petra Štochlová, Murat Ertekin, Martina Đodan, Tomislav Dubravac,
Kris Vandekerkhove, Pieter D. Kofman, David Rossney and Alicia Unrau

1 Introduction

1.1 Coppice forests in Europe

Coppice is a forest regenerated from vegetative shoots that may originate from the stump and/or from the roots, depending on the species.

In contrast to forests originating from seed (the so-called *high forest*), the rotation period of coppice forests can be significantly shorter (approx. 5-30 years, depending on the type of coppice system). In 2000, about 16% of the productive forests in Europe were managed as coppice, covering a total area of about 23 million ha [53].

All European coppice forests consist of broad-leaved tree species. Among them, eucalypts, a non-native species, is a bit of an outlier in terms of the environmental concerns discussed in this document. Even though eucalypts can be managed to be highly productive and cost-effective, they can have major detrimental effects to the environment such as soil depletion and fire risk.

Willows, poplars and black locust are treated as *short-rotation coppice* (SRC), which is usually regarded as part of agricultural-production systems.

1.2 Forms of coppice forests

There are different forms of coppice forests: simple coppice, coppice with standards, coppice selection, pollarding and short rotation coppice (Figure 1).

1.3 The biological and ecological process of vegetative regeneration

Re-sprouting is a natural adaptation of trees and shrubs that enables their survival after having been damaged. Coppicing is the operation of felling and vegetative regeneration of a forest. Coppice forests are thus usually a result of human activities (cutting). However, it is also possible for coppice to result from natural disturbances (e.g., wind throw, fire, animals,

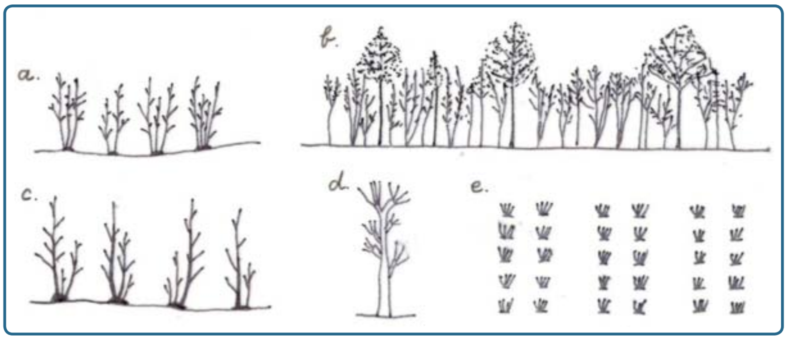


Figure 1. Different types of coppice forests: simple coppice (a), coppice with standards (b), coppice selection (c), pollarding (d), short rotation coppice (e) (drawn by J. Carvalho)

Corresponding Author: Valeriu-Norocel Nicolescu, nvnicolescu@unitbv.ro

storm, pathogens, etc.) and a few species can also sprout naturally (e.g., strawberry tree, Figure 2, as well as wild cherry, hazel).

The result of re-sprouting is the production of *coppice shoots* (coppice sprouts) that originate from coppice stools (stumps, Figure 3, and roots).

There are three forms of coppice shoots [25]:

a. Stump shoots (sprouts): originate from *dormant buds* buried in the bark. They have the same age as the tree on which they have been formed and can live in a dormant state for a long time, usually breaking the dormancy after major disturbance, e.g. cutting the tree.

b. Stool shoots (sprouts): grow from *adventitious buds*, which develop in the same season of the cut from callus tissue formed between the bark and the wood at the cut surface. They are not directly connected to the vascular system of the stump on which have been formed and are less frequent than the stump shoots.

c. Root suckers: originate from *adventitious buds* along the tree roots. Such shoots (Figure 4; following page) can occur:

- On standing trees, either after the soil has warmed due to exposure to sunlight or fire, or following the loss of apical dominance.
- Following the cutting of the above ground tree
- When shallow and/or thin tree roots are disturbed or wounded.

Figure 2. Natural sprouting in strawberry tree (Photo: J. Carvalho)

The stump shoots are more desirable than the stool shoots as they are more numerous, show a higher vigour, can develop independent roots sooner than the stool shoots, have a lower proportion of rot and are more intimately attached to the stump and so less prone to be separated from it. Consequently, the stump shoots should be favoured after cutting.

Compared to stump and stool shoots, root suckers do not show basal curvature, are less affected by disturbances (wind, snow) and rot and can separate fully and more quickly from the originating roots.

White poplar, aspen and black locust can produce large amounts of root suckers, a response that is encouraged when the original tree is cut or damaged.

a b c d e

Figure 3. Stump and stool shoots on: hornbeam (a), sweet chestnut (b), eucalypt (c), sessile oak (d) and common ash (e) (Photos: V.N. Nicolescu and V. Bruckman)

a b

Figure 4. Root suckers of silver linden (a) and black locust (b) (Photos: V.N. Nicolescu and C. Hernea)

Shoot production

The potential for shoot production mainly depends on the species, tree age, season of cutting and site conditions. In terms of the species, all native broadleaved tree species produce shoots and can be treated as coppice, albeit to different extents. European beech, for example, only re-sprouts at a young age (up to 20-25 years) and on richer soils; on more acidocline soils it re-sprouts poorly and so is considered unsuitable for coppice management on such sites. Other species, such as silver birch, also re-sprout best at lower ages and are therefore better suited for coppice systems with shorter rotations (<20 years).

The majority of broadleaved tree species, however, can produce shoots vigorously and abundantly up to an age of 40 years (e.g. Turkey oak, Holm oak, willows, poplars (not trembling), elms, black alder), while certain tree species can produce shoots for up to 100 years, or even indefinitely (e.g. pedunculate oak, sessile oak, Hungarian oak, sweet chestnut, linden, elms, and hornbeam), although the vitality of shoots decreases considerably at higher ages and stump diameter.

The production of shoots also depends on the *season of cutting*: the best time to cut for simple coppice is considered to be late winter - early spring, before the beginning of growing season. The only major exceptions to this optimal period are the oak tan-bark coppice, which is cut in May or early June, after the growing season has commenced, and alder, willow and poplar coppices on swampy sites, which are cut in winter or summer, when the ground is firm or dry enough.

Light conditions is another important factor for re-sprouting: the stumps should be in full light to produce shoots, as a shaded stump will coppice weakly and shoots will grow slowly. For light-demanding species (e.g. oaks, willows), this effect is more important than for more shade-tolerant species (i.e. linden, hornbeam, hazel), which still re-sprout well under the semi-open canopy of coppice with standards.

Coppicing also depends greatly on the *climate*: summer droughts and early or late frosts can reduce or even halt the production of shoots. A warmer climate fosters re-sprouting (in terms of the abundance and vigour of shoots), but this can result in the stump becoming exhausted more quickly.

Re-sprouting is also more abundant and can be longer (up to 300 years or even more) on rich soils with a good water supply than on poorer and drier soils. The same phenomenon occurs on warm, sunny and drier slopes, which are more favourable for re-sprouting than the colder, shaded and more humid ones.

Sprouting is also affected by wind, snow and browsing, which induce the detachment of stool shoots and compromise the vegetative reproduction of trees. Periods of continued high browsing pressure (by deer or livestock) may lead to depletion and eventual death of the stools.

Sucker production

On one hand, suckering depends on the *species*: the most important sucker producers are poplars (trembling/aspen, white, black and hybrid), black locust, grey alder, linden, field elm, field maple, wild cherry, wild service tree, Pyrenean oak, and holm oak. Root suckering rarely occurs in oaks (pedunculate, sessile, pubescent), European beech, hornbeam, common ash, and Norway maple. On the other hand, sucker production also depends on *soil conditions*: more suckers occur on sites with lighter (sandy) and mobilized soils than on heavy and compact ones.

The distance to which certain tree species produce suckers can be up to 10 m (black locust, wild cherry, white poplar, wild service tree, etc.) or even longer (35 m in aspen), thus allowing the trees' expansion to surrounding openings.

1.4 Socio-economic values of coppice forests

For centuries, coppice forests served as a sustainable source of *raw materials* for the local communities [11] (Figure 5). A steep decrease in demand for firewood due to the widespread use of fossil fuels led to a strong decrease in coppice forests over the past two centuries, especially in many Central- and Western European countries. However, over the last two decades there has been a renewed and growing interest in coppicing in Europe due to the increasing demand for energy production from renewable resources, as desired by EU policy. This development was mainly triggered by climate change mitigation policies in the wake of Kyoto Protocol [55]. In addition, an increase in the price of firewood over the past few years has also stimulated a recent interest in coppicing as a forest management alternative [32].

Coppice forests may provide the following:

Rural livelihoods: regular income, sustainable employment and resources

Bio-economy: renewable, sustainable and environmentally friendly biomaterials & fuels

Protection function: prevents soil erosion, rock fall, landslide & avalanche

Sharing economy: community use & recreation

Provision: timber & non-timber forest products

Enrichment: biodiversity & cultural landscapes

Figure 5. Timber forest products from coppice: sweet chestnut in England (a) and Italy (b), black locust in France (c) and oak in Austria (d) (Photos: V.N. Nicolescu, J. Carvalho and E. Hochbichler)

Traditionally, coppice forests were managed to provide wood material, with the main product having been firewood. Further common products were charcoal, basketry, sticks, fencing, mining timber, poles, pulpwood, and small-sized timber.

Recently, studies have shown that biomass can be economically harvested from traditional coppice forest systems using modern machines [47]. This makes coppice forests an interesting alternative source for obtaining woody biomass, for instance for energy or biochar production [37].

Short-rotation coppice (SRC, Figure 6) is another possible way of producing biomass for energy. Harvesting of SRC should be fully mechanized.

Non-wood products such as truffles and fungi, tanbark, wild forest fruits and honey from domesticated bees can also be obtained from coppice forests. Furthermore, in certain cases, coppice can be beneficial for the development of hunting game. The periodic felling creates opportunities for the development of ground vegetation, which provides food for herbivores.

Coppice forests are often described as "hotspots of biodiversity" [51]. The mix of young open and older closed-canopy stages promotes the diversity of fauna and flora (e.g. [11]). Habitat quality may be divergent, depending on current management practices.

Coppice with standards or over-matured (outgrown) coppice woodlands may, for instance, offer a large number of ecological niches as the stand structure tends to be heterogeneous and contain more deadwood [10]. The young open phases of the coppice cycle are beneficial to numerous light-demanding and thermophylous species. There is a significant interaction between coppice woodlands and the surrounding landscape in terms of habitat quality, as is shown in the case of bird communities [5]. Dense stands inhibit or limit the development of herbaceous ground vegetation and therefore decrease diversity of herb species after crown closure.

Coppice is an ancient form of forest management and so is part of Europe's historical and cultural heritage. It proved to be a very effective way of producing raw material for traditional uses. In many European regions, large woodland areas were coppiced in the past, but in the last 100 years many coppices have either been converted into high-forest or are abandoned and overaged.

Figure 6. Short rotation coppice (Photos: V.N. Nicolescu)

2 Coppice Forests and Their Silviculture

2.1 Simple coppice

Simple coppice is a forest management system in which trees are systematically and repetitively cut and regeneration is vegetative, by means of sprouting or suckering (often from the stump, alternatively from roots).

Simple coppice is applied especially on broadleaved tree species that can withstand repeated cutting, such as oaks, sweet chestnut, hornbeam, linden, eucalypts, ash, alders, black locust, poplars. European beech is less responsive to coppice [9] [21], so that the use of this tree species in simple coppices is less recommended. For birches, coppicing is possible if relatively short rotations (6-12 years) are applied. In these guidelines we are focusing on the most relevant tree species: oaks (Figure 7), beech, eucalypts, sweet chestnut, hornbeam, black locust, and silver birch.

The duration of rotations depends mainly on the species, re-sprouting ability, maximum productivity, targeted wood dimensions and local site conditions. Rotations are usually between 5 (willow osier) and 40 years (oak, hornbeam, beech), but can reach up to 60 years (alder). New shoots in this type of forest grow very fast at the beginning, as a result of their developed root system. Thus, the height and diameter increment culminates 20-30 years earlier than in forest originating from seeds, in accordance with local soil fertility and climate parameters (i.e. temperature, rainfall). The logged wood often has lower technical (industrial) wood quality, as it frequently includes knots, is curved in lower part of the trunk and may contain many technical defects.

As the majority of broadleaved species only re-sprout well until about 40 years after cutting, the rotation of stands treated as simple coppice generally ranges from 15 to 25 (30) years [24] [27]. Such stands produce small-diameter trees used for firewood, basket work, pea and bean sticks, hoops, hurdles, fascines, fencing, vine and hop poles, handles for tools and implements, pulpwood, etc. [34].

The rotation can be longer, usually up to around 35 years, if larger timber is desired. This is the case for oaks, sweet chestnut and black locust when the timber is produced for items such as wood barrels, flooring, mining timber, solid furniture [26] [42] [48] [49] [50].

There are many advantages of simple coppice:

- simple management
- low costs of natural regeneration
- low impact silvicultural interventions
- low vulnerability (wind throw, etc.)

However, many disadvantages also exist:

- unstable price of firewood
- high cutting/harvesting costs
- less market flexibility with lower product diversification potential

Silvicultural management / operations

The intensity and techniques of silvicultural interventions depend on the production goals. Both natural regeneration (shoot origin) and planting trees (seed origin) can be used to establish simple coppice stands. When using natural regeneration, 5 to 10 trees per ha

Figure 7. Holm oak simple coppice in Spain (Photo: P. Vericat)

should be left after cutting as potential seed trees. In artificial regeneration 1 to 3-year-old seedlings are planted with density of 1,000-1,500 ha^{-1} (eucalypts) or 4,000-5,000 ha^{-1} (black locust). These species are cut two years after planting. In the case of other species, such as sweet chestnut, the plants are cut 7-8 years after establishment.

Seedlings are also used to replace poorly sprouting or dying stumps. These operations can also be made by layering (chestnuts) and root suckering (black locust and lime). In managing eucalypts, fertilization is recommended after every harvest cut.

Between two coppice cuts, tending operations such as *cleaning-respacing* and *thinning* are sometimes required to improve productivity; they target the removal of unwanted species or individuals, improvement of the quality and quicker growth of final crop, and also produce small and medium-sized material that may increase financial return [34]. The number of these operations depends primarily on the rotation length, competition among shoots, and the wood market. For instance, in the black locust coppice stands of Hungary and Romania with rotations of 25-35 years, there are 1-2 cleaning-respacing and 1-2 thinning interventions [1] [42], compared to only 2 thinning in France [13]. In sweet chestnut coppices, the number of tending operations ranges from none in Britain [17] to 3 in Greece [8]. In eucalypt coppice there is only one thinning operation, 1 or 2 years after the cut.

Simple coppices reaching the rotation age are worked by the method of *annual coupes by area*, after deciding the rotation based on the size of material required. The total area treated as simple coppice is divided into annual coupes equal to the number of years in the rotation; each year, one coupe is coppiced. All material should be removed from the cutting area before flushing begins, so as to avoid damage to the fragile young shoots [16] [33] [46].

After repeated coppicing, stools begin to rot and die (Figure 8) and show a gradual decline in yield, so that the potential of producing young and vital shoots decreases with increasing age and shoot diameter [23] [26] [35].

In order to maintain high productivity, the stools should be replaced after 2-3 coppice cycles in temperate regions [33] [52]. However, from a biodiversity conservation perspective it is recommended to preserve the old stools as they contain many microhabitats and rare epiphytes.

Figure 8. Old sessile oak trees treated as coppice with a high density of cavities and decaying wood; less productive than vigorous young stools but with high conservation value (Photos: V.N. Nicolescu)

2.2. Pollarding

Pollarding consists of cutting the tops of trees as to stimulate production of numerous straight shoots on the top of the cut stem (Figure 9). The shoots grow out of reach of browsing animals and flooding waters, which are the two main reasons for this type of management. Most typical pollards exist today along riversides and meadows. The most common species used are poplars, ash, willows, plane-trees, beech, chestnut, mulberry, oaks, linden, elms, black locust, maples, hornbeam and hazel.

Traditionally, some species were pollarded for both wood and fodder production, while beech and oak pollards were used to produce small-sized wood. With the shift in demand from small-sized wood and fodder to larger industrial wood (trunks), this type of pollarding has gradually been abandoned, especially with beech and oak. Furthermore, pollarded trees often show low trunk quality (hollow trunks and rot holes due to the regular cutting) and lower diameter growth. Many of the pollarded oak trees that may be found in the landscape (e.g. Britain, Turkey, Sweden) indeed have hollow trunks as a result of this kind of cutting.

Pollarding was and still is used for park alley and garden trees, along streets, roadsides, and hop gardens. In certain regions (e.g. Portugal), pollarded plane-trees are used to hold cables and vine plants. In areas with long pastoral traditions (Basque Regions of France and Spain) or with large-scale silvo-pastoral systems (Spain, Portugal), pollarding is done at heights of 2.5 to 3 (3.5) m, well out of the reach of cattle and sheep.

The most important forestry use of the pollarding system is to stabilize the banks of rivers, streams, and ditches, mainly with willows and poplars. In this case, pollarding is done at heights between (1) 2 and 3 m - *above the highest flooding levels over a long chronosequence* - to

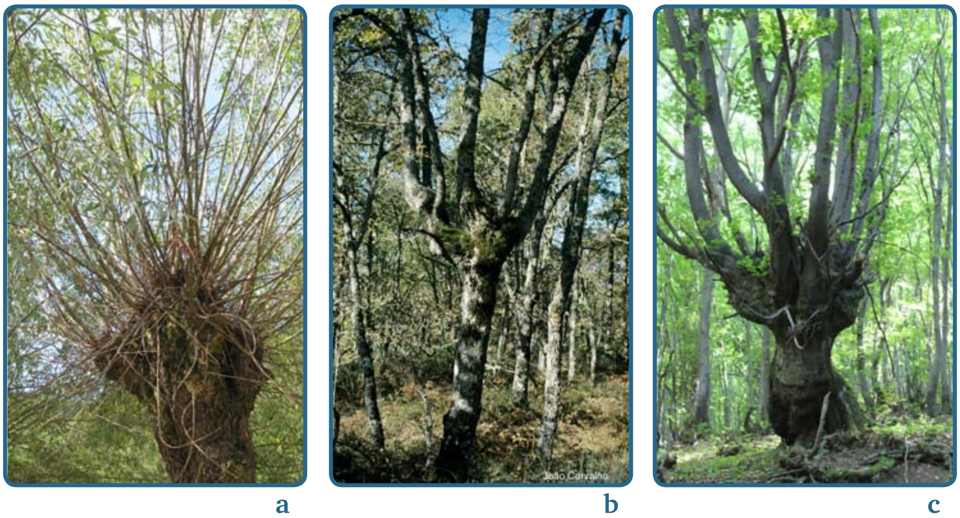


Figure 9. Repeatedly pollarded white willow (a), pedunculate oak (b) and European beech (c) (Photos: V.N. Nicolescu, J. Carvalho and O. Cardoso)

avoid any damage to the high stump caused by the flooding waters. In case of willow pollards, the cutting of shoots is carried out in the same way as simple coppice, especially during the winter. In time, after 2-3 cycles of cuts of 15-20 years, willow pollards begin to deteriorate (often becoming hollow) and the coppicing potential and vigour of shoots becoming increasingly reduced. Consequently, pollards are replaced with seedlings or so-called *rods*, which are (1 or) 2 m long and 3-5 cm thick, and that will be treated subsequently as pollards.

On the pollard tops, shoots are trimmed off periodically so that after this series of cuttings, the upper part of trunk looks like a reversed stump, sometimes called a 'chair' (Figure 10). After pollarding, many shoots may grow more or less vertically from the cut tree. These shoots may be subsequently thinned or left for self-thinning.

2.3 Coppice selection system

In a coppice selection system (CSS), a *target diameter* is fixed according to the size of aimed wood product, followed by an estimate of the age at which material of this size will be produced. This age determines the rotation, which is divided into a number of felling cycles (for instance: a rotation of 30 years includes three felling cycles of 10 years). The total area of forest under CSS is divided into annual coupes equal in number to the number of years in the felling cycle. Each year, coppice felling is carried out in one of the annual coupes [34]. Shoots of one to three (seldom four) ages coexist on the same stool, depending on the number of felling cycles in the rotation. Only shoots reaching the target diameter are cut, while the others are thinned.

The coppice selection system has historically been applied in certain parts of Europe, such as the Pyrenees, Apennines, Tessin Canton and the Balkan Peninsula, mainly in European beech and Holm oak forests (Figure 11).

In the case of European beech forests, the coppice selection system was commonly used in areas with poor soils and severe climatic conditions, where trees grow slowly. Under such

Figure 10. Pollarding of a narrow-leaved ash tree (Photo: J. Carvalho)

Figure 11. Coppice selection with European beech in Bosnia and Herzegovina (Photo: O. Cardoso)

conditions, the application of coppice selection system consisted of:

- Pyrenees: rotation of 30 years, with 2 felling cycles of 15 years or 3 of 10 years;
- Morvan Massif: rotation of 36 years, with 4 cycles of 9 years;
- Apennine Massif: rotation of 27-36 years, with 3 cycles of 9-12 years.

Two examples of coppice selection in European beech and Holm oak stands are depicted in Table 1.

Within the coppice selection stands, young shoots are better protected from frost, snow and grazing, due to the cover of older and largest shoots; apart from this, the soil remains permanently covered. Coppice selection is therefore interesting in the context of soil protection and habitat conservation. On the other hand, cutting at ground level is more difficult, it can damage smaller trees and the harvesting is more challenging and costly than clear-cutting.

When weighing these factors, this silvicultural system is considered to have more disadvantages than advantages, so that it has not been expanded outside the area where it was initially performed. Moreover, in cases of CSS with low productivity and vitality, these have been converted to high forests or selection forests, an example of which are the pure beech stands in Croatia.

2.4 Coppice with standards

Coppice with standards (CWS) is a silvicultural system in which selected stems are retained, i.e. *standards*, at each coppice harvest to form an uneven-aged overstorey that is removed selectively on a rotation consisting of a multiple of the coppice rotation [30].

Such stands are "the oldest form of irregular forest" [22], and comprise of two distinct elements [6] [16] [31] [33] (Figure 12):

(a) A lower, even-aged storey (*underwood*), originating from shoots and treated as coppice. This storey plays an *economic* role (produces small and medium-sized timber, used especially as firewood), as well as a *cultural* role (protects the soil and the trunks of standards in the upper storey).

Table 1. Two examples of coppice selection systems used in Europe

Species	Region	Cutting technique	Rotation, felling cycle and products	Further information	Ref.
European beech	Italian Alps, Apennines, regions of Piemonte & Tuscany	Selection coppice (uneven-aged coppice) The largest trees are cut, the smaller are thinned	Rotation: 6-12 years Total cycle: 36 years Firewood, charcoal	1-2 shoots are kept per stump Current use is limited; Trend: convert to high forest	[15] [38]
Oak & hornbeam	Central & Western Europe (France, Belgium, Germany)	Even-aged coppice layer below: mainly hornbeam, hazel & field maple Uneven aged standards above: mainly oak (*Q. robur* & *Q. petraea*)	Rotation: 8-15 years (up to 30 years) for the coppice; Selective felling of standard trees at every rotation (standard age = 2-6 rotations)	Prescribed stem numbers and shares of different age classes in the standards	[3] [7] [39] [43] [54]

Figure 12. Coppice with standards in Austria (Photo: E. Hochbichler)

(b) An upper, uneven-aged storey (*overwood*) composed of taller but scattered trees (*standards*), originating from both shoots and seeds, distributed as uniformly as possible and treated as high forest. It is also has *economic* (produces a certain proportion of large timber) and *cultural* roles (provides seeds for natural regeneration) [14] [19] [40].

To establish a CWS stand, one first determines the age of the coppice rotation, then the following operations are carried out [39] [18] [19]:

1. Once the rotation age ***r*** (usually 20-25 years) has been reached, the coppice stand is clear cut as simple coppice, while reserving a certain number of a desired species in good form and increment as standards.

2. After another simple coppice rotation of 20-25 years, the great majority of standards of ***2r*** (40-50 years) are again reserved, extracting those that have deteriorated or are slow-growing. The majority of individuals are removed from the coppice storey, while a certain number of trees are reserved as second cohort of standards ***r***.

3. The same operation is repeated regularly for several coppice rotations of ***r*** years so the coupe about to be felled consist of coppice aged ***r*** years together with standards aged ***2r***, ***3r***, ***4r***... years, and a number of young prospective standards, aged ***r*** years.

Standards should originate from seed or, if not possible, from young and vigorous shoots, already individualized from the stool, or from root suckers. The trees reserved as standards should: originate from valuable and light-demanding species; have tall, large, balanced and open crowns; be wind-firm and; be scattered as regularly as possible [2] [6] [16] [33].

In CWS, standards are tall, but with shorter boles than high forest trees, and have wide and large crowns [19] [44] [50] – Figure 13). On the other hand, diameter increments are often considerably higher than in high forests.

The most recommended broadleaved standards are oaks, elms and ash. Other important species are sycamore, Norway maple, wild cherry, wild service tree, service tree, black walnut [6] [14] [33] [36]. European beech is not well-suited, mainly because of its tendency to sun scorch when isolated, in addition to its densely foliaged crowns, which casts a large shadow that negatively affects the growth of the coppice storey [6] [45] [52].

The number of standards in a CWS at a certain moment has evolved from a minimum of 16 young trees/ha (Flanders, 16th century [54]) or 30 trees/ha (Britain, 1543 [17]) to 40-50 trees/ha (France, Forest Law of 1827 [4]) or even 100 trees/ha (Germany [16]).

a b

Figure 13. Oak standards in Austria (a) & France (b) (Photos: E. Hochbichler and J. Carvalho)

Nowadays, the proposed number of standards is 50-100 trees/ha for all age classes; the number of standards in each age class should be about half of the number in the age class immediately younger. For instance, in a stand with 100 standards/ha, there can be 50 standards in age class I (youngest), 30 in age class II, 13 in age class III, and 7 in age class IV (oldest) [26]. Hochbichler [28] [29] has developed stem number guidelines for different overwood cover percentages. The number of standards ranges between 82 and 163 trees/ha before cut in relation to an overwood canopy cover of 33% and 66% [target diameter of 60 cm; moderate sites; height of the overwood: 18-20 m; rotation: 30 years].

The rotations adopted for standards, "that should be reserved as long as they are healthy, vigorous, and growing sustainably" [36] reaches: silver birch from 40-60 years [28]; wild cherry (40) 50-70 years [19] [28] [36]; ash, elms, *Acer* sp. 75 (90)-100 years [19] [28] [36]; *Sorbus* sp. 50-70 years [19] [36] to 80-120 years [28]; oaks 100-130 years [17] [22] [28].

The **underwood** (coppice storey) in CWS consists of a mixture of species coppicing vigorously, able to withstand the shadow of standards (i.e. at least semi-shade tolerant species), and producing firewood [31] [45]. The most recommended species for underwood are hornbeam, field maple, European beech, linden, sweet chestnut, hazel [19] [27] [31] [45] [46] [52] [18]. The rotations of underwood used to be between 8 and 15 years, but are nowadays 20-30 years [7] [20] [28].

In CWS, the silvicultural operations to carry out depend on the stand storey:

(a) Underwood: release cutting, cleaning-respacing and 1-2 thinning(s); the latter operation if it is considered necessary to prepare the standards for their life after the cutting of coppice storey [40].

(b) Standards: Removal of epicormic branches along the stems (especially of pedunculate oak) that receive a surplus of light after the cutting of coppice storey [2] [9] [33]. These branches should be maximum 3 cm in diameter and the recommended season for cutting is before the beginning of a new growing season. Dead and dying branches, as well as those that are too long, should be also removed.

3 Conversion of Coppice Forests to High Forests

There are numerous reasons for coppice conversion, such as a change in management objectives or the targeted yield products (firewood vs. industrial wood), or concerns related to soil protection, conservation and landscape.

The most common conversions applied in European forests are (a) from simple coppice to either coppice with standards or high forests and (b) from coppice with standards to high forests.

There are currently two ways of achieving this aim: *direct* and *indirect* conversion. The former manages shoots of species already in the area, whereas the latter entails removing all species in the area and planting new species that are considered appropriate.

Some methods of *direct conversion* and *indirect conversion* are described in the following:

3.1 Direct conversion

In this case, the transition from simple coppice to high forest does not involve another silvicultural system. The method of direct conversion includes (i) *conversion by ageing* (conversion by full cessation of simple coppice cuttings), (ii) *mixed conversion* (conversion by partial cessation of simple coppice cuttings), and (iii) *conversion by replacement/restoration*.

(i) Conversion by ageing (conversion by full cessation of simple coppice cuttings): This is considered a *passive* procedure of conversion, where the simple coppice is no longer cut so that stands reach a maturity in which they are able to regenerate naturally by seed. During the waiting period, tending operations (e.g., cleaning, thinning) are applied depending on the stage of development. These interventions are halted after 60-80 years, after which silvicultural systems typical to high forests can be applied in order to regenerate the stands naturally by seed.

Conversion by ageing is applicable to healthy, vigorous and productive simple coppice stands, with full canopy cover, in which the target species are found in high proportion and the soil conditions are favourable to natural regeneration by seed. However, this method of conversion creates at least three problems:

- It takes many decades, depriving the forest owner from all income for quite a long period of time.
- The method is limited to the situation described above ("healthy, vigorous and productive simple coppice stands...").
- The method does not improve the age-class distribution of stands.

Due to the issues mentioned above, conversion by ageing has been abandoned since the 19th century in countries such as France, having been replaced by the so-called *method of selection*, or *intensive management of crop trees* (fr. *balivage intensif*), at least in vigorous stands that are rich in valuable broadleaved tree species. This is an *active* type of conversion and includes:

- Selection and paint marking of crop trees (originating from stump shoots or, preferably, from seeds). These should be vigorous, of good quality and as evenly spaced as possible.
- Initial application of high thinning in favour of crop trees. The subsequent thinnings are heavy and concentrated around the vigorous and valuable crop trees, in order to provide them with a "free-growth" state at crown level. This state will favour high wood production and the beginning of a rich seed production, supporting the conversion towards high forest at relatively young ages.

(ii) Mixed conversion (conversion by partial cessation of simple coppice cuttings): This is a *partially passive* method that targets the normalization of age-class structure of stands. In this respect, every 10 years a part of simple coppice stands are no longer exploited and are left to grow older in order to produce industrial wood, while the rest of the stands are treated as simple coppice. Proceeding in this fashion, the area of simple coppiced stands continuously decreases until they cease to exist, while the area covered with high forests increases and these stands form successive age classes.

(iii) Conversion by replacement: Is an *active* method that is usually used in degraded simple coppice stands that have a low proportion of valuable tree species, low canopy cover, low productivity, old stumps and low potential of natural regeneration by seed, compacted and fallow soils, etc.

The restoration of such coppice stands for their conversion to high forest can be done by:

- Clear-cutting, followed by planting, mostly of conifer tree species, such as pines or Norway spruce.
- Clear-cutting, followed by manual/mechanical seeding of species such as oaks.
- Use of high forest silvicultural systems, such as uniform shelterwood cutting (Figure 14).

Figure 14. Successive stages of conversion by using the uniform shelterwood system; holm oak stand in Croatia (Photos: T. Dubravac)

3.2 Indirect conversion

This method removes all current species and introduces new species to the area. It requires assessing each new species in order to ensure that it is appropriate for the local habitat.

This practice is widely practiced in artificial forests. For example, shoots of valuable tree species, such as beech and oaks, that are lost due to damage, may have been replaced by low value species (such as hornbeam, cranberry, shrubs). These undesired species must be removed from what were once oak and beech forests; subsequently, the soil is prepared and beech and oak seedlings are planted and tended.

This method can also be applied to coppice with standards (Figure 15). In this case, when cutting the coppice storey of 20-30 years, a high number of standards (500-600 trees per ha or even more) are left standing, while extracting the older standards of ***3r*** and ***4r*** ages if necessary. The conversion cutting begins 30 years after the selection of standards, when such trees are already 60 years of age (***2r***) and can produce seeds needed for natural regeneration.

Figure 15. Indirect conversion of a mixed broadleaved simple coppice to coppice with standards in Austria (Photo: E. Hochbichler)

4 Restoration of Coppice Forests

Restoration is particularly recommended in cases where vegetation cover has declined and can no longer be defined as forest. This can result from a variety of causes, such as inappropriate harvesting operations, poor silvicultural management, illegal logging, excessive grazing, or disturbances such as fires, wind throws, wind breaks, etc. In some regions, for example the Mediterranean, restoration can prevent further ecological site degradation, such as soil loss and the prevention of bare karst formation. It is important to remember that the formation of soil is particularly slow in such conditions (i.e. very slow organic matter turnover). It is this protective function that is the primary driver for this type of intervention; after a disturbance the interventions should be carried out quickly in order to stop the degradation process.

Degraded coppice forests have low soil fertility, poor soil structure, high risk of erosion and an insufficient number of seed trees. The prerequisite for a successful restoration is the removal of the predominant negative influence(s) that initiated the degradation (e.g., browsing, fires, etc.). This is a complex and expensive activity that is not possible when negative forces cannot be prevented effectively.

As with conversion, there are two types of restoration: *active* and *passive*. Planting (in groups or clusters) or sowing are the most commonly used methods in active restoration. Passive restoration allows for natural colonisation and successional processes to occur.

Proper species selection is essential in order to better suit degraded soil conditions and serve as a climate adaptation strategy. Appropriately selected tree species lower the possibility of degradation initiated by climate disturbances (e.g. fires, wind throw) occuring in the future. Climate change-induced disturbances, such as droughts, can directly affect the planting success during restoration, especially in the Mediterranean region.

Some specific cases of restoration of coppice forests are described below.

4.1 Aged / abandoned / neglected simple coppices

In aged/abandoned simple coppice forests (Figure 16) there is a need for a detailed survey of the sprouting ability of remaining stumps after cutting.

It is generally thought that the possibility to use remaining stumps for natural regeneration is rather low, although current research shows that some tree species (e.g., oaks, sweet chestnut) have a long-lasting sprouting ability, even as aged trees. It is recommended that the restoration of coppicing is done gradually, i.e. not cutting all shoots of the stool at once, but leaving a number of younger, vigorous shoots (sap suckers) that will enhance the re-sprouting. If re-sprouting is successful, all shoots can be cut again when reaching the rotation age [41]. If the sprouting (especially the production of stump shoots) is not satisfactory, additional planting and sowing should follow the cut.

Figure 16. Neglected simple coppice stand of *Quercus faginea* in Spain (Photo: M. Piqué-Nicolau)

4.2 Neglected pollard trees

Pollard trees that have been neglected due to social-economic changes are of high ecological and cultural value; they should be conserved and, if possible, restored. They can be an important seed source for natural regeneration. On the other hand, one result of neglect can be that the large crowns hinder the growth of younger regeneration after sowing/planting. In this case, shade-tolerant species should be used as a coppice layer, resulting in a specific type of coppice with standards, or a pollarded wood pasture [12] [41]. Such forests have a lower wood production potential but may be of high ecological and landscape value.

The restoration of neglected pollards can be done by cutting the shoots. A good idea would be to plant a new pollard next to the old one that will eventually replace it.

4.3 Abandoned coppice with standards

Another need for restoration arises in abandoned coppice with standards, which possess an unbalanced CWS structure due to the prolongation of the underwood's rotation age. The prescription of restoration activities depends on (i) the number of adequate, quality overwood trees per hectare, as well as (ii) the regeneration ability of (former) underwood trees. If there are enough high quality trees in the overwood (20-40 individuals/ha), the cut of the coppice should be combined with a selective cut in the overstory in order to provide enough light for re-sprouting. The harvesting of standards should be done carefully in order to minimise damage to the coppice stools. In case there is a lack of natural regeneration by seed, the high stump sprouting ability should be utilised, along with the planting or sowing of valuable tree species for the overwood.

References

1. Anonymous 2000. *Norme tehnice pentru îngrijirea și conducerea arboretelor 2.* București: Ministerul Apelor, Pădurilor şi Protecţiei Mediului.
2. Bagneris, G. 1878. *Éléments de Sylviculture. 2ème édition.* Nancy: Imprimerie Berger-Levrault et Cie.
3. Bary-Lenger, A. and Nebout, J-P., 1993. *Le chêne. Les chênes pédonculé et sessile en France et en Belgique. Écologie, économie, histoire, sylviculture.* Editions du Perron, Liège.
4. Bastien, Y. 1999. *Les modes de traitement des forêts.* Nancy: Ecole Nationale du Génie Rural, des Eaux et des Forêts.
5. Berg, Å. 2002. *Breeding birds in short-rotation coppices on farmland in central Sweden—the importance of Salix height and adjacent habitats.* Agriculture, Ecosystems & Environment 90, pp. 265-276.
6. Boppe, L. 1889. *Traité de Sylviculture.* Paris et Nancy: Berger-Levrault et Cie, Libraires-Éditeurs.
7. Boudru, M. 1989. *Forêt et sylviculture: traitement des forêts.* Gembloux: Les Presses Agronomiques de Gembloux.
8. Bourgeois, C. 1991. *Le châtaignier de la montagne sacrée.* Forêt-entreprise 4, pp. 40.
9. Broilliard, Ch. 1881. *Le traitement des bois en France à l'usage des particuliers.* Paris et Nancy: Berger-Levrault et Cie, Libraires-Éditeurs.
10. Bruckman, V. J., Yan, S., Hochbichler, E. and Glatzel, G. 2011. *Carbon pools and temporal dynamics along a rotation period in Quercus dominated high forest and coppice with standards stands.* Forest Ecology and Management 262, pp. 1853-1862.
11. Buckley, G. P. 1992. *Ecology and management of coppice woodlands.* London and New York: Chapman & Hall.
12. Cantero, A., Passola, G., Aragon, A., de Francesco, M., Mugarza, V. and Riano, P. 2015. *Notes on pollards. Best practices' guide for pollarding.* EU-LIFE project TRASMOCHOS, www.trasmochos.net.
13. Carbonnière, T., Debenne, J-N., Merzeau, D. and Rault, M. 2007. *Le robinier en Aquitaine.* Forêt-entreprise 177, pp. 13-17.
14. Chivulescu, Th. 1886. *Catehismul silvicultorului. Noțiuni de silvicultură (generalități)*. București: Tipografia proprietari F. Göbl şi Fii.
15. Coppini, M. and Hermanin, L. 2007. *Restoration of selective beech coppices: A case study in the Appenines (Italy).* Forest Ecology and Management 249, pp. 18-27.
16. Cotta, H. 1841. *Principes fundamentaux de la science forestière. 2ème édition corrigée.* Paris: Bouchard-Huzard and Nancy: George-Grimblot, Thomas et Raybois.
17. Crowther, R.E. and Evans, J. 1984. *Coppice.* Forestry Commission Leaflet 83. London: HMSO.
18. Dengler, A. 1935. *Waldbau auf ökologischer Grundlage. Ein Lehr- und Handbuch.* Berlin: Verlag von Julius Springer.
19. Drăcea, M.D. 1942. *Curs de Silvicultură. Vol. I. Regime și tratamente.* București: Editura Politehnicei.
20. Dubourdieu, J. 1997. *Manuel d'aménagement forestier.* Technique & Documentation, Paris: Lavoisier.

21. Fankhauser, F. 1921. *Guide pratique de Sylviculture. Troisième édition.* Lausanne et Genève: Librairie Payot et Cie.

22. Garfitt, J.E. 1995. *Natural management of woods: continuous cover forestry.* New York-Chichester-Toronto-Brisbane-Singapore: Research Studies Ltd.; Taunton, England: John Wiley & Sons Inc.

23. Hamilton, L. 2000. *Managing coppice in Eucalypt plantations.* Agriculture Notes no. 0814, Kingston: State of Victoria, Department of Primary Industries.

24. Hamm J. 1900. *Leitsätze für den Mittelwaldbetrieb.* Forstwissenschaftliches Centralblatt, 8, pp. 392-404.

25. Harmer, R. 1995. *Management of coppice stools.* Research Information Note 259. Wrecclesham, Alice Holt Lodge: The Forestry Authority Research Division.

26. Harmer, R., and Howe, J. 2003. *The silviculture and management of coppice woodlands.* Edinburgh: Forestry Commission.

27. Hartig, G. 1877. *Lehrbuch für Förster. II Band.* Stuttgart: J.G. Cott'sche Buchhandlung.

28. Hochbichler, E. 2008. *Fallstudien zur Struktur, Produktion und Bewirtschaftung von Mittelwäldern im Osten Österreichs (Weinviertel).* Österr. Gesellschaft für Waldökosystemforschung und experimentelle Baumforschung an der Universität für Bodenkultur, Forstliche Schriftenreihe 20.

29. Hochbichler, E. 2009. *Coppice forestry in Austria.* In: *Forest, Wildlife and Wood Sciences for Society Development - Conference proceedings* (eds. Marusak, R., Kratochvilova, Z., Trnkova, E. and Hajnala, M.), Czech University of Life Sciences in Prague, Faculty of Forestry and Wood Sciences, pp. 19-35.

30. IUFRO 2005. *Multilingual pocket glossary of forest terms and definitions.* IUFRO SilvaVoc Terminology Project, IUFRO, Vienna, 96 p.

31. Jolyet, A. 1916. *Traité pratique de Sylviculture. 2e édition*. Paris: Librairie J.-B. Baillière et Fils.

32. Kneifl, M., Kadavy, J. and Knott, R. 2011. *Gross value yield potential of coppice, high forest and model conversion of high forest to coppice on best sites.* Journal of Forest Science 57(12), pp. 536-546.

33. Lorentz, B. and Parade, A. 1867. *Cours élémentaire de culture des bois. 5-ème édition.* Paris: Mme Ve Bouchard-Huzard and Nancy: Nicolas Grosjean.

34. Matthews, J.D. 1991. *Silvicultural systems*. Oxford: Clarendon Press.

35. Matula, R., Svátek, M., Kůrová, J., Úradniček, L., Kadavý, J. and Kneifl., M. 2012. *The sprouting ability of the main tree species in Central European coppices: implications for coppice restoration.* European Journal of Forest Research 131, pp. 1501-1511.

36. Muel, E. 1884. *Notions de Sylviculture.* Paris: Ducher et Cie, Editeurs.

37. Nicolescu, V.N., Hochbichler, E. and Bruckman, V. 2016. *Sustainable biomass potentials from coppice forests for pyrolysis: chances and limitations*. In: Bruckman, V.J., Apaydın-Varol, E., Uzun, B.B. and Liu J. (eds.) *Biochar - A Regional Supply Chain Approach in View of Climate Change Mitigation*, Cambridge University Press, Cambridge, pp. 139-161.

38. Nocentini, S. 2009. *Structure and management of beech (Fagus sylvatica L.) forests in Italy.* iForest - Biogeosciences and Forestry 2, 105-113.

39. Poskin, A. 1934. *Le chêne pédonculé et le chêne sessile – leur culture en Belgique.* Duculot, Gembloux.

40. Rădulescu, A. and Vlad, I. 1955. Regime şi tratamente. In: *Manualul Inginerului Forestier 80 - Cultura pădurilor și Bazele naturalistice*, București: Editura Tehnică, pp. 471-511.

41. Read, H. 2000. *Veteran trees: A guide to good management.* English Nature.

42. Rédei, K., Veperdi, I., Osváth-Bujtás, Z., Bagaméry, G., and Barna, T. 2007. *La gestion du robinier en Hongrie.* Forêt-entreprise, 177, pp. 44-49.

43. Rubner, H. 1960. *Die Hainbuche in Mittel- und West-Europa. Untersuchungen über ihre urspringlichen Standorte und ihre Forderung durch die Mittelwaldwirtschaft. Forschungen fur Deutschen Landeskunde 121.* Selbstverlag der bundesanstalt für Landeskunde und Raumforschung, Bad Godesberg.

44. Savill, P.S. 1993. *Coppice and coppice-with-standards.* Oxford: Oxford Forestry Institute.

45. Schwappach, A. 1904. *Forestry*. London: The Temple Primers.

46. Schwappach, A., Eckstein, K., Herrmann, E. and Borgmann, W. 1914. *Manual silvic. Partea a V-a Cultura pădurilor.* București: Alfred Baer.

47. Spinelli, R., Ebone, A. and Gianella, M. 2014. *Biomass production from traditional coppice management in northern Italy.* Biomass and Bioenergy 62, pp. 68-73.

48. Stähr, F. 2013. *Renaissance and global utilisation of the coppice system – Is the historical silvicultural system „coppice forest" topical again?* Available at: www.hnee.de/staehrVortrag-EKonferenz-englisch-Konferenzband(1).pdf [Accessed 10 September 2013]

49. Stajic, B., Zlatanov, T., Velichkov, I., Dubravac, T. and Trajkov, P. 2009. *Past and recent coppice forest management in some regions of south eastern Europe.* Silva Balcanica, 10(1), pp. 9-19.

50. Starr, C. 2008. *Woodland management. A practical guide.* Ramsbury: The Crowood Press.

51. Terada, T., Yokohari, M., Bolthouse, J. and Tanaka, N. 2010. *Refueling Satoyama Woodland restoration in Japan: Enhancing restoration practice and experiences through woodfuel utilization*. Nature and Culture, 5, pp. 251-276.

52. Troup, R.S. 1928. *Silvicultural systems.* Oxford: Clarendon Press.

53. UN/ECE-FAO 2000. *Forest resources of Europe, CIS, North America, Australia, Japan and New Zealand. Main Report.* Geneva: Geneva Timber and Forest Study Papers 17.

54. Vandekerkhove, K., Baeté, H., van der Aa, B., de Keersmaeker, L., Thomaes, A., Leyman, A. and Verheyen, K. 2016. *500 years of coppice-with-standards in Meerdaal Forest (Central Belgium).* iForest Biogeosciences and Forestry, 9, pp. 509-517.

55. Zlatanov, T. and Lexer, M.J. 2009. *Coppice forestry in south-eastern Europe: problems and future prospects.* Silva Balcanica 10(1), pp. 5-8.

Annex

List of common and scientific names of tree species used in the guidelines

Common name	Scientific name
Alder	*Alnus* sp.
• Black	*A. glutinosa*
• Grey	*A. incana*
Ash	*Fraxinus* sp.
• Common	*F. excelsior*
• Narrow-leaved	*F. angustifolia*
Beech	*Fagus* sp.
• European	*F. sylvatica*
• Southern European	*F. moesica*
Birch	*Betula* sp.
• Silver	*B. pendula*
• Pubescent	*B. pubescens*
Cherry	
• Wild (sweet)	*Prunus avium*
Chestnut	
• Sweet	*Castanea sativa*
Elm	*Ulmus* sp.
• Field	*U. campestris*
Eucalypt	*Eucalyptus* sp.
Hazel	*Corylus avellana*
Hornbeam	*Carpinus* sp.
• European	*C. betulus*
• Oriental	*C. orientalis*
Linden	*Tilia* sp.
• Small-leaved	*T. cordata*
• Silver	*T. tomentosa*
Locust	*Robinia* sp.
• Black	*R. pseudoacacia*

Common name	Scientific name
Strawberry tree	*Arbutus unedo*
Maple	*Acer* sp.
• Norway	*A. platanoides*
• Field	*A. campestre*
• Sycamore	*A. pseudoplatanus*
Mulberry	*Morus* sp.
Oak	*Quercus* sp.
• Holm	*Q. ilex*
• Hungarian	*Q. frainetto*
• pedunculate	*Q. robur*
• pubescent	*Q. pubescens*
• Pyrenean	*Q. pyrenaica*
• Sessile	*Q. petraea*
• Turkey	*Q. cerris*
Plane tree	*Platanus* sp.
Poplar	*Populus* sp.
• black	*P. nigra*
• trembling, aspen	*P. tremula*
• hybrid	*P. x euramericana*
• white	*P. alba*
Service tree	*Sorbus* sp.
• wild	*S. torminalis*
• common	*S. domestica*
Walnut	
• black	*Juglans nigra*
Willow	*Salix* sp.
• osier, white	*S. alba*

Two Potentially Invasive Tree Species of Coppice Forests: *Ailanthus altissima* and *Robinia pseudoacacia*

Alexander Fehér and Gheorghe F. Borlea

Introduction

Biological invasions lead to ecosystem degradation and threaten biodiversity and related ecosystem services. The two trees species that are most likely to invade coppice forests are *Ailanthus altissima* and *Robinia pseudoacacia*.

While *Robinia* is at times itself considered a species suitable for coppice management, *Ailanthus* is almost solely considered invasive in Europe. The latter is rarely cultivated, with only a few exceptions of Short Rotation Forestry management in Mediterranean countries (Bianco et al. 2014).

Despite the invasive nature of these two species, both also have certain uses and advantages. Along with providing a description of the general characteristics of *A. altissima* and *R. pseudoacacia*, this article will address some of these negative and positive aspects.

Ailanthus altissima

Species and Range

The *Ailanthus* genus (*Simaroubaceae* family) comprises tree species distributed in the Middle East and the Far East, but its only temperate zone representative is the tree of heaven or sky-tree (*Ailanthus altissima*). One of the other species, *Ailanthus confucii*, was native to Europe in the Tertiary (Eocene-Pliocene). *A. altissima* is native to Northern-Central China (in the Yangtze River regions), Northern Vietnam and North Korea. It was introduced to Europe and the United States in 1784, with its recent secondary range covering almost the whole of Europe, and it has spread to new areas of Asia, Africa, South America and Australia. The common names refer to the species' ability to grow up to 30 m high, as well as its outstanding fertility and competitive ability, especially on poor soils and in polluted air. The species can invade as seedlings or ramets derived from one or more individuals, forming concentric patches (clumps) in open grazing areas, forest gaps and clearcuts, including coppice (Knapp and Canham 2000, Call and Nilsen 2003). In some European countries (e.g. Greece), it is common in hedgerows surrounding arable lands and in adjacent wetlands, but quite rare in shrublands, grasslands and forests (!) (Fotiadis et al. 2011).

Ecology

A single tree can produce more than 2 million seeds, some of which are persistent. It also has a powerful ability to sprout without damage; its suckering and clumping system is impressive, capable of extending to more than 100 m in diameter. *A. altissima* is less successful in heavily canopied forests (high forests), but coppicing, cultivation, browsing or any natural disturbance (e.g. frost, fire, stem or root damage) will stimulate its expansion and colonisation. Any vegetative propagules can set adventitious shoots and roots, and *A. altissima* has many seed dispersal mechanisms: wind (medium dispersal distance 120 m), water, birds, rodents and human agencies (people or machinery).

Corresponding Author: Alexander Fehér, alexander.feher@uniag.sk

The species can tolerate pollution and poor site conditions, being indifferent to soil fertility, and it can adapt to a broad range of natural and artificial soils, including barren rocky layers, sandy or clay loams, dry calcareous and shallow soils, artificial deposits of gravel, sand and other materials, saline soils (roots can be submerged in sea water), as well as acidic and alkaline soils. It can withstand conditions in most urban and industrial areas, but it is sensitive to ozone (Gravano et al. 2003).

It has a large ring-porous wood structure with which water is rapidly transferred from its roots to its leaves and, conversely, it can reduce transpiration on hot days by summer branch drop (Kowarik 1983, Harris 1983, Lepart et al. 1991). It effectively reduces water loss by stomatal closure and lowered root hydraulic conductance (Trifilo et al. 2004). Two-year-old seedlings develop coarse, lateral, unbranched and widely spreading roots up to 2 m long. *A. altissima* is classified as a shade-intolerant, early successional species (Knapp and Canham, 2000). Delayed hard frosts may cause injury to young plants and to the upper shoots of older plants; however, it can survive temperatures as low as -35 °C. The tree has allelopathic properties in bark extracts, leaves, and seeds etc. due to flavonoid substances such as acacetin, apagenin etc. (Udvardy 2008). The direct influence of secondary metabolites of *Ailanthus* on biodiversity in natural ecosystems has been questioned by Mihoc et al. (2015).

Figure 1. Canopied, uncut coppice forest (left), and *A. altissima* growing in a clearing (right), Bábsky Les, Slovakia (Photo: Fehér 2015)

The forest understoreys of *A. altissima* are usually species-poor and rather cosmopolitan in character; its root sucker density negatively correlates with floristic richness (e.g. in France: Motard et al. 2011).

No significant natural enemies are known for *A. altissima*, but mistletoe (*Viscum album*) can cause its death. A rare decline in *Ailanthus altissima* was reported from Styria (Austria), where both older (35 year-old) and young trees were infected with agricultural soil microfungi (*Verticillium* sp., *Phomopsis ailanthi, Nectria coccinea, Fusarium* sp. and *Verticillium* sp.), causing dieback of branches in the upper crown, with bark necroses extending down the stem (Maschek and Halmschlager 2018).

Case Study

Description

In our case study, the invasive behaviour of *A. altissima* was studied after making clearings in an aged oak-hornbeam coppice forest in Bábsky les (Slovakia) in 2015 and 2016. Each of the three sample plots measured 400 m^2:

A : clearing made in 2006,

B : clearing made in 2014, and

C : canopied coppice forest in process of aging at present – the uncut control (Fig. 1).

Observations

The herb layer of the two studied clearings (A and B) was dominated by nitrophilous species, with *Sambucus ebulus* and *Galium aparine* together forming almost 100% cover.

After spontaneously invading, *A. altissima* outcompeted the native apophytic and synanthropic forest species through allelopathy and nitrogen accumulation, dramatically changing the species composition. In **area A**, the phytocoenological relevée had the highest abundance of the following species: *A. altissima, Sambucus ebulus, Galium aparine, Geum urbanum,* *Mercurialis perennis, Pulmonaria officinalis* and *Urtica dioica*. In **area B**, most abundant were *A. altissima, Quercus cerris, Carpinus betulus, Galium odoratum* and *M. perennis*, while in **area C** *Q. cerris* and *Acer campestre* were dominant. The behaviour of different species depended on the nature of the competition. In **area B**, *M. perennis* had a different seasonal optimum than *A. altissima*; *S. ebulus* (when simultaneously cut with *A. altissima*) re-grew more quickly than *A. altissima* but *G. aparine* and *Bromus benekenii* disappeared under dominant *A. altissima*. In **area A**, *Hedera helix* and *Clematis vitalba* spread, but *Melica uniflora* and *G. aparine* disappeared when *A. altissima* dominated (Fehér et al. 2017, unpubl.). Plant communities of clearings in the same forests were also studied by Pilková (2014), who related the species composition to different environmental conditions of water, nutrients, light, continentality, soil reaction and temperature (Fig. 2).

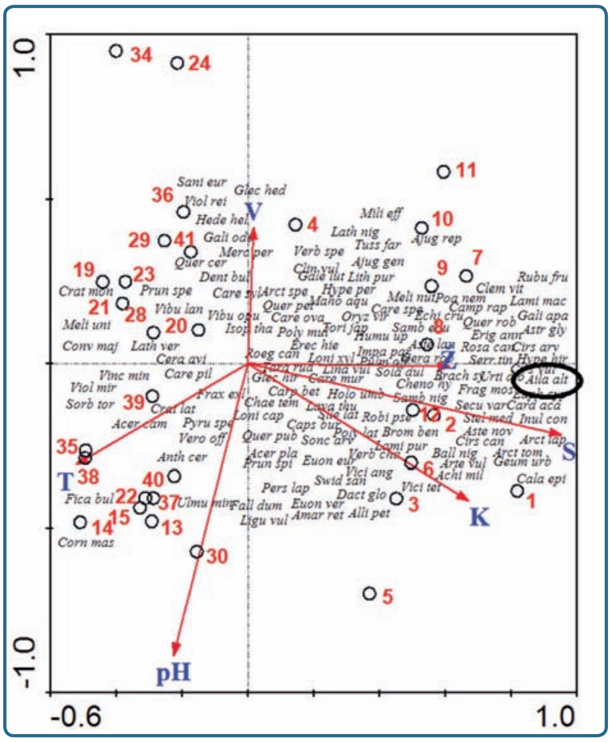


Figure 2. Occurrence of *Ailanthus altissima* is interrelated with nutrients and light (Pilková 2014, modified by Fehér). Ellenberg values: V - water, Ž - nutrients, S - light, K - continentality, pH - soil reaction, T - temperature

Management

To control *A. altissima* is quite problematic: for example, prescribed fire during the dormant season had a limited impact on its distribution (Rebbeck et al. 2017). Short-term mechanical and chemical treatment combinations did not reduce the number of resprouts over a five year period, although resprout biomass was reduced. Nevertheless, the long-term control of *A. altissima* resprouting was efficient, mainly as a result of reduced above-ground and below-ground growth; cutting alone, however, did not reduce it significantly. Some herbicides can be used to treat *A. altissima* but the required effect is poor (http://rvm.cas.psu.edu). The best control strategy is repeated and combined mechanical-chemical treatment.

Conclusion

We can conclude that the presence of *Ailanthus altissima* in forests influences the species composition and structure of ecosystems, as well as the services provided by them. Sladonja et al. (2015) have carried out a detailed assessment of the disadvantages and advantages of the species: In terms of potential biological threat, *A. altissima* has a high invasive potential (fast growth and regeneration, allelopathy, high resistance to pollution and tolerates a wide range of environmental conditions), causes a decrease of biodiversity (i.e. replaces natural flora), is toxic and causes allergic reactions and dermatitis. On the other hand, it can provide certain ecosystem services, such as provisional services (pharmaceutical use, honey production, timber, paper, essential oils etc.), regulating services (erosion control, land reclamation etc.), cultural services (ornamental use, shade etc.) and supporting services (nutrient cycling, soil formation etc.). The extract from *A. altissima* is an antioxidant, antimicrobial and phytotoxic, having anticancer properties and is source of ailanthone (quassinoids), which has potential in treating malaria, HIV etc.

Robinia pseudoacacia

Species and Range

The second invasive plant, black locust (*Robinia pseudoacacia*), belongs to the family *Fabaceae*. Approximately 20 species of *Robinia* are known in North and Central America, the majority being shrubs. The *Robinia* genus was present in geohistorical Europe (Eocene-Miocene) (Keeler 1990). *R. pseudoacacia* is native to the Eastern part of North America where it has a patchy distribution, the most important being in the Appalachian Mountains (Cierjacks et al. 2013). It has become common in many parts of the world, including almost the whole of Europe (mainly Central and South-East), Asia, North and South Africa, South America, Australia and New Zealand. There are more than 3 million ha of plantations worldwide (Hanover et al. 1991). In Europe, other species of the genus are quite rare (e.g. *R. viscosa* and *R. hispida*).

Ecology

R. pseudoacacia is a tree that can reach over 30 m in height and can live for well over 200 years. The root system is strong and produces suckers with root nodules that can fix nitrogen (at c. 30 kg of N year^{-1} ha^{-1}) and it can adapt well to the local soil conditions. The species grows well on sand dunes and alkaline soils and tolerates drought, but cannot survive in anaerobic soils with stagnant water. Although young plants can tolerate shade, older trees require light.

Figure 4. *R. pseudoacacia* coppice a few years after the selection of stems, Romania (Photo: Fehér 2015)

Figure 3. *Robinia pseudoacacia* coppice stand, Slovakia (Photo: Fehér 2015)

Seeds remain on the tree for a long time (even until the following year) and a single individual can produce 15.000-17.000 seeds per year. Seed production increases exponentially with age; a 50-year-old stand can produce 1 billion seeds ha^{-1} year^{-1}. The seeds are dispersed by wind and endozoochory. Germination is limited by a hard episperm, so that only a portion of the current year's seed may germinate annually; seeds in the soil seed bank can remain viable for over 40 years (Bartha et al. 2008). Abiotic factors, such as low temperature, can damage the seed perisperm and may limit seed germination. Young seedlings can grow up to 1 m tall in the first year; flowering occurs after five years. Vegetative propagation is sometimes dominant, arising either from the stem or root suckers. Its "rope-like roots" can be as long as 20 m. Due to this excellent vegetative propensity, coppicing is the most common form of management (Fig. 3 & 4).

Alliances

Stands of *R. pseudoacacia* are usually mono-dominant, but mixed forests are formed when they invade other forests (eg. oak forests, Fig. 5). The ground flora of *Robinia* forest is rich in nitrophilous plants, such as *Chelidonium majus, Ballota nigra* and *G. aparine*. Within the

Figure 5. Mixed aged oak-horbeam coppice forest invaded by *R. pseudoacacia*, Slovakia (Photo: Fehér 2010)

Rhamno-Prunetea class we can distinguish three alliances with *R. pseudoacacia*:

1. *Chelidonio majoris-Robinion pseudoacaciae* monodominant mesic groves with a well developed shrub layer and the associations *Chelidonio majoris-Robinietum pseudoacaciae* and *Poa nemoralis-Robinietum pseudoacaciae*;

2. *Balloto nigrae-Robinion pseudoacaciae* woodlands in dry, sandy habitats with grass-dominated herb layers and the association *Arrhenathero elatioris-Robinietum pseudoacaciae* and

3. *Euphorbio cyparissiae-Robinion pseudoacaciae* stands on dry shallow soils, with the association *Melico transsilvanicae-Robinietum pseudoacaciae* (Chytrý 2013).

Distribution, Management & Use in Europe

In Europe, the best ecological conditions for *R. pseudoacacia* are in the Central-East, due to its continentality. Most production of black locust is in Hungary, where it covers 22-24 % of all forests (two-thirds of which are of coppice origin). About 50 years ago, Hungary had more black locust forests than all other European countries put together (Frank et al. 2017; "Hungary" report in Chapter 6 of this volume).

The new Hungarian forest act (Act 2009 XXXVII) allows for the coppicing of black locust. Different technologies are used, such as afforestation with deep loosening, trenching or deep ploughing, or semi-natural reforestation with root suckers and man-made reforestation using deep loosening or complete soil preparation (Frank et al. 2017). Rarely, the trees are also pollarded (e.g. Slovakia, Fig. 6). In Hungary, the tree is often defined as a national treasure or cultural heritage ("Hungaricum") and the majority of foresters and the local population disagree with the dominant European perception of an "invasive plant to be removed". The Hungarian understanding of the species is exemplified by the following statement: "The economic viability of biomass production by black locust has been debated many times ... but established in a multi-purpose, ecocycle-based agricultural system where its invasive character is carefully controlled and its usefulness is fully utilised (applying even clone selection for site-adaptation and best possible performance), both environmental sustainability and profitability should be guaranteed." (Némethy et al. 2017). In other Central and Eastern European countries (Slovakia, Romania etc.) new plantations are rarely established, but old plantations are maintained. A very productive variety with distinct features was described in Southern Romania. The profitability of black locust as short rotation coppice can be questionable (Stolarski et al. 2017) but it can be ecologically and environmentally attractive in previous mining and agricultural areas (Carl et al. 2017).

Figure 6. Pollarded *Robinia pseudoacacia* trees along a lane, Slovakia (Photo: Fehér 2010)

In the rest of Europe, *Robinia* is not planted, or only rarely, for example to limit soil erosion on sand dunes and hill slopes. The species is one of the most important melliferous trees (half of the Hungarian honey production originates from the black locust) and it produces excellent fuelwood, garden furniture and raw material for pulp. It can be important for soil improvement and N fixation, and for the phytoremediation of heavy metals and polycyclic aromatic hydrocarbons. Forests create shelter for wildlife, and parts of the plant can be eaten. The fresh flowers, for example, were traditionally consumed in Hungary, Slovakia and Romania, and sometimes still are today. The seeds are likely edible as well, although some authors label them as toxic since most parts of the tree contain toxalbumin and other toxins. Black locust also has medicinal properties (e.g. as an antispasmodic, emollient, diuretic and laxative). *R. pseudoacacia* is fast growing when young and resistant to harmful pests and diseases. It tolerates pollution well, but prevents natural succession processes and reduces local biodiversity. When it colonises an area, it changes the habitat radically through allelopathy, N fixation, altered water balance and shading, etc.) and it is almost impossible to control. The prescribed control strategy is a combination of mechanical and chemical treatments (for a minimum of 3 years), but new seedlings will emerge from the soil seed bank for many years afterwards.

Discussion

It is challenging to compare the invasive competition of *A. altissima* with *R. pseudoacacia*. Although *R. pseudoacacia* originally arrived earlier than *A. altissima*, the latter was able to spread at a faster rate over a period of 30 years (Radtke et al. 2013). During the coppice cycle of native species, both *Ailanthus* and *Robinia* can invade synchronously and successfully colonise fresh clear-cuts. Coppice management, consisting of repeated clear cuttings every 20-30 years, favours this spread. In the United States, Call (2002) observed that *A. altissima* and the native *R. pseudoacacia* were frequently found on disturbed sites and presented similar growth and reproductive characteristics, yet each had distinct functional roles, such as allelopathy and nitrogen fixation. *A. altissima* was the better competitor in mixed plantations; it consistently produced larger above- and below-ground relative yields. Locally, increased disturbances could lead to more opportunities for *A. altissima* to invade and negatively interact with *R. pseudoacacia*, besides replacing the native species.

We can conclude that both *A. altissima* and *R. pseudoacacia* are successful invaders that have become naturalised in many temperate regions. They are good competitors in relation to other trees and understory herbs in coppice forests, forest gaps and clear cuts (Tab. 1). They outcompete the local forest vegetation communities protected in NATURA 2000, and have a negative impact on biodiversity. NATURA 2000 habitats that are endangered by invasions of these species include 9170 *Galio-Carpinetum* oak-hornbeam forests, 91G0 Pannonic woods with *Quercus petraea* and *Carpinus betulus* and 91H0 Pannonian woods with *Quercus pubescens* etc. (Viceníková and Polák 2003). In other countries, the occurrence of either *A. altissima* or *R. pseudoacacia* is used as a criterion to assess the state of the NATURA 2000 habitat condition (Polák and Saxa, 2005). Nevertheless, in some European countries black locust is considered important both culturally and economically, and is well accepted and understood to be part of the cultural heritage. Such countries are interested in its future preservation (mainly in Hungary),

Table 1. Attributes of invasive behaviour in *Ailanthus altissima* and *Robinia pseudoacacia*

Attributes of invasive behaviour	*Ailanthus altissima*	*Robinia pseudoaccacia*
early flowering maturity	3-4 y	5 y
flowers are easily pollinated by insects	yes	yes
no danger of late frosts	yes	yes
very prolific annual fruiting and sprouting	yes	yes
easy propagule dispersion by wind, water, animals, hazards	yes	yes
successful natural regeneration	yes	yes
rapid rooting and growth	yes	yes
successful vegetative propagation by adventitious buds	yes	yes
allelopathic substances inhibit growth of other seedlings and herbs	yes	yes
no important pests and parasites or predators	yes	yes
high tolerance of climatic conditions, pollution and infertile soils	yes	yes
seeds preserve their germination ability for a long time	yes	yes
nitrogen accumulation in the soil	yes	yes
expected life span	c. 150 y	c. 250 y

but in others this is debated (eg. Romania, Slovakia). Coppice regimes should take into careful consideration the invasive potential of both species, especially in the continental climates of Central and Eastern Europe. A positive ecological utilisation of both species is also possible, such as the phytoremediation of soils contaminated by heavy metals (e.g. Cudic et al. 2016).

References

Bartha, D., Csiszár, Á., Zsigmond, V. 2008. Black locust (Robinia pseudoacacia L.). In Botta-Dukát, Z., Balogh, L. eds., *The most important invasive plants in Hungary*. Institute of Ecology and Botany – Hungarian Academy and Sciences, Vácrátót, pp. 63-76.

Bianco P., Ciccarese L., Jacomini C., and Pellegrino P. 2014. *Impacts of short rotation forestry plantations on environments and landscape in Mediterranean basin*. Rapporti 196/14. ISPRA – Istituto Superiore per la Protezione e la Ricerca Ambientale, Roma: 115 ISBN 978-88-448-0618-7

Call L.J. 2002. *Analysis of intraspecific and intraspecific interactions between invasive exostic tree-of-heaven (Aillanthus altissima) and the native black locust (Robinia pseudoaccacia)*. Master thesis, Virginia Polytechnic institute and State University, p 25-32

Call L. J., Nilsen E. T. 2003. *Analysis of Spatial Patterns and Spatial Association between the Invasive Tree-of-Heaven (Ailanthus altissima) and the Native Black Locust (Robinia pseudoacacia)*. American Midland Naturalist, Vol. 150, No. 1 (Jul., 2003), pp. 1-14

Carl, C., Biber, P., Landgraf, D., Buras, A., Pretzsch, H. 2017. *Allometric models to predict aboveground woody biomass of black locust (Robinia pseudoacacia L.) in short rotation coppice in provious mining and agricultural areas in Germany.* Forests, 8: 9.

Chytrý, M. ed. 2013. *Vegetace České republiky 4. Lesní a křovinná vegetace*. Vegetation of the Czech Republic 4. Forest and scrub vegetation. Academia, Praha.

Cierjacks A, Kowarik I, Joshi J, Hempel S, Ristow M, et al. 2013. *Biological Flora of the British Isles: Robinia pseudoacacia*. Journal of Ecology 101: 1623–1640

Cudic, V., Stojiljkovic, D., Jovovic, A. 2016. *Phytoremediation potential of wild plants growing on soil contaminated with heavy metals.* Arhiv za Higijenu Rada i Toksikologiju – Archives of Industrial Hygiene and Toxicology, 67: 229-239.

Fehér, A., Halmova, D., Koncekova, L., Borlea, G.F. 2016. *Coppice forest and invasive species: the case of Ailanthus altissima, a successful survivor in Eastern and Central Europe*. Unpublished manuscript, pp. 1–14.

Fotiadis, G., Kyriazopoulos, A.P., Fraggakis, I. 2011. *The behaviour of Ailanthus altissima weed and its effects on natural ecosystems*. Journal of Environmental Ecology, 32: 801-806.

Frank, N., Folcz, Á., Molnár, D. 2017. Hungary. In Nicolescu, V.-N. et al. eds, *National perspectives on coppice from 35 EuroCoppice member countries*. COST – Albert Ludwig Univesity, Freiburg, pp. 32-34.

Hanover J.W., Mebrathu T., Bloese P., 1991. *Genetic improvement of black locust: a prime agroforestry species*. Forestry Chronicle 67, 227-231

Harris P.T., Cannon G.H., Smith N.E., Muth N.Z.. 2013. *Assessment of plant community restoration following tree-of-heaven (Ailanthus altissima) control by Verticillium albo-atrum.* Biol Invas 15: 1887–1893.

Keeler, H. L. 1990. *Our native trees and how to identify them*. New York. Charles Scribner's Sons. pp 97-102

Knapp L.B., C.D. Canham C. D., 2000. *Invasion of an old growth forest in New York by Ailanthus altissima: Sapling growth and recruitment in canopy gaps*. J. Torrey Bot. Soc. 127:307–315.

Kowarik I. 1983. *Zur Einbürgerung und zum pflanzengeographishen Verhalten des Götterbaumes (Ailanthus altissima (Mill.) Swinge) im französischen Mittelmeergebiet (Bas-Languedoc)*. Phytocoenologia 11: 389–405.

Lepart J., Debussche M., 1991. *Invasion processes as related to succession and disturbance. Biogeography of mediterranean invasions*. In: Groves RH, Castri F di (eds.). Cambridge, UK: Cambridge University Press, 159-177.

Maschek O., Halmschlager E., 2018. *Effects of Verticillium nonalfalfae on Ailanthus altissima and associated indigenous and invasive tree species in eastern Austria.* European Journal of Forest Research, Volume 137, Number 2, 197-209

Mihoc, C., Bostan C., Maria, A., Constantinescu, T., Borlea, F. 2015. *The influence of Ailanthus altissima (P. Mill.) secondary metabolites on biodiversity in natural ecosystems*. Journal of Biotechnology, 208: S110-S110.

Motard, E., Muratet, A., Clair-Maczulajtys, D., Machon, N. 2011. *Does the invasive species Ailanthus altissima threaten floristic diversity of temperate pen-urban forests?* Comptes Rendus Biologies, 334: 872-879.

Némethy, S., Dinya, L., Bujdosó, Z., Zádori, I., 2017. Black locust (Robinia pseudoacacia) a multipurpose tree – invasive but useful. In Prčík, M. ed.*, Fast-growing trees and plants growing for energy purposes*. *Working material*. Slovak University of Agriculture, Nitra, pp. 17-17.

Pilková, I. 2014. *Štruktúra a dynamika lesnej vegetácie modelového územia Báb. Dizertačná práca.* KEE FPV UKF, Nitra.

Polák, P., Saxa, A. 2005. *Priaznivý stav biotopov a druhov európskeho významu. Manuál k programom starostlivosti* NATURA 2000. ŠOP SR, Banská Bystrica.

Radtke, A., Ambrass, S., Zerbe, S., Tonon, G., Fontana, V., Ammer, C. 2013. *Traditional coppice forest management drives the invasion of Ailanthus altissima and Robinia pseudoacacia into decidious forests*. Forest Ecology and Management, 291: 308-317.

Rebbeck, J., Hutchinson, T., Iverson, L., Yaussy, D., Fox, T. 2017. *Distribution and demographics of Ailanthsu altissima in an oak forest landscape managed with timber harvesting and prescribed fire*. Forest Ecology and Management, 401: 233-241.

Sladonja, B., Sušek, M., Guillermic, J. 2015. *Review on invasive tree of heaven (Ailanthus altissima (Mill.) Swingle) conflicting values: assessment of its ecosystem services and potential biological threat*. Environmental Management, 56: 1009-1034.

Stolarski, M.J., Olba-Ziety, E., Rosenqvist, H., Krzyzaniak, M. 2017. *Economic efficiency of willow, poplar and black locust production using different soil amendments.* Biomass and Bioenergy, 106: 74-82.

Trifilo P., Raimondo F., Nardini A., Gullo M.L., Salleo S. 2004. *Drought resistance of Ailanthus altissima: root hydraulics and water relations*. Tree Physiol 24:107–114.

Udvardy, L. 2008. Tree of heaven (Ailanthus altissima (Mill.) Swingle). In Botta-Dukát, Z., Balogh, L. eds., *The most important invasive plants in Hungary*. Institute of Ecology and Botany – Hungarian Academy and Sciences, Vácrátót, pp. 121-127.

Viceníková, A., Polák, P. eds. 2003. *Európsky významné biotopy na Slovensku.* ŠOP SR, Banská Bystrica.

Active Management of Traditional Coppice Forests: An Interface Between Silviculture and Operations

João Carvalho, Natascia Magagnotti, Valeriu-Norocel Nicolescu,
Philippe Ruch, Raffaele Spinelli and Eduardo Tolosana

Coppice and Coppice Silviculture

Coppice is a forest regenerated from vegetative shoots that originate from the stump and/or from the roots, depending on the species.

The potential of producing shoots depends on the species, tree age, season of cutting, site conditions and other factors. Most broadleaved tree species (e.g. oaks, sweet chestnut, linden, willows, poplars, hornbeam, elms, alders, black locust, eucalypts, etc.) produce shoots and can be treated as coppice.

There are different forms of coppice forests: simple coppice, coppice with standards, coppice selection and pollarding (examples in Fig. 1).

Coppice forests can provide many different products and services, such as wood and non-wood products, biodiversity, protection and heritage ecosystem services.

Approximately 16% of all productive forests in Europe are classified as coppice, covering a total area of ca. 23 million ha. These are mainly located in the far west, south and south-eastern parts of the continent. Over half of European coppice forests are situated in industrialized countries, such as France, Italy and Spain.

Since the renewal of coppice stands depends on active human intervention, abandonment is the greatest threat to the existence of coppice. The widespread abandonment that has occurred within the past century is a result of the social and economic transformation of European society, which has made traditional coppicing practices less profitable in many countries.

Converting coppice forest to high forest is an approach used to attempt to increase owner revenues and maintain active management. In some circumstances, this approach has been driven by subsidies or legal requirements. Such instruments do not, however, always achieve desirable results: Conversion requires suitable site, species and market conditions, and should not be generalized.

Under certain economic conditions there has been the opposite effect, where coppice has been degraded through overexploitation. The restoration of such coppice forests is possible and has been performed in some parts of Europe.

A new and interesting opportunity for expanding the active management of coppice stands is offered by the modern bio-economy, which is generating a large and sustained demand for biomass feedstock. Coppice management can supply this market with significant amounts of wood if the production can be achieved at competitive cost.

Coppice forests are acknowledged for providing important amenity, cultural and environmental services with the potential to generate greater revenues in the future.

Figure 1. Example of simple coppice (left) and pollarding (right) (Photo: V.N. Nicolescu)

Corresponding Author: Natascia Magagnotti, magagnotti@ivalsa.cnr.it

Coppice Products and Operations

Many wood products can be obtained from coppice forests, such as firewood, biomass chips, fencing, assorted and industrial wood (pulp, panels, tannin etc.). Coppice also offers a variety of non-wood forest products, such as truffles, mushrooms and honey.

The market for these products can be local, regional and even international. Niche markets are also available for traditional small-scale products, such as baskets and crafts.

The industrial scale of some markets (pulpwood, panels, biomass etc.) offers great opportunities for reviving active coppice management. These specific markets require a high production capacity in order to supply large amounts of wood (Fig. 2).

Figure 2. Mechanized felling and bunching in a eucalypt coppice (Photo: E. Tolosana)

High production capacity is only achievable through the increased mechanization of harvest operations, which would also help to compensate for the effects of the high cost of labour and the labour shortages that are being experienced in most industrialized countries.

Technological progress has made possible the effective introduction of mechanized felling to coppice operations (Fig. 3), significantly increasing worker safety and productivity. Professional management of mechanized harvesting can prevent or minimize undesired effects, such as soil, stump and stand damage.

The productivity of motor-manual and mechanized harvesting improves with increasing tree size and harvest intensity. Productivity is also higher on flat lands and gentle slopes than on rough terrain. Long extraction distances have a negative impact on harvesting costs.

When harvesting is mechanized, the amount of wood removed must be large enough to offset the high fixed cost of transporting machines to the worksite.

Specific harvesting techniques and equipment (whole-tree harvesting, bundling, chipping, etc.) are required for the supply of feedstock to the biomass sector (Fig. 4).

Work safety has become a priority across Europe, and the accident rate and severity in mechanized felling is much lower compared with the motor-manual option.

Figure 3. Mechanized felling and processing (Photo: P. Ruch)

Figure 4. Coppice harvesting residues are chipped into renewable fuel (Photo: E. Tolosana)

Considerations for Active Coppice Management

Active coppice management should be sustainable in all terms (economic, ecological, social), but also requires financial viability in the absence of subsidies or other financial aid. The total area of coppice forests in Europe is so large that subsidies can only be directed towards special cases.

Silvicultural prescriptions should be formulated in such a way that their practical implementation is easy and cost-effective.

The coppice silvicultural system and rotation should be chosen depending on the species and the requirements of the local, regional, national or international markets.

Abandoned, neglected or overexploited coppice forests are likely to degrade and may not fully (re-)cover their functions. Such degraded forests should be restored by using different techniques, which are seldom cost-effective and, thus, require subsidization.

Figure 5. Processor and yarder (Photo: R. Spinelli)

The financial viability of the commercial harvest of coppice in industrialized economies requires that a minimum amount of wood is removed and that a certain harvest intensity is applied. The combination of these two conditions determines the minimum harvest area. At the same time, there are maximum limits for harvest area that should not be exceeded, in order to preserve the ecological, protection and aesthetic functions of coppice forests.

Figure 6. Cable yarder extraction is the best solution when site conditions are not favourable to machine access (Photo: R. Spinelli)

Wherever labour costs are high, selective and low-intensity thinning incurs net operation losses. Mechanization can, however, increase the productivity, profitability and safety of coppice management operations. It can also compensate for the decreasing availability of rural labour in some regions. Mechanized harvesting requires specific work conditions and involves specific risks (Fig. 5 & 6).

Aside from the general conditions for successful operation, mechanization also requires sufficient annual utilization to depreciate the large capital outlay. If coppice rejuvenation is not impeded, then one may consider extending the cutting season beyond traditional practice. This is an important prerequisite when cutting is mechanized and the equipment can only be used in coppice forests.

Generally, the quality of cut in mechanized felling is poorer than that of motor-manual felling (Fig. 7). If poor cut quality compromises coppice re-sprouting and/or growth, then remedial action should be taken. On the other hand, if no adverse consequences are experienced on coppice re-sprouting and/or growth, then some tolerance for poor cut quality is advocated.

The unregulated access of machinery to the forest may result in damage to stumps, residual trees, advanced regeneration and soil. Therefore, preventive measures must be taken, especially when site conditions are unfavorable.

Whole-tree harvesting may negatively affect soil fertility, especially on poor sites and when leaves are also removed from the site. Therefore, whole-tree harvesting should be applied with caution, after a careful evaluation of site conditions and of potential undesired effects.

Figure 7. Motor-manual felling (Photo: R. Spinelli)

Concluding Statements

Coppice forests are an important renewable resource for Europe, with a large potential for providing products and services that have, thus far, only been used to a small extent.

The new awareness of the potential of coppice forests together with the existing and future markets for renewable biomass offer an ideal opportunity for reviving active coppice management.

Unlocking the full potential of coppice forests requires a strong connection between silviculture and forest operations.

3 Utilisation

Getting down to business.

What products can be produced?

How are the different types of coppice harvested?

What are the impacts of different harvesting methods on soil?

Visit this chapter for:

Coppice products

Guidelines for coppice utilization

Impacts on soil relating to coppice harvesting operations

Coppice Products

Natascia Magagnotti, Janine Schweier, Raffaele Spinelli, Eduardo Tolosana, Paula Jylhä, Ivan Sopushynskyy, Pavol Otepka, Ljupco Nestorovski, Mário Costa, Abel Rodriguez, David Rossney, Philippe Ruch, Petros Tsioras, Karl Stampfer, Matevž Mihelič, Nike Krajnc, Vasillaq Mine, Piotr Mederski and Andrew McEwan

Introduction

Coppice is a traditional form of forest management that has been widely practiced in Europe since ancient times. Some studies quoted that, in the Mediterranean area, coppiced forests were already established in the Etruscan-Roman period (Matthews 1989, Gabbrielli 2006).

The management system relies on the ability of broadleaved tree species to regenerate quickly from cut stumps and root systems following felling. Both the size of felled area and periods between felling vary depending on the silvicultural needs of different species and local economic factors.

Typical rotation lengths and species in different countries are detailed in the table below.

Coppice management usually provides a regular supply of small dimension material after just a few years of growth. The continued popularity of this type of forest management may be attributed to a relative ease of management and the fact that it is still possible to practice coppicing satisfactorily without large capital investment. Farmers and loggers can cut stools with simple and affordable tools, obtaining products that can serve multiple purposes. The felled stems are often small enough to be easy

Table 1. Most common rotation ages and species in some European Countries (compiled based on the experience of report authors)

Country	Rotation (Years)	Species
Finland	5 - 6	Willows
Slovakia	10 - 30	Birch, Oak spp.
Portugal	12 - 30	Chestnut, Eucalypt, Oak spp.
Italy	12 - 40	Beech, Chestnut, Oak spp., Hornbeam
Spain	15 - 30	Beech, Chestnut, Oak spp.
United Kingdom	10 - 50	Ash, Birch, Chestnut, Hornbeam
Greece	10 - 50	Beech, Chestnut, Oak spp.
Albania	10 - 60	Arbutus, Oak spp.
France	10 - 60	Beech, Chestnut, Hornbeam, Oak spp.
Macedonia	30 - 60	Ash, Beech, Oak spp., Hornbeam
Slovenia	30 - 60	Beech, Chestnut, Robinia
Ukraine	30 - 60	Ash, Alder, Beech, Birch, Oak spp.
Poland	60	Alder

Corresponding author: Natascia Magagnotti, magagnotti@ivalsa.cnr.it

to handle manually, with simple/low specification mechanized forestry systems or with tools already in use on the farm or for other purposes (i.e tractors, trailers, horses, etc.). Furthermore, coppiced forests are usually harvested during winter and this fits well with the work timetable of farmers.

The final harvest of a mature coppice forest commonly yields between 90 and 200 m^3/ha, depending on species, age and site productivity. Stems cut in coppice stands are generally transformed into small-size assortments. Average stem size varies between 0.05 and 0.25 m^3.

Historical and Current Trends

Coppice forest management increased with demographic growth during the 17th-19th centuries and with early industrialization (iron industry, glass factories, tile and lime kilns) which created high demand for firewood and charcoal, especially if coal was not locally available (Parde 1991, Woronoff 1990).

In the past century, with the widespread use of other energy sources such as gas and oil and the use of posts and poles made of concrete or from coniferous species, coppicing entered a period of decline and many coppiced forests became neglected. Furthermore, the migration of people from villages to towns contributed to the abandonment of rural areas and consequently also of the forests.

Now, due to higher fossil fuel prices and efforts to replace fossil fuels by CO_2 neutral renewable energy, there is once again a strong demand for relatively cheap fuel wood. However, this increase is only in part a demand for traditional small-scale firewood; it also includes large commercial operations that supply both domestic and industrial biomass markets.

There is also an increasing demand for 'environmentally friendly' materials for use in agriculture, horticulture and in bioengineering, such as soil and bank protection, which means that coppice products have a 'second chance' to satisfy these needs.

The general trends of coppice over the past centuries can be summarised as long-term growth, a period of short-term decline and, currently, recent revival.

Wood Products

Firewood

Firewood was the first source of fuel and has always been used for heating, cooking and lighting. Historically, small diameter trees were cut for fuelwood and species more useful for building purposes were conserved. Firewood was never completely surplanted by fossil fuels and it enjoyed a revival in recent years with the increasingly severe oil crisis (Warsco 1994). In fact, Europe still uses more traditional firewood than any other industrial energy wood product (Nybakk et al. 2003). In total, Europe consumes over 100 million solid m^3 of firewood per year, about twice as much as US and Canada put together (FAO 2007).

The production of firewood exceeds 17% of the total wood production in Norway, whereas in Finland and Sweden the level is nearer 10%. In Central Europe, firewood production reaches up to 50% of the total wood production (e.g. Hungary 52%) and in some Southern European countries it reaches more than 70% (e.g. Italy 70%, Greece 72%) (EUROSTAT 2015).

Firewood consumption reached 22 million m^3 solid in France (Elyakime and Cabanettes 2013), about 2.5 million m^3 in Spain, 18 million m^3 in Italy (Caserini et al. 2008) and Slovenian households used about 1.1 million m^3 of firewood every year (Čebul et al. 2011).

Figure 1. Firewood from coppice: piled at the roadside, near the forest and ready for transport (on the left) and split thereafter (right) (Photos: Ivalsa)

Firewood (Figure 1) is extracted from the forest in different lengths, from 2 to 6 m in northern Europe, and from 1 to 2 m in southern Europe, due to the different extraction methods (Magagnotti et al. 2012, Zimbalatti and Proto 2009). It is sold to consumers both as round-wood and as split logs in different lengths (typically 25-30-50 cm or 1-2 m billets).

Most common species used for firewood are beech, oak spp., black locust, hornbeam, ash and alder. Traditionally, chestnut has not been popular as firewood for an open fire because of its tendency to crack and spit during the burning process. Nowadays, with the modern enclosed fireplaces and downdraft boilers, these disadvantages are not as relevant; chestnut has become more widely used, especially since it is more readily available and the price is lower compared to other species.

Firewood has a strong presence in today's markets. In the future a possible slow decline is predicted due to wood stoves and boilers with high energy efficiency and the replacement of solid wood with the new technologically-advanced user-friendly wood-based fuels, namely wood chips and pellets.

Charcoal

Charcoal is produced from hardwoods, such as oak, beech, birch, hornbeam, by pyrolysis and is a porous solid fuel having a high calorific value (31MJ/kg). Therefore, the combustion of charcoal gives off high heat, without flames. The main advantage of the product is that the combustion emits no harmful emissions (tar, tannins, methane, etc.). These qualities have led to the product being widely used for domestic purposes: charcoal is popular choice for outdoor cooking.

In former times, charcoal was produced directly in the forest and you can still find small flat spaces in coppice forests where the simple earth kilns were operated. It is suitable for a large variety of domestic and industrial uses. As "active coal" it is also used as an absorbent material in filters and as a reducing agent in metallurgy. It can easily be transported and stored.

Nowadays charcoal represents a minor market in the EU, although there are exceptions. In the Carpathian mountains of Ukraine, there are notable examples of industrial charcoal-making operations, developed for the export markets over the past 5 years, and currently turning over 0.5 million m^3 of wood into charcoal. Traditional production methods can also be revived to link cultural heritage with tourism; in Slovenia, for example, a private forest owner cooperative successfully markets traditionally produced charcoal as a cultural product, for use in outdoor cooking, while the local municipality offers tourists the opportunity to experience this traditional activity.

Chips

Wood chips are wood particles with a length of 2-5 cm, a width of 2-3 cm and a thickness of few millimetres (Figure 2). Chipping is a common way to process woody biomass from coppice woodland, mainly processing the residues and non-firewood species. The efficiency of the operations is determined by appropriate chipper selection and work techniques (Figure 3). Generally, chips are obtained from forest residues like branches and tops while trunks are used for firewood or poles. This holds true as long as the prices for firewood or poles are higher than the price for chips.

Species such as poplar or willow from short rotation coppice that do not have an alternative market are ideal for chip production.

Figure 2. Example of wood chips

Figure 3. Chipper working at the landing, chipping coppice wood

Figure 4. Chestnut poles that have been debarked and sharpened (Photos: Ivalsa)

Chipping has the potential not only to increase the total harvest through a better utilization of the available above ground biomass, but also gives a solution to the problem of residue management (Pottie and Guimier 1985, Asikainen and Pulkkinen 1998). The demand for chips is linked to the uptake of modern boilers and power stations that are more efficient and have lower emission rates than traditional stoves (Strehler 2000).

Industrial Roundwood

Coppiced beech and chestnut from France and Spain is used in industries producing paper, board and panel materials. In 2014, approximately 4.4 million m^3 of industrial hardwood was used in France (two pulpwood factories in France, as well as one in Belgium, plus about 10 panel and board factories) (Agreste 2014). Eucalypt from Spain, Portugal and South Africa is used in many pulp and paper mills.

Poles, Posts and Other Fencing Assortments

Traditionally, the three coppice species chestnut, oak and black locust have been preferred to produce posts and poles because of their natural resistance to decay, which is particularly important for materials that have contact with the ground. With increasing environmental awareness and concerns regarding the use of chemicals for preserving softwood species, these coppiced alternatives are becoming popular once more (Figure 4).

Larger diameter poles are used in land consolidation works, such as revetments and can be durable for up to 50 years, while small diameter poles are used for gardens and small holdings. Chestnut poles have been used in vineyards since ancient time.

Even today there is an industrial scale production of vineyard poles in Italy, regionally concentrated close to wine-producing areas. It is heavily modernised to remain competitive with alternatives such as concrete, steel and impregnated softwood.

UK and France have extensive experience in splitting bigger coppice boles to produce fencing materials, but many other types of fencing also exist (Figure 5).

Production of oak poles and similar assortments is limited because the price for firewood from oaks is high compared to other species.

Construction, Furniture and Flooring

Boles of larger dimension from oak and black locust are used as sawnwood for the production of outdoor furniture and solid wood for indoor furniture. A new development is the production of parquet flooring (Fonti and Giudici, 2002) with high resistance and beautiful colour in two main products: the so-called "mosaic" and "laminated, ready to lay". Chestnut wood is also used for outside decking thanks to its resistance to weather conditions.

In Austria, cherry from 40 year old coppice forests is used to make high value furniture. In Poland, long rotation coppice alder is used to produce high quality plywood.

Craft Products

A number of other wooden objects can be obtained by material from coppice forests. In most cases they are made by artisans as locally produced handicraft souvenirs and include items such as baskets, walking sticks, carvings, sculptures, toys and eating utensils (plates, spoons, etc).

Figure 5. Example of fencing in the field (Photo: Ivalsa)

Non Wood Products

Coppice forests can provide many non wood forest products with great potential and market. For extensive research on non wood forest products in general, see COST Action FP1203 "European non-wood forest products" (www.nwfps.eu).

Some examples of non wood products from coppice forests are:

Honey and Beeswax

Honey (Figure 6) is used as sweetener in many recipes and as a spread, but also in medical traditions to treat wounds and coughs. Honey is also the main ingredient in an alcoholic beverage called mead. Honey is mainly from chestnut, black locust, eucalypt and linden. Honey and beeswax are used in the cosmetic and pharmaceutical industries as well.

Mushrooms and Truffles

Many edible mushrooms grow in association with chestnut or oaks – including truffles (*Tuber* spp.) and porcinis (*Boletus edulis*), both highly prized in many countries as side dish, or with rice, pasta and meat. Truffle oil is a delicacy made from high quality olive oil infused with concentrated truffles (mainly black winter truffles).

Figure 6. Honey produced in *Salix* coppice stands; prepared as a taste-testing to compare different honey types (Photo: D. Lazdina)

Fruit

Local fruits and nuts are harvested from coppice woodland on a small local scale and can be important to some communities.

Traditional Medical Herbs

Some non wood products are used as medicinal herbs in the Ukraine and the Republic of Macedonia.

Game

The habitats provided by managed coppice forests are ideal for many animal and plant species that are adapted to particular levels of open space and shade. Some game species also find the habitats suitable, so coppice is often exploited for rearing and hunting.

Biochemicals

Tannin is utilized mainly from chestnut and oaks. It is prepared by hot water extraction of the bark and timber, followed by spray-drying of the solution. Vegetable tannin was used for leather production, but its use has decreased since the 1950s because of synthetic tannins. Nowadays its characteristics are appreciated for premium quality leather.

New Products and their Promotion in the Framework of a Green Economy

The demand for coppice products has recently been increasing, mainly for energy purposes. This trend is in part influenced by the recent developments of management techniques, both in harvesting and processing technology. For example, it is quite common to have integrated recovery of logs for firewood and poles, and branches and tops for chips. It is likely that in many countries the use of wood chips will increase.

The trend of the increasing demand is not homogenous in all regions due to different forest, economic, cultural and social aspects. For example, chestnut demand for furniture production is higher in central Italy, while the production of chestnut laminated beams and panels is increasing in north-eastern Italy (Pettenella 2001).

The development of new markets and green economies can be supported by new management and marketing instruments, such as new approaches in the selling system, efficient promotion and certification.

It is not easy to find the right "recipe" for promoting the use of coppiced products in the framework of a possible green economy. These trends and markets are at different levels in different countries, according to economic, environmental and social conditions and to species composition.

There are some instruments that can promote and boost the market chances:

- **Networking, association and promotion:** reinforcement of the producers' market power.
- **New selling system:** small local markets, which permit the local producers to sell directly to consumers; E-business; Business to business with the sales of semi-finished products and DIY (do it yourself) products.
- **Promotion of legal labour:** because of less taxes and minor costs, companies with illegal workers can sell products – especially firewood – at lower price, causing a distorted market.
- **New developments in harvesting and processing technologies:** in recent years, new technologies that require different levels

of power and investment have arrived on the market. There is a wide choice of tractors, trailers, winches, cable-yarders, fire-wood processors, chippers and many more. Public administration should control and promote training courses in safety and technical matters. Short and practical training courses could help logging companies in increasing their competitiveness and productivity.

- **Promotion by public authorities:** the use of coppiced products could be encouraged through regulations, public investments and promoting programs. For example, a municipality could use benches made from chestnut wood in public parks, or stimulate the use of chestnut poles in vineyards and when installing wooden highway barriers. Cooperation between public authorities and producers could be one success factor in promoting and developing coppiced products. Another is increasing the coordination between local producers.
- **Diversification of products:** to enter and/or develop profitable markets and empower forest owners and operators. In many situations, high firewood prices discourage the production of other assortments, such as poles. However, the economic benefit of good firewood prices can be uncertain since it can change under many circumstances, such as new products, warm winters or regulations on the air quality allowed in old stoves. A possible addition could be, for example, pellets and microchips; the market is currently booming and the products are easier to manage and more suitable to modern life style. Operators should try to diversify their production with a wide range of valuable assortments.

Conclusions

In the past, vast areas of coppice forest in Europe supplied the local population with products such as firewood, charcoal, tannin, and fodder, as well as shelter for animals and a large variety of poles used in agriculture and construction.

Despite some decades of decline, the current economic trends point to a good future for coppice management. It has the potential to gain importance again locally, strengthen rural communities and help avoid the depopulation of mountainous regions and other rural areas.

The current danger is that neglective or disruptive management activities can have more serious silvicultural and ecological consequences than in more 'natural' forest systems. Thus, abandoning coppice forests may not only lead to to an impoverishment of rural communities, but also to environmental degradation and ecological catastrophes.

Without active management there will be no coppice and without income from coppice, there will be no management. Therefore, rural development policies should encourage and promote the diversification of rural activities and multi-functional models that are suitable for coppice forests.

In addition to the traditional products already mentioned, there are new products that are valuable in the context of the green economy, particularly in the area of energy. One priority should be to promote the efficiency of coppiced forests and to pursue this management as a system. It is not seen to be viable to create more coppice from high forest, but to try to dissuade foresters from trying to convert more coppice to high forest. Coppice forest will only be able enjoy the benefits of the modern green economy if coppice management is modernized.

Acknowledgements

The authors are grateful to EuroCoppice members Gero Becker, Pieter D. Kofman and Alicia Unrau for their review of the document.

References

Agreste - Enquête annuelle de branche exploitation forestière. 2014. http://agreste.agriculture.gouv.fr/enquetes/forets-bois-et-derives/recolte-de-bois-et-production-de

Asikainen A., Pulkkinen P. 1998. *Comminution of Logging Residues with Evolution 910R chipper, MOHA chipper truck, and Morbark 1200 tub grinder*. J. For. Eng. 9: 47-53.

Caserini S., Fraccaroli A., Monguzzi A., Moretti M., Angelino E. 2008. *Stima dei consumi di legna da ardere ed uso domestico in Italia*. Ricerca commissionata da APAT e ARPA Lombardia, Rapporto finale. (accessed 14-11-2015) http://www.isprambiente.gov.it/contentfiles/00004100/4156-stima-dei-consumi-di-legna-da-ardere.pdf

Čebul T., Krajnc N., Piškur M. 2011. *Biomass Trade Centre II Work Package 2: Regional Report on Promotion of the new investment in wood biomass production (D 2.1)* Country: Slovenia.

Elyakime B., Cabanettes A. 2013. *Financial evaluation of two models for energy production in small French farm forests*. Renewable Energy 57: 51-56.

EUROSTAT. 2015. *Roundwood, fuelwood and other basic products* [Online]. Available: http://ec.europa.eu/eurostat/web/main/home.

FAO 2007. *State of the world's forests 2007* (accessed 14-11-2015) http:// www.fao.org/docrep/009/a0773e/a0773e00.HTM; 2007

Fonti P., Giudici F. 2002. *Produzione di parquet a partire da legname di castagno proveniente da boschi cedui del Sud delle Alpi*. Schweiz. Z.Forstwes.153 (1): 10 –16

Gabbrielli A. 2006. *Le vicende storiche e demografiche italiane come causa dei cambiamenti del paesaggio forestale*. Annali A.I.S.F., Vol. LV:133-166

Magagnotti N., Pari L., Spinelli R. 2012. *Re-engineering firewood extraction in traditional Mediterranean coppice stands*. Ecological Engineering 38:45– 50

Matthews J.D. 1989. *Silvicultural systems*. Clarenden Press. Oxford. 284

Nybakk E., Lunnan A., Jenssen J., Crespell P. 2013. *The importance of social networks in the Norwegian firewood industry*. Biomass and Bioenergy 57: 48-56

Parde J. 1991. *Forges et forêts: recherche sur la consommation proto-industrielle du bois*. Revue Forestière Française 4:338-340.

Pottie M., Guimier D. 1985. *Preparation of forest biomass for optimal conversion*. FERIC Special Report SR-32, Pointe Claire, Canada. 112 p

Strelher A. 2000. *Technologies of wood combustion*. Ecological Engineering 16:25–40

Warsco K. 1994. *Conventional fuel displacement by residential wood use*. Forest Products Journal 44: 68-74

Woronoff D. 1990. *Histoire des forêts françaises, XVIe-XXe siècles. Résultats de recherche et perspectives*. Les Cahiers du Centre de Recherches Historiques 1990-6. 8 p

Zimbalatti G., Proto A. 2009. *Cable logging opportunities for firewood in Calabrian forests*. Biosystems Engineering 102:63-68

Guidelines for Coppice Forest Utilization

Natascia Magagnotti, Janine Schweier, Raffaele Spinelli, Petros Tsioras, David Rossney, Eduardo Tolosana, Abel Rodrigues and Stefan P. P. Vanbeveren

1 Introduction

Coppice management is extremely efficient; it offers the benefits of easy management, prompt regeneration and a short waiting time. Efficiency is also achieved during harvesting, because coppice is often clearcut, which allows concentrated harvest and simple felling arrangements. On the other hand, coppice management has some important limitations, especially the relatively small tree size and the exclusive reliance on hardwoods, which tend to limit future product outputs and productivity.

In recent years, new applications of the coppice concept have been developed for industrial use and/or for a changing agriculture. Today, we may identify three broad types of coppice stands, as follows (Table 1):

Table 1. Three types of coppice stands that have implications for utilization practices

		Conventional Coppice	Short rotation forestry (SRF)	Short rotation coppice (SRC)
Species	(type)	*Quercus* sp. *Fagus sylvatica* L. *Ostrya carpinifolia* L. *Castanea sativa* Mill. etc.	*Populus* spp. *Eucalyptus* spp. *Acacia* spp.	*Salix* sp. *Populus* sp. *Eucalyptus* sp.
Rotation	(years)	15 - 30 / 40	5 - 15	1 - 5
Product	(type)	Firewood	Pulpwood	Chips
Economy	(domain)	Industrial and small-scale forestry	Industrial forestry	Industrial agriculture
Harvest	(technology)	Forest	Forest	Agriculture

Corresponding Author: Natascia Magagnotti, magagnotti@ivalsa.cnr.it

Conventional coppice (Figure 1)
Established with indigenous hardwood species (oaks, chestnut, beech, hornbeam etc.) and occasionally exotic ones (*Robinia*). It is usually harvested on 15-30/40 year rotations for a large variety of products and is managed within the framework of a rural economy, according to local traditional practice. It is harvested using a wide range of techniques and usually uses equipment from small scale agriculture, although the use of specialized forestry machinery is increasing.

Figure 1. Motor-manual felling in a conventional chestnut coppice

Short rotation forestry (SRF) (Figure 2)
Stands are established with exotic fast-growing species (*Eucalyptus, Acacia*) and harvested on 5-15 year rotations to produce industrial feedstock (generally pulpwood). SRF is often developed within the framework of a large-scale industrial economy to supply industrial plants. SRF stands are often (but not exclusively) managed as coppice and they occasionally undergo shoot reduction treatments (thinning). Stands are generally harvested with industrial forestry equipment, but also occasionally with small-scale forestry equipment.

Figure 2. Mechanized industrial felling in a eucalypt SRF plantations managed as coppice (Photo 1 & 2: R. Spinelli)

Short rotation coppice (SRC) (Figure 3)
Stands are established on ex-arable land with fast-growing species, indigenous (willow, poplar) or exotic (*Eucalyptus, Robinia*). They are harvested on 1-5 year rotations to produce industrial feedstock (generally energy biomass) and managed within the framework of small-scale or industrial agriculture. So far, SRC represents a niche sector and it is generally harvested with modified agricultural equipment.

Figure 3. Single-pass harvesting in SRC established with willow (Photo: J. Schweier)

2 Conventional Coppice

The traditional management of conventional coppice forests is quite simple and is based on clear cutting at the end of rotation. Standards may be released in conventional coppice, with a density ranging from 50 to 100 trees per hectare (ha), depending on the species. No standards are released in SRF and SRC plantations. The final harvest of a mature coppice stand commonly yields between 90 and 200 m^3 ha^{-1}, or more, depending on species, age and site productivity. The harvest obtained from thinning (conversion) over-mature coppice generally varies from 40 to over 200 m^3 ha^{-1}. Generally, clear-cutting accrues profits, whereas thinning (conversion) generates losses.

Management has a strong effect on product type and harvesting productivity. Stems are cut before they can become very large and are best suited for conversion into small-size assortments. Mean stem volume typically varies between 0.05 and 0.25 m^3.

High production capacity is only achieved through the increased mechanization of harvest operations, which also helps to compensate for the effects of high labour costs and increasing labour shortages experienced in most industrialized countries (Spinelli and Magagnotti 2011). Technological progress has made the effective introduction of mechanized felling to coppice operations possible, significantly increasing worker safety and productivity. Professional management of mechanized harvesting can prevent or minimize undesired effects, such as soil, stump and stand damage (Cacot et al. 2015). When mechanized harvesting is applied, the scale of the operation and the wood removal must be large enough to offset the high fixed cost of moving machines to the worksite (Väätäinen et al. 2006).

Work safety has become a priority across Europe and the rate and severity of accidents in mechanized felling is much lower compared with the motor-manual option (Albizu et al. 2013).

2.1 Products

Europeans have exploited a wide range of broadleaved tree species in woodlands since the Stone Age. In fact, this prehistoric period of human evolution might more accurately be called the 'Wood Age', reflecting the over-riding importance of wood-based technology at this historic period.

Our ancestors learned to harness the ability of broadleaved tree species to sprout and re-grow when cut. This typically yielded multiple stems, the size of which simply depended on the time they were left to grow. The multiple shoots tended to yield sticks and poles that were straight-grained and relatively branch free; properties that still prove useful to us today.

The lightweight and straight material made good weapons (spears, bows and arrows), tool handles for axes, blades, adzes and ploughs, fencing and building materials (Figure 4). The straight grained wood split easily, yielded

Figure 4. Split chestnut gate hurdles by G and N Marshman Ltd. West Sussex, UK (Photo: D. Rossney)

almost limitless possibilities for strong but lightweight product designs and dried quickly and thoroughly, as is important for firewood.

Traditional products may be categorized as follows:

Building Materials

Includes whole stems (ca. 20 cm +) used in the round, hewn by axes into square sections, riven (split by hammer and wedge) and latterly sawn and jointed into the variety of dimensions required for timber framing.

Dwellings, fencing and weaving

Younger coppice poles have been used from earliest times to construct dwellings and fences, typically with durable species such as sweet chestnut and oak, if these were available. Hazel is less durable, but widespread and capable of producing large quantities of long clean rods. Such characteristics are ideal for a variety of products, such as woven panels used as 'hurdles' for fencing animals; 'wattle and daub', which is an in-filled stick and mud wall in timber framed buildings; and even small, round, skin covered boats called 'coracles', which were used in England during the Iron Age (Figure 5).

Figure 5. Examples of coracles by Guy Mallinson Woodland Workshop, Hereford, UK (Photo: D. Rossney)

Fuel

Firewood for heating or cooking has always been a large consumer of coppice wood, including the use of 'faggots' (or 'slash bundles'; bundled sticks), which give quick heat for bread ovens. Coppice was also turned into charcoal wherever fuel was required for smelting metal, until this practice was superseded by coking coal. In areas with iron ore, where no coal existed, industrial-scale coppicing and charcoal production continued into the 20th century.

Other products

These included bark for leather tanning and weaving, fruits and nuts, such as chestnuts (Figure 6) and hazels, foliage as fodder for animals, pannage (seasonal practice of feeding pigs in woodland on fallen acorns and other nuts) and collected herbs, fungi and medicinal plants growing in coppice woodland ecosystems.

In addition, there are household products that make use of small-dimensioned material, which is 'woven' into small (decorative) creations/objects, for example, small baskets and brooms. These products have been used through the ages, and still are today. An important market now is for tourists or city dwellers purchasing them (mostly) out of nostalgia, which affords an opportunity for some rural communities to earn part of their living from this activity.

Figure 6. Chestnuts, one of many coppice products (Photo: R. Spinelli)

Figure 7. Extraction of firewood with pack mules (Photo: R. Spinelli)

2.2 Harvesting

Traditional harvesting systems

In ancient times, manual work was dominant and it made sense to reduce cut stems to such a size that could be easily handled manually. Firewood was typically cut into one-meter lengths at the stump site, before loading it on pack animals for extraction and transportation (Carette 2003) (Figure 7). With minimal adjustments, animal extraction remained in use until a few years ago in industrial countries such as Italy and France (Baldini and Spinelli 1989) and it is still widespread in the Balkans. Modern adaptations to this ancestral system have been the introduction of chainsaws for felling and processing and of trucks for transportation, so that animal work is limited to extraction. Small stem size, an uncomfortable working position and the need to cut stems into manageable lengths result in a very low productivity of motor-manual felling and processing, which is reported in a range between 0.3 and 1.4 m^3 per scheduled machine hour (SMH) per operator (Spinelli et al. 2016a).

Modified traditional harvesting systems

The search for a mechanical substitute for the traditional mule started in the late 1980s. Over time, various micro-tractors have been designed and tested (Magagnotti et al. 2012), but none have ever obtained commercial success. Eventually, pack-mules have been replaced by the so-called pack-tractor, i.e. a farm tractor equipped with front and rear bins capable of containing ca. 3 tonnes (t) of one-meter logs (Piegai and Quilghini 1993). Small payload size prevents efficient use of these vehicles on distances further than a few hundred meters, while the limited mobility of an encumbered farm tractor limits its use to relatively easy terrain, or areas with a good network of skid trails. On suitable terrain, productivity is higher than reported for mule teams, varying from 2 to 4 m^3 SMH^{-1} with a crew of two (Spinelli et al. 2016a).

Mechanized cut-to-length harvesting

Mechanized cut-to-length (CTL) harvesting (Figure 8) is based on the introduction of the classic harvester-forwarder combination. While representing a radical technological innovation, CTL harvesting is not a revolutionary system change because it includes the same task sequence followed in the traditional system. The system is adapted to mechanization by increasing log length to 2 or 3 m, since one-meter long logs are too short for efficient mechanical handling. Appropriate machine choice and operator skill are necessary when applying CTL harvesting to coppice stands. The

Figure 8. Mechanized cut-to-length harvesting (Photo: R. Spinelli)

productivity of a modern harvester deployed in conventional coppice operations may vary from 2 to almost 10 m^3 SMH^{-1}, depending on stem size and operator proficiency. The productivity of the forwarder commonly ranges between 5 and 10 m^3 SMH^{-1}, depending on machine model and extraction distance (Spinelli et al. 2016a).

Whole-tree harvesting

Whole-tree harvesting (WTH) consists of felling trees and extracting them whole to the landing, where they are processed into commercial assortments. The main advantages of WTH are the simple in-forest handling, as well as postponement of processing to the landing, where it can be mechanized if terrain constraints make the stand inaccessible to harvesters. Motor-manual directional felling may proceed at a pace between 1 and 4 m^3 SMH^{-1} $operator^{-1}$. If terrain is accessible to mechanical equipment, then feller-bunchers can be introduced and productivity will increase dramatically, reaching values between 4 and over 8 m^3 SMH^{-1} (Schweier et al. 2015). The main operational benefit of mechanized felling is that the better presentation of felled trees boosts extraction productivity. This may range from less than 3 m^3 SMH^{-1} for skidding with a forestry-fitted farm tractor to 5 or even 8 m^3 SMH^{-1} when a dedicated skidder is used. On steep terrain, cable yarding (Figure 9) is the cost-effective alternative to building an extensive network of skidding trails and results in a much lighter site impact compared with ground-based logging (Spinelli et al. 2010). Productivity is somewhat lower than in ground-based operations, varying from 3 to 7 m^3 SMH^{-1} (Spinelli et al. 2014). The main difference with ground-based extraction is crew size, which increases to 3 or occasionally 4 workers, whereas only 1 or 2 workers are required for a skidder.

Figure 9. Cable yarding on steep terrain (Photo: R. Spinelli)

Once at the landing, whole trees are converted into conventional assorted products (i.e. firewood, pulpwood etc.) or thrown straight into a chipper. Whole-tree chipping was tested relatively early on in the Italian coppice stands (Baldini 1973) and has become a widespread commercial activity over the last decade due to a booming demand for biomass chips.

Despite all its many advantages, WTH must be considered with some caution because of the risk of soil nutrient depletion (Helmisaari et al. 2011).

Tree-length harvesting

In tree-length harvesting (TLH), trees are delimbed and topped before extraction, but not cut to length. It reduces inefficient stump-site work compared with traditional short wood harvesting, but increases the retention of biomass on-site, helping to mitigate possible adverse effects and making it suitable for site of low fertility (Mika and Keeton 2013). TLH operation determines a large (>50%) increase of stump-site work compared with WTH, whereas landing work is reduced only slightly. Decreased work efficiency leads to a general increase of logging cost, which has been estimated at 10-15% over WTH (Spinelli et al. 2016b).

3 Short Rotation Forestry

In Europe, short rotation forestry (SRF) stands, planted with exotic, fast-growing species and managed as coppice, are mainly located in the Iberian Peninsula. Among these fast-growing species, *Eucalyptus* is the most prominent and is cultivated for pulp and paper industry; it will be the focus of this chapter.

Eucalyptus was first planted in the Iberian Peninsula in Vila Nova da Gaia (Portugal) in 1829, while the first eucalypts planted in Galicia (Spain), around 1850, were likely *E. globulus*. Nowadays, the estimated surface of eucalypt plantations is approximately 0,8 Mha in Portugal and 0,6 Mha in Spain. The Iberian eucalypt industrial wood production was estimated at 10,9 Mm^3 in 2009, which represented 47% of the industrial wood fellings, but only 6% of Iberian forest surface.

3.1. Products

The main planted *Eucalyptus* species is *E. globulus*. It is very efficient in cellulose fiber production, so the main destination of its wood is the pulp industry. There are several pulp mills of different companies operating in Spain and Portugal and in 2009 they had a demand of nearly 12 Mm^3. Nowadays, *E. globulus* occupies the largest forest area in Portugal with 812.000 ha, mainly allocated for pulp production under an intensive coppice system, with a full year growing cycle. *E. globulus* is the only significant eucalypt species in Portugal.

Other uses of eucalypt forests are less frequent, but there are some smaller mills producing veneer, laminated panels and beams used for farming mussels beneath sea water. In addition, essences and honey are widely obtained from these cultivated forests.

3.2. Harvesting

E. globulus is a sprouting species and is thus traditionally coppiced. In the past, the more drought-resistant *E. camaldulensis* was widely planted in the southwest of Spain, but in the past decades most of its plantations have been removed or substituted by more productive *E. globulus* clones. Lastly, from the beginning of 21st century, the more freeze, pest and diseases resistant species *E. nitens* has become more frequent in the northwest of Spain, especially in Galicia.

The most productive Spanish eucalypt plantation area is located within Galicia and the Cantabrian region. A constraint on these plantations is the very fragmented forest ownership (average ownership size of less than 2 ha, divided into several plots), which limits the harvesting systems and the plantation profitability. Accordingly, most of the Spanish harvesting contractors are small-sized enterprises that have had trouble to adapt to a proper mechanization due to lack of investment capability and, in many cases, lack of adequate training and entrepreneurial culture.

In Spain, the usual plantation frame ranges from 2x3 m to 3x3 m (final density; there are no thinnings) and the rotation age varies from 12 to 15 years, although it could eventually be longer. Fertilizing and cleaning of competing vegetation are usual practices. Treatments against pest and diseases are quite common. Fire risk and fire protection are of high importance for eucalypt management.

When a *E. globulus* plantation is coppiced, felling and sprouting are followed by the selection of the best sprouts: 1 to 3 per stump, after 1 or 2 years. The second rotation is thought to produce some 10-15% more volume

Figure 10. Felling by chainsaw (Photo: E. Tolosana)

compared to the original plantation, while the next rotations continue to decrease in yield to the point at which it is more productive to plant again. During the past decade, many coppices have been uprooted and re-planted again using genetically improved material.

Eucalypt coppices in Portugal are characterized by a 12 year rotation cycle and that growth continues throughout the year. The average biomass productivity ranges from about 14 to 16 t ha^{-1} $year^{-1}$, which is equal to about 14 to 15 m^3 $year^{-1}$. Recent data shows a high dependence between biomass productivity and rainfall, reflected by a sharp decrease in the second year of a two year draught period (2004 - 2005), characterized by half yearly precipitation values. The decrease of above ground biomass productivity in the second year was half the order of magnitude compared to usual values.

<u>The traditional logging systems are based on:</u>

Motor-manual felling and processing

With chainsaw; where forest harvesters are not available and/or the terrain conditions are unfavorable for mechanization (Figure 10).

Semi-mechanized felling and processing

Felling by chainsaw and processing using forest CTL-harvesters, frequently based on tracked excavators but also specialized Nordic machines. One of the reasons felling often has remained to be motor-manual is the interest of the forest owners in keeping the stump height as low as possible and getting a good cut quality. In steep terrains, felling is always performed by chainsaw. Whole trees are then slipped or winched to temporary forest roads where they are processed by machines.

The most common equipment for extraction is an adapted farm tractor or local small to medium-sized forwarder, using the CTL harvesting system.

The use of residual biomass in Spain has changed over the years. In the past, the logs were debarked at the harvesting site and branches, tops and bark left on the terrain. From the 1990s onwards, the trend has been to transport the wood with bark to the mill (Figures 11) and use stationary drum debarking machines to separate the bark, which is burnt for combined heat and power (CHP) generation at the mills.

Felling mechanization in eucalypt plantations has been encouraged in the past years.

Figure 11. Transportation of wood with bark to the mill (Photos: E. Tolosana)

Figure 12. Mechanized felling and processing

Figure 13. Mechanized felling (Photos: E. Tolosana)

Besides the traditional systems mentioned above, companies are trying to implement two new harvesting systems:

- Fully mechanized felling and processing with specialized forest harvesters (Figures 12 and 13)
- Fully mechanized felling with disc saw or knife feller-buncher, followed by processing with forest processors

To haul the logs off, the trend is to use larger, increasingly Nordic, forest forwarders.

Regarding eucalypt residual biomass harvesting in Spain, the prevalent system is based on bundlers (Figure 14); Portuguese or Nordic machines equipped with knives - instead of chainsaws - to cut the biomass bales. This allows the use of the same machinery to handle the logs and the bundles and avoids the preparation of landings to organize chipping operations, which is often difficult in the typically small plantations.

Besides this, one of Spain's leading forest management companies, ENCE, is trying to improve forest harvesting operations by providing their logging contractors with Total Quality Management (TQM) instructions, in order to increase the utilization rate and productivity. To this end, ENCE has developed apps that communicate daily reports by the contractors through mobile phones and they are providing their contractors with technical and managerial support to optimize their operational efficiency. Despite the inclusion of a GPS tracking system, the road transport optimization still has much room for development.

There is a recent strong trend to substitute *E. globulus* with *E. nitens* in some Galician forest areas despite the fact that the latter is less efficient in producing cellulose fiber and does not resprout well, which limits coppicing. The main drivers are the threats by pest and diseases, towards which *E. globulus* is more sensitive, and the much higher growth potential of the *E. nitens* in many climate and terrain conditions.

Besides this species change, in Spain there is a trend to abandon coppicing in some areas; mainly where *E. nitens* is planted, but also other areas. Some reasons are: coppicing requires a more intense management than first plantation at final density; pulpwood quality is worse in coppice; coppice harvesting presents some mechanization difficulties; there is a decrease in yield after multiple coppicing; and new technologies allow the production of pulp from removed stumps.

In Portugal, the main trends of pulp production follow a consequent forest biotechnological breeding program of *E. globulus*, which aim at improving the biomass productivity and resistance to biotic and abiotic agents, such as drought.

Figure 14. Bundler, often used for eucalypt in Spain (Photo: E. Tolosana)

4 Short Rotation Coppice

Short rotation coppice (SRC) is a dedicated crop, mainly planted on agricultural land and designed to produce large quantities of raw materials at regular intervals.

Fast-growing tree species considered for SRC can be indigenous (willow, poplar) or exotic (eucalypt, black locust).

The planting density ranges from about 6,000 to 15,000 plants (usually unrooted cuttings) per ha, planted in single or twin rows, according to the species and the rotation lengths. The tree growth is influenced by site characteristics (such as soil and climate) and genotype selection should be made accordingly. SRCs are harvested in rotations of 1-5 years for the production of industrial feedstock (generally energy biomass).

The plantations are generally harvested with modified agricultural equipment that can harvest small stems. Forest equipment is only used if stems are too large and too close to one another. Planting is done with vegetative material (uprooted cuttings), whereas resprouting after harvest happens naturally from the existing root systems.

4.1 Products

The main purpose is to grow wood for energy (Figure 15), but it also can be used for other products, such as industrial feedstock or in the bio-refinery industry. In most cases, stems are chipped immediately after the cutting and blown into a tractor-trailer unit that accompanies the forage harvester. These chips have a moisture content of 50-60% (Spinelli et al. 2008, Vanbeveren et al. 2015) and a low heating value. Chips can be dried (naturally or

Figure 15. Short rotation coppice crops are mainly chipped and used for energy (Photo: J. Schweier)

Advantages of SRC

- High biomass yields
- Regular incomes in short intervals
- Groundwater protection
- Ecological planning
- Phyto-remediation
- Increase of value added in rural areas
- Diversification of landscape
- Higher biodiversity compared to agricultural fields

Disadvantages of SRC

- High moisture content of freshly cut chips (poplar 50-60% wet weight basis)
- Difficult storage of wet chips
- Technical limitations on difficult terrain (slope)
- High costs on small sites
- Dependence on harvester availability
- Lower biodiversity compared to forests and uncultivated grass/shrublands

Figure 16. Unloading of chips; the chips should be used immediately if possible (Photo: J. Schweier)

artificially) to reach a desired moisture content. However, during the storage there is a dry matter loss of 10 - 20% (Schweier et al. 2017) due to microbiological activities, which reduce the chip quality and can create self-ignition and health problems. The latter are caused mainly by fungi, especially when their spores become airborne during fuel handling. Therefore, chips should be used immediately (Figure 16). If this is not possible, chips should be stored at a proper distance from residential areas and should be handled with appropriate precautions.

If the market recognizes the added value, the use of surplus heat, when available, could be a good and efficient option for drying chips (Schweier and Becker 2013).

Chips from SRC have a relatively high bark content, which is important because bark has higher elemental concentrations and a lower density compared to wood (Tharakan et al. 2003). During the combustion of material with a high bark percentage, problems arise from damage to the boilers (Guidi et al. 2008) and fouling can occur. Bark ratio is reduced in biannual systems, where harvesting is done at minimum 2 - 3 year intervals, which produces more favorable chip quality than annual harvesting. Therefore, clones with a lower bark percentage should be selected and trees should not be cut before an acceptable fibre-to-bark ratio is obtained (Spinelli et al. 2009).

4.2 Harvesting

There are two dominant harvesting systems used for SRC: the single pass cut-and-chip and the double pass cut-and-store technique.

Single pass cut-and-chip technique

Stems are cut, chipped and discharged into accompanying tractor-trailer units in one single pass, using only one harvesting machine (Figure 17). Generally, the system is based on a prime mover equipped with a header and 2 - 4 tractor-trailer units to move the chips to a collection point. There, the wood chips can be reloaded onto road transportation vehicles, or used directly as feedstock if an energy plant is close-by.

The coppice header can be placed on the front of the mover or on the side. Headers for SRC can be modified maize choppers (e.g. the Claas HS-1) or purpose-built (e.g. Claas HS-2 or the Italian GBE). According to site characteristics, these machines can reach very high productivities with peak values up to 80 green tonnes per hour (Spinelli et al. 2008) and guarantee consistent chip sizes. An additional advantage of modified forage harvesters is that they allow the farmer to run their machines in winter as well, when agricultural field work is not possible. The main disadvantage is the machines' weight, as this limits their use to flat and solid terrain. Modified forage harvesters require stems of a particular size and row spacing. Cut stems usually enter the chopper horizontally, but if stems are too close to each other, or too long, the cut stems can become entangled with standing stems and jam the header (Spinelli et al. 2009).

Figure 17. Examples of single pass cut-and-chip system: the harvesting machine cuts and chips the stems and the chips are discharged directly into a tractor-trailer units. (Photos: J. Schweier)

Mower-chippers can be a good alternative for dense plantations and larger diameters due to their capability to chip the stem in an upright position (Pecenka and Hoffmann 2015).

Double pass cut-and-store technique

With the double pass cut-and-store technique, the processes of cutting and chipping are split into two steps: one machine first cuts and windrows the stems (Figure 18) and a second picks them up and chips them (usually some weeks to months later), blowing the chip into conventional silage trailers. The main benefits are the capacity to concentrate the cutting within a short period of time (thus exploiting good weather windows) and the possibility to chip the material according to market demand or required moisture content.

Until now, single pass cut-and-chip harvesting is the most common technique used in SRC, due to the technological progress and research that it underwent. Other techniques do exist, such as the singe pass cut-and-bale and the single pass cut-and-billet technique, which produce wood bales in the first case and billets in the latter (Vanbeveren et al. 2017), but they do not yet reach market value. Thanks to their more powerful engine, cut-and-chip harvesters have a higher average productivity (30 green tonnes per hour) than whip harvesters (19 green tonnes per hour) (ibid.).

Conclusions

Among possible sources of energy biomass, SRC has a high potential to contribute to the renewable energy mix.

Since harvesting costs are estimated to be above 50% of the total cost of the biomass produced from SRC, the optimization of these operations is required.

Good performance can be obtained when several factors concur, such as: good terrain and weather conditions, adequate machine selection, appropriate crop density and exact row spacing.

Figure 18. Example of the cutting in the double pass cut and store techniques. The stems will be chipped later (Photo: J. Schweier)

5 Conclusion

Despite some decades of decline, the current economic trends point to a good future for coppice forests (Figure 19).

Coppice management can be applied in many ways, according to different species, level of mechanization and specific local condition; it can also be aimed at different products.

Active coppice management already plays a vital part in rural economies, but can increase its potential when a certain level of modernization is acquired.

Mechanization is a possible solution to make coppice management a modern industrial business instead of a part-time activity. Modern harvesting systems, of different scales, can compensate for the difficulty in acquiring sufficient rural labor and maintaining young workers in the forestry sector.

It is important to select or, in some cases, further develop the right felling technology to guarantee the rejuvenation of the coppiced stands. Stump crowding and small stem size can be considered common elements that have an impact on operational choices in many coppiced stands. The presence of multiple stems on the same stump offers a serious challenge to mechanized felling in coppice harvesting operations, because stem crowding hinders felling head movements. Small stem size affects the type of products one can obtain from coppice stands, while limiting work productivity.

An effective introduction of mechanized felling requires the selection of a suitable machine but also a skilled and professional operator who can prevent or minimize undesired effects, such as soil, stump and stand damage.

Figure 19. Coppice provides a wide range of products and is important for rural economies (Photos: upper left C. Suchomel, lower middle R. Spinelli, lower right J. Schweier, rest A. Unrau)

It is also necessary to promote a certain level of mechanization to improve safety. Manual work is associated with the highest accident risk and severity, and it accounts for most of the fatal accidents recorded in forest operations.

Silvicultural practices may need to be adapted to new harvesting technology and to favor, whenever possible, proper removals and the use of machines. In many cases coppice forests are situated in difficult terrain with poor access. The improvement and adaptation of the existing infrastructure (road density and quality) to the requirements of mechanized operations is one important prerequisite for successful mechanization.

Although much progress has already been made, the introduction of mechanized operations still encounters resistance.

Better knowledge concerning the techniques of mechanized harvesting in coppice forests is required. International initiatives such as the COST Action FP1301 EuroCoppice may help to bridge gaps in such areas.

Rural development policies should encourage coppice management in order to promote the diversification of rural activities.

It is important to continue the regular utilization of coppice in order to preserve it as a system of forestry. This utilization will promote ecological, protection and aesthetic functions of coppice forests and can guarantee income to owners, loggers and rural communities.

Acknowledgements

The authors are grateful for the comments by the following EuroCoppice WG3 Members who participated in the Limoges meeting on June 19th, 2017: Pierre Ackerman, Mariusz Bembenek, Emmanuel Cacot, Mário Costa, Paula Jylhä, Zbigniew Karaszewski, Piotr Mederski, Matevž Mihelič, Ljupco Nestorovski, Pavol Otepka, Anton Poje, Philippe Ruch, Kjell Suadicani, and Morgan Vuillermoz.

References

Albizu P.M., Tolosana-Esteban E., Roman-Jordan E. 2013. *Safety and health in forest harvesting operations. Diagnosis and preventive actions. A review.* Forestry Systems 22: 392-400.

Baldini S. 1973. *Relazione sulla utilizzazione sperimentale di bosco ceduo nella FD di Cecina.* Cellulosa e Carta 6: 37-51.

Baldini S., Spinelli R., 1989. *Utilizzazione di un bosco ceduo matricinato con esbosco effettuato da animali*. Monti e Boschi 89: 39-43.

Cacot E., Grulois S., Thivolle-Cazat A., Magaud P. 2015. Mechanization of French logging operations: challenges and prospects in 2020. In: Kanzian C, Erber G, Kühmaier M (Ed.) *"Forest Engineering: "Making a positive contribution"*. Abstracts and Proceedings of the 48th Symposiom on Forest Mechanization. Linz, Austria 2015. 512 p.

Carette J. 2003. *La mulasserie, ses origines, ses pratiques*. Ethnozootechnie 72: 7-11.

Guidi W., Piccioni E., Ginanni M., Bonari E. 2008. *Bark content estimation in poplar (Populus deltoides L.) short-rotation coppice in Central Italy*. Biomass and Bioenergy 32: 518-524.

Helmisaari H., Hanssen K., Jacobson S., Kukkola M., Luiro J., Saarsalmi A., et al. 2011. *Logging residue removal after thinning in Nordic boreal forests: Long-term impact on tree growth*. Forest Ecology and Management 261: 1919-1927.

Magagnotti N., Pari L., Spinelli R. 2012. *Re-engineering firewood extraction in traditional Mediterranean coppice stands*. Ecological Engineering 38: 45-50.

Mika A., Keeton W. 2013. *Factors contributing to carbon fluxes from bioenergy harvests in the U.S. Northeast: an analysis using field data*. Global Change Biology and Bioenergy 5: 290-305.

Piegai F., Quilghini G. 1993. *Esbosco a soma con trattore*. Monti e Boschi 2:36-44.

Schweier J., Becker G. 2013. *Economics of poplar short rotation coppice plantations on marginal land in Germany.* Biomass and Bioenergy 59: 494-502.

Schweier J., Molina-Herrera S., Ghirardo A., Grote R., Dìaz-Pinès E., Kreuzwieser J., Haas E., Butterbach-Bahl K., Rennenberg H., Schnitzler J.-P., Becker G. 2016. *Environmental impacts of bioenergy wood production from poplar short rotation coppice grown at a marginal agricultural site in Germany*. Global Change Biology Bioenergy, 9(7), 1207-1221.

Schweier J., Spinelli R., Magagnotti N., Becker G. 2015. *Mechanized coppice harvesting with new small-scale feller-bunchers: results from harvesting trials with newly manufactured felling heads in Italy*. Biomass and Bioenergy 72: 85-94.

Spinelli, R., Cacot, E., Mihelic, M., Nestorovski, L., Mederski, P., Tolosana, E. 2016a. *Techniques and productivity of coppice harvesting operations in Europe: a meta-analysis of available data.* Annals of Forest Science 73, pp. 1125-1139

Spinelli R., Ebone, A., Gianella M. 2014. *Biomass production from traditional coppice management in northern Italy.* Biomass and Bioenergy 62: 68-73.

Spinelli R., Magagnotti N. 2011. *The effects of introducing modern technology on the financial, labour and energy performance of forest operations in the Italian Alps*. For Pol Econ 13: 520-524.

Spinelli R., Magagnotti N., Aminti G., De Francesco F., Lombardini C. 2016b. *The effect of harvesting method on biomass retention and operational efficiency in low-value mountain forests*. European Journal of Forest Research 135: 755-764.

Spinelli R., Magagnotti, N., Nati, C., 2010. *Benchmarking the impact of traditional small-scale logging systems used in Mediterranean forestry.* Forest Ecology and Management 260:1997-2001.

Spinelli R., Nati, C., Magagnotti, N. 2009. *Using modified foragers to harvest short-rotation poplar plantations*. Biomass and Bioenergy 33: 817-821.

Spinelli R., Nati, C., Magagnotti, N. 2008. *Harvesting short-rotation poplar plantation for biomass production*. Croatian Journal of Forest Engineering 29(2): 129-139.

Tharakan P.J., Volk T.A., Abrahamson L.P., White E.H. 2003. *Energy feedstock characteristics of willow and hybrid poplar clones at harvest age.* Biomass and Bioenergy 25: 571-580.

Väätäinen K., Asikainen A., Sikanen L., Ala-Fossi A. 2006. *The cost effect of forest machine relocations on logging costs in Finland*. Forestry studies 45: 135-141.

Vanbeveren S.P.P., Spinelli R., Eisenbies M., Schweier J., Mola Yudego B., Magagnotti N., Acuna M., Dimitriou I., Ceulemans R. 2017. *Mechanised harvesting of short-rotation coppices.* Renewable and Sustainable Energy Reviews 76: 90-104.

Vanbeveren S.P.P, Schweier J., Berhongaray G., Ceulemans R. 2015. *Operational short rotation woody crop plantations: Manual or mechanized harvesting?*. Biomass and Bioenergy 72: 8-18.

Impacts of Coppice Harvesting Operations on Soil

Rodolfo Picchio, Marco Senfett, Irene Luchenti and Rachele Venanzi

Introduction

Coppice is a traditional method of stand regeneration to produce woody biomass, a management system that is still widespread in many regions worldwide. Until the middle of the 20th century, coppice forests were common in most parts of Europe; although this has since changed, several issues relating to coppicing are still relevant. In Italy, coppice has much economic and social relevance for hilly and mountainous areas. Coppice produces timber for firewood and charcoal production (Picchio et al. 2011b) and has been an important source for litter collection and pasture (Gimmi et al. 2008; Glatzel 1999). At the same time, coppice harvesting could have a significant degrading influence on woody regeneration, fauna and the soil, causing compaction, horizon mixing and topsoil removal (Korb et al. 2007). In particular, compaction reduces both soil porosity and pore connectivity, thus increasing soil density and shear strength (Klvac et al. 2010; Picchio et al. 2012b; Williamson and Neilsen 2000). Such soil degradation can decrease tree growth (Grigal 2000), while carbon dioxide efflux from the soil may change significantly (Olajuyigbe et al. 2012). In this paper, two different coppices were analyzed, characterized by different stand types of Turkey oak (*Quercus cerris* L.) and chestnut (*Castanea sativa* Mill.).

In Italy, the traditional management of Turkey oak is coppice with standards, which involves felling about 80–85% of the total woody biomass and releasing about 70–120 standards/ha. For chestnut, the forests are mainly managed as coppices with standards, for productive and phytosanitary purposes (to cater for bleeding canker or chestnut blight), felling about 85-90% of the total woody biomass and releasing about 30–100 standards/ha. Logging systems may differ, depending on silvicultural management and the final product. The technical and economic utilization of coppice forests depends on various factors, including the type of terrain, transportation networks and harvesting technologies, as well as the silvicultural treatment and logging system (Cavalli and Grigolato 2010; Vusic et al. 2013). Although in recent years significant innovations in the technology and methodology of forest operations have occurred (Picchio et al. 2012a, 2011b), the majority of private and public coppice forests are still harvested using traditional methods, i.e. motor manual felling with chainsaws or using mules and/or agricultural tractors for extraction (Picchio et al. 2011a, 2011b; Laschi et al. 2016). The effects of harvesting can affect changes to the vegetation, nutrient availability, soil microclimate, soil structure and litter quantity and quality (Borchert et al. 2015; Edlund et al. 2013). In particular, operations such as forwarding and skidding have a high potential for causing soil compaction (Jamshidi et al. 2008; Cambi et al. 2015, 2016). However, properly managed forest ecosystems are claimed to be highly resilient in the long term (Sánchez-Moreno et al. 2006). Some studies also suggest that compaction can be avoided by minimizing areas of soil disturbance and soil compaction by designing thinner networks of strip roads (Mederski 2006).

Corresponding Author: Rodolfo Picchio, r.picchio@unitus.it

In coppice management, the time between harvests is called “rotation”, or sometimes also “cutting cycle” (Espelta et al. 1995; Retana et al. 1992). During this time the stands are mostly restocked by natural regeneration through seedlings (gamic) and sprouts (agamic), a process that is strictly dependent on physico-chemical soil quality. This aspect of soil quality should also include some assessment of different biodiversity patterns. Biodiversity conservation has long been a goal of European conservation policy (CBD 2010; CEC 1998) and the monitoring of this aspect is essential to support management decisions that maintain multiple forest ecosystem functions (CBD 2001). A better understanding of the importance of biological diversity is needed to support the provision of multiple forest ecosystem services (Corona et al. 2011; Mattioli et al. 2015).

Within the COST Action FP1301 EuroCoppice, studies specifically designed to analyze the impact of the silvicultural treatment and logging operations on forest soils in coppices were performed using both standard and “innovative” wood extraction systems. In addition to the usual physical and chemical analyses (pH, organic matter, bulk density, penetrometric and shear resistance) (Cambi et al. 2015), an innovative methodology using an arthropod-based Biological Soil Quality index “QBS-ar” was applied (Parisi et al. 2005; Venanzi et al. 2016). The use of this index has valuable potential as a tool in ecosystem restoration programs in monitoring soil function and biodiversity, and in preventing the negative effect of soil compaction due to logging activities (Blasi et al. 2013).

Methodologies

Similar study methods were applied to the two different coppice types in order to determine the impacts on soil, while some differences between each type were determined by the site conditions. The silvicultural treatment applied was coppice with standards, aiming to guarantee a profit for the forest owner and to maintain an even-aged forest. For each area (described in Venanzi et al. (2016)), transects were examined in order to estimate that proportion impacted by machinery. Each transect was rectangular in shape (2 m x 50 m), laid crosswise to the maximum slope, making it possible to assess the percentage of the surface impacted by forest operations. In each forest, one random sampling plot (SP) per hectare was selected (18 for Turkey oak forest and 40 for chestnut forest) to determine: bulk density (BD), pH, organic matter content, penetration resistance (PR), and shear resistance (SR). Each SP was a circular area of 12 m in diameter, in which two different points (PO) were visually selected (e.g. based on the presence or absence of damaged understory, crushed litter, soil ruts or soil mixing) to represent disturbed or undisturbed soil conditions. To estimate the impact solely caused by the above ground removal of woody biomass (the silvicultural treatment, excluding the winching and skidding), it was compared with a control in a neighboring forest parcel which had remained undisturbed for over 10 years.

A QBS-ar analysis was carried out in each treatment by taking three soil core samples, each measuring 100 cm^2 and 10 cm deep. Microarthropods were extracted using a Berlese-Tüllgren funnel and the specimens were collected and identified to different taxonomic levels (class: Myriapoda; order: Insecta, Chelicerata and Crustacea). Soil quality was estimated with the QBS-ar index (Parisi et al. 2005; Gardi et al. 2008; Tabaglio et al. 2009;

Menta et al. 2010), based on the premise that the higher soil quality, the higher would be the expected number of microarthropod groups well adapted to soil habitats. Soil organisms were separated according to their morphological adaptation to soil environments; each of these forms is associated with an EMI score (eco-morphological index), which ranges from 1 to 20, according to the degree of adaptation. The QBS-ar index value is obtained from the EMI sum of all collected groups. The organisms belonging to each biological taxon were counted in order to estimate their density at the sampled depth and the ratio of the number of individuals and the sample area to 1 dm^2 of the surface.

Results and discussion

The proportion of forest surface impacted by logging operations is strictly related to the adequacy of the road network. In the coppices studied, the tractors skidded the trees on the forest floor only occasionally, and in these cases the impact was not only due to the amount of winching, but also the frequency of vehicle movements. The forest surface strongly impacted by forest operations ranged from 3.4% to 26.9% of the total area, showing a statistical difference between situations with good or inadequate forest trail networks. These results were notably lower than those obtained in other studies which had much higher densities of trees released after harvesting.

There were significant differences in bulk density, heavily influenced by both the silvicultural treatment and the impact by vehicles on the soil (Table 1 and Figure 1). Soil bulk density values were higher in the disturbed areas compared with undisturbed ones (average increase from 0.073 g/cm^3 to 0.209 g/cm^3, ranging from 10% to 27%). This was considered to be mainly the result of compaction caused by load transportation and in some cases vehicle traffic, but it affected only a low percentage of forest area. In comparison with the control (where there was no harvesting in the past decade), the BD in the undisturbed areas increased from 0.123 g/cm^3 to 0.210 g/cm^3, ranging from 19% to 39%. This was probably due to precipitation directly affecting the soil in all forest areas where above-ground biomass was removed.

Compared with the observations for bulk density, penetration resistances did not always show significantly greater values between the control and undisturbed areas, ranging from 0 to 0.06 MPa; 0-88%. However, the PR increased

Table 1. Results of the ANOVA and Tukey test for soil characteristics (average ± SD; letters show groups with statistically significant difference); differences tested between disturbed, undisturbed and control soil (Marchi et al. 2016; Venanzi et al. 2016)

Area	Soil typology	Bulk density [g/cm^3]	Penetration resistance [MPa]	Shear resistance [t/m^2]	Organic matter [%]	QBS-ar index
Quercus	Undisturbed	0.773±0.098a	0.128±0.05a	3.622±0.88a	13.5±1.85a	172a
	Disturbed	0.982±0.080b	0.294±0.09b	8.773±2.48b	11.1±2.20a	93b
	Control	0.650±0.101c	0.068±0.03c	2.544±0.74c	19.0±2.09b	251c
Castanea	Undisturbed	0.747±0.150a	0.066±0.011a	1.550±0.272a	18.1±1.3a	213a
	Disturbed	0.820±0.210b	0.276±0.090b	4.113±0.591b	13.1±1.6b	102b
	Control	0.537±0.110c	0.069±0.012a	1.569±0.310a	19.2±1.3a	198c

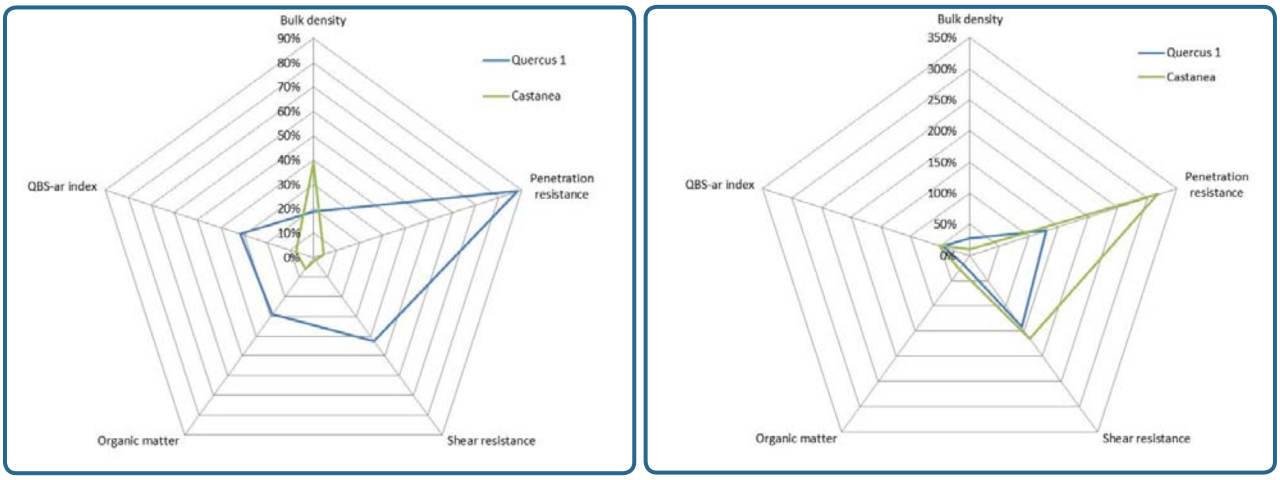


Figure 1. Percentage of impact for soil characteristics, on the left differences tested between undisturbed and control (silvicultural treatment) and on the right differences tested between undisturbed and disturbed soil (Marchi et al. 2016; Venanzi et al. 2016)

from 0.166 MPa to 0.210 MPa (ranging from +130% to +318%) when comparing disturbed and undisturbed areas. Similarly, while the soil shear resistance was not always greater in the control compared with the undisturbed areas (range from 0 to 1.08 t/m^2; 0-42%), in comparing disturbed and undisturbed areas, the SR increased from 2.56 to 5.15 t/m^2 (ranging from 142% to 165%). These relative differences among the three variables of bulk density and penetrometric and shear resistance showed similar significant trends, the greatest being for the latter two.

Soil organic matter content was also analyzed within the control site that had no utilization, and then within the forest areas harvested in this study. The organic matter content was lower in all areas affected by vehicle movements and from extracted loads. In chestnut coppice there was no significant statistical difference between areas undergoing harvesting (but not impacted by vehicles) compared with the control site. The areas disturbed by mechanical vehicle movement show a notable decrease in organic matter content, from 18 to 28%. This decrease can be linked to reduced mineralization as a result of less microbial activity in the disturbed area (Astolfi et al. 2011). Organic matter content was lower in all areas impacted by vehicles, while the removal of the above-ground woody biomass seems to only have caused significant change in Turkey oak coppice, at least during the first two years after the harvesting. Similarly, pH changes, which can influence many soil parameters and processes (Astolfi et al. 2011), did not seem to be affected by either the silvicultural treatment or the logging operations.

The QBS-ar index showed significant differences between the silvicultural treatment and the control, as well as between undisturbed and disturbed soils, indicating that the micro-arthropod community was affected in part by the silvicultural treatment and always by forest operations. Further analysis still in progress, two years after the treatment, shows that the QBS-ar index was lower than in the control within all of the areas directly involved with logging activities (temporary tracks), but that the recovery of the impacted soil was significant, but slow. From the same research in progress, the QBS-ar index was also affected by the silvicultural treatment, but in the soil surfaces not impacted by logging activities, recovery of the microarthropods was rapid. These results show that vehicle movement had a major impact on the soil condition, while the silvicultural treatment alone also had a clearly defined impact, but one that was recovered from quickly.

The QBS-ar index showed a high range of variation from disturbed to control areas (93–251 in Turkey oak, corresponding to a range of 8% to 52%), as was also observed by Blasi et al. (2013) and Rüdisser et al. (2015). In summary, the microarthropod communities were probably affected by the bunching and extraction operations of vehicle traffic and log dragging, causing soil compaction, while their density was similarly lower in all areas affected by vehicles and logging. Moreover, there was a statistically significant difference between the area subject to silvicultural treatment (but not impacted by vehicles) compared with the control site. In this case, however, it seems that the silvicultural treatment had a positive effect, perhaps related to an increase in soil nutrients immediately after the harvesting.

The QBS-ar can be considered a very useful qualitative indicator for coppice forests, as it is extremely sensitive to environmental variations caused by anthropic disturbance. This study has also shown that forest soil is extremely fragile in physical, as well as chemical and biological terms, and their highly complex interaction. Forest soils are extremely vulnerable to natural or anthropic disturbances, for example in logging operations (Vossbrink and Horn 2004). It is therefore extremely important that the impacts caused by forest management are quantified and the results used to design lower impact logging methods. These observations show that tractor tracks consistently cause compaction that can extend to a depth of at least 10 cm, creating a high risk of water runoff and wash out, which over time can cause a loss of fertile soil. Compacted soil can also impede seed germination, hinder regeneration and decrease forest productivity and continuity. Moreover, increased compaction causes a loss of soil micro- and macroporosity, reducing oxygen and moisture in the soil and drastically reducing micro-biological activity and fine root growth (Lynch et al. 2012). From a phytopathological viewpoint, increases in water runoff facilitate the expansion and transmission of pathogens as spores and rhizoids (Vannini et al. 2010). The overall consequence of soil compaction is a decrease of soil permeability, growth and nutrient supply to root systems. These negative consequences have also been shown by others (Heinonen et al. 2002; Alakukku 2000).

The coppice management system and the silvicultural treatment applied did not show any particular problems (i.e. in terms of seedling regeneration, fluctuations in seed production, prolonged periods of uncovered soil), but reduced impact logging (RIL) methodologies could be beneficial (Enters et al. 2002; Maesano et al. 2013). The logging operations in this case were carried out with appropriate mechanization, with tractors only skidding the trees on the forest floor occasionally, although physical-mechanical impacts caused by vehicle movement on forest soils (off the track) are evident even here. Carefully designed skid roads are therefore recommended, as well as setting out strip roads, skid trails and forwarder use so as to reduce soil disturbance. In future research, it would be interesting to evaluate the capacity for recovery from soil damage over longer periods of 2–16 years. For this specific study and other similar forest situations, if silvicultural treatments and logging activities are well planned and sustainable forest management guidelines were followed, no particular post-harvesting operations would be necessary. A forest road network that is viable and functional will further ensure a limited impact on forest soil, with impacted soil surfaces of <5–10%. It is important to consider the results of studies such as this one when compiling guidelines, criteria and indicators of sustainable forest management.

References

Alakukku, L., 2000. Response of annual crops to subsoil compaction in a field experiment on clay soil lasting 17 years. In: Horn, R., van den Akker, J.J.H., Arvidsson, J. (Eds.), *Subsoil Compaction: Distribution, Processes and Consequences*. Advances in Geoecology, 32. Catena Verlag, Reiskirchen, pp. 205–208.

Astolfi, S., Zuchi, F., De Cesare, L., Badalucco, S., Grego, S., 2011. *Cadmium-induced changes in soil biochemical characteristics of oat (Avena sativa L.) rhizosphere during early growth stages*. Soil Res. 49 (7), 642–651.

Blasi, S., Menta, C., Balducci, L., Conti, D.F., Petrini, E., Piovesan, G., 2013. *Soil microarthropod communities from Mediterranean forest ecosystems in Central Italy under different disturbances.* Environ. Monit. A 185, 1637–1655.

Borchert, H., Huber, C., Göttlein, A., Kremer, J., 2015. *Nutrient concentration on Skid trails under Brush-Mats – Is a redistribution of nutrients possible?* Croat. J. For. Eng. 36 (2), 243–252.

Cambi, M., Certini, G., Fabiano, F., Foderi, C., Laschi, A., Picchio, R., 2016. *Impact of wheeled and tracked tractors on soil physical properties in a mixed conifer stand.* IForest 9, 89–94.

Cambi, M., Certini, G., Neri, F., Marchi, E., 2015. *The impact of heavy traffic on forest soils: a review*. For. Ecol. Manage. 338, 124–138.

Cavalli, R., Grigolato, S., 2010. *Influence of characteristics and extension of a forest road network on the supply cost of forest woodchips*. J. For. Res. 15 (3), 202–209.

CBD, 2001. *Sustainable management of non-timber forest resources.* Montreal: convention on biological diversity; Technical Series No. 6.

CBD, 2010. COP 10 Decision X/2 *Strategic Plan for Biodiversity 2011–2020*, <http://www.cbd.int/decision/cop/?id=12268> (accessed 12.12.15).

CEC, 1998. *European Community Biodiversity Strategy*. <http://europa.eu/legislation summaries/other/l28183 en.htm> (accessed 12.12.15).

Corona, P., Chirici, G., McRoberts, R.E., Winter, S., Barbati, A., 2011. *Contribution of large-scale forest inventories to biodiversity assessment and monitoring*. For.Ecol. Manage. 262, 2061–2069.

Edlund, J., Keramati, E., Servin, M., 2013. *A long-tracked bogie design for forestry machines on soft and rough terrain*. J. Terramechanics 50 (2), 73–83.

Enters, T., Durst, P.B., Applegate, G.B., Kho, P.C.S., Man, G., 2002. Applying reduced impact logging to advance sustainable forest management. In: *International Conference Proceedings 26 February to 1 March 2001, Kuching, Malaysia* Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific Bangkok, Thailand.

Espelta, J.M., Riba, M., Retana, J., 1995. *Patterns of seedling recruitment in West-Mediterranean Quercus ilex forests influenced by canopy development.* J. Veg. Sci. 6, 465–472.

Gardi, C., Menta, C., Leoni, A., 2008. *Evaluation of environmental impact of agricultural management practices using soil microarthropods.* Fresenius Environ. Bull. 17 (8b), 1165–1169.

Gimmi, U., Bürgi, M., Stuber, M., 2008. *Reconstructing anthropogenic disturbance regimes in forest ecosystems: a case study from the Swiss Rhone valley*. Ecosystems 11 (1), 113–124.

Glatzel, G., 1999. *Causes and consequences of accelerated tree growth in Europe.* EFI Proc. 27, 65–74.

Grigal, D.F., 2000. *Effects of extensive forest management on soil productivity*. For. Ecol. Manage. 138, 167–185.

Heinonen, M., Alakukku, L., Aura, E., 2002. Effects of reduced tillage and light tractor traffic on the growth and yield of oats (Avena sativa). In: *Advances in Geoecology*. Catena Verlag, Reiskirchen, pp. 367–378 (35).

Jamshidi, R., Jaeger, D., Raafatnia, N., Tabari, M., 2008. *Influence of two ground-based skidding systems on soil compaction under different slope and gradient conditions*. Int. J. Eng. Sci. 19, 9–16.

Klvac, R., Vrána, P., Jirousek, R., 2010. *Possibilities of using the portable falling weight deflectometer to measure the bearing capacity and compaction of forest soils*. J. For. Sci. 56 (3), 130–136.

Korb, J.E., Fulé, P.Z., Gideon, B., 2007. *Different restoration thinning treatments affect level of soil disturbance in ponderosa pine forests of Northern Arizona*. USA. Ecol. Restor. 25, 43–49.

Laschi, A., Marchi, E., González-García, S., 2016. F*orest operations in coppice: environmental assessment of two different logging methods*. Sci. Total Environ. 562, 493–503.

Lynch, J., Marschner, P., Rengel, Z., 2012. *Effect of Internal and External Factors on Root Growth and Development*, Chapter in: *Marschner's Mineral Nutrition of Higher Plants (Third Edition)*, 331–346.

Maesano, M., Picchio, R., Lo Monaco, A., Neri, F., Lasserre, B., Marchetti, M., 2013. *Productivity and energy consumption in logging operation in a Cameroonian tropical.* For. Ecol. Eng. 57, 149–153.

Marchi, E., Picchio, R., Mederski, P.S., Vusić, D., Perugini, M., Venanzi, R., 2016. *Impact of silvicultural treatment and forest operation on soil and regeneration in Mediterranean Turkey oak (Quercus cerris L.) coppice with standards*. Ecological Engineering, 95, 475-484.

Mattioli, W., Mancini, L.D., Portoghesi, L., Corona, P., 2015. *Biodiversity conservation and forest management: the case of the sweet chestnut coppice stands in Central Italy*. Plant Biosyst. (in press).

Mederski, P., 2006. *A comparison of harvesting productivity and costs in thinning operations with and without midfield*. For. Ecol. Manage. 224, 286–296, http://dx.doi.org/10.1016/j.foreco.2005.12.042

Menta, C., Leoni, A., Tarasconi, K., Affanni, P., 2010. *Does compost use affect microarthropod soil communities?* Fresenius Environ. Bull. 19, 2303–2311.

Olajuyigbe, S., Tobin, B., Saunders, M., Nieuwenhuis, M., 2012. *Forest thinning and soil respiration in a Sitka spruce forest in Ireland*. Agrc. For. Meteorol. 157,86–95.

Parisi, V., Menta, C., Gardi, C., Jacomini, C., Mozzanica, E., 2005. *Microarthropod communities as a tool to assess soil quality and biodiversity: a new approach in Italy.* Agric. Ecosyst. Environ. 105, 323–333.

Picchio, R., Magagnotti, N., Sirna, A., Spinelli, R., 2012a. *Improved winching technique to reduce logging damage*. Ecol. Eng. 47, 83–86.

Picchio, R., Neri, F., Maesano, M., Savelli, S., Sirna, A., Blasi, S., Baldini, S., Marchi, E., 2011a. *Growth effects of thinning damage in a Corsican pine (Pinus laricio Poiret) stand in central Italy*. For. Ecol. Manage. 262 (2), 237–243.

Picchio, R., Neri, F., Petrini, E., Verani, S., Marchi, E., Certini, G., 2012b. *Machinery-induced soil compaction in thinning of conifer stands.* For. Ecol.Manage. 285, 38–43.

Picchio, R., Spina, R., Maesano, M., Carbone, F., Lo Monaco, A., Marchi, E., 2011b. *Stumpage value in the short wood system for the conversion into high forest of an oak coppice*. For. Stud. China 13 (4), 252–262.

Retana, J., Riba, M., Castell, C., Epelta, J.M., 1992. *Regeneration by sprouting of holm-oak (Quercus ilex) stands exploited by selection thinning.* Vegetatio 99–100, 355–364.

Sánchez-Moreno, S., Minoshima, H., Ferris, H., Jackson, L.E., 2006. *Linking soil properties and nematode community composition: effects of soil management on soil food webs*. Nematology 8 (5), 703–715.

Tabaglio, V., Gavazzi, C., Menta, C., 2009. *Physico-chemical indicators and microarthropod communities as influenced by no-till: conventional tillage and nitrogen fertilisation after four years of continuous maize*. Soil Tillage Res. 105,135–142.

Vannini, A., Natili, G., Anselmi, N., Montaghi, A., Vettraino, A.M., 2010. *Distribution and gradient analysis of ink disease in chestnut forests.* For. Pathol. 40 (2), 73–86.

Venanzi, R., Picchio, R., Piovesan, G., 2016. *Silvicultural and logging impact on soil characteristics in Chestnut (Castanea sativa Mill) Mediterranean coppice*. Ecol. Eng. 96, 82–89.

Vossbrink, J., Horn, R., 2004. *Modern forestry vehicles and their impact on soil physical properties*. Eur. J. For. Res. 123, 259–267.

Vusic, D., Susnjar, M., Marchi, E., Spina, R., Zecic, T., Picchio, R., 2013. *Skidding operations in thinning and shelterwood cut of mixed stands—work productivity, energy inputs and emissions*. Ecol. Eng. 61, 216–223.

Williamson, J.R., Neilsen, W.A., 2000. *The influence of soil and forest site on rate and extent of soil compaction and profile disturbance of skid-trails during round based harvesting*. Can. J. For. Res. 30, 1196–1205.

4 Conservation

Unique conditions.

How does coppice contribute to biodiversity?

Is coppice considered in Natura 2000 site management plans?

Coppice forests on steep slopes – how do they impact stability and rockfall?

Their rich past and cultural heritage, illustrated on the example of the Czech Republic.

Visit this chapter for:

Conservation of Coppice and High Forest Management within the Natura 2000 Network – A Review

Peter Buckley and Jenny Mills

Abstract

The Natura 2000 network protects some of the most threatened species and habitats in the European Union, of which forests account for about 50% of the total designated area. This paper examines the broad habitat preferences of the terrestrial species listed in Annexes of the Birds and Habitats Directives, of which a majority are associated with non-forest habitats. By comparison, European red lists and the various country and regional level lists of species of principal importance contain many more species and species groups than the Directive Annexes. Foresters are likely to use a much narrower suite of species, often based only on the Annexes, when setting practical conservation targets for woodlands.

Achieving the objective of 'favourable conservation status', as required by the Directives, should apply equally to the designated forest habitat types and their listed specialist species. European Commission literature describes these habitats in terms of their typical tree, shrub and herbaceous species, although in practice a mixture of iconic and specialist Annex species may be used for making conservation assessments. Recognising the value of traditional coppice and its long anthropogenic history can be considered a valid reason for conservation in itself, but this form of management is now in serious decline all over Europe. High forests and old growth habitats, together with their associated species, also have equal claims for protection under the Natura 2000 network. Given the difficulty of simultaneously achieving species and habitat targets in the context of both early and late-successional aspects of forest conservation, we consider different silvicultural strategies that may achieve wider biodiversity benefits in the forest environment.

Key words

Natura 2000, Birds and Habitat Directives Annex species, forest habitat type, indicator species, coppice, silvicultural system

Corresponding Author: Peter Buckley, peterbuckleyassociates@gmail.com

Introduction

Some of the most valued and threatened species and habitats in Europe are protected within the Natura 2000 network under the Birds Directive (European Commission 1979) and the Habitats Directive (European Commission 1992). The latter Directive targets more than 230 'habitat types' and 1500 animal and plant species for conservation in its various Annexes, many of which are rare, threatened or endemic. They include 303 animals, 586 plants (Habitats Directive Annex II, HDII) and more than 190 birds (Birds Directive Annex I, BDI). For a further 400 species and sub-species listed in Annex IV of the Habitats Directive (HDIV), which includes many that are also listed in HDII, a strict protection regime must be applied across their entire natural range in the European Union (EU), both within and outside Natura 2000 sites.

Approximately 375,000 km^2 of forests are included in the Natura 2000 Network, representing around 50% of its total area and 21% of the total forest resource in the EU (European Commission 2015). A large proportion of this forest would undoubtedly have been coppiced in the past: based on the average of 24 European countries, up to 15% of the area is presently classified as coppice, together with a probably much greater extent of neglected or converted former coppices (Buckley and Mills, 2015). Considering the large protected area and the strong emphasis given to conserving the threatened biodiversity of forest ecosystems within the EU, one would anticipate that a high proportion of Directive-protected species would be found in, or be dependent on, forested habitats. To discover whether this is the case, the habitat preferences of species listed in BDI and HDII were investigated. The contribution that the traditional forestry techniques of coppicing and pollarding can bring to the protection of biodiversity in Natura 2000 sites was also considered.

Many of the species on the BDI and HDII lists are species of conservation concern, judged as vulnerable or under threat by the International Union for Conservation (IUCN). We consider the composition of different taxa making up these lists, their endemicity, threat status, and their preferences for forest habitats or other, more open ones. In the case of forest and woodland habitats, the definition of 'favourable conservation status', as applied by the Bird and Habitat Directives to both habitats and species, especially more 'typical' species as well as the Natura 2000 species, depends on the ability of different forest management regimes to conserve them. Here we focus initially on traditional coppice forest management, a widespread but now rapidly disappearing silvicultural practice in Europe, and the implications that abandonment or conversion to high forest might have for protecting habitats and species. At the same time we consider what additional protected species niches high forest systems might provide. Finally, we discuss management strategies that might deliver combinations of both early and late-successional growth stages, and which may serve to increase species diversity in forested landscapes.

Methods: allocating broad habitat preferences to species

Using the HDII and BDI Annexes, each protected species was allocated to one or a number of broad habitat types, using the hierarchical classification proposed by the European Environment Agency (EUNIS) (European Environment Agency n.d.). The EUNIS species browser (http://eunis.eea.europa.eu/species.jsp) lists the 'most preferred habitats' in its quick facts for nearly all of these species. These, excluding fish, were allocated to the 10 EUNIS hierarchical habitats (http://eunis.eea.europa.eu/habitats-code-browser.jsp) described in Table 1. If no habitats were listed for a species on the EUNIS database, the world IUCN Red List species details (http://www.iucnredlist.org/details/) were consulted. When not listed in either database, it was recorded in the 'Insufficient data' column, except for fewer than 10 cases where information was taken, for example, from Wildscreen ARKive (http://www.arkive.org), EEA Eionet (https://www.eionet.europa.eu), Joint Nature Conservation Committee (http://jncc.defra.gov.uk), Environment Directorate General of the European Commission (http://ec.europa.eu/environment/index_en.htm) and Birdlife International (http://www.birdlife.org)

While recording this data, it was also noted if a species was on the IUCN Red List and if it was an endemic.

Table 1. Summary of 10 broad habitat types and their descriptions, based on the hierarchical classification proposed by the European Environment Agency (EUNIS)

1	**Marine**	Marine habitats: fully saline, brackish or almost fresh. Includes marine littoral habitats including tidal saltmarshes; marine littoral habitats and strandlines; waterlogged littoral saltmarshes and associated saline or brackish pools.
2	**Coastal**	Habitats are those above spring high tides, including coastal dunes and wooded coastal dunes, beaches and cliffs. Supra-littoral habitats include strandlines, moist and wet coastal dune slacks and dune-slack pools.
3	**Inland surface waters**	Non-coastal fresh or brackish waterbodies (rivers, streams, lakes and pools, springs), including their littoral zones. Also constructed waterbodies (canals, ponds, etc.) supporting semi-natural communities and seasonal waterbodies.
4	**Mires, bogs and fens**	Wetlands, with the water table at or above ground level for at least half of the year, dominated by herbaceous or ericoid vegetation. Includes inland saltmarshes and waterlogged habitats where the groundwater is frozen.
5	**Grasslands**	Dry or only seasonally wet land with >30% vegetation cover. Dominated by grasses and other non-woody plants, including mosses, macro-lichens, ferns, sedges and herbs. Includes semiarid steppes, successional weedy vegetation and managed grasslands (e.g. recreation fields and lawns).
6	**Heathland**	Dry or only seasonally inundated land with >30% vegetation cover. Includes tundra; heathland dominated by shrubs or dwarf shrubs not above 5m tall. Also shrub orchards, vineyards, hedges, climatically-limited dwarf trees (krummholz) >3 m high, *Salix* and *Frangula* carrs.
7	**Woodland**	Dominated by trees over 5m, with a canopy cover of at least 10%. Includes lines of trees, coppices, tree nurseries, plantations and fruit and nut tree orchards. Includes *Alnus* and *Populus* swamp woodland and *Salix*. Excludes *Corylus avellana* scrub and *Salix* and *Frangula* carrs.
8	**Sparsely vegetated**	Habitats with less than 30% vegetation cover which are dry or only seasonally wet. Includes caves and passages including underground waters and disused underground mines, and habitats with permanent snow and surface ice.
9	**Cultivated**	Habitats maintained solely by frequent tilling or recently abandoned arable land and gardens.
10	**Constructed**	Primarily human settlements, buildings, industrial developments, transport networks and waste dumps. Includes artificial saline and non-saline waters with wholly constructed beds or heavily contaminated water, virtually devoid of plant and animal life.

Results

Species groupings

We calculate that 80-90% of BDI and HDII species are also registered on the International Union for Conservation of Nature Red List of Threatened Species (IUCN 2015), which classifies species on the basis of their relative extinction risk, consistent with their need for protection (Fig. 1). Relative to their species numbers, plants, birds and mammals are well represented, but some taxa, such as the arthropods, have received less attention, with under 50% of HDII species recorded on the world Red List, perhaps reflecting the relative scarcity of specialists dealing with this numerous group. Moreover, the species chosen for protection under HDII and HDIV are subject to taxonomic, geographic and aesthetic bias, with preferences given to larger, iconic species, but also including many that are widespread (Cardoso 2012). This bias is evident in the relative dominance of vertebrates compared with very few in the arthropod group, which in turn is biased towards Lepidoptera and Coleoptera, while completely lacking large insect Orders such as Diptera and Hymenoptera. Although plant species make up the largest group in HDII, only 32 bryophytes and no fungi or lichens are included (Orlikowska et al. 2016).

Endemicity and threat status

Listing of HDII species is heavily influenced by their endemic status. Overall, 415 primarily terrestrial species or subspecies (41.7%) are strict endemics, i.e. restricted to one EU country or to Macaronesia. Plants and molluscs have the highest share of endemic taxa (63.8% and 48.3% respectively), with reptiles and amphibians intermediate and breeding birds

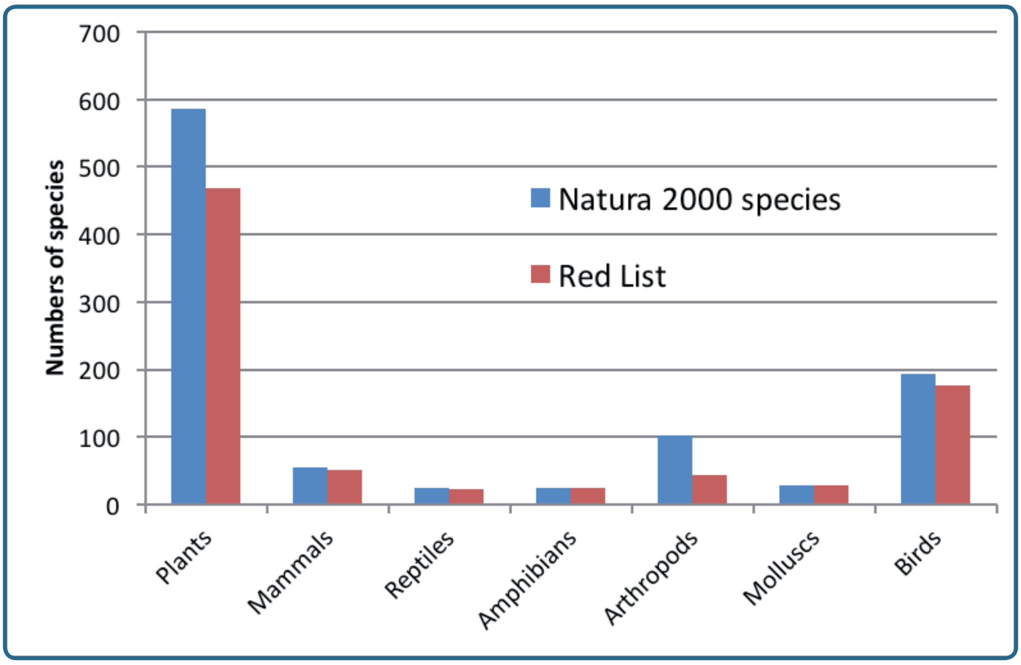


Figure 1. Numbers of BDI and HDII species and on the world IUCN Red List present in each taxonomic group, excluding fish

the lowest (4.9%) (Fig. 2). The low number of arthropods (8.3%) almost certainly reflects an incomplete assessment of this very diverse group. Macaronesian plant species, being by definition full endemics, make up over a quarter of all HDII plants, while of the non-Macaronesian plants, 55.9% are also strictly endemic.

While reptiles, molluscs and plants were relatively more threatened, many mammals, amphibians and birds were of 'least concern' on the IUCN World Red List, but when viewed in a narrower European context, several species may be perceived as more threatened.

Nearly half of BDI and HDII species (48%) fell into the threatened categories (critically endangered, endangered, vulnerable and near-threatened) on the world Red List.

The figures were (Fig. 3):

- 87% for reptiles,
- 68% for molluscs,
- 55% for plants,
- 52% for amphibians
- 43% for mammals,
- 36% for arthropods
- 21% for birds.

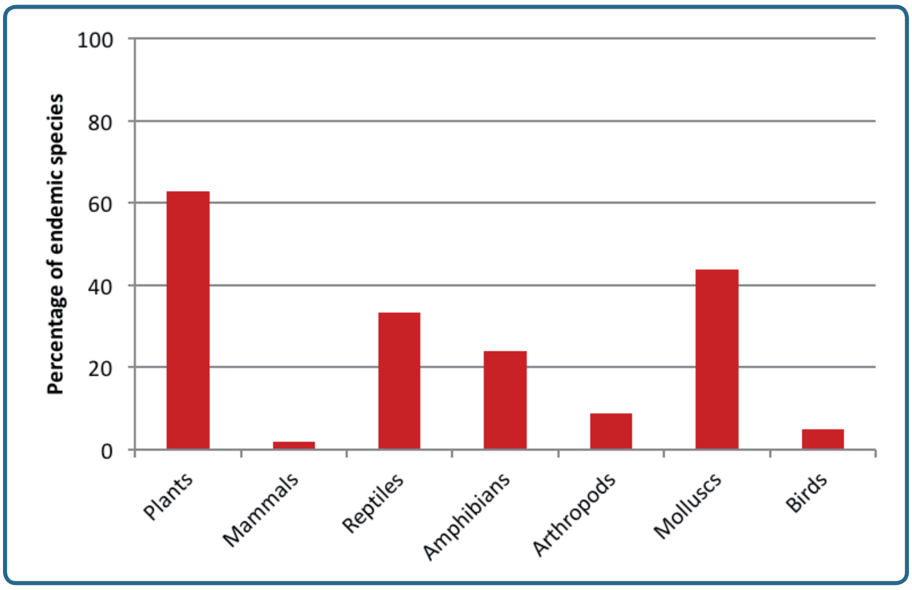


Figure 2. Percentage of BDI and HDII endemic species, by taxonomic groups (excluding fish)

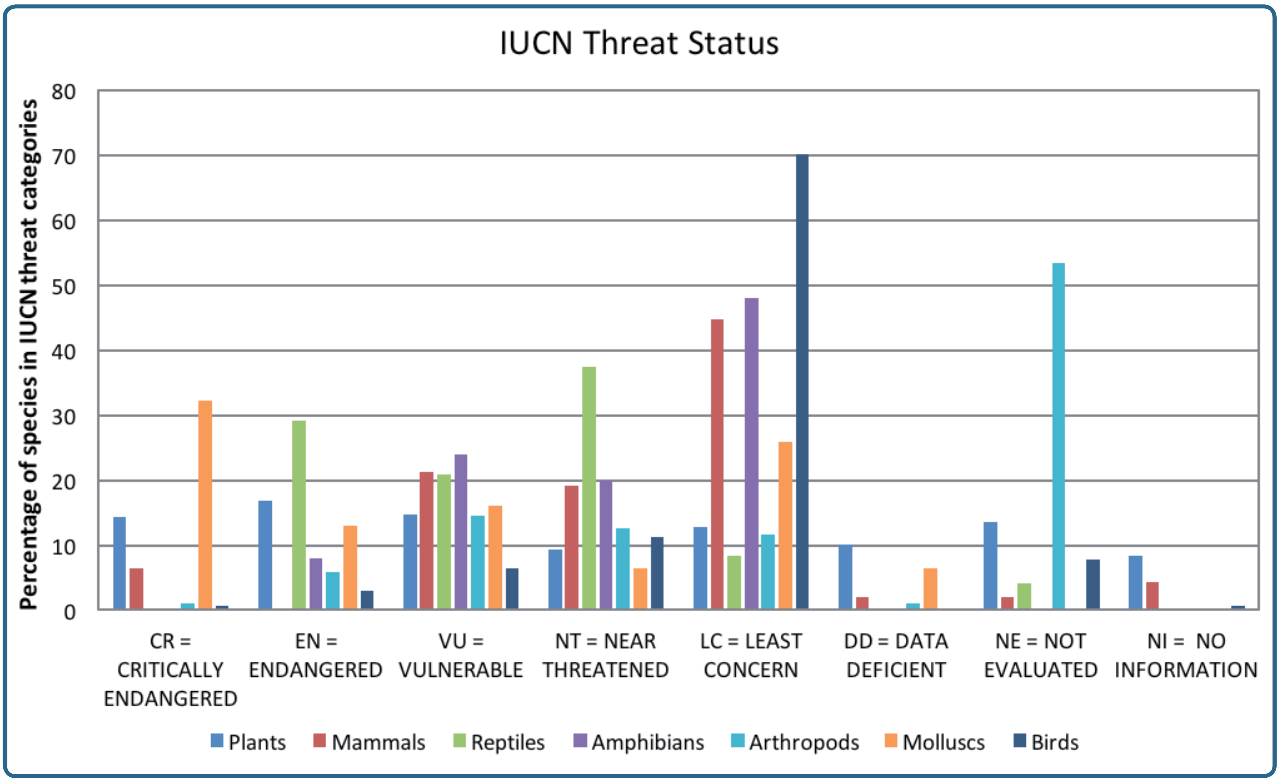


Figure 3. Percentage of BDI and HDII species from different terrestrial taxonomic groups in the IUCN world list categories

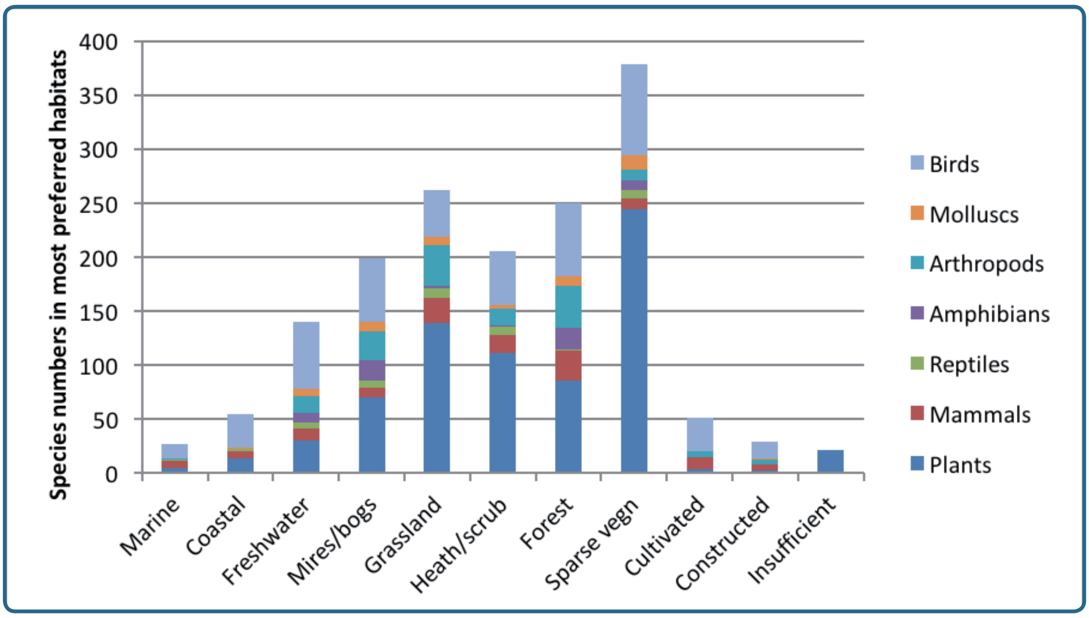


Figure 4. Numbers of BDI and HDII species occurring in different EUNIS habitat types

Habitat distributions of protected species

The most frequent preferred species habitats were in sparsely vegetated habitats, with grasslands, forests, heathlands and wetlands intermediate, and relatively few in marine, coastal, cultivated and construction sites (Fig. 4). Several plant species were given preferred habitat status in sparse vegetation, although many could also be categorised more specifically as species of sand dunes, cliffs, tundra and alpine habitats. Of particular interest was the 'forest and woodland' category, which contained relatively balanced proportions of the different taxonomic groups compared with other categories, including a comparatively high number of arthropods, amphibians and mammals, although relatively fewer plants and reptiles than in other open habitats. As forests cover such a large part of the Natura 2000 network, it is not surprising that they shelter a large number of Directive-protected species. Collectively, however, the great variety of more open habitats (e.g. sparse vegetation, grassland, heath, etc.) contain significantly more. The vast majority of these BDI and HDII species appeared to be associated with non-forest or relatively open conditions.

Spatial hierarchies of protected species

Lists of rare species tend to become more refined as the area of interest narrows. A hierarchical gradient taken from the IUCN world perspective, diminishing in scope for Natura 2000 and the European Red Lists, and further to the more localised level of countries and regions, shows that species lists of principal conservation importance often tend to become more focused and lengthier (Table 2). In separate European countries and regions, protected species lists are generally focused more at this level than at the BDI and HDII Annex level: those species relatively widely distributed at a European level effectively become 'rarer' at a local level, and therefore more notable. Compared with the BDI or HDII species annexes, European Red Lists contain many more species, often more than three times the number. This is particularly obvious for invertebrate Red Lists of dragonflies (Kalkman et al. 2010), saproxylic beetles (Nieto and Alexander 2010), non-marine molluscs (Cuttlelod et al. 2011), butterflies (van Swaay et al. 2011) and bees (Nieto et al. 2014). At a national level the picture is even more variable: in Britain, for example, as would be expected from this country's size and its history of glacial impoverishment, the numbers of vascular plants, mammals, reptiles and amphibians were lower than the equivalent BDI and HDII annexes and European red lists, but a greater effort has been made to cover non-vascular plants, invertebrates, fungi and lichens. In other countries and regions, such as France, Estonia and Flanders, the same tendency to specialise within some of the broader taxonomic groups is seen (Table 2).

Table 2. Numbers of terrestrial species (mostly terrestrial or freshwater) selected at different spatial levels for biodiversity conservation: the IUCN world red list, the BDI and HDII, the IUCN European red lists, UICN French red lists, the UK Biodiversity Action Plan, Estonian protected species and Flanders red lists

Taxonomic group	HDII and BDI species on IUCN world red list[1]	HDII and BDI species (Natura 2000)[2,3]	European red list (EU27)	France red lists	Britain – species of principal importance[4]	Estonian protected species[5]	Flanders red lists
Vascular plants	412	554	*1750[6]	1018[7,8]	382	215	1152[9]
Non-vascular plants	1	32	* †		552	46	
Mammals	45	47	179[10]	99[11]	25	18	65[12]
Total invertebrates	75	135			597	52	
Dragonflies	11	11	*134[13]		3	5	64[14]
Saproxylic beetles	9	17	*408[15]		10	3	19[16]
Molluscs	31	31	*1805[17]		29	4	
Lepidoptera	14	38	421‡[18]	253‡[19]	195	10	72‡[20]
Bees	0	0	1900[21]		44	18	
Reptiles	23	24	128[22]	35[23]	6	5	6[24]
Amphibians	25	25	82[25]	35[23]	4	11	16[24]
Fungi/lichens	0	0	0		782	97	
Birds	150	162	399[26]	345[27]	105	93	200[28]

*to be completed by 2018 † bryophytes only ‡ butterflies only

[1]IUCN (2015) [2]European Commission (1992) [3]European Commission (1979) [4]Natural Environment and Rural Communities (NERC) Act (2006a, 2006b), Nature Conservation (Scotland) Act (2004) [5]Riigi Teataja (2014a, 2014b) [6]Bilz et al. (2011) [7]UICN France et al. (2012) [8]UICN France et al. (2009) [9]Van Landuyt et al. (2006) [10]Temple and Terry (2007) [11]UICN France et al. (2009) [12]Maes et al. (2014) [13]Kalkman et al. (2010) [14]De Knijf (2006) [15]Nieto and Alexander (2010) [16]Thomaes et al. (2015) [17]Cuttelod et al. (2011) [18]van Swaay et al. (2010) [19]UICN France et al. (2014) [20]Maes et al. (2011) [21]Nieto et al. (2014) [22]Cox and Temple (2009) [23]UICN France et al. (2015) [24]Jooris et al. (2012) [25]Temple, Cox (2009) [26]Birdlife International (2015) [27]UICN France et al. (2011) [28]Devos et al. (2004).

At forest species protection level, Britain's state forestry service (the Forestry Commission) has produced a web-based decision support system for its managers dealing with Habitats and Rare, Priority, and Protected species (HaRPPS). This provides information on about 123 woodland species, including:

- 25 mammals,
- 37 birds,
- 4 herptiles,
- 21 invertebrates,
- 13 vascular plants and
- 23 fungi and lower plants (Forest Research 2011),

allowing forest managers to predict which species might be present in a given area and to test the impact of forest operations on them.

Although the British lists of species of principal importance for conservation cover all habitats, including forests (NERC Act 2006a,b; Nature Conservation (Scotland) Act 2004) there are big disparities with HaRRPS for different taxonomic groups: mammals, birds and herptiles are well covered, whereas vascular plants, bryophytes, liverworts and invertebrates are not (Fig. 5). Practising forest managers should be able to identify iconic animals and birds in their well-protected groups, but are less likely to have specialist knowledge of some invertebrates, fungi, vascular and non-vascular plants.

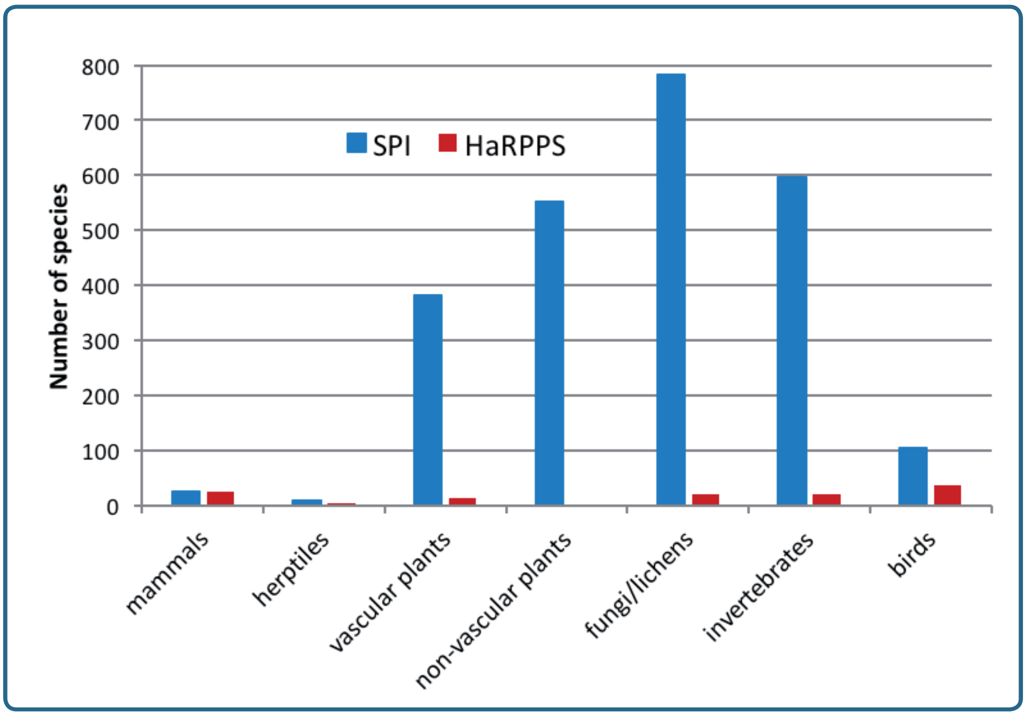


Figure 5. Numbers of species of principal importance (SPI) in Britain by taxonomic group, relative to that of the Forestry Commission's information system for use in woodland habitats (Habitats and Rare, Priority and Protected Species HaRPPS) (Forest Research 2011)

Discussion

Favourable conservation status

The emphasis placed on rare or iconic species is not always effective in promoting species diversity, as the overriding issue for forest species is fundamentally the protection of their habitat and its quality. However, when compiling the Standard Data Forms for the designation of Natura 2000 sites, agencies tend to focus on rare species, irrespective of whether they are only a fraction of a metapopulation that extends beyond the boundary of the protected area (Battisti and Fanelli 2014). In fact, in terms of ecological integrity, achieving a 'favourable conservation status', a legal requirement of Natura 2000 designation, applies to any 'typical species' of a HDI habitat (Rees et al. 2013). The Directive applies equally to the habitat, which must be stable or increasing and likely to sustain its structure and function for the foreseeable future. The reality is that only 15% of the protected forest habitats in the EU are reported as being in a favourable condition due to multiple factors, such as fires, disease, browsing, pollution, urbanisation, etc., but mainly to forest and plantation management, such as the removal of dead and dying trees (European Commission 2015). Among the human activities reported on Standard Data Forms, agriculture and forestry were associated with more than 86% of a sample of Natura 2000 sites, of which forestry activities affected 59% (Tsiafouli et al. 2013). Many broadleaved forest HDI habitats described as 'Temperate Forests of Europe' in the European Commission's Interpretation Manual of European Union Habitats EU28 (European Commission 2013) have the potential to be coppiced, based on the re-sprouting potential of the dominant trees (Mairota et al. 2016), although most is now high forest. The summary descriptions of each forest habitat type are of essentially widespread or characteristic plant species (Table 3), including several relatively common herbs and grasses, which depend on the forest margins and the more frequently open canopies that could be provided by coppice management. Very few HDII species (i.e. rarities and endemics) are listed. When this suite of 'typical', widespread species is present, it follows that a 'favourable conservation status' is more likely to be achieved for rarer ones.

To support the regular monitoring of Natura 2000 sites a range of species specialists associated with long-term anthropogenic management of their forest habitat could be identified, as recognised by the Habitats Directive (Epstein et al. 2015). Such 'indicator species' would not necessarily be rare endemics or HDII species, but could represent several taxa, including vascular plants, bryophytes, wood-decaying fungi, epiphytic lichens, saproxylic beetles and land snails (Nordén et al. 2014). Some of these are more properly indicators of traditional high forest or old growth, but many ancient woodland 'indicator plants' with limited dispersal characteristics (sensu Hermy et al. 1999; Verheyen et al. 2003; Kimberley et al. 2013) are also associated with former coppice habitats; Decocq et al. (2005) even suggested that they might be better labelled 'coppice-woodland species'. In northwest Germany, Schmidt et al. (2014) listed 67 ancient woodland indicator plants, most of them typical of closed forests, but with 13% preferring forest edges and clearings, while Pellisier et al. (2013) identified 40 'core' and 38 'periphery' forest species based on a large database of over 1800 forest patches in northern France.

Aesthetic as well as biodiversity criteria can be taken into account in species protection. In the Zurich Canton of Switzerland, aesthetic criteria were involved in an action plan to restore the typical flora (from a target list of 172 species) associated with 'light' or open-canopied forests, which was carried out on a portion of the total forest area of 47,500 ha (Bürgi et al. 2010). The areas selected were based on an analysis of the target species and forest management practices, recognising not only anthropocentric history but also the ecological continuity of coppice habitats within the region, much in the spirit of the Habitats Directive.

Provision for coppice specialists

Traditional coppice management, often based on regular short rotations over centuries, has produced a habitat for species that are adapted to the dynamic of rapidly altering light, temperature and hydrological regimes (Peterken 1993, Rackham 2003, Szabo 2010). These regular, intense pulses of disturbance tend to boost the diversity in both the ground flora and shrub layers (Ash and Barkham, 1976; Decocq et al. 2004; Brunet et al. 2010; Verheyen et al. 2012; Campetella et al. 2016). The transient woodland structure produced is important for many songbirds that forage and nest in young growth, as well as for other open-ground

Table 3. Species with frequencies of 10% (2/20) or more that are named in the summaries of 20 different forest habitat types from the 'Forests of Temperate Europe' (Annex 1 code 9100); the list is based on 26,433 Natura 2000 sites where at least 100 sites are devoted to each forest habitat type

Trees	/20		/20		/20
Quercus petraea	8	*Acer tartaricum*	3	*Ilex aquifolium*	2
Fagus sylvatica	6	*Betula pubescens*	3	*Populus nigra*	2
Quercus cerris	6	*Fraxinus angustifolia*	3	*Populus tremula*	2
Quercus robur	6	*Fraxinus excelsior*	3	*Quercus pyrenaica*	2
Carpinus betulus	5	*Euonymus verrucosus*	3	*Sorbus domestica*	2
Acer campestre	4	*Picea abies*	3	*Taxus baccata*	2
Sorbus torminalis	4	*Quercus pubescens*	3	*Tilia tomentosa*	2
Tilia cordata	4	*Acer pseudoplatanus*	2	*Ulmus glabra*	2
Abies alba	3	*Alnus glutinosa*	2	*Ulmus minor*	2
Shrubs	/20		/20		/20
Euonymus verrucosus	3	*Frangula alnus*	2	*Vaccinium myrtillus*	2
Ligustrum vulgare	3	*Pyrus pyraster*	2		
Buxus sempervirens	2	*Ruscus aculeatus*	2		
Herbaceous Species	/20		/20		/20
Carex montana	4	*Anemone nemorosa*	2	*Hieracium sabaudum*	2
Dentaria spp.	4	*Buglossoides purpurocaerulea*	2	*Lathyrus niger*	2
Festuca heterophylla	3	*Carex michelii*	2	*Luzula forsteri*	2
Knautia drymeia	3	*Cyclamen purpurascens*	2	*Molinia caerulea*	2
Potentilla micrantha	3	*Galium schultesii*	2	*Potentilla alba*	2
Pteridium aquilinum	3	*Galium sylvaticum*	2	*Pulmonaria mollis*	2
Tanacetum corymbosum	3	*Helleborus odorus*	2	*Tamus communis*	2

foragers (Camprodon and Brotons 2006; Fuller 2012). After coppicing, the resulting sunny and warm miocroclimate creates suitable conditions for a range of butterflies, macromoths and other invertebrates (e.g. Sparks et al. 1996; Fartmann et al. 2013; Horák et al. 2014), which take advantage of increased understorey flowering and abundant sources of pollen and nectar.

While many thermophilic and opportunistic species are cosmopolitan, others are more restricted to the coppice habitat. They include many vascular plants tolerant of intermittent shading, accompanied by a large insect biomass dependent on flowers and young foliage (Warren and Key 1991; Greatorex-Davies and Marrs 1992). In order to maintain viable populations, sufficient canopy openings and forest margins must be present, whether created anthropogenically or by a natural disturbance dynamic. Some beneficiaries that are specialists of the coppice habitat are considered of high conservation value: there are examples of conservation coppicing carried out expressly to support a single species or group of species. Examples are rare butterfly populations such as the Scarce Fritillary (*Euphydryas maturna*) and many others that are not necessarily listed in HDII and HDIV (e.g. van Swaay et al. 2006; Kobayashi et al. 2010; Fartman et al. 2013; Dolek et al. 2018). Very low densities of standards in coppice, covering as little as 10-15% of the stand, have been recommended in order to maintain open conditions for butterfly conservation (Clarke et al. 2011). Coppicing may also be maintained specifically for other iconic species such as the hazel grouse (*Bonasa bonasia*), where coppice provides a substitute for its optimum forest habitat of shrub layers in gaps of old-growth forests (Kajtoch et al. 2012), for migrant songbirds that nest and forage in scrub (e.g. *Sylvia* species), and small mammals such as the hazel dormouse (*Muscardinus avellanarius*) (Ramakers et al. 2014; Sozio et al. 2016).

Many other species also benefit from the openings created by coppicing. However, in long-neglected or converted coppice stands, plant species diversity and some red-listed herb layer species tend to diminish rapidly (Van Calster et al. 2008a; Kopecky et al. 2013; Vild et al. 2013; Müllerová et al. 2015). In formerly grazed and coppiced sub-continental oak forest in the Czech Republic, these declining and endangered species tended to persist in locations with high light availability and relatively higher pH (Roleček et al. 2017). Similarly, in comparing vegetation data from still-active selection coppices with beech-dominated high forests in the Banat region in Romania, the coppices were slightly more diverse, containing thermophilous and non-forest species more typical of more open grassland habitats, although they were similar in herb species richness to high forests (Šebesta et al, 2017). The re-application of traditional forest management practices may be able to reverse successional tendencies in long-abandoned or converted former coppices. In lowland thermophilous oak forest, restoration of a litter-raking treatment effectively increased the richness and cover of both forest and dry grassland species over a 5-year period (Douda et al. 2017). The restoration of canopy thinning, analogous to coppicing, in a long abandoned ancient coppice-with standards woodlands, has been shown to potentially support and revive light-demanding woodland floras (Vild et al. 2013) and also to increase the functional diversity responses of plant and ground-dwelling spider communities (Šipoš et al. 2017).

Several researchers have shown that vascular plants in the herb layer of beech forests were marginally more diverse in managed stands or after disturbance at the plot level, compared with unmanaged stands, later to decline with neglect (e.g. Schmidt 2005; Bartha et al. 2008; Garadnai et al. 2010; Mölder et al. 2014). At the patch level, Campetella et al. (2016) showed that a rich species pool of specialist plants associated with beech forest in the Central Apennines could be maintained under active management, i.e within a landscape mosaic comprising different woodland development stages. In the same region, Scolastri et al. (2016) found that beech forests, whether classified as old coppice-with-standards or as high forest, contained many heliophilous plants indicative of past light regimes, as well as many shade-tolerant, understorey species typical of 9210* Apennine beech forests with *Taxus* and *Ilex* recognised in the European Commission's Habitat Directive Interpretation Manual (European Commission, 2013). Cervillini et al. (2017) considered that with canopy cover stabilising between 10 and 16 years, approximately 10 years before coppice harvesting, many such specialists of shaded beech forests were able to persist.

Conversion to high forest

Coppices gradually change their biological character when they are abandoned or are converted into high forests. Several long-term studies have investigated the vegetational and edaphic changes resulting from this transition in European forests (Debussche et al. 2001; Peterson 2002; Decocq et al. 2004, 2005; Van Calster et al. 2007, 2008b; Baeten et al. 2009; Verheyen et al. 2012; Kopecký et al. 2013; Verstraeten et al. 2013; Becker et al. 2016). Most of these recorded a decline in species-richness of the tree, shrub and herb layers, with homogenisation increasing under the shade cast by a developing canopy, together with increases in shade-tolerant, vernal and eutrophic species.

Changes in the vegetation, such as increasing tree cover, may be happening in parallel with coppice abandonment, frequently detected in signals of eutrophication and acidification resulting from increased atmospheric deposition (Verheyen et al. 2012), as well as potential climate change. Peterson (2002), investigating a chronosequence of sample plots in ageing coppice in Denmark (median age = 40 years), suggested that increasing shade, together with the build-up of acidifying litter, tended to reduce species density and to favour clonal forest species. In Belgium, Van Calster et al. (2007) also reported increases in soil acidity in coppice-with-standards undergoing conversion to high forest from 1967-2005, at least partly explained by the poor litter quality under canopies of *Fagus sylvatica* and *Quercus robur*. In recordings made over an interval of 50 years, Verstraeten et al. (2013) found that the species pool of understorey herbs in former coppice-with standards generally declined, as did Ellenberg light indicator values, while those for nitrogen availability increased. The high input of atmospheric deposition within this period shifted the plant community towards a more N-demanding and shade-tolerant type.

In Germany, similar observations were made by Becker et al. (2016) in coppice-with-standards woodlands which had been in conversion for c. 100 years. They recorded decreases in species richness, accompanied by increases in nitrophilic and shade-tolerant species over a recording interval of 41 years, although the legacy of coppicing was still evident in the composition of the tree, shrub and herb layers, suggesting that the influence of former management could persist for more than a century. In beech-dominated forest that had formerly been under a coppice-with–standards regime, Heinrichs and Wolfgang (2017) detected relatively more homogenisation over time in those understorey communities situated on dry, nutrient-poor and sun-exposed slopes, which tended to lose light-demanding, drought tolerant and oligotrophic species, compared with a more mesic forest community, which tended to gain in generalist species. A more recent resurvey interval, with a baseline set in the 1990s, detected similar increases in nitrophilous and mesotrophic light-demanding species in formerly coppiced thermophilous oak forests in SW Poland (Reczyńska and Świerkosz 2016). However, in this case an increase in plant biodiversity and an inferred decrease in soil pH occurred over the 20-year interval, coinciding with major reductions in sulphur emission levels between 1960 and 2000. Other drivers of change were declining soil moisture and increased ungulate grazing.

Provision for other forest habitats

Notwithstanding the apparent lack of deadwood for saproxylic niches in coppices, it has been pointed out that some are capable of maintaining microhabitats such as dendrothelms and mould cavities in old coppice stools, pollards or standard trees (Lassauce et al 2012; Vandekerkove et al. 2016, Larrieu et al. 2016). Microhabitats in ageing stands of trees are key components of biodiversity – for example tree cavities will benefit several mammals, birds, arthropods, but also fungi, bryophytes and lichens, including several obligate saproxylic beetles listed in Annex II of the Habitats Directive such as *Limoniscus violaceus*, *Osmoderma eremitica, Cerambyx longicorn* and *Lucanus cervus*. As stands age and amounts of deadwood increase, old coppices may even have the potential to allow saproxylic species to re-colonise. In the medium term at least, they may favour species with a preference for sun-exposed wood (Vandekerkhove et al. 2016).

The reductions in herb-layer diversity commonly observed in unmanaged forests do not apply to many other species groups. A meta-analysis of European forest literature found a marginally wider species diversity in unmanaged forests compared with managed ones, the differences increasing with time since abandonment (Paillet et al. 2010). Management tended to favour light-demanding understorey vascular plants, ruderals and competitive species, whereas bryophytes, lichens, fungi, saproxylic beetles and carabids, more dependent on closed-canopy, benefited from abandonment. However, the way in which high forests are managed may considerably effect the biodiversity of species requiring longer rotations. A systematic Biodiversity Exploratory Project on beech high forests in Germany actually found a greater species diversity in managed forests compared with unmanaged ones, but the former contained higher average amounts of deadwood, possibly accounting for a higher diversity of specialist deadwood beetles, mosses and lichens (Müller et al. 2015).

Conversely, in three European biogeographical regions Zehetmair et al. (2015a,b) found no differences between commercially exploited Natura 2000 sites and matching non-Natura 2000 stands of 9130 *Asperulo-Fagetum* forest in terms of their densities of forest-dwelling bats or beetle diversity (including saproxylic species). This suggested Natura 2000 status alone would not make the stands more ecologically effective, especially for encouraging late succession species, and that additional conservation efforts were needed in these designated stands. This would require more deadwood, both standing and fallen, retention of 'habitat trees' with microhabitats such as cavities and bark pockets, and mature, living trees as potential recruits. Current forest certification schemes and local forest administration rules increasingly advocate such conservation measures, but non-selective and intensive harvesting practices in many forest types still tends to remove senescent trees and reduce deadwood (Larrieu et al. 2016). This is particularly the case in actively managed coppice woodland with few, if any, mature trees, except in ageing stands that are no longer exploited.

In another forest type, old thermophilic oak forests, canopy openness favoured saproxylic species (fungi, lichens, beetles, ants, bees and wasps), inferring that coppice and wood pasture could maintain their populations in more open conditions (Horák et al. 2014). Similarly, in lowland oak forest in southern Moravia, canopy openness favoured an optimum diversity of spiders (Košulič et al. 2016), although these authors suggested that small-scale disturbances created by conservation thinning and selective harvesting, rather than extensive coppicing, could adequately maintain the various successional stages required. In old-growth, predominantly beech forest in the Czech Republic Horák et al. (2016) also found that saproxylic beetle richness was positively influenced by canopy openness, as well as by the the quantity of deadwood, whereas saproxylic fungi species responded more to canopy closure, deadwood quantity and higher levels of humidity. The higher temperatures under more open canopies might also partially compensate for a lack of deadwood (Schulze et al. 2016). Deadwood and old-growth conditions equally benefit the diversity of bird and bat communities. Cavity-nesting birds, as well as gleaner bats, were positively associated with standing deadwood in a study comparing managed and unmanaged stands of both lowland and upland forests in France (Bouvet et al. 2016). More nesting and feeding opportunities were available when microhabitats such as cavities and cracks were abundant, but insectivore birds, which require more open forests with well-developed shrub layers, were negatively affected by high densities of living trees.

Clearly, a range of forest age-classes or patches at a landscape scale would help to optimise their species diversity. While British literature tends to emphasise the benefits of young growth associated with coppice for birds, both European and North American studies emphasise the merits of later stand development for this same taxonomic group, perhaps reflecting the fact that Britain has relatively fewer old-growth stands (Quine et al. 2007). Thus, some balance between the extent of open and closed forests should deliver the maximum biodiversity for all taxa.

Strategies to increase biodiversity

What other forms of silviculture might mirror the biodiversity associated with coppice management? Clear-cutting routines, which create abundant open space after harvesting, have aspects in common with a coppice cycle, although in coppice the canopies generally recover faster through vegetative regeneration and are also harvested earlier. Contrasting with traditional coppice-with-standards, the more frequent harvests in forests undergoing selective cutting may actually disadvantage the ancient woodland flora by causing greater disturbance (Decocq et al. 2005). In another context, the type of timber-harvesting practice, whether clear-cutting, thinning or selective, had relatively little effect on understorey plant diversity in temperate North American forests (Duguid and Ashton 2013). However, in this case selective cutting did increase plant species diversity compared with unharvested controls, possibly because the frequency of interventions increased the opportunity for early successional ruderals to co-exist with late successional perennials, analogous to the situation in harvested traditional coppices in Europe.

High forests, if neglected or managed along continuous cover, selection, or close-to-nature forestry lines, are far less likely to sustain large populations of light-demanding, thermophilic species, unless disturbance is sufficiently frequent and on a scale large enough to trigger patches of young growth across the landscape. In a comparison of intensively managed shelterwoods in Germany with the more extensive felling practices in Romania, where a period of self-thinning was followed by clear-cutting, Schulze et al. (2014) suggested that shelterwoods were probably less effective in promoting a wider biodiversity. At a practical level, some forest owners might prefer the simplicity of a clear-cutting routine to more intricate, close-to-nature management designed to optimise stand structure, species composition, amounts of deadwood and habitat trees for conservation (Borrass, 2014).

The few studies directly comparing managed and unmanaged forests have tended to agree that veteran trees and deadwood should be retained in order to support a full biodiversity of species, because the disintegration phase in forest development generally provides the highest biodiversity (Winter and Brambach 2011). If a few trees are allowed grow to large diameters, e.g. for more than 150 years, they will increasingly provide the cavities, dendrothelms, bark cracks and fungal sporophores that are missing in younger stands. For beech-fir forests Larrieu et al. (2012) recommended conserving 10-20% of the forest area as veteran trees, retaining at least some individuals of >70cm diameter; similarly, for beech forests, Gossner et al. (2013) suggested retaining 'habitat' trees of >50cm diameter.

Since coppice rotations are far too short to allow trees to enter the disintegration phase, longer rotations incorporating significant amounts of young growth could be achieved in irregular and strip shelterwoods, wood pastures and standards within the coppice. Standards could potentially provide some microhabitats and deadwood, but are traditionally felled at relatively young biological ages, typically at 100 years or less (Matthews 1989; Harmer and Howe 2003), and would need to be retained for longer if their full biodiversity potential were to be realised. Larrieu et al. (2012; 2016) considered that intervals of 50 years without harvesting in coppice-with-standards was insufficient to reach tree-bearing microhabitat densities approaching those of old-growth forests; double this period was more likely to achieve it. Large diameters of deadwood, favoured by many saproxylic beetles, can coexist within relatively open and sunny conditions in coppices and wood-pastures (Seibold et al. 2015; Sebek et al. 2015). Rather longer standard tree rotations of 125 years have been recommended by others for conservation reasons, covering 20-25% of the area (Hopkins and Kirby 2007). A greater proportion of older trees within coppice is provided by the 'single tree orientated silviculture' method advocated by Manetti et al. (2016), in which low densities of target trees within the coppice are selected (e.g. 100 ha^{-1}) and thereafter favoured by frequent thinning of their immediate neighbours, until they become valuable timber trees. This system produces a varied horizontal and vertical canopy structure comprising isolated trees, thinned stools and unmanaged coppice, although the crop trees are destined to be harvested when biologically still young, at merchantable size. Another silvicultural technique is to manage groups of standards as mini-high forests, embedded within the coppice stand (Mairota et al. 2016).

Standing and lying deadwood accumulation is strongly linked to biodiversity; the larger pieces providing a stable and enduring environment for the larvae of large-bodied beetles (Gossner et al. 2013). In European forests, a deadwood threshold of the order of >20-50m^3 ha^{-1} has been suggested as necessary to support a high diversity of saproxylic organisms (Müller and Bütler 2010; Lachat et al. 2013). However, a significant patch-scale threshold of >300 m^3 ha^{-1} was found in old-growth, mixed-montane forests in the Czech Republic, more than twice the level recommended by Müller and Butler (2010) for this type of forest (Horák et al. 2014). In south-eastern Germany, both the quantity and the diversity of deadwood (in contrasting sunny and shady situations) were found to be important drivers of saproxylic beetle assemblages in a mixed montane broadleaved/coniferous forest (Seibold et al. 2016). An extensive review of biodiversity within European beech forests by Brunet et al. (2010) concluded that the general sensitivity of species groups to shelterwood management roughly followed the order:

herbaceous plants
< soil macrofungi
< ground dwelling arthropods
< land snails
< saproxylic fungi
< hole nesting birds and saproxylic insects
< epiphytic lichens and bryophytes
< epixylic bryophytes,

a further argument for retaining a proportion of veteran trees in order to fully represent the saproxylic and epiphytic species. Shortening rotation lengths, as in the increased exploitation of wood energy in aged coppices, could negatively impact saproxylic biodiversity if ‘habitat trees’ are not retained (Lassauce et al. 2013).

To optimise conservation objectives, it is frequently suggested that older trees and old-growth features should be deliberately interspersed amongst conventional forest cycles - an ideal situation would be a mosaic of different forest structures and ages at a landscape or regional scale. Several authors cited conservation measures using variable retention harvests, in which patches of unharvested ‘tree islands’, or *‘îlots de sénescence’*, are connected by a network of ‘deadwood corridors’, set within a productive, multi-aged forest matrix (Vandekerkove et al. 2013; Mason and Zapponi 2015; Larrieu et al. 2106). High density patches of mature trees would theoretially provide a more humid microclimate for fungi, bryophytes and lichens than would the spatially separated trees in a conventional coppice-with-standards arrangement. The best places for retaining veteran trees are likely to be within forest patches possessing a long history of continuity (Brin et al. 2016). Deadwood could also be retained in situ as part of regular harvesting, where the particular tree species may also be important. Gossner et al. (2016) suggested that leaving some larger-sized logs of subordinate trees such as *Carpinus betulus* behind on the forest floor could help to conserve saproxylic beetle diversity more effectively than would leaving larger amounts of dominant species, such as beech.

A study by Winter and Brambach (2011) showed that uniformly managed forests were less diverse in the number of different forest growth stages that they represented than their equivalent in matched forest reserves. A landscape mosaic consisting of different forest types and ages might be expected to provide habitats for far more species than one type more uniformly managed (Schulte et al. 2006). Interacting patchworks, networks, and gradients within the landscape will ultimately determine forest conservation and biodiversity (Forman 1995; Lindenmayer and Franklin 2002). If, on the other hand, a whole landscape were given over to the small-scale dynamics of close-to-nature silviculture, this would tend to reduce overall beta-diversity and homogeneity in forest structure (Decocq et al. 2005). Building in increased structural diversity, using a variety of systems - clear-felling, shelterwood cutting, group selection, single tree selection, etc. - would offer greater complexity from a silvicultural point of view (Schall and Ammer 2013).

Conclusions

The Natura 2000 network uses criteria of species rarity and endemicity to represent Europe's threatened biodiversity. This is also true at international, national and regional levels, where priority species and some habitats are given special conservation and protection status. With the emphasis on the protection of rare and threatened species, this appears to be more of a bottom-up exercise than one based on the habitat type (Maiorano et al. 2015). The former is a fine filter, whereas the latter, though a coarse filter, could nevertheless be regarded as a surrogate for the presence of notable and rare species. However, the Natura 2000 system can be said to provide a positive 'umbrella' for many groups of non-Annex species, with some exceptions such as amphibians and reptiles (European Commission 2016; van der Slius et al. 2016).

An intimate knowledge of habitat requirements is needed to manage and maintain healthy populations and to balance the claims of several competing species. However, the Natura 2000 exercise will always be incomplete: many taxonomic groups have yet to be assessed or updated, as can be seen from the continuous revision of the European Red Lists and priority species lists used by different countries. In particular, invertebrates (such as arachnids and molluscs), soil fauna, bats and small mammals have poor representation. Taking one example, only 17 saproxylic beetles are listed on HDII whereas 407 appear on the EU27 Red List, 57 (14%) of which are in the threatened categories. Many are still 'data deficient', with more waiting to be assessed, some of which will likely be found to be threatened (Nieto and Alexander 2010) (Table 2).

Although the HDII list is in serious need of revision and regular updating (Hochkirch et al. 2013), this is likely to remain a long-term project. A recent EU Working Document on the two Natura 2000 Directives found that they were indeed 'fit for purpose' in achieving the broader framework of EU Biodiversity policy. While it could be argued that more improvements in species coverage and alignment with international agreements would be desirable, these could generate uncertainty, leading to delays in the full implementation of the Directives while increasing costs and decreasing legal certainty (Milieu et al. 2016).

Comparatively few Natura 2000 species are 'coppice' specialists, but these and more generalist species have an important role to play. Götmark (2013) suggested that, depending on forest size and objectives, four types of conservation management strategies should be combined:

1) minimal intervention, which could eventually apply to coppices that are no longer managed;

2) traditional management, based on historical research, such as coppicing and pollarding;

3) non-traditional management, for example to promote old-growth characteristics, though this is not applicable to most coppices, or a particular composition of tree species; and

4) management specifically to promote threatened, indicator and other species.

A silvicultural portfolio embracing the extremes of all successional stages, from coppicing of young trees through to old growth, best promises to enhance diversity at a landscape level. Forestry certification schemes currently set standards for tree retention and deadwood, but some also acknowledge the contribution to biodiversity of traditional forest management, such as coppicing and pollarding. A review of the impacts of forestry practices in Britain and

Ireland found that most improvements to forest biodiversity resulted from the temporary open space after harvesting, or through permanent open space, often associated with the road and ride network (Bellamy and Charman 2012). Given the potentially huge array of species comprising forest biodiversity, young growth alone cannot provide niches for all of them, whereas, in coppicing it can be used to promote iconic species as well as cosmopolitan ones. Other species, including many of those listed in the Annexes of Natura 2000, depend on high forest structures and old growth by combining different forest development stages. Overall biodiversity will only increase if both the protected and 'typical' species of forest habitats are given equal scrutiny.

References

Ash JE, Barkham JP (1976) *Changes and variability in the field layer of a coppiced woodland in Norfolk, England*. J Ecol 64: 697–712. http://www.jstor.org/stable/2258779

Baeten, L., Brauwens, B., De Schrijver, A., de Keersmaeker, L., Van Calster, H., Vandekerkhove, K., Roelandt, B., Beeckman, H. & Verheyen, K. 2009. *Herb layer changes (1954–2000) related to the conversion of coppice-with-standards forest and soil acidification*. Appl Veg Sci 12: 187–197. doi: 10.1111/j.1654-109X.2009.01013.x

Bartha S, Merolli A, Campetella G, Canullo R (2008) *Changes of vascular plant diversity along a chronosequence of beech coppice stands, central Apennines, Italy.* Plant Biosyst 142:572–583. doi: 10.1080/11263500802410926

Battisti C, Fanelli G (2014) *Don't think local! Scale in conservation, parochialism, dogmatic bureaucracy and the implementing of the European Directives*. J Nat Conserv 24:24–30. doi: 10.1016/j.jnc.2015.01.005

Becker T, Spanka J, Schröder L, Leuschner C (2017) *Forty years of vegetation change in former coppice-with-standards woodlands as a result of management change and N deposition*. Appl Veg Sci 20: 304–313, doi: 10.1111/avsc.12282

Bellamy P, Charman E (2012) *Review of biodiversity impacts of practices typically undertaken in certified forests in Britain and Ireland*. RSPB Research Report No. 46. RSPB, Sandy, UK

Bilz M, Kell SP, Maxted N, Lansdown, RV (2011) *European Red List of Vascular Plants*. Publications Office of the European Union, Luxembourg.

BirdLife International (2015) *European Red List of Birds*. Office for Official Publications of the European Communities, Luxembourg. doi: 10.2779/975810

BirdLife International (n.d.) BirdLife Data Zone. http://www.birdlife.org/datazone/home. Accessed 31 January 2016

Borrass L (2014) *Varying practices of implementing the Habitats Directive in German and British forests*. For Policy Econ 38:151–160. doi: 10.1016/j.forpol.2013.05.008

Bouvet A, Paillet Y, Archaux F, Tillon L, Denis P, Gilg O, Gosselin F (2016) *Effects of forest structure, management and landscape on bird and bat communities*. Environ Conserv 1:1-13. doi: 10.1017/S0376892915000363

Brin A, Valladares L, Ladet S, Bouget C (2016) *Effects of forest continuity on flying saproxylic beetle assemblages in small woodlots embedded in agricultural landscapes*. Biodivers Conserv 25:587–602 doi: 10.1007/s10531-016-1076-z

Brunet J, Fritz Ö, Richnau, G (2010) *Biodiversity in European beech forest—a review with recommendations for sustainable forest management*. Ecol Bulls 53:77–94

Buckley P, Mills J (2015) Coppice silviculture: from the Mesolithic to the 21st century. In: Kirby K J, Watkins C (eds) *Europe's changing woods and forest: from wildwood to managed landscapes*. CABI International, Wallingford, UK, pp 77-92

Bürgi M, Steck C, Bertiller, R (2010) *Evaluating a Forest Conservation Plan with Historical Vegetation Data. A Transdisciplinary Case Study from the Swiss Lowlands*. Gaia 19:204–212

Campetella G, Canullo R, Gimona A, Garadnai J, Chiarucci A, Giorgini D, Angelini E, Cervellini M, Chelli S, Bartha S (2016) *Scale dependent effects of coppicing on 1 the species pool 2 of late-successional beech forest*. Appl Veg Sci 19:474-485. doi: 10.1111/avsc.12235

Cardoso, P (2012) *Habitats Directive species lists: urgent need of revision*. Insect Conserv Divers 5: 169–174. doi: 10.1111/j.1752-4598.2011.00140.x

Cervellini M, Fiorini S, Cavicchi A, Campetella G, Simonetti E, Chelli S, Canullo R, Gimona A (2016) *Relationships between understory specialist species and local management practices in coppiced forests – Evidence from the Italian Apennines*. Forest Ecol Manag 385: 35–45

Clarke SA, Green DG, Bourn NA, Hoare DJ (2011) *Woodland Management for butterflies and moths: a best practice guide*. Butterfly Conservation, Wareham, UK

Cox NA, Temple HJ (2009) *European Red List of Reptiles*. Office for Official Publications of the European Communities, Luxembourg

Cuttelod A, Seddon M, Neubert E (2011) *European Red List of Non-marine Molluscs*. Publications Office of the European Union, Luxembourg. doi:10.2779/84538

Decocq G, Aubert M, Dupont F, Alard D, Saguez R, Wattez-Franger A, de Foucault B, Delelis-Dusollier A, Bardat J. (2004) *Plant diversity in a managed temperate deciduous forest: understorey response to two silvicultural systems*. J Appl Ecol 41: 1065–1079. doi: 10.1111/j.0021-8901.2004.00960.x

Decocq G, Aubert M, Dupont F, Bardat J, Wattez-Franger A, Saguez R, De Foucault B, Alard D, Delelis-Dusollier A (2005) *Silviculture-driven vegetation change in a European temperate deciduous forest*. Ann For Sci 62: 313-323. http://dx.doi.org/10.1051/forest:2005026

De Knijf G (2006) De Rode Lijst van de libellen in Vlaanderen. In: De Knijf G, Anselin A, Goffart P, Tailly M (eds) *De libellen (Odonata) van Belgi: verspreiding - evolutie - habitats*. Libellenwerkgroep Gomphus ism Instituut voor Natuur- en Bosonderzoek, Brussels, Belgium, pp 241-257

Devos K, Anselin A, Vermeersch G (2004) Een nieuwe Rode Lijst van de broedvogels in Vlaanderen (versie 2004). In: Vermeersch G, Anselin A, Devos K, Herremans M, Stevens J, Gabrils J,Van Der Krieken B (eds) *Atlas van de Vlaamse broedvogels 2000-2002*. Instituut voor Natuurbehoud, Brussels, Belgium, pp 60-75

Dolek M, Kőrösi A, Freese-Hager A (2018) *Successful maintenance of Lepidoptera by government-funded management of coppiced forests*. J Nat Conserv 43: 75–84

Douda J, Boubilik K, Doudová J, Kynci M (2017) *Traditional forest management practices stop forest succession and bring back rare plant species*. J Appl Ecol 54: 761-771 doi: 10.1111/1365-2664.12801

Duguid MC, Ashton MS (2013) *A meta-analysis of the effect of forest management for timber on understory plant species diversity in temperate forests.* For Ecol Manag 303:81–90. doi: 10.1016/j.foreco.2013.04.009

Environment Directorate General of the European Commission (n.d) http://ec.europa.eu/environment/index_en.htm Accessed 22 January 2017

Epstein Y, López-Bao JV,Chapron G (2015) *A Legal-Ecological Understanding of Favorable Conservation Status for Species in Europe.* Conserv Lett 9:81-88. doi: 10.1111/conl.12200

European Commission (1992) *Council Directive 92 / 43 / EEC of 21. May 1992 on the conservation of natural habitats and of wild fauna and flora*. Official Journal of the European Communities 35: 7–50. (Consolidated version 01.01.2007)

European Commission (1979) *Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds*. Official Journal of the European Communities (codified version 26.1.2010)

European Commission (2013) *Interpretation Manual of European Union Habitats EU 28. European Commission (D-G Environment)*, Brussels, Belgium.

European Commission (2015) *Natura 2000 and Forests Part I-II. EU Technical Report 2015-088*. Office for Official Publications of the European Communities, Luxembourg.

European Commission (2016) Commission Staff Working Document Fitness Check of the EU Nature Legislation (Birds and Habitats Directives) Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds and Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. http://ec.europa.eu/environment/nature/legislation/fitness_check/docs/nature_fitness_check.pdf, Accessed 9 January 2017

European Environment Agency (n.d.) *EUNIS habitat type hierarchical view*. http://eunis.eea.europa.eu/habitats-code-browser.jsp. Accessed 31 January 2016

European Environment Agency (n.d.) Species search. http://eunis.eea.europa.eu/species.jsp.Accessed 31 January 2016

Fartmann T, Müller C, Poniatowski D (2013) *Effects of coppicing on butterfly communities of woodlands*. Biol Conserv 159:396–404. doi: 10.1016/j.biocon.2012.11.024

Forest Research (2011) *Habitats and rare, priority, protected species* (HaRPPS v. 2.0.3). http://www.harpps.org.uk/harppsapp/harpps2/web/welcome. Accessed 31 January 2016Forman RTT (1995) Land Mosaics: The Ecology of Landscape and Regions. Cambridge University Press, Cambridge.

Garadnai J, Gimona A, Angelini E, Cervellini M, Campetella G,Canullo R (2010) *Scales and diversity responses to management in beech coppices of central Apennines (Marches, Italy): from floristic relevés to functional groups*. Braun-Blanquetia 46:271-278.

Gossner MM, Lachat T, Brunet J, Isacsson G, Bouget C, Brustel H, Brandl R, Weisser WW, Mueller J (2013) *Current near-to-nature forest management effects on functional trait composition of saproxylic beetles in beech forests*. Conserv Biol 27:605-614. doi: 10.1111/cobi.12023

Gossner MM, Wende B, Levick S, Schall P, Floren A, Linsenmair KEE, Steffan-Dewenter I, Schulze E-D, Weisser WW (2016) *Deadwood enrichment in European forests – Which tree species should be used to promote saproxylic beetle diversity?* Biol Conserv 201:92–102. doi: 10.1016/j.biocon.2016.06.032

Götmark F (2013) *Habitat management alternatives for conservation forests in the temperate zone: Review, synthesis, and implications*. For Ecol Manag 306:292-307. doi: 10.1016/j.foreco.2013.06.014

Greatorex-Davies JN, Marrs RH (1992) The quality of coppice woods as habitats for invertebrates. In: Buckley, GP (ed) *Ecology and management of coppice woodlands*. Chapman and Hall, London, pp 271-296

Harmer R, Howe J (2003) *The silviculture and management of coppice woodlands*. Forestry Commission, Edinburgh, UK

Heinrichs S, Schmidt W (2017) *Biotic homogenization of herb layer composition between two contrasting beech forest communities on limestone over 50 years*. Appl Veg Sci 20: 271–281. doi: 10.1111/avsc.12255

Hermy M, Honnay O, Firbank L, Grashof-Bokdam C, Lawesson JE (1999) *An ecological comparison between ancient and other forest plant species of Europe, and the implications for forest conservation*. Biol Conserv 91:9–22. doi: 10.1016/S0006-3207(99)00045-2

Hochkirch A, Schmitt T, Beninde J, Hiery M, Kinitz T, Kirschey J, Matenaar D, Rohde, Stoefen A, Wagner N, Zink A, Lötters S, Veith M, Proelss A (2013) *Europe needs a new vision for a Natura 2020 network*. Conserv Lett 6:462-467. doi: 10.1111/conl.12006

Hopkins JJ, Kirby KJ (2007) *Ecological change in British broadleaved woodland since 1947*. Ibis 149:29–40. doi: 10.1111/j.1474-919X.2007.00703.x

Horak J, Vodka S, Kout J, Halda JP, Bogusch P, Pech P (2014) *Biodiversity of most dead wood-dependent organisms in thermophilic temperate oak woodlands thrives on diversity of open landscape structures*. For Ecol Manag 315: 80–85. doi:10.1016/j.foreco.2013.12.018

Horák J, Kout J, Vodka Š, Donato DC (2016) *Dead wood dependent organisms in one of the oldest protected forests of Europe: Investigating the contrasting effects of within-stand variation in a highly diversified environment*. For Ecol Manag 363:229–236. doi: 10.1016/j.foreco.2015.12.041

IUCN (2015) *The IUCN Red List of Threatened Species*. http://www.iucnredlist.org. Accessed 31 January 2016

Joint Nature Conservation Committee (n.d.) http://jncc.defra.gov.uk. Accessed 22 January 2017

Jooris R, Engelen P, Speybroeck J, Lewylle I, Louette G, Bauwens D, Maes D (2012) *De IUCN Rode Lijst van de amfibieën en reptielen in Vlaanderen, Rapporten van het Instituut voor Natuur- en Bosonderzoek INBO.R.2012.22*. Instituut voor Natuur- en Bosonderzoek, Brussels, Belgium.

Kajtoch Ł, Zmihorski M, Bonczar Z (2012) *Hazel Grouse occurrence in fragmented forests: habitat quantity and configuration is more important than quality*. European Journal of Forest Research 131:1783-1795. DOI: 10.1007/s10342-012-0632-7

Kalkman VJ, Boudot J-P, Bernard R, Conze K-J, De Knijf G, Dyatlova E, Ferreira S, Jović M, Ott J, Riservato E, Sahlén G (2010). *European Red List of Dragonflies.* Publications Office of the European Union, Luxembourg. doi:10.2779/84650

Kimberley A, Blackburn GA, Whyatt JD, Kirby K, Smart SM (2013) *Identifying the trait syndromes of conservation indicator species: how distinct are British ancient woodland indicator plants from other woodland species?* Appl Veg Sci 16:667–675. doi: 10.1111/avsc.12047

Kobayashi T, Kitahara M, Ohkubo T, Aizawa M (2010) *Relationships between the age of northern Kantou plain (central Japan) coppice woods used for production of Japanese forest mushroom logs and butterfly assemblage structure.* Biodivers Conserv 19:2147-2166. doi:10.1007/s10531-010-9870-5

Kopecky M, Hedl R, Szabo P (2013) *Non-random extinctions dominate plant community changes in abandoned coppices*. J Appl Ecol 50:79–87. doi: 10.1111/1365-2664.12010.

Košulič O, Michalko R, Hula V (2016) *Impact of Canopy Openness on Spider Communities: Implications for Conservation Management of Formerly Coppiced Oak Forests*. PLoS ONE 11(2): e0148585. doi:10.1371/journal.pone.0148585

Lachat T, Bouget C, Bütler R, Müller J (2013) In Kraus D, Krumm F (eds). *Section 2.2: Integrative approaches as an opportunity for the conservation of forest biodiversity*. Eur For Inst, Freiburg, Germany.

Larrieu L, Cabanettes A, Delarue A (2012). *Impact of silviculture on dead wood and on the distribution and frequency of tree microhabitats in montane beech-fir forests of the Pyrenees*. Eur J For Res 131:773-786. doi:10.1007/s10342-011-0551-z

Larrieu L, Cabanettes A, Gouix N, Burnel L, Bouget C, Deconchat M (2016) *Development over time of the tree-related microhabitat profile: the case of lowland beech–oak coppice-with-standards set-aside stands in France*. Eur J For Res136:37–49. doi: 10.1007/s10342-016-1006-3

Lassauce A, Anselle P, Lieutier F, Bouget C (2012) *Coppice-with-standards with an overmature coppice component enhance saproxylic beetle biodiversity: A case study in French deciduous forests*. For Ecol Manag 266:273–285. doi:org/10.1016/j.foreco.2011.11.016

Lassauce A, Larrieu L, Paillet Y, Lieutier F, Bouget C (2013) *The effects of forest age on saproxylic beetle biodiversity: implications of shortened and extended rotation lengths in a French oak high forest.* Insect Conserv Divers 6:396–410. doi: 10.1111/j.1752-4598.2012.00214.x

Lindenmayer DB, Franklin, JF (2002) *Conserving Forest Biodiversity*. Island Press, Washington, DC

Maiorano L, Amori G, Montemaggiori A, Rondinini C, Santini L. Saura S, Boitani L. (2015) *On how much biodiversity is covered in Europe by national protected areas and by the Natura 2000 network: insights from terrestrial vertebrates*. Conserv Biol 29:986–995. doi: 10.1111/cobi.12535

Maes D, Vanreusel W, Jacobs I, Berwaerts K, Van Dyck H (2011) *Een nieuwe Rode Lijst dagvlinders. De IUCN-criteria toegepast in Vlaanderen*. Natuur.focus 10: 62-71

Maes D, Baert K, Boers K, Casaer J, Criel D, Crevecoeur L, Dekeukeleire D, Gouwy J, Gyselings R, Haelters J, Herman D, Herremans M, Huysentruyt F, Lefebvre J, Lefevre A, Onkelinx T, Stuyck J, Thomaes A, Van Den Berge K, Vandendriessche B, Verbeylen G, Vercayie D (2014). *Instituut voor Natuur- en Bosonderzoek, Brussel. De IUCN Rode Lijst van de zoogdieren in Vlaanderen. Rapporten van het Instituut voor Natuur- en Bosonderzoek (INBO.R.2014.1828211)*. Instituut voor Natuur- en Bosonderzoek, Brussels, Belgium.

Mairota P, Buckley P, Suchomel C, Heinsoo K, Verheyen K, Hédl R, Terzuolo PG, Sindaco R, Carpanelli A (2016) *Integrating conservation objectives into forest management: coppice management and forest habitats in Natura 2000 sites*. iForest 9: 560-568. doi: 10.3832/ifor1867-009

Mairota P, Manetti MC, Amorini E, Pelleri F, Terradura M, Frattegiani M, Savini P, Grohmann F, Mori P, Terzuolo PG, Piussi P (2016). *Opportunities for coppice management at the landscape level: the Italian experience.* iForest 9: 775-782. – doi: 10.3832/ifor1865-009

Manetti MC, Becagli C, Sansone D, Pelleri F (2016). *Tree-oriented silviculture: a new approach for coppice stands.* iForest 9: 791-800. doi: 10.3832/ifor1827-009

Mason F, Zapponi L (2015). *The forest biodiversity artery: towards forest management for saproxylic conservation*. iForest 9:205-216. doi: 10.3832/ifor1657-008

Matthews, JD (1989) *Silvicultural systems.* Clarenden Press, Oxford, UK

Milieu Ltd, Institute for European Environmental Policy, ICF International, Ecosystems Ltd. (2016) *Evaluation Study to support the Fitness Check of the Birds and Habitats Directives.* Draft emerging findings for Fitness Check Conference 20 November 2015. Milieu Ltd, Brussels, Belgium. http://ec.europa.eu/environment/nature/legislation/fitness_check/docs/consultation/Fitness%20Check%20final%20draft%20emerging%20findings%20report.pdf. Accessed 14 September 2016

Mölder A, Streit M, Schmidt W (2014) *When beech strikes back: How strict nature conservation reduces herb-layer diversity and productivity in Central European deciduous forests*. For Ecol Manag 319:51–61. doi: 10.1016/j.foreco.2014.01.049

Müller J, Bütler R (2010) *A review of habitat thresholds for dead wood: a baseline for management recommendations in European forests*. Eur J For Res 129:981–992. doi: 10.1007/s10342-010-0400-5

Müller J, Boch S, Blaser S, Fischer M, Prati D (2015) *Effects of forest management on bryophyte communities on dead wood.* Nova Hedwigia 100:423–438. doi: 10.1127/nova_hedwigia/2015/0242

Müllerová J, Hédl R, Szabó P (2015) *Coppice abandonment and its implications for species diversity in forest vegetation*. For Ecol Manag 343:88–100. doi: 10.1016/j.foreco.2015.02.003

Nature Conservation (Scotland) Act 2004 Section 2(4): Species of principal importance for biodiversity conservation in Scotland. http://www.lnhg.org.uk/scottish-biodiversity-list.htm. Accessed 11 September 2016

Natural Environment and Rural Communities (NERC) Act (2006a) Section 42: Species of principal importance in England http://webarchive.nationalarchives.gov.uk/20140711133551/http://www.naturalengland.org.uk/ourwork/conservation/biodiversity/protectandmanage/habsandspeciesimportance.aspx. Accessed 11 September 2016

Natural Environment & Rural Communities (NERC) Act 2006: Section 42 List of species of principal importance for conservation of biological diversity in Wales. http://www.eryri-npa.gov.uk/__data/assets/pdf_file/0003/486156/SpeciesList.pdf. Accessed 11 September 2016

Nieto A, Alexander KNA (2010) *European Red List of Saproxylic Beetles*. Publications Office of the European Union, Luxembourg. doi: 10.2779/84561

Nieto, A, Roberts SPM, Kemp J, Rasmont P, Kuhlmann M, García Criado M, Biesmeijer JC, Bogusch P, Dathe HH, De la Rúa P, De Meulemeester T, Dehon M, Dewulf A, Ortiz-Sánchez FJ, Lhomme P, Pauly A, Potts SG, Praz C, Quaranta M, Radchenko VG, Scheuchl E, Smit J, Straka J, Terzo M, Tomozii B, Window J, Michez D (2014) *European Red List of Bees.* Publications Office of the European Union, Luxembourg. doi: 10.2779/77003

Nordén B, Dahlberg A, Brandrud TE, Fritz Ö, Ejrnaes R, Ovaskainen O (2014) *Effects of ecological continuity on species richness and composition in forests and woodlands: A review.* Ecoscience 21: 34-45. doi: 10.2980/21-1-3667

Orlikowska EH, Roberge J-M, Blicharska M and Mikusiński G (2016) *Gaps in ecological research on the world's largest internationally coordinated network of protected areas: A review of Natura 2000*. Biol Conserv 200:216–227. doi:10.1016/j.biocon.2016.06.015

Paillet Y, Bergès L, Hjältén J, Ódor P, Avon C, Bernhardt-Römermann M, Bijlsma R-J, De Bruyn L, Fuhr M, Grandin U, Kanka R, Lundin L, Luque S, Magura T, Matesanz S, Mészáros I, Sebastià M-T, Schmidt W, Standovár T, Tóthmérész B, Uotila A, Valladares F, Vellak K, Virtanen R (2010) *Biodiversity differences between managed and unmanaged Forests: meta-analysis of species richness in Europe*. Conserv Biol 24:101–112. doi: 10.1111/j.1523-1739.2009.01399.x

Pellissier V, Touroult J, Julliard R, Siblet JP, Jiguet F (2013) *Assessing the Natura 2000 network with a common breeding birds survey*. Anim Conserv 16:566–574. doi: 10.1111/acv.12030

Peterken GF (1993) *Woodland Conservation and Management, 2nd edn*. Chapman & Hall, London

Petersen PM (2002) *Importance of site conditions and time since abandonment for coppice vegetation on Langeland, Denmark*. Nord J Bot, 22: 463–481. doi: 10.1111/j.1756-1051.2002.tb01400.x

Quine, CP, Fuller RJ, Smith KW, Grice PV (2007) *Stand management: a threat or opportunity for birds in British woodland?* Ibis 149:161–174

Rackham O (2003) *Ancient woodland: its history, vegetation and uses in England.* Castlepoint Press, Dalbeattie, UK

Ramakers JJC, Dorenbosch M, Foppen RPB (2014) *Surviving on the edge: a conservation-oriented habitat analysis and forest edge manipulation for the hazel dormouse in the Netherlands*. European J Wildlife Res 60: 927–931. doi: 10.1007/s10344-014-0849-5

Rees SE, Sheehan EV, Jackson EL, Gall SC, Cousens SL, Solandt J-L, Boyer M, Attrill MJ (2013) *A legal and ecological perspective of 'site integrity' to inform policy development and management of Special Areas of Conservation in Europe.* Mar Pollut Bull 72:14-21. doi: 10.1016/j.marpolbul.2013.03.036

Reczyńska K, Świerkosz K (2016) *Compositional changes in thermophilous oak forests in Poland over time: do they correspond to European trends?* Appl Veget Sci doi: 10.1111/avsc.12290

Riigi Teataja (2014a) I ja II kaitsekategooriana kaitse alla võetavate liikide loetelu. https://www.riigiteataja.ee/akt/760301?leiaKehtiv. Accessed 15 September 2016

Riigi Teataja (2014b) III kaitsekategooria liikide kaitse alla võtmine https://www.riigiteataja.ee/akt/13360720?leiaKehtiv. Accessed 15 September 2016

Roleček J, Vild O, Sladký J, Řepk R (2017) *Habitat requirements of endangered species in a former coppice of high conservation value*. Folia Geobot 52: 59-69. doi: 10.1007/s12224-016-9276-6

Sozio G, Iannarilli F, Melcore I, Boschetti M, Fipaldini D, Luciani M, Roviani D, Schiavano A, Mortelliti A (2016) *Forest management affects individual and population parameters of the hazel dormouse Muscardinus avellanarius*. Z Säugetierkd 81: 96–103: http://dx.doi.org/10.1016/j.mambio.2014.12.006

Schall P, Ammer C (2013) *How to quantify forest management intensity in Central European forests*. Eur J For Res 132: 379-396. doi: 10.1007/s10342-013-0681-6

Schmidt W (2005) *Herb layer species as indicators of biodiversity of managed and unmanaged beech forests*. For Snow Landsc Res 79:111–125.

Schmidt M, Kriebitzsch W-U and Ewald J (eds) (2014) *Waldartenlisten der Farn- und Blütenpflanzen, Moose und Flechten Deutschlands*. Bundesamt für Naturschutz, Bonn, Germany.

Schulte LA, Mitchell RJ, Hunter Jr ML, Franklin JF, McIntyre RK, Palik BJ (2006) *Evaluating the conceptual tools for forest biodiversity conservation and their implementation in the US*. For Ecol Manag 232: 1-11. doi: 10.1016/j.foreco.2006.05.009

Schulze E, Bouriaud L, Bussler H, Gossner M, Walentowski H, Hessenmöller D, Bouriaud O and v. Gadow K (2014) *Opinion Paper: Forest management and biodiversity*. Web Ecol 14:3–10. doi: 10.5194/we-14-3-2014

Schulze ED, Aas G, Grimm GW, Gossner MM, Walentowski H, Ammer C, Kühn I, Bouriaud O, von Gadow K (2016) *A review on plant diversity and forest management of European beech forests*. Euro J For Res 135:51-67 doi: 10.1007/s10342-015-0922-y

Scolastri A, Cancellier L, Iocchi M, Cutini M (2017) *Old Coppice vs High Forest: the impact of beech forest management on plant species diversity in central Apennines (Italy)*. J Plant Ecol 10: 271–280 doi: 10.1093/jpe/rtw034

Sebek P, Bace R, Bartos M, Benes J, Chlumska Zuzana, Dolezal J, Dvorsky M, Kovar J, Machac O, Mikatova B, Perlik M, Platek M, Polakova S, Skorpik M, Stejskal R, Svoboda M, Trnka F, Vlasin M, Zapletal M, Cizek L (2015) *Does a minimal intervention approach threaten the biodiversity of protected areas? A multi-taxa short-term response to intervention in temperate oak-dominated forests*. For Ecol Manag 358:80–89. doi: 10.1016/j.foreco.2015.09.008

Šebesta J, Maděra P, Řepka R, Matula R (2017) *Comparison of vascular plant diversity and species composition of coppice and high beech forest in the Banat region, Romania*. Folia Geobot 52:33. doi: 10.1007/s12224-016-9279-3

Seibold S, Brandl R, Buse J, Hothorn T, Schmidl J, Thorn S, Müller J (2015) *Association of extinction risk of saproxylic beetles with ecological degradation of forests in Europe*. Conserv Biol 29:382-390. doi: 10.1111/cobi.12427

Seibold S, Bässier C, Brandl R, Büche B, Szallies A, Thorn S, Ulyshen MD, Müller, J (2016) *Microclimate and habitat heterogeneity as the major drivers of beetle diversity in dead wood*. J Appl Ecol 53:934-943. doi: 10.1111/1365-2664.12607

Šipoš J, Hédl R, Hula V, Chudomelová M, Košulič O, Niedobová J and Riedl V (2017) *Patterns of functional diversity of two trophic groups after canopy thinning in an abandoned coppice*. Folia Geobot 52. doi: 10.1007/s12224-017-9282-3

Szabo P (2010) *Driving forces of stability and change in woodland structure: a case-study from the Czech lowlands.* For Ecol Manag 259: 650–656. doi: http://dx.doi.org/10.1016/j.foreco.2009.11.026

Temple HJ, Cox NA (2009) *European Red List of Amphibians*. Office for Official Publications of the European Communities, Luxembourg

Temple HJ, Terry A (2007) *The Status and Distribution of European Mammals*. Office for Official Publications of the European Communities, Luxembourg

Thomaes A, Drumont A, Crevecoeur L, Maes D (2015) *Rode lijst van de saproxyle bladsprietkevers (Lucanidae, Cetoniidae en Dynastidae) in Vlaanderen. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2015 (INBO.R.2015.7843021)*. Instituut voor Natuur- en Bosonderzoek, Brussels, Belgium.

Tsiafouli MA, Apostolopoulou E, Mazaris A D, Kallimanis AS, Drakou EG, Pantis JD (2013) *Human activities in Natura 2000 sites: a highly diversified conservation network.* EnvironManag.51: 1025–1033. doi:10.1007/s00267-013-0036-6

UICN France, FCBN, MNHN (2012) La Liste rouge des espèces menacées en France - Flore vasculaire de France métropolitaine : Premiers résultats pour 1 000 espèces, sous-espèces et variétés. http://www.uicn.fr/IMG/pdf/Tableau_Liste_rouge_flore_vasculaire_de_metropole.pdf. Accessed 1 February 2016

UICN France, MNHN, SHF (2015) La Liste rouge des espèces menacées en France - Chapitre Reptiles et Amphibiens de France métropolitaine. Paris, France. http://www.uicn.fr/IMG/pdf/Liste_rouge_France_Reptiles_et_Amphibiens_de_metropole.pdf. Accessed 1 February 2016

UICN France, MNHN, OPIE, SEF (2014) La Liste rouge des espèces menacées en France - Chapitre Papillons de jour de France métropolitaine. Paris, France. http://www.uicn.fr/IMG/pdf/Liste_rouge_France_Papillons_de_jour_de_metropole.pdf. Accessed 1 February 2016

UICN France, MNHN, SFEPM, ONCFS (2009). La Liste rouge des espèces menacées en France - Chapitre Mammifères de France métropolitaine. Paris, France. http://www.uicn.fr/IMG/pdf/Liste_rouge_France_Mammiferes_de_metropole.pdf. Accessed 1 February 2016

UICN France, SFO, FCBN (2009). La Liste rouge des espèces menacées en France Orchidées de France métropolitaine. Paris, France. http://www.uicn.fr/IMG/pdf/Liste_rouge_France_Orchidees_de_metropole.pdf. Accessed 1 February 2016.

UICN France, MNHN, LPO, SEOF, ONCFS (2011) La Liste rouge des espèces menacées en France - Chapitre Oiseaux de France métropolitaine. http://www.uicn.fr/IMG/pdf/Liste_rouge_France_Oiseaux_de_metropole.pdf. Accessed1 February 2016

Van Calster H, Baeten L, De SchrijverA, De Keersmaeker L, Rogister JE, Verheyen K, Hermy M (2007) *Management driven changes (1967–2005) in soil acidity and the understorey plant community following conversion of a coppice-with-standards forest.* For Ecol Manag 241: 258–271. doi: http://dx.doi.org/10.1016/j.foreco.2007.01.007

Van Calster H, Baeten L, Verheyen K, De Keersmaeker L, Dekeyser S, Rogister JE, Hermy M (2008b) *Diverging effects of overstorey conversion scenarios on the understorey vegetation in a former coppice-with-standards forest.* For Ecol Manag 256: 519–528. doi: http://dx.doi.org/10.1016/j.foreco.2008.04.042

Van Calster H, Vandenberghe R, Ruysen M, Verheyen K, Hermy M, Decocq G (2008a) *Unexpectedly high 20th century floristic losses in a rural landscape in northern France*. J Ecol 96:927–936. doi: 10.1111/j.1365-2745.2008.01412.x

van der Sluis T, Foppen R, Gillings S, Groen T, Henkens R, Hennekens S, Huskens K, Noble D, Ottburg F, Santini L, Sierdsema H, van Kleunen A, Schaminee J, van Swaay C, Toxopeus B, Wallis de Vries M, Jones-Walters L (2016) *The "Umbrella Effect" of the European Natura 2000 protected area network*. Alterra report 2730B, Wageningen.doi: 10.18174/385796

Vandekerkhove K, Thomaes A, Jonsson BG (2013) Connectivity and fragmentation: island biogeography and metapopulation applied to old-growth elements. In: Kraus D, Krumm F (eds) *Integrative approaches as an opportunity for the conservation of forest biodiversity*. European Forest Institute, Joensuu, pp 104–115

Vandekerkhove K, Thomaes A, Crèvecoeur L, De Keersmaeker L, Leyman A, Köhler F (2016) *Saproxylic beetles in non-intervention and coppice-with-standards restoration management in Meerdaal forest (Belgium): an exploratory analysis*. iForest 9: 536-545. doi: 10.3832/ifor1841-009t

Van Landuyt W, Hoste I, Vanhecke L (2006) Rode Lijst van de vaatplanten van Vlaanderen en het Brussels Hoofdstedelijk Gewest. In: Van Landuyt W, Hoste I, Vanhecke L, Van den Bremt P, Vercruysse W, De Beer D (eds) *Atlas van de Flora van Vlaanderen en het Brussels Gewest.* Instituut voor Natuur- en Bosonderzoek, Nationale Plantentuin van België & Flo.Wer., Brussels, Belgium, pp. 69-81

van Swaay CAM, Warren MS, Lois G (2006) *Biotope use and trends of European butterflies*. J Insect Conserv 10: 189–209. doi: 10.1007/s10841-006-6293-4

van Swaay C, Cuttelod A, Collins S, Maes D, López Munguira M, Šašić M, Settele J, Verovnik R, Verstrael T, Warren M, Wiemers M, Wynhof I (2010) *European Red List of Butterflies*. Publications Office of the European Union, Luxembourg. doi:10.2779/83897

van Swaay C, Maes D, Collins S, Munguira ML, Šašic M, Settele J, Verovnik R, Warren M, Wiemers M, Wynhoff I, Cuttelod A (2011) *Applying IUCN criteria to invertebrates: how red is the Red List of European butterflies?* Biol Conserv 144:470-478. doi: 10.1016/j.biocon.2010.09.034

Vild O, Roleček J, Hédl R, Kopecký M, Utinek D (2013) *Experimental restoration of coppice-with-standards: Response of understorey vegetation from the conservation perspective*. For Ecol Manag 310:234–241. doi: 10.1016/j.foreco.2013.07.056

Verheyen K, Guntenspergen GR, Biesbrouck B, Hermy M (2003) *An integrated analysis of the effects of past land use on forest herb colonization at the landscape scale.* J Ecol 91:731–742. doi: 10.1046/j.1365-2745.2003.00807.x

Verheyen K, Baeten L, De Frenne P et al (2012) *Driving factors behind the eutrophication signal in understorey plant communities of deciduous temperate forests*. J Ecol 100: 352–365. doi: 10.1111/j.1365-2745.2011.01928.x

Verstraeten G, Baeten L, Van den Broeck T, De Frenne P, Demey A, Tack W, Muys B and Verheyen K (2013) *Temporal changes in forest plant communities at different site types*. Appl Vegetation Science 16 237–247. doi: 10.1111/j.1654-109X.2012.01226.x

Warren MS, Key RS (1991) Woodlands: past, present and potential for insects. In: Collins NM, Thomas JA (eds) *The Conservation of Insects and Their Habitats*. Academic Press, London pp155-211

Wildscreen ARKive (n.d.) http://www.arkive.org Accessed 22 January 2017

Winter S, Brambach F (2011) *Determination of a common forest life cycle assessment method for biodiversity evaluation*. Forest Ecology and Management 262: 2120-2132. doi: 10.1016/j.foreco.2011.07.036

Zehetmair T, Müller J, Runkeld V, Stahlschmidte P, Winter S, Zharovg A, Gruppe Axel (2015a) *Poor effectiveness of Natura 2000 beech forests in protecting forest-dwelling bats.* J Nat Conserv 23: 53–60

Zehetmair T, Müller J, Zharov A, Gruppe, A (2015b) *Effects of Natura 2000 and habitat variables used for habitat assessment on beetle assemblages in European beech forests.* Insect Conserv Divers 8:193–204. doi: 10.1111/icad.12101

The Status of Coppice Management within Forested Natura 2000 Sites

Paola Mairota and Peter Buckley

Most forest habitats that are listed for their nature conservation importance in the Habitats Directive of the European Union and the Bern Convention have been modified for centuries by human intervention. It is well documented that many forests throughout Europe were traditionally coppiced (cf. Piussi & Redon 2001; Kirby & Watkins 2015), thus influencing the woodland ecology not only at the stand level, but at wider spatial (landscape) and temporal scales, creating specific communities that are often the focus of nature conservation initiatives. As such, coppice management falls within the scope of the Habitats Directive (Council Directive 92/43/EEC; European Commission 2003; Loidi & Fernandez-Gonzalez 2012). However, this form of silvicultural system has become obsolete in many of the EU28 countries, particularly those in the north and east, whereas in others it is still very relevant to the country's economy (Figure 1). Nowadays, the trend towards non-intervention in coppice stands, or their conversion to high forest, is the de facto approach within areas protected for conservation.

In order to examine prevailing attitudes towards coppicing within sites designated under the Natura 2000 framework as Sites of Community Importance or Special Areas of Conservation (SCIs or SACs), a study was carried out within the framework of the EuroCoppice COST Action FP1301 to examine the relevant Site Management Plans (SMPs) in six participating countries. The aim was to sample the extent to which different countries recognised coppicing activities, and what extent they considered alternative options that might better secure the conservation status of the habitat in question (The full study is available in the open source iForest article Mairota et al. 2016a). These six countries (Belgium, Czech Republic, Estonia,

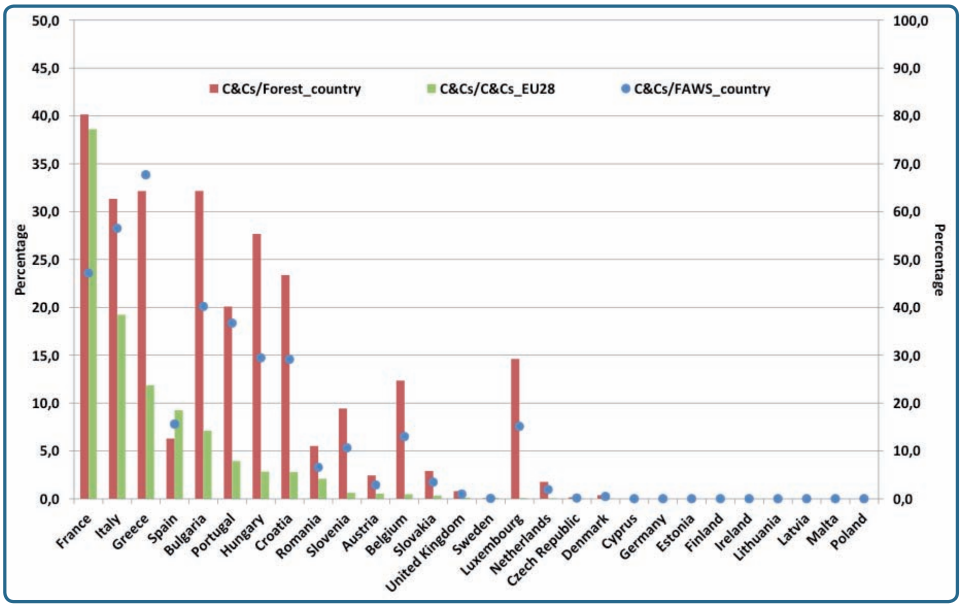


Figure 1. Left axis: Share of simple coppice (C) and coppice with standards (Cs) woodlands over the forest area of the country (C&Cs/Forest-country), and share of country simple coppice and coppice with standards in the EU (C&Cs/C&CS EU); Right axis: Share of simple coppice/coppice with standards woodlands over the forest available for wood supply in the country (C&Cs/FAWS country) (Processed from UNECE-FAO 2010 data)

Corresponding Author: Paola Mairota, paola.mairota@uniba.it

Germany, Italy and the United Kingdom), represent a range of EU Biogeographical Regions, including both small and large regions, different administrative systems (centralized to devolved) and greatly differing amounts of forest cover. In addition, a sub-national level (at either the NUTS1 or NUTS2 regional scale) was chosen to review Natura 2000 Site Management Plans (SMPs) for three of these countries (Germany, Italy and the United Kingdom).

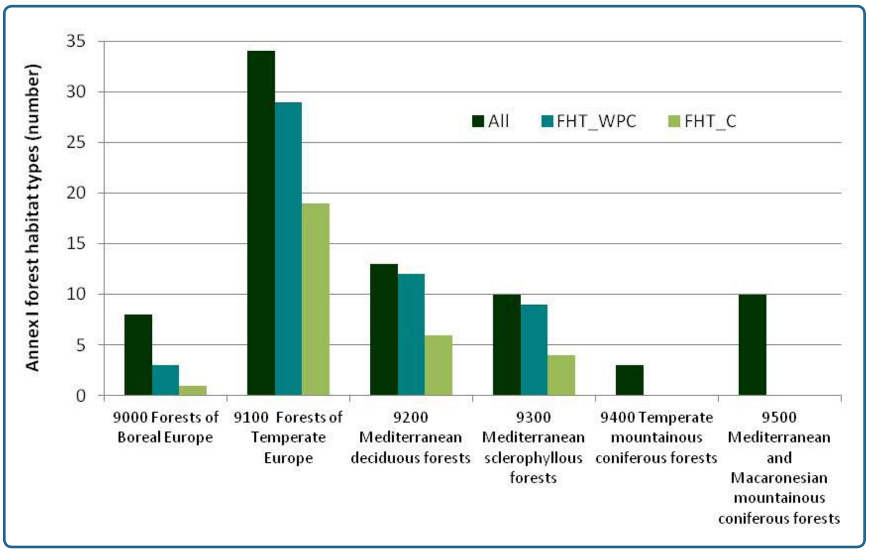


Figure 2. Distribution of forest habitat types in the main forest categories according to the Habitats Directive and incidence of both forest habitat types with potential for coppice and forest habitat types for which coppice is reported in the sample countries.
FHT_WPC: forest habitat types with potential for coppice;
FHT_C: Forest habitat types which have been coppiced historically.

The share of Natura 2000 area in the sample countries is comparable to the EU28 terrestrial average, which is 14.6%. Of this, 73.9% is protected under the SCIs and SACs of the Habitats Directive, while the remainder falls under the Birds Directive. However, progress in formulating SMPs in compliance with the Habitats Directive's recommendations varies widely between the EU countries, as is mirrored in the six sample countries. In Italy there are a number of NUTS2 regions without enforced, or even envisaged SMPs, but here compliance to the Directive is ensured by collective conservation measures for those habitat types belonging to the same biogeographical zone (IT-D4 Friuli Venezia Giulia), or macro-environmental category (IT-C1 Piemonte and IT-F4 Puglia).

As a general tendency, it appears that a greater proportion of forest areas were designated as SCIs/SACs than many other habitats. The majority (68 %) of the 78 Annex I forest habitat types recognised by the Habitats Directive have the potential to be coppiced, i.e. the dominant species is capable of resprouting. This ability varies among the main forest habitat categories (i.e. 9000 'Forests of Boreal Europe', 9100 'Forests of Temperate Europe', 9200 'Mediterranean deciduous forests', 9300 'Mediterranean sclerophyllous forests') (Figure 2).

In the sample countries, 38% of the habitat types were considered to have been coppices in the past, with more and more evidence to this effect being reported (e.g. Madera et al. 2017). However, coppicing is no longer allowed in Estonia (where non-intervention is the current management strategy in protected areas), while it is only allowed for research purposes in the Czech Republic. Management prescriptions for coppices in SCIs/SACs tend to be rather strict in Italy (detailing specific aspects such as coupe size, rotation length, number of standards, standard age category, sporadic tree species release and canopy cover). Conversely, coppicing done to conserve particular target species is still practised in parts of the United Kingdom and Germany. Similar signs of a strict conservation interest have in fact also been noted in Italy (Negro et al. 2014), where a debate has recently begun between the Italian chapter of Pro Silva (a Europe-wide association of silviculturists) and two national scientific societies dealing with vegetation science (SISV) and forest ecology (SISEF).

A closer look was taken at a number of SCI/SAC management plans (172 SMPs, 51% of those available) of five administrative regions in three sample countries (IT-E2 Umbria and ITF-4 Puglia (NUTS2), UK-J, South East England and UK-L Wales (NUTS1), and DE-B Rhineland-Palatinate (NUTS1). This revealed that coppice management was rarely encouraged and that conversion to high forest was often thought desirable. While the justification for this view was seldom provided, other than in generic/anecdotal terms, it was frequently argued that high forest could achieve higher financial returns, or that high forest, regenerating from seed, was the more 'natural' condition. That being said, no scientific study has thus far convincingly demonstrated that a high forest/wilderness state could achieve a more 'favourable conservation status' than that provided by coppice in most SCI/SAC forest habitats (European Commission 2013). On the other hand, a number of studies have provided increasing evidence of the importance of coppice in promoting biodiversity through its provision of open habitats (e.g. Garadnai et al. 2010, Mölder, 2010, Müllerová 2015).

SMPs generally addressed the notable species listed in Annex II where they occurred within the habitat, but were less concerned with other species that might benefit from coppice management (Buckley and Mills 2015). This is in spite of the Habitat Directive's aim to protect the habitat per se, with its array of characteristic (but not necessarily rare) species; in this case, species that are frequently associated with the mosaic of age classes created by coppice woods or coppice-with-standards.

Another common feature was that, notwithstanding differences in the amount of detail required by the individual regional authorities dealing with SMPs, these plans were often rather descriptive or aspirational documents and provided no comprehensive management prescriptions or schedules. Their utility as the first level of a cascade process for integrated landscape/forest planning (sensu Baskent & Keles 2005) is therefore very limited. This is concerning, because decisions to abandon coppice at the stand level, or to select another (high forest) silvicultural solution, has a strong impact on forest landscape structure and functioning and could affect some key elements of biodiversity. A number of technical practices, such as the group selection of standards or single tree silviculture, when combined with non-intervention and conversion to high forest, have the potential to increase forest landscape micro- and macro-heterogeneity (Cf. Mairota et al. 2016b). This is a desirable objective in order to maintain high levels of beta-diversity in the long run (e.g. Hunter 1990, Buckley 1992, Fuller & Warren 1993, Mairota & Piussi 2006, Chiarucci et al. 2008, Garadnai et al. 2010, Kopecký et al. 2013 and Buckley & Mills 2015).

A case can be made for a more balanced approach to forest management (combining coppice, high forest and non-intervention), as this appears most likely to revive and maintain specific forest landscape habitats and site conditions, as well as revitalise local economies. Overcoming socio-economic factors and, especially, the cultural factors behind SMP strategies and attitudes is necessary. One factor that may become important is the increasing demand for wood for energy (Mantau et al. 2010, UN-ECE-FAO 2011). In response to the EU Renewable Energy Directive 2009/28/EC and in compliance with the Framework Program for the Forestry Sector, Horizon 2020 should improve the transparency of wood-fuel flows in agreement with the EU 995/2010 Timber Regulation.

References

Baskent EZ, Keles S (2005). *Spatial forest planning: A review*. Ecological Modelling 188: 145-173.

Buckley GP (ed) (1992). *Ecology and management of coppice woodlands*. Chapman & Hall, London, UK, pp. 336.

Buckley GP, Mills J (2015). The Flora and Fauna of Coppice Woods: Winners and Losers of Active Management or Neglect? In: *Europe's Changing Woods and Forests: From Wildwood to Managed Landscapes* (Kirby K, Watkins C eds). CABI, Wallingford, UK, pp. 129-139

Chiarucci A, Bacaro G, Rocchini D (2008). *Quantifying plant species diversity in a Natura 2000 network: old ideas and new proposals*. Biological Conservation 141: 2608-2618.

European Commission (2013). *Guidelines on Wilderness in Natura 2000*. Technical Report 2013/069. Office for Official Publications of the European Communities, Luxembourg, pp.98

Fuller RJ, Warren MS (1993). *Coppiced woodlands: their management for wildlife*. Nature Conservation Committee, Peterborough, UK, pp. 29

Garadnai J, Gimona A, Angelini E, Cervellini M, Campetella G, Canullo R (2010). *Scales and diversity responses to management in Beech coppices of central Apennines (Marche, Italy): from floristic relevés to functional groups*. Braun-Blanquetia 46: 271-278

Hunter Jr ML (1990). *Wildlife, forests, and forestry. Principles of managing forests for biological diversity*. Prentice Hall, Upper Saddle River, New Jersey, USA, pp. 370

Kirby, K. J., Watkins, C. (eds) (2015). *Europe's changing woods and forests: from wildwood to managed landscapes*. CAB International, UK

Kopecký M, Hédl R, Szabó P (2013). *Non-random extinctions dominate plant community changes in abandoned coppices.* Journal of Applied Ecology 50: 79-87.

Loidi J, Fernández-González F (2012). *Potential natural vegetation: reburying or reboring?* Journal of Vegetation Science 23: 596–604

Madera P, Machala M, Slach T, Friedl M, Cernušáková L, Volarík D, Buček A. (2017). *Predicted occurrence of ancient coppice woodlands in the Czech Republic*. Iforest 10:778-795

Mairota P, Buckley P, Suchomel C, Heinsoo K, Verheyen K, Hédl R, Terzuolo PG, Sindaco R and Carpanelli A (2016a). *Integrating conservation objectives into forest management: coppice management and forest habitats in Natura 2000 sites.* i-Forest 9:560-568 doi: 10.3832/ifor1867-009

Mairota P, Manetti MC, Amorini E, Pelleri F, Terradura M, Frattegiani M, Savini P, Grohmann F, Mori P, Terzuolo PG, Piussi P (2016b). *Opportunities for coppice management at the landscape level: the Italian experience*. iForest 9: 775-782. – doi: 10.3832/ifor1865-009

Mairota P, Piussi P (2006). Gestione del bosco e conservazione della biodiversità: l'analisi eco-paesistica applicata a territori boscati della Toscana meridionale [Forest management and biodiversity conservation: landscape ecological analysis of wooded lands in southern Toscana (Italy)]. In: *Selvicoltura sostenibile nei boschi cedui [Sustainable silviculture in coppice woodlands]* (Fabbio G ed) Annali C.R.A. Istituto Sperimentale per la Selvicoltura. 33: 187-230

Mantau, U., Saal, U., Prins, K., Steierer, F., Lindner, M., Verkerk, H., Eggers J., Leek N., Oldeburger J., Asikainen A., Anttila, P. (2010). *Real potential for changes in growth and use of EU forests*. EUwood. Final report.

Mölder A, Streit M, Schmidt W (2014). *When beech strikes back: How strict nature conservation reduces herb-layer diversity and productivity in Central European deciduous forests.* Forest Ecology and Management 319: 51–61.

Müllerová J, Hédl R, Szabó P, (2015). *Coppice abandonment and its implications for species diversity in forest vegetation.* Forest Ecology and Management 343: 88–100.

Negro, M., Vacchiano, G., Berretti, R., Chamberlain, D. E., Palestrini, C., Motta, R., & Rolando, A. (2014). *Effects of forest management on ground beetle diversity in alpine beech (Fagus sylvatica L.) stands*.Forest ecology and management,328, 300-309.

Piussi P, Redon O (2001). Storia agraria e selvicoltura [Agrarian history and silviculture]. In: *Medievistica italiana e storia agraria* (Cortonesi A, Montanari M eds) CLUEB, Bologna, Italy, pp. 179-209.

UN-ECE/FAO (2000). *Forest Resources of Europe, CIS, North America, Australia, Japan and New Zealand (TBFRA-2000)*. ECE/TIM/SP/17, Geneva, Switzerland, pp. 466

Prevention of Soil Erosion and Rockfall by Coppice and High Forest – A Review

Peter Buckley, Christian Suchomel, Christine Moos and Marco Conedera

Introduction

An important regulating ecosystem service of forests is their ability to protect against natural hazards such as soil erosion and rockfall, particularly on steep slopes. The ability to provide this service strongly depends on the forest structure and condition (e.g. Dorren et al. 2007, Imaizumi et al. 2008, Fuhr et al. 2015, Moos et al. 2017). With coppice, however, the question remains whether clear-cutting might actually exacerbate slope erosion, and if, in their abandoned or converted state, coppice stools could eventually become unstable and prone to collapse. In such a case, the risk of rockfall may be enhanced (Radtke et al. 2014).

At higher altitudes in the European mountain regions of Switzerland, Austria, Slovenia, Italy, Cyprus and Spain, coniferous forest species such as Norway spruce (*Picea abies)*, silver fir (*Abies alba*) and European larch (*Larix decidua*) predominate in protection forests, while broad-leaved species with innate coppicing ability are more prevalent at lower altitudes. These include European beech (*Fagus sylvatica*), oak (*Quercus* spp.), chestnut (*Castanea sativa*), lime (*Tilia* spp.), maple (*Acer* spp.), ash (*Fraxinus* spp.), hazel (*Corylus avellana*), whitebeam and wild service tree (*Sorbus* spp.), hornbeam (*Carpinus betulus* L.), hop hornbeam (*Ostrya carpinifolia*), and black locust (*Robinia pseudoacacia*) (Jancke et al. 2013). Beech in particular may reach as far as the upper timberline (1600-2000m asl) in the Alps, as in southern Switzerland (Ceschi 2014), or in Slovenia (Perret et al. 2015).

Corresponding Author:
Peter Buckley, peterbuckleyassociates@gmail.com

Tree cover increases rainfall interception and transpires away soil moisture, thereby reducing runoff, so that a continuous or semi-continuous canopy may give good slope protection. Standing and lying trees can slow down, deviate, or stop falling rocks, and thus reduce their propagation and intensity (Perret et al. 2004, Dorren et al. 2007). By adopting appropriate forms of silviculture and eco-engineering, these forests can permanently reduce the risks to human life and property, although in extreme cases the trees may have to be supplemented or replaced by civil engineering and bioengineering solutions (Dorren et al. 2005, Dorren et al. 2007). From one point of view the high stem densities in coppice form strong physical barriers and extensive rooting networks (Gerber and Elsener 1998) and can re-grow rapidly after cutting, when parts of the root system may remain alive. On the other hand, abandoned coppices on slopes can develop a large aerial biomass relative to their root system (Conedera et al. 2010), which in time may cause stool instability and uprooting (Vogt et al. 2006). On more gentle farmland slopes in lowland regions, where the soil surface may be periodically exposed by arable cultivation, one alternative might be to grow short-rotation coppice stands of *Populus, Alnus* and *Robinia* to protect against soil erosion (Petzold et al. 2014).

The goal of this paper is to give an overview on the effect of coppice stands on risks induced by erosion, landslides and rockfall and to discuss management strategies aiming at high protection capacity of these forests.

1. The role of tree canopies

Trees intercept and transpire moisture, as well as increasing both water infiltration into the soil and the water storage capacity, thus delaying levels of soil saturation that could cause incipient slope stability (Forbes and Broadhead 2011). The level of this effect strongly depends on the type of vegetation (e.g. forest structure, species composition) and season (Anderson et al. 1976). While harvesting removes the coppice canopy, the probability of slope failure will depend upon the frequency of cutting, the amount of litter and brash left behind, and the presence of unharvested trees (Piussi and Puglisi 2012). Remaining tree roots tend to increase infiltration by increasing soil pore formation and forming networks that facilitate a faster drainage than if no channels were present (Vergani and Graf 2016). The recovering canopy of the transpiring crop may also reduce excessive soil moisture and, therefore, the risk of surface instability, although in cool, temperate regions where precipitation usually exceeds evapotranspiration, the advantages may be small. Nevertheless, soil loss resulting from forest harvesting can become an issue at slope gradients above 8-9° and it increases significantly above 20°, when major landslides and debris flows are likely to occur (Borrelli et al. 2016).

2. Root reinforcement

Shallow landslides occuring on slopes carry earth, mud, clay and other debris; they are generally less than 2m deep (Rickli and Graf 2009, Sidle and Bogaard 2016) and are often triggered by heavy rainfall or earthquakes. Tree rooting forms a fibrous reinforcement, increasing the soil shear strength: in general, the coarse roots (>10 mm diameter) act as anchors or soil nails, while fine to medium roots (0.01-10 mm diameter) tend to reinforce and 'pin' together the soil profile (Stokes et al. 2009). We can distinguish basal root reinforcement along a potential slip surface, lateral root reinforcement at the margins of the landslides, and stiffening effects of soil under tension and compression (Mao et al. 2012, Schwarz et al. 2015, Cohen and Schwarz 2017). These effects are mainly influenced by root density, root tensile strength and depth of rooting. The glue-like exudates of root mycorrhizae provide additional soil strength by contributing to the formation of soil aggregates (Bronick and Lal 2005). In an investigation of a steep slope revegetated 25 years earlier by hydroseeding and supplementary planting of grey alder (*Alnus incana*) and purple osier willow (*Salix purpurea*), Burri et al. (2009) showed that soil aggregate stability approached that of a nearby mature ('climax') beech forest on a similar incline. In coppices, a window of susceptibility to erosion begins when roots start to decay after cutting, and persists until new woody vegetation and root growth is achieved.

Slopes also appear to influence root morphology, with the larger roots orientated uphill and assisting soil anchorage, as observed in downy oak (*Quercus pubescens*) and manna ash (*Fraxinus ornus*) by Chiatante et al. (2003). Di Iorio et al. (2005) found the same tendency in maiden (uncoppiced) trees of downy oak, growing on slopes ranging from 14 - 34°, where the first-order laterals tended to cluster asymmetrically, in an upslope direction, and to form resistant I-beam cross-sections. This adaptive root architecture emphasizes the resistance of these up-slope roots to pullout, counteracting the turning moment that tall, upright tree stems of abandoned coppice stools are constantly subject to. A study of managed and abandoned chestnut coppices in northern Italy, situated on slopes of 13 - 35°, showed denser but shallower rooting in the 0 - 50 cm soil profile of a currently managed stand compared with overaged stands (Bassanelli et al. 2013). This may have been influenced by the renewal of the root systems after each coppicing event, although there was less soil depth than in the abandoned coppice sites. The study showed that root tensile strength was not affected by abandonment, but simulation modelling suggested that slopes of >35° were intrinsically unstable and likely to lead to shallow landslides, particularly those with high levels of soil moisture saturation. These authors concluded that maintaining a regular coppice cycle was essential to prevent shallow landslides occurring on steep slopes. On the other hand, Dazio et al. (2018) suggested that aging chestnut coppice stands in southern Switzerland tended to provide progressively more root reinforcement, owing to an increasing proportion and absolute number of coarse roots.

The roots of different tree species appear to react differently to coppicing. In birch (*Betula* spp.) coppice, Bédéneau and Pagès (1984) found that medium to coarse (>5 mm diameter) roots were the same age as the stool, suggesting that the old root system remained intact, whereas in chestnut the roots were freshly regenerated (Dazio et al. 2018). The latter also seems to hold true for beech (Amorini et al. 1990, Bagnara and Salbitano 1998) and maple (Lees 1981) but not for some *Eucalyptus* species, which tended to keep their original root systems after cutting (Riedacker,1973, Wildy and Pate 2002). It seems likely that the drastic reduction of carbohydrate resources resulting from stem loss forces the plant to direct its energies into shoot production, with root development (especially that of coarse roots) lagging behind. This is exacerbated when short rotations are applied; in a hybrid poplar plantation, for example, coppicing caused the plants to use carbohydrates stored in the roots for the new stem growth, potentially inhibiting rooting (Lee 1978, Bédéneau and Auclair 1989).

The amount of rooting, and particularly the development of structural coarse roots, has particular implications for coppice. In maiden trees and in old coppice, there is some evidence that the ratio of coarse to fine roots increases over time, whereas younger coppice tends to be more dependent on fine rooting (Montagnoli et al. 2012, Di Iorio et al. 2013). Laboratory and field pullout tests (Giadrossich et al. 2013, Vergani et al. 2016) have been used to estimate the tensile force of root bundles, which also clearly demonstrate a power law relationship between root diameter and tensile force. Root reinforcement can be estimated using a number of different models, most recently by the Root Bundle Model (RBM) (Schwarz et al. 2013), which uses a Weibull survival function to account for mechanical variability and the relative contributions of different combinations of coarse and fine roots. Simulations show that coarse roots are disproportionally influential in effecting root reinforcement - the maximum tensile force of a single root of 50 mm diameter being the equivalent of more than 500, 1 mm diameter roots (Vergani et al. 2017).

Trees that root relatively deeply, such as European ash (*Fraxinus excelsior*), *Quercus* spp., aspen (*Populus tremula*) and alder (*Alnus glutinosa*) give better soil anchorage, especially when species with different root forms are mixed together (Rayner and Nicoll 2012). With an increasing ratio of coarse to fine roots developing within a tree crop over time, we might expect that root reinforcement, and consequently soil stability, would also increase as coppices are converted, or gradually develop into high forests. In over-mature coppice crops, coarse roots will also extend outwards from the stool, stabilising a greater surface area than would be the case of recently cut coppice, which is more dependent on its finer roots (Dazio et al. 2018). On the other hand, by virtue of their very high stem densities, many coppices may reinforce the soil surface with their rooting as effectively as high forests. Breaking forces, taking into account root diameter, are also quite variable between species: for example, Vergani et al. (2012) found that beech roots were almost twice as resistant as larch (*Larix decidua*) and spruce. The order was beech (84N) >sycamore (65N) >hop-hornbeam (56N) >ash (47N) >larch (46N) >sweet chestnut (44N) >Norway spruce (40N).

When the shear zone lies below rooting depth, particularly on relatively impermeable clays liable to slope instability, the reinforcing effect of roots is expected to be negligible (van Beek et al. 2005). However, the hydrological regulation under a forest may have a positive influence on soil stability. When coppices on slopes are cut, a potential problem could arise if the rate of decay of the original root system is not compensated by the rapid regrowth of fine and coarse roots, or if the interval between harvesting and root regrowth is prolonged. New roots may not counterbalance the decay of the old root system in those species that tend to renew their roots after coppicing, lowering root reinforcement (Vergani et al. 2017). However, some coarse roots can take several years to decay and this may provide a sufficient interval of protection from the risk of shallow landslides. In felled beech stands in Northern Tuscany, Preti (2013) found that root tensile strength declined in a roughly linear fashion, at 11% per year for a total decay time of c. 9 years. This work also predicted that deforested slopes could be liable to shallow landslides within a decade of tree death, a period in which heavy rain- or snowfall events could easily occur. Silvicultural treatments could mitigate this risk, for example by extending the rotation period, as this might raise the level of root reinforcement and conserve soil resources (Rubio and Escudero 2003). Standard trees retained among the coppice could also provide pockets of permanent anchorage when the coppice is cut. Finally, uneven-aged or selective coppicing will maintain a permanent canopy and therefore reinforce rooting. In many situations, however, conversion of coppice to high forest can be extremely expensive and demanding compared to the default option of abandonment, or even coppicing on a short rotation (Vergani et al. 2017).

Uprooting of abandoned chestnut coppice (>50 years) was also investigated by Vogt et al. (2006) in the southern Swiss Alps on slopes of 20 - >30°. The uprooted stems were taller and larger, with the probability of overturning increasing on steeper slopes, particularly in hollows and gullies. To avoid large trees becoming unstable due to their increasing gravitational load, the authors recommended re-coppicing or thinning within the coming 30 years. Being more vulnerable to windthrow, the surface scars created by uprooting might form starting points for erosion. However, Conedera et al. (2010) did not consider this to be a long term issue, because any gaps were likely to be filled by forest regeneration in due course. Although surcharge resulting from the weight of overaged stools has also been suggested as a factor likely to cause shallow landslides and a reason for continued coppicing, this has been largely discounted (Stokes et al. 2008, Vergani et al. 2017).

3. The barrier effect

On very steep slopes exceeding 30° in the source (or release) area of rockfall, the protective effect of trees can actually be negative (Dorren et al. 2007) if, by swaying to and fro in the wind, they act as levers to loosen and tear open the soil profile (Frehner et al. 2005). On the other hand, apart from tree roots binding the soil surface together, they may intrude into rock fissures and also promote the decomposition of rocks by organic acids (Frehner et al. 2007).

Both in the areas of transit (usually on >30° inclines) and deposition (<30° inclines), the protective effect of forests against falling rocks is basically due to the barrier effect of

Figure 1. Trees acting as barriers on a steep slope (Photo: Christian Suchomel)

standing and lying trees (Figure 1). Collisions with trees slow down or stop rocks, with sparse forests offering less protection than dense stands (Foetzki et al. 2004, Dorren et al. 2007). The main parameters influencing the degree of protection are: the forest density (number of stems ha^{-1}), the diameter distribution of the trees, the tree species' specific energy dissipative capacity, the length of the forested part of the slope, the block volume and the block's kinetic energy (Dorren et al. 2005, Moos et al. 2017). It is often suggested that only rocks <2 m^3 can be halted by single trees, but there are some examples from the Alps where rocks up to 20 m^3 have been halted (Dorren et al. 2007, Ernst 2017). Several studies have shown that the basal area, i.e. the total surface covered by tree stems in a given area, is a good indicator of the protective effect of forests against rockfall (Berger and Dorren 2007, Dupire et al. 2016, Moos et al. 2017). Not only large diameter trees (> 36 cm), but also small trees can stop larger blocks (> 1 m^3), provided that part of the kinetic energy has already been dissipated. Thus, coppices stands may offer sufficient protection against larger blocks when combined with larger trees on the upper part of a slope (Dorren et al. 2005).

A study by Dupire et al. (2016) used the rockfall algorithm Rockyfor3D (Dorren 2012) to generate simulations of the rockfall hazard in 3886 forest plots in the French Alps, based on sloping terrain of 20° or more. Using measures of the plot basal area and the mean tree diameter, they were able to calculate the minimum length of forest to needed to obtain a reduction of 99% in rockfall hazard. The study found that coppices dominated by deciduous *Fagus sylvatica* and *Quercus* spp. were the most effective stands in this respect, compared with pure coniferous stands of *Pinus* spp. and *Larix decidua*. Stands with high stem densities, high basal areas and greater biological and structural diversity were the most efficient, with the presence of a large number of trees being more important than lower densities of thicker trees.

Again using the RockyFor3D simulation model of rockfall (Dorren 2012), Fuhr et al. (2015) assessed the protection efficiency of pure and mixed uneven-aged stands dominated by beech, silver fir and Norway spruce along a maturity gradient. 'Young' stands with the highest stem densities gave the best protection against 1-2 m^3 rocks, but even the neglected 'sub-adult' and 'mature' stands had tree densities of >500 ha^{-1}. The 'mature' stands, containing some individuals up to 220-260 years old and a significant number of very large trees (>77.5cm DBH) still offered high levels of protection, particularly against the larger sizes of rocks. Recently logged plots were considered much less effective, as the low-cut stumps could act as springboards, rather than obstacles, for the falling rocks. Moreover, mature stands contained high volumes of deadwood, including snags, which increased the roughness of the forest floor and, after modifying the simulation model to consider this, the stopping distance of large rocks was reduced by 28%. Radtke et al. (2014) recommended a slight extension of the coppice cycle in broadleaved mixed stands dominated by *Ostrya carpinifolia* and *Fraxinus ornus*, arguing that 25-year coppice forests gave better protection than young coppice, while beyond 40 - 50 years of age many stools tend to lose stability or break apart.

4. Spatial arrangement of coppices

Coppice stems may be dense and clustered, with the multiple stems per stool in young stands tending to confer more protection than sparser, older stands with fewer stems per stool. A high stem density can reduce many risks (Ringenbach 2013), but in unmanaged stands the declining stem density, through natural self-thinning, decreases the probability of rock collisions. This could be balanced to some extent by the increasing diameter and mechanical resilience of older trees, unless they are more prone to rot, as well as by the build-up of high volumes of deadwood in unmanaged stands. Older stems have thicker, more absorbent and energy-disspating bark with which to resist rockfall and are more likely to arrest larger boulders with less stem damage. The higher stem densities associated with young stems may be effective against smaller (<0.25 m^3) rock sizes (Omura and Marumo 1988, Cattiau et al. 1995). Working in coppice stands of *Orno-Ostryetum* forest in northern Italy, Radtke et al. (2014) concluded that overaging did not adversely affect their protection function, at least for stands <60 years old, although the gaps between stools were generally larger. They also found that in theory, a random distribution of stems had a higher protective effect than clustered distributions because the gaps between coppice stools decreased the likelihood of tree impacts. In a test case on Apennine coppice, the average distance between tree/boulder contacts (ADC), a measure of the energy absorbed by a forest structure, needed to be adjusted upwards from a theoretical single-stem arrangement so as to account for the higher rates of energy dissipation by coppiced trees (Ciabocco et al. 2009). They suggested that management based on the now-obsolete coppice selection system, where some stems are retained on individual stools at each cutting, or coppices with large reserves or standards, could give good rockfall protection. Radtke et al. (2014) also found that the protective effect against large rocks was still one-third greater in the overaged coppice stands than the equivalent site without significant tree cover immediately following coppicing, provided that a few standard trees remained.

Ciabocco et al. (2009) conducted a series of impact tests on fresh beech stems (3-10 cm DBH) using a reinforced 84 kg concrete pendulum bob, swung to impact with clamped, single coppice stems. As expected, this demonstrated that mechanical resistance increased with stem diameter and lessened with the height of impact. However, it was surmised that highly flexible young coppice stems, generally of smaller diameter than those in mature forests, could decelerate boulders effectively and that the clumping of stems on stools could act as additional small retention fences. Although probably limited in their ability to protect against rocks >1 m^3, simultaneous impacts against more than one stem on the same stool could effectively trap rocks between them (Figure 2). Nevertheless it was uncertain whether this multi-stemmed coppice structure produced a greater protective effect. Furthermore, the basal sweep of stems associated with slopes, resulting from growth stresses that form tension wood, could weaken them against impacts.

The history and spatial pattern of rockfall was investigated by Favillier et al. (2015) on sub-montane broadleaved forest on slopes of

Figure 2. Rock caught in a coppice stool (Photo: Christian Suchomel)

25 - 39° in the Vercors massif of the French Alps. An exhaustive analysis of wounds and bark scarring on the stems of individual trees and coppice stools revealed, as expected, a high incidence of impacts from rockfall near the top of the release zone, at frequencies of <20 years, as well as laterally in topographic depressions, which tended to funnel any rockfall. At 150 m downslope, the frequency of the damage interval fell to >40 years. Favillier et al. (2015) also demonstrated that the fast-growing downy oak, with its thicker bark, might be capable of absorbing more impact energy with less damage than an Italian maple (*Acer opalus*) of similar age. In a rockfall corridor in the French Alps, Stokes et al. (2005) showed that beech suffered less from stem breakage, wounding and uprooting than did the other species tested. Through winching experiments to break or uproot a tree, they found that beech was twice as resistant as silver fir and three times more than Norway spruce, which tended to uproot. In similar experiments, Dorren et al. (2005) ranked species in the following order of energy of dissipation: pedunculate oak (*Quercus robur*) >beech >sycamore >silver fir > larch/Norway spruce. There was a strong exponential relationship between stem DBH and the amount of energy dissipated from an impacting rock. Such differences could be attributed to the different xylem structure of the broadleaves, which can make them more resistant to splitting and deformation, and their greater number of roots that are anchored at a greater depth.

5. Silvicultural comparisons

In the southern Italian Apennines, Ferretti et al. (2014) developed a Synthetic Index of Protection (SIP) against soil erosion to compare the efficiency of different types of canopy of tree species, shrub and herbaceous layers, based on their respective interception values. Taking this (and slope angle) into account, they determined the most suitable silvicultural treatments providing a continuous canopy cover. Beech selection coppices, in which some stems were always retained on the stools, provided good protection, as did the conversion to an uneven-aged beech high forest structure, although both options were costly. With Turkey/downy oak forest cover, the alternatives were:

a) to continue coppicing,

b) to convert to high forest via a shelterwood system, or

c) to retain about 50 standards ha^{-1} along with the coppice (Ferretti et al. 2014).

The authors suggested making very small felling coupes, predicated on getting good natural regeneration, either from seedlings or coppice resprouting. Becker et al. (2013) argued that on steep slopes, small diameter coppice poles of low volume were both uneconomic and technically difficult to harvest. They suggested that on dry, steep slopes of up to 16.7°, slow-growing stands of oak could be grown on longer rotations (50-80 years) in order to produce a more profitable mass per unit ratio. High quality trees could be retained as standards (at densities of 20-30 ha^{-1}) to be harvested after two coppice rotations (100-160 years), while some poorer-quality trees could be left to die back naturally and become 'habitat trees'. Steeper slopes would require more expensive methods to be employed, such as cable harvesting.

The relatively small stem sizes associated with coppice might be considered most appropriate in the deposition zone of slopes, at a point where the slope incline eases and most travelling rocks have been slowed by impacts on trees further up in the transit zone. Although regrowth of coppices after cutting is rapid, the same practice of restricting felling coupes to 40m in the fall line is commonly advocated (Dorren et al. 2015). Pure coppice stands are only recommended in areas with short transit area slopes of less than 75 m length (Frehner et al. 2005). Coupe sizes of 0.5 ha or more were less likely to give protection, since a weakened root reinforcement might allow loose rocks to reach their maximum velocity when travelling through the felling coupe. It was therefore recommended to keep clear cuts small and well-distributed throughout the whole protection area, with maximum widths of 20 m on steep slopes regularly prescribed. In the case of preventing shallow landslides, as opposed to rockfall, Vennetier et al. (2014) also recommended limiting clear cuts to <0.5 ha, certainly <1 ha, or adopting a selection silviculture to protect the soil, pointing out that the increased cutting intensity, as in coppicing for fuelwood, might exacerbate the risk of erosion.

Conclusions

After coppicing, stands regrow quickly and soon achieve stem densities of a critical diameter, which are able to withstand soil erosion and minor rockfalls, as well as recover quickly from stem wounding and breakages. As the stems of traditional, in-rotation coppices rarely exceed 15 - 20 cm DBH, their protection function tends to be limited for rocks greater than 1 m^3 (Jancke et al. 2009). With abandonment, and increasing stem size, there is always the risk of stools being uprooted on unstable steep slopes during high winds or due to soil oversaturation, although the same would equally apply to mature high forest crops. Overaged coppice stands will eventually self-thin, increasing their stool spacing, but Fuhr et al. (2015) showed that old stands were able to retain moderate stem densities, as well as some trees large enough to intercept large blocks of c. 5 m^3, while the high volumes of deadwood presented additional barriers.

By maintaining high stem densities, active coppicing does appear to provide an effective protection service against rockfall. As many former coppice forests develop into high forests, either through conversion or abandonment, they often retain the high stem densities that tend to reduce rockfall hazard (Dupire et al. 2016). Coppice harvests are also likely to be more economic in the deposition zone, below the steeper slopes, and may still be more cost-effective than converting the stand to a high forest structure. Coppicing also promotes strong lateral rooting reinforcement against soil shear, with many broadleaves tending to have deep roots. The 'retention fences' resulting from multiple stems on the same stool may be more effective in trapping rocks than discrete, single stems of equivalent diameter, especially if rocks impact more than one stem simultaneously, although this may be counterbalanced by the clumped stem distributions forming large gaps between stools.

Beech and several other broadleaves also have roots with a stronger tensile strength than those of conifers, their frequent competitors in mountain situations; for a given DBH their stems are also more able to dissipate rockfall energy. It is not clear, however, to what extent root reinforcement retains its effectiveness immediately after cutting, before canopy cover is re-established. Conversion or abandonment of coppices on very steep slopes does not necessarily impair their protection services. Most evidence points to high forests as being inherently more stable structures with respect to soil erosion, due to their greater amount of coarse rooting compared with coppice. Hence the abandonment of coppicing on vulnerable slopes may not adversely affect the ability to regulate shallow landslides, and may actually increase soil stabilisation, especially in the case of those tree species that need to renew their root system immediately after harvesting. However, in the special case of river banks and gullies, which are liable to debris flows during floods, managed coppice can avoid the overturning of large stems and their transport down swollen rivers (Rudolf-Miklau and Hübl 2010).

Since abandoned and over-mature coppices are even-aged, they will eventually break up synchronously. Under these circumstances, and particularly in the slow-growing conditions of mountain habitats, there may be insufficient naturally-seeded regeneration to take over the protection function of root reinforcement, especially if large gaps form. Thus, several authorities advocate only clearing small coupes at a time, or uneven-aged/group selection systems, which rely on small canopy openings that fill with natural regeneration. All of this assumes the presence of relatively few domestic or wild browsing animals, as the fresh shoots on a coppice stool and natural seedling regeneration are both equally vulnerable. If coppicing operations are to be continued on slopes, protection can be enhanced by keeping gap sizes to a minimum, retaining standards and ensuring natural regeneration.

References

Amorini E., Fabbio G., Frattegiani M. and Manetti M.C. (1990) *L'affrancamento dei polloni. Studio sugli apparati radicali in un soprassuolo avviato ad alto fusto di faggio*. Ann. Ist. Sper. Selv. Arezzo, XIX (1988): 199-262.

Anderson H.W., Hoover, M.D., Reinhart, K.G. (1976) *Forests and Water. Effects of forest management on floods, sedimentation and water supply*. Forest Service, U.S. Department of Agriculture, Berkeley, California, 121 pp.

Bagnara L. and Salbitano F. (1998) *Struttura delle ceppaie e dei sistemi radicali in cedui di faggio sui monti Sibillini*. Sherwood 30: 31-34.

Bassanelli C., Bischetti G.B., Chiaradia E.A., Rossi L. and Vergani C. (2013) *The contribution of chestnut coppice forests on slope stability in abandoned territory: a case study.* Journal of Agricultural Engineering 44: 68-73.

Becker G., Bauhus J., and Konold W (eds.) (2013) Optionen einer zukunftsgerichteten Niederwaldwirtschaft in Rheinland-Pfalz -Forschungsergebnisse und Schlussfolgerungen im Überblick. In: *Schutz durch Nutzung: Ein Raum-Zeit-Konzept für die multifunktionale Entwicklung der Stockausschlagwälder in Rheinland-Pfalz*, page 5 – 23. (Culterra 62) Freiburg i.Br. 216 pages, ISBN 978-3-933390-50-9.

Bédéneau M. and Auclair D. (1989) *Effect of coppicing on hybrid poplar fine root dynamics*. Annales des Sciences Forestières 46: 294- 296.

Bédéneau M. and Pagès L. (1984) *Study of the growth rings of roots of coppiced trees*. Ann. Sci. For. 41: 59-68.

Borrelli P., Panagos P., Langhammer J., Apostol B. and Schütt B (2016) *Assessment of the cover changes and the soil loss potential in European forestland: First approach to derive indicators to capture the ecological impacts on soil-related forest ecosystems*. Ecological Indicators 60: 1208–1220.

Bronick C.J. and Lal, R. (2005) *Soil structure and management: a review*. Geoderma 124: 3–22.

Burri K., Graf F. and Böll A. (2009) *Revegetation measures improve soil aggregate stability: a case study of a landslide area in Central Switzerland*. For. Snow Landsc. Res. 82: 45–60

Cattiau V., Mari E. and Renaud J.P. (1995) *Forêt et protection contre les chutes de rochers*. Ingéneries EAI 3: 45-54.Ceschi I. (2014) Il bosco del Canton Ticino. 2nd edition, Armando Dadò Editore, Locarno, 431 p.

Chiatante D., Sarnataro M., Fusco S., Di Iorio A. and Scippa G.S. (2003) *Modification of root morphological parameters and root architecture in seedlings of Fraxinus ornus L. and Spartium junceum L. growing on slopes*. Plant Biosystems 137: 47-55.

Ciabocco G., Boccia L. and Ripa M.N. (2009) *Energy dissipation of rockfalls by coppice structures*. Natural Hazards and Earth Systems Science 9: 993–1001.

Cohen D. and Schwarz M. (2017) *Tree-roots control of shallow landslides*. Earth Surf. Dynam. Discuss. 1–43. 10.5194/esurf-2017-10.

Conedera M., Pividori M., Pezzatti G.B. and Gehring E. (2010) Il ceduo come opera di sistemazione idraulica - la stabilità dei cedui invecchiati. In: Carraro, V. and Anfodillo, T. (eds) Atti del 46° Corso di Cultura in Ecologia: “Gestione multifunzionale e sostenibile dei boschi cedui: criticità e prospettive”. San Vito, 7-10 giugno 2010. 85-91.

Dazio E., Conedera M. and Schwarz M. (2018) *Impact of different chestnut coppice managements on root reinforcement and shallow landslide susceptibility*. Forest Ecology and Management 417: 63–76.

Di Iorio A., Lasserre B., Scippa G.S. and Chiatante D. (2005) *Root System Architecture of Quercus pubescens Trees Growing on Different Sloping Conditions*. Annals of Botany 95: 351-361.

Di Iorio A., Montagnoli A., Terzaghi M., Scippa G.S. and Chiatante D. (2013) *Effect of tree density on root distribution in Fagus sylvatica stands: a semi-automatic digitising device approach to trench wall method*. Trees 27: 1503-1513.

Dorren L.K.A. (2012) *Rockyfor3D (v5.1) revealed - Transparent description of the complete 3D 484 rockfall model*. ecorisQ paper (www.ecorisq.org): 31 pp.

Dorren L., Berger F. and Métral R. (2005) *Gebirgswald. Der optimale Schutzwald gegen Steinschlag*. Wald und Holz: 2–4.

Dorren L., Berger F., Frehner M., Huber M., Kühne K., Métral R., Sandri A., Schwitter R., Thormann J.-J. and Wasser B., (2015) *Das neue NaiS-Anforderungsprofil Steinschlag*. Schweizerische Zeitschrift fur Forstwesen 166 (1), 16–23. 10.3188/szf.2015.0016.

Dorren L., Berger F., Jonsson M., Krautblatter M., Mölk, M., Stoffel M. and Wehrli A. (2007) *State of the art in rockfall – forest interactions*. Swiss Forestry Journal 158 (6):128–141. DOI: 10.3188/szf.2007.0128.

Dupire S., Bourrier F., Monnet J-M., Bigot S, Borgniet L., Berger F. and Curt T. (2016) *The protective effect of forests against rockfalls across the French Alps: Influence of forest diversity*. Forest Ecology and Management 382: 269–279.

Ernst, J., 2017. *Schutzwald und Steinschlagrisiko - Bestimmung der räumlichen Auftretens-wahrscheinlichkeit von mehreren Sturzkörpern während eines Ereignisses*. Master thesis, Bern, 134 pp.

Favillier A., Lopez-Saez J., Corona C., Trappmann D., Toe D., Stoffel M., Rovéra G. and Berger F. (2015) *Potential of two submontane broadleaved species (Acer opalus, Quercus pubescens) to reveal spatiotemporal patterns of rockfall activity*. Geomorphology 246: 35–47.

Ferretti F., Cantiani P., de Meo I. and Paletto A. (2014) *Assessment of soil protection to support forest planning: an experience in southern Italy*. Forest Systems 23: 44-51

Fidej G., Mikoš M., Rugani T., Jež J., Kumelj Š. and Diaci J. (2015) *Assessment of the protective function of forests against debris flows in a gorge of the Slovenian Alps*. iForest 8: 73-81 [online 2014-06-17] URL: http://www.sisef.it/iforest/contents/?id=ifor0994-

Foetzki A., Jonsson M., Kalberer M., Simon H. and Lundström T. (2004) Interaction between trees and natural hazards in subalpine spruce forests. In: *TRACE - Tree Rings in Archaeology, Climatology and Ecology*. DENDROSYMPOSIUM, Birmensdorf, Switzerland. April 22nd - 24th.

Forbes K. and Broadhead J. (2011) *Forest and Landslides. The role of trees and forests in the prevention of landslides and rehabilitation of landslide-affected areas in Asia*. FAO; RAP Publication 19/2011.

Frehner M., Wasser B. and Schwitter R. (2005) *Nachhaltigkeit und Erfolgskontrolle im Schutzwald. Wegleitung für Pflegemaßnahmen in Wäldern mit Schutzfunktion*. Hg. v. Bundesamt für Umwelt, Wald und Landschaft (BUWAL). 564 p.

Frehner M., Wasser B. and Schwitter R. (2007) *Sustainablity and success monitoring in protection forests. Guidelines for managing forests with protective functions*. Partial translation by Brang P. and Matter C. Environmental Studies no. 27/07. Federal Office for the Environment (FOEN), Bern.

Fuhr, M., Bourrier, F. and Cordonnier, T. (2015) *Protection against rockfall along a maturity gradient in mountain forests*. Forest Ecology and Management 354: 224–231

Gerber C. and Elsener O. (1998) *Niederwald im Steinschlaggebiet*. Wald und Holz 14 :8-11.

Giadrossich F., Schwarz M., Cohen D., Preti F. and Or D. (2013) *Mechanical interactions between neighbouring roots during pullout tests*. Plant and Soil 367: 391-406.

Gosteli H. (2009) *Steinschlag und Felssturz*. Bundesamt für Umwelt BAFU. Nationale Plattform Naturgefahren. Bern. Link: http://www.planat.ch/de/wissen/rutschung-und-felssturz/steinschlag-felssturz/entstehung-s-f/ (last retrieval 23.05.2015).

Imaizumi F., Sidle R.C. and Kamei R. (2008) *Effects of forest harvesting on the occurrence of landslides and debris flows in steep terrain of central Japan*. Earth Surf. Process. Landforms 33 (6), 827–840. 10.1002/esp.1574.

Jancke O., Berger F. and Dorren L.K.A. (2013) *Mechanical resistance of coppice stems derived from full-scale impact tests Earth Surf*. Process. Landforms 38: 994–1003.

Jancke O., Dorren L.K.A., Berger, F., Fuhr, M. and Köhl M. (2009) *Implications of coppice stand characteristics on the rockfall protection function.* Forest Ecology and Management 259: 124–131. DOI: 10.1016/j.foreco.2009.10.003.

Lee, D. K. (1978) *The influence of the geometry and distribution of root systems on coppice regeneration and growth of hybrid poplars*. Retrospective Theses and Dissertations. 6502. http://lib.dr.iastate.edu/rtd/6502

Lees J.C., (1981) *Three generations of red maple stump sprouts*. Fredericton, NB. Maritimes Forest Research Centre, M-X-199, 1-9.

Mao Z., Saint-André L., Genet M., Mine F-X., Jourdan C., Rey H., Courbaud B. and Stokes A. (2012) *Engineering ecological protection against landslides in diverse mountain forests: Choosing cohesion models*. Ecological Engineering 45: 55–69.

Montagnoli A., Terzaghi M., Di Iorio A., Scippa G.S. and Chiatante D. (2012) *Fine-root seasonal pattern, production and turnover rate of European beech (Fagus sylvatica L.) stands in Italy Prealps: possible implications of coppice conversion to high forest*. Plant Biosystems: 146, 1012-1022.

Moos C., Dorren L. and Stoffel M. (2017) *Quantifying the effect of forests on frequency and intensity of rockfalls*. Nat. Hazards Earth Syst. Sci. 17 (2), 291–304. 10.5194/nhess-17-291-2017.

Omura H. and Marumo Y. (1988) *An experimental Study of the fence Effects of Protection Forests on the Interception of Shallow Mass Movement*. Mitteilungen der Forstlichen Bundes-Versuchsanstalt Mariabrunn 159: 139-147.

Perret S., Dolf F., and Kienholz H. (2004) *Rockfalls into forests: Analysis and simulation of rockfall trajectories - considerations with respect to mountainous forests in Switzerland*. Landslides 1: 123-130 doi:10.1007/s10346-004-0014-4.

Petzold R., Butler-Manning D., Feldwisch N., Glaser T., Schmidt P.A., Denner M. and Feger K-H. (2014) *Linking biomass production in short rotation coppice with soil protection and nature conservation*. iForest 7: 353-362

Piussi P. and Puglisi, S. (2012) *Copertura forestale e franosità*. Atti dei Convegni dei Lincei, ACL.

Preti, F. (2013) *Forest protection and protection forest: Tree root degradation over hydrological shallow landslides triggering*. Ecological Engineering 61: 633–645.

Radtke A., Toe D., Berger F., Zerbe S. and Bourrier F. (2014) *Managing coppice forests for rockfall protection: lessons from modeling*. Annals of Forest Science 71: 485-494.

Rayner B. and Nicoll B. (2012) *Potential for woodland restoration above the A83 in Glen Croe to reduce the incidence of water erosion and debris flows*. Forest Research, Edinburgh.

Rickli C. and Graf F. (2009) *Effects of forests on shallow landslides - case studies in Switzerland*. Forest Snow and Landscape Research 82: 33-44.

Riedacker A. (1973) *Les tallis d'eucalyptus au Maroc*. Annales de la recherche forestiere au Maroc, 13:157-349.

Ringenbach A. (2013) *Steinschlagmodellierung im Schutzwald unter Berücksichtigung verschiedener Bestandesstruktur*. Masterarbeit. Universität Zürich, Zürich. Geographisches Institut. Link: www.wm.ethz.ch/education/diplom/concluded/msc_ringenbach.pdf (last retrieval 03.06.2015).

Rubio A. and Escudero A. (2003) *Clear-cuts effects on chestnut forest soils under stressful conditions: lengthening of time-rotation*. Forest Ecology and Management, 183, 195- 204.

Rudolf-Miklau F. and Hübl J. (2010) *Managing risks related to drift wood (woody debris)*. http://www.interpraevent.at/palm-cms/upload_files/Publikationen/Tagungsbeitraege/2010__868.pdf (last retrieval 15.07.2017).

Schwarz M., Giadrossich F., and Cohen D. (2013). *Modeling root reinforcement using a root-failure Weibull survival function*. Hydrology and Earth System Sciences 17: 4367-4377.

Schwarz M., Rist A., Cohen D., Giadrossich F., Egorov P., Büttner D., Stolz M. and Thormann J.-J. (2015) *Root reinforcement of soils under compression*. J. Geophys. Res. Earth Surf. 120: (10) 2103–2120. 10.1002/2015JF003632.

Sidle R.C. and Bogaard T.A. (2016) *Dynamic earth system and ecological controls of rainfall-initiated landslides*. Earth-Science Reviews, 159: 275-291.

Stokes A., Salin F., Kokutse A.D., Berthier S., Jeannin H., Mochan S., Dorren L., Kokutse N., Ghani M. A., and Fourcaud T. (2005) *Mechanical resistance of different tree species to rockfall in the French Alps*. Plant and Soil 278: 107-117.

Stokes A., Norris J., van Beek L.P.H., Bogaard T., Cammeraat E., Mickovski, S.B., Jenner A., Di Iorio A. and Fourcaud T. (2008) How vegetation reinforces soil on slopes. In: *Soil stability and erosion control: ecotechnological solutions*. Springer.

Stokes, A., Atger, C., Bengough, A.G., Fourcaud, T., Sidle, R.C., 2009. *Desirable plant root traits for protecting natural and engineered slopes against landslides*. Plant and Soil 324, 1–30.

van Beek L.P.H., Wint J., Cammeraat L.H. and Edwards J.P. (2005) *Observation and Simulation of Root Reinforcement on Abandoned Mediterranean Slopes*. Plant Soil 278: (1-2), 55–74. 10.1007/s11104-005-7247-4.

Vennetier M., Ladier J. and Rey F. (2014) *Erosion control on forest soils with vegetation, under global change*. Revue Forestière Française Special Issue, "REGEFOR 2013 WORKSHOPS - Is the management of forest soil fertility at a turning point?", 119-132.

Vergani C., Chiaradia E.A. and Bischetti G.B. (2012) *Variability in the tensile resistance of roots in Alpine forest tree species*. Ecological Engineering 46: 43– 56.

Vergani C. and Graf F. (2016) *Soil permeability, aggregate stability and root growth: a pot experiment from a soil bioengineering perspective*. Ecohydrology 9: 830-842.

Vergani C., Schwarz M., Soldati M., Corda A., Giadrossich F., Chiaradia E.A., Morando P., and Bassanelli C. (2016) *Root reinforcement dynamics in subalpine forests following timber harvest: a case study in Canton Schwyz, Switzerland*. Catena 143: 275-288.

Vergani C., Giadrossich F., Buckley P., Conedera M., Pividori M., Salbitano F., Rauch H.S., Lovreglio R. and Schwarz M., (2017) *Root reinforcement dynamics of European coppice woodlands and their effect on shallow landslides: a review*. Earth-Science Reviews 167: 88-102.

Vogt J., Fonti P., Conedera M. and Schröder B. (2006) T*emporal and spatial dynamic of stool uprooting in abandoned chestnut coppice forests*. Forest Ecology and Management 235: 88–95.

Volkwein A., Gerber W., Krummenacher B., Glover J., Bartelt P., and Christen M. (2013) *Steinschlag - Bessere Schutzmaßnahmen dank Forschung*. Eidg. Forschungsanstalt für Wald, Schnee, und Landschaft WSL. Birmensdorf. Link: http://www.wsl.ch/fe/gebirgshydrologie/massenbewegungen/prozesse/steinschlag/index_EN (last retrieval 15.07.2017).

Wildy D.T. and Pate J.S. (2002) *Quantifying above and below ground growth responses of the western Australian oil mallee, Eucalyptus kochii subsp. plenissima, to contrasting decapitation regimes*. Annals of Botany, 90:(2), 185-197.

Historical Coppicing and its Legacy for Nature Conservation in the Czech Republic

Radim Hédl

Introduction

I wrote this contribution having in mind a twofold perspective on coppicing: a historical one and an ecological one. The logic connecting these two otherwise distinct views is that the long-term presence, or even dominance in some regions of coppice management in the Czech Republic has influenced both past and current forest ecosystems. And vice versa, the historical range of coppicing has been largely determined by ecological factors. One cannot fully understand one aspect without the other. Despite being so widespread an activity, ranging from the prehistory up to the first half of the 20th century, coppicing has been deliberately and entirely abandoned in the past decades. The research devoted to historical and ecological aspects of former coppice management partly aims to restore it for conservation and production purposes. In the Czech Republic, this process is just begun - nevertheless, this is stunning progress compared to the situation less than two decades ago, when coppicing was completely absent from nature conservation handbooks (e.g. Míchal and Petříček 1999) and not even mentioned in forestry. Up until now, several research projects directly or indirectly focusing on coppicing have been completed, or are still running, and a growing interest among the conservationists can be clearly observed. As foresters tend to be much more conservative as a whole, the future of coppicing restoration for wood production remains somewhat less promising.

Brief historical perspective on coppicing from the Middle Ages to the 20th century

Coppicing was a widespread management system in the Czech lands (Bohemia, Moravia and Silesia) at least since the Late Middle Ages. Its historical range strongly correlates with the extent of lowlands (150 to about 500 m a.s.l.), which occupy roughly one-third to half of the country area. This correlation is apparently because the lowlands are the most fertile, and hence the most densely populated areas of the Czech Republic since prehistory. Coppicing was a primary source of fuel energy, so the constant production of fuelwood was of high societal concern, at least until it was replaced by fossil fuels at some time during the 19th century.

Forest has always been relatively scarce in the lowlands of the Czech Republic. Only sites least favourable for agriculture, such as slopes or stony soils, were left to forest management. This could explain why coppicing, an intense and effective fuelwood production system of the past, prevailed in the lowlands. Two noteworthy examples, illustrating which factors historically played a role in decision making with regard to the forest management type,

Corresponding Author: Radim Hédl, radim.hedl@ibot.cas.cz

were presented by Szabó and Hédl (2013). Coppicing was clearly preferred where the natural conditions allowed. Non-timber forest systems, including wood pasture, were probably applied only in the relatively less suitable situations. To fully understand the driving factors for particular types of management in the past would, however, require further research. This situation was typical for central and northern Bohemia, southern Moravia and adjacent parts of Silesia (Figure 1). The structure of forest vs. agricultural land use remained conservative for centuries in these regions, with crop fields predominating and forest areas being relatively small (Mackovčin et al. 2011).

In Moravia and Silesia, the proportion of coppicing systems within all types of forest management can be relatively precisely established for the 18th and 19th centuries. This information has been obtained through extensive research, using all available archival material for the region (http://longwood.cz/?page_id=165). The share of coppicing in Moravia and Czech Silesia ranged from zero to 100% in individual cadastres (civil parishes), showing a strongly uneven pattern. In the densely populated lowlands, the proportion of coppicing on all forest systems was typically more than 50%, often 80–100% (apart from quite significant areas without forest). In contrast, forested uplands had little or no coppicing management and in the transitional belts the coppicing proportion varied between zero to about 30–40%. Interestingly, the corresponding geographic pattern of coppicing in Moravia could be traced back to the Middle Ages (14th century), pointing to the long-term stability of coppicing systems for at least six centuries (Szabó et al. 2015).

In Bohemia, the western part of the Czech Republic, no reliable data for a similarly detailed mapping of the historical coppicing area exists. Land use and management data from the so-called Stable Cadastre, a land use survey of the 1820s–1840s, was rewritten long after the survey and in an unsystematic manner (P. Szabó, pers. comm.). Although this information is now freely available on the internet (http://archivnimapy.cuzk.cz/uazk/pohledy/archiv.html), further critical research is required in order to construct a detailed map of the historical coppicing for Bohemia. Nevertheless, approximations can be made: a map of the historical area of coppicing in the whole Czech Republic has recently been published by Maděra et al. (2017), which confirms that coppicing prevailed in the lowlands of both Bohemia and Moravia (Figure 1).

A map of coppice forests for 1947, presented in the above-cited paper, shows a very similar pattern, indicating a persistence of coppice at time when there was no active coppicing in the country any more. The leading researchers in forestry at that time emphasised the negative

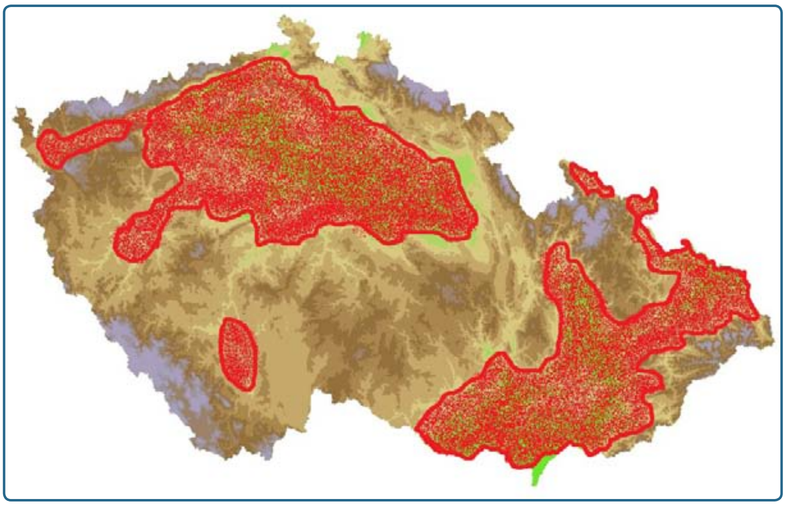


Figure 1. The approximate historical range of coppice forests in the Czech Republic, based on historical research by P. Szabó and his colleagues and published maps by Maděra et al. (2017). The area with significant historical coppicing (outlined in red) correlates with the lower altitudes (150 to 500 m a.s.l.). Current coppicing restoration work (not shown) is confined to no more than seven small-scale sites (situation in 2018).

aspects of coppicing, instead proposing methods for converting the remaining coppices into high forest (e.g. the special issue of Lesnictví [Forestry] devoted to coppicing, 1957/2). Probably the last deliberate coppicing activity was performed shortly before the WW II. Studies using tree-rings and archival resources (maps and written documents) confirm the story of gradual coppicing abandonment over the past two centuries in Děvín, one of the most significant sites with historical coppicing in the Czech Republic (Altman et al. 2013, Müllerová et al. 2014). The last regular coppicing was applied there in 1935/1937.

Legacy of historical coppicing and effects of coppicing abandonment in today's forests

The legacy of historical coppice management in forests of the Czech Republic has yet to be published. Persistent effects of past coppicing management in the present forest ecosystems has so far received only little attention. To the author's knowledge, there has been no systematic study of the effects of past coppicing on abiotic (e.g. soil chemistry) or biotic properties of forest ecosystems. The latter includes the distribution of individual species and communities, as well as patterns in biodiversity. Why would this knowledge be worth the attention of researchers, conservationists and forest managers?

The approach is similar to other studies on the legacy of past land use. Several studies have shown a marked legacy of ancient land use on soil properties and biotic communities (reviewed by Hermy and Verheyen 2007). These legacy effects could be somewhat more complex (and subtle) than coarse transitions from agricultural land to forest. However, they may be at least partly responsible for the current distribution of oak (Maděra et al. 2017) or the biodiversity of forest understory vegetation (Figure 2). Unpublished research by Hédl et al. shows that 19th century coppicing in Moravia significantly explains current species richness at the plant community level. Plots in cadastres with the 19th century coppicing show a higher number of vascular plant species than in plots where coppicing was absent. However, the contribution of coppicing, independent from other factors, is relatively low. At a still broader perspective, patterns of the historical coppicing (outlined above) largely coincide with the potential vegetation (after Neuhäuslová et al. 1998). Oak and oak-hornbeam forests are the types of potential vegetation prevalent in areas where coppicing once dominated. One must keep in mind that the natural conditions largely correlate with land use and partly with management types, so statements about the net effects of coppicing on the actual or potential distribution of species or ecological communities require careful differentiation.

Figure 2. Coppicing in the Děvín Nature Reserve, Pálava, showed positive effects on flowering of herb species of forest understory, such as *Primula veris*.

On the other hand, changes in biodiversity and composition following coppicing abandonment are relatively well documented. Related research is based on two types of evidence: recent resurveys of vegetation plots, recorded at times shortly after the coppicing abandonment, and comparisons of sites with varying or contrasting parameters of environmental conditions, resembling the situation in active coppices. Both types of studies were performed in forests with historically prevalent coppicing in southern Moravia and central Bohemia. Several groups of organisms were targeted in these studies: vascular plants and their communities (Hédl et al. 2010, Kopecký et al. 2013, Müllerová et al. 2015), butterflies (Benes et al. 2006, Freese et al. 2006), epigeic invertebrates (Spitzer et al. 2008) and saproxylic beetles (Vodka et al. 2009, Vodka and Cizek 2013). Paradoxically, historical coppicing has sometimes been associated with extant, but declining populations of some species (Konvicka et al. 2008, Roleček et al. 2017), whereas research has shown that past coppicing may not be responsible for these changes (Szabó 2013), especially not for the long-term survival of the studied populations. Generally, coppicing and wood pasture, along with other non-forestry uses such as litter raking, could have comparable effects on biodiversity (e.g. Vild et al. 2015, Chudomelová et al. 2017, Douda et al. 2017).

Summarising the published studies from sites in the Czech Republic, the main conclusion would be that the coppicing abandonment has led to a decline in biodiversity. This concerns the species-rich deciduous lowland forests, where coppicing was the dominant forest management system up to the first half of the 20th century. The decline affected both individual species requiring forest habitats with frequent canopy opening and the ecological communities where species richness decreased and homogenization of species assemblages was documented. Remaining knowledge gaps concern the effects of coppicing abandonment on other groups of organisms, namely those requiring shadier conditions and biomass accumulation.

Figure 3. Coppicing restoration in the Na Voskopě Nature Reserve, Bohemian Karst. Clearings have been made to monitor the ability of coppiced individuals to resprout and the effects on biodiversity.

Largely motivated by the alarming results of the above-cited studies, some coppicing has been restored in the past decade in order to promote vanishing biodiversity. At present, seven sites (some of them with several sub-sites) have so far been restored to traditional coppicing (Figure 3). The total extent of these sites hardly exceeds a few hectares, and most of them are found in protected areas, including natural reserves and national parks. Nonetheless, plans aim to restore at least a hundred hectares, pooling all sites. Results from freshly restored coppices showed positive effects on species and/or functional diversity of various taxonomic groups (Vild et al. 2013, Sebek et al. 2015, Šipoš et al. 2017, Hédl et al. 2017); the last case cited is of a newly established traditional coppice on former agricultural land. An important feature of coppicing restoration studies is that they capture the effects of one-time canopy opening rather than the long-lasting effects of coppice management. Several coppicing cycles would have to be run to assess the actual effects on ecological communities under the current environmental conditions.

Acknowledgements

I would like to thank my colleagues, in particular Péter Szabó, Markéta Chudomelová, Jan Šipoš and Ondřej Vild, for countless discussions on the topic in the past years. Support to the presented research was (among others) from the projects of the Grant Agency of the Czech Republic no. 17-09283S, European Research Council FP7/2007–2013 no. 278065, and the long-term research development project RVO 67985939 to the Institute of Botany, Czech Academy of Sciences.

References

Altman, J., Hédl, R., Szabó, P., Mazůrek, P., Riedl, V., Müllerová, J., Kopecký, M., & Doležal, J. (2013). *Tree-rings mirror management legacy: dramatic response of standard oaks to past coppicing in Central Europe.* PLOS ONE, 8(2), e55770.

Benes, J., Cizek, O., Dovala, J. & Konvicka, M. (2006). *Intensive game keeping, coppicing and butterflies: the story of Milovicky Wood, Czech Republic*. Forest Ecology and Management, 237, 353–365.

Chudomelová, M., Hédl, R., Zouhar, V., & Szabó, P. (2017). *Open oakwoods facing modern threats: Will they survive the next fifty years?* Biological Conservation, 210, 163–173.

Douda, J., Boublík, K., Doudová, J., & Kyncl, M. (2017). *Traditional forest management practices stop forest succession and bring back rare plant species*. Journal of Applied Ecology, 54, 761–771.

Freese, A., Benes, J., Bolz, R., Cizek, O., Dolek, M., Geyer, A., Gros, P., Konvicka, M., Liegl, A. & Stettmer, C. (2006). *Habitat use of the endangered butterfly Euphydryas maturna and forestry in Central Europe.* Animal Conservation, 9, 388–397.

Hédl, R., Šipoš, J., Chudomelová, M., & Utinek, D. (2017). *Dynamics of herbaceous vegetation during four years of experimental coppice introduction.* Folia Geobotanica, 52, 83–99.

Hermy, M., & Verheyen, K. (2007). *Legacies of the past in the present-day forest biodiversity: a review of past land-use effects on forest plant species composition and diversity.* Ecological Research, 22(3), 361–371.

Konvicka, M., Novak, J., Benes, J., Fric, Z., Bradley, J., Keil, P., Hrcek, J., Chobot, K. & Marhoul, P. (2008). *The last population of the Woodland Brown butterfly (Lopinga achine) in the Czech Republic: habitat use, demography and site management.* Journal of Insect Conservation, 12, 549–560.

Kopecký, M., Hédl, R., & Szabó, P. (2013). *Non-random extinctions dominate plant community changes in abandoned coppices.* Journal of Applied Ecology, 50, 79–87.

Mackovčin, P., Borovec, R., Demek, J., Eremiášová, R., Havlíček, M., Chrudina, Z., Rysková, R., Skokanová H., Slavík, P., Svoboda, J., & Stránská, T. (2011). *Changes of land use in the Czech Republic. Collection of maps in scale 1:200 000.* The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Průhonice and Brno.

Maděra, P., Machala, M., Slach, T., Friedl, M., Černušáková, L., Volařík, D., & Buček, A. (2017). *Predicted occurrence of ancient coppice woodlands in the Czech Republic.* iForest-Biogeosciences and Forestry, 10(5), 788–795.

Míchal, I. & Petříček, V. (Eds.) (1999). *Péče o chráněná území: II. Lesní společenstva.* Agentura ochrany přírody a krajiny České republiky, Praha.

Müllerová, J., Szabó, P., & Hédl, R. (2014). *The rise and fall of traditional forest management in southern Moravia: A history of the past 700 years.* Forest Ecology and Management, 331, 104–115.

Müllerová, J., Hédl, R., & Szabó, P. (2015). C*oppice abandonment and its implications for species diversity in forest vegetation.* Forest Ecology and Management, 343, 88–100.

Neuhäuslová, Z., Blažková, D., Grulich, V., Husová, M., Chytrý, M., Jeník, J., Jirásek, J., Kolbek, J., Kropáč, Z., Ložek, V., Moravec, J., Prach, K., Rybníček, K., Rybníčková, E., & Sádlo, J. (1998). *Map of the potential vegetation of the Czech Republic*. Academia, Praha.

Roleček, J., Vild, O., Sladký, J., & Řepka, R. (2017). *Habitat requirements of endangered species in a former coppice of high conservation value.* Folia Geobotanica, 52, 59–69.

Sebek, P., Bace, R., Bartos, M., Benes, J., Chlumska, Z., Dolezal, J., Dvorsky, M., Kovar, J., Machac, O., Mikatova, B., Perlik, M., Platek, M., Polakova, S., Skorpik, M., Stejskal, R., Svoboda, M., Trnka, F., Vlasin, M., Zapletal, M., Cizek, L. (2015). *Does a minimal intervention approach threaten the biodiversity of protected areas? A multi-taxa short-term response to intervention in temperate oak-dominated forests.* Forest Ecology and Management, 358, 80–89.

Šipoš, J., Hédl, R., Hula, V., Chudomelová, M., Košulič, O., Niedobová, J., & Riedl, V. (2017). *Patterns of functional diversity of two trophic groups after canopy thinning in an abandoned coppice*. Folia Geobotanica, 52, 45–58.

Spitzer, L., Konvicka, M., Benes, J., Tropek, R., Tuf, I. H., & Tufova, J. (2008). *Does closure of traditionally managed open woodlands threaten epigeic invertebrates? Effects of coppicing and high deer densities.* Biological Conservation, 141, 827–837.

Szabó, P., (2013). The end of common uses and traditional management in a Central European wood. In: Rotherham, I.D. (Ed.), *Cultural Severance and the Environment*. Springer, Dordrecht, pp. 205–213.

Szabó, P., & Hédl, R. (2013). *Socio-economic demands, ecological conditions and the power of tradition: past woodland management decisions in a Central European landscape.* Landscape Research, 38(2), 243–261.

Szabó, P., Müllerová, J., Suchánková, S., & Kotačka, M. (2015). *Intensive woodland management in the Middle Ages: spatial modelling based on archival data*. Journal of Historical Geography, 48, 1–10.

Vild, O., Roleček, J., Hédl, R., Kopecký, M., & Utinek, D. (2013). *Experimental restoration of coppice-with-standards: Response of understorey vegetation from the conservation perspective.* Forest Ecology and Management, 310, 234–241.

Vild, O., Kalwij, J. M., & Hédl, R. (2015). *Effects of simulated historical tree litter raking on the understorey vegetation in a central European forest*. Applied Vegetation Science, 18, 569–578.

Vodka, Š., & Cizek, L. (2013). *The effects of edge-interior and understorey-canopy gradients on the distribution of saproxylic beetles in a temperate lowland forest*. Forest Ecology and Management, 304, 33–41.

Vodka, S., Konvicka, M., & Cizek, L. (2009). *Habitat preferences of oak-feeding xylophagous beetles in a temperate woodland: implications for forest history and management*. Journal of Insect Conservation, 13, 553–562.

5 Governance

It depends on people.

Management plans, ownership, markets and more.

What limits the management of coppice for small-scale forest owners?

The community counts - an example of community-owned coppice forests in Serbia.

Visit this chapter for:

Socio-economic factors influencing coppice management in Europe

The potential barriers to persistence and development of small scale coppice forest management in Europe

More than a century of experience: the community forest Beočin in Serbia

Socio-Economic Factors Influencing Coppice Management in Europe

Debbie Bartlett, Rubén Laina, Nenad Petrović,
Giulio Sperandio, Alicia Unrau and Miljenko Županić

The data compiled to produce this fact sheet comes from six countries that have been used as case studies and, while not necessarily representative, these provide a wide perspective on the issues influencing decisions regarding coppice management and the alternative approaches adopted. This was agreed as the common understanding of the term governance for the purpose of this fact sheet. The focus is on traditional coppice rather than short rotation coppice (SRC) on agricultural land. The term forest has been used throughout although it should be noted that in British English the appropriate word would be woodland; forest has a rather different meaning and would not be used in the context of coppice.

In each country, coppice must be considered within the context of the national forest resource, illustrated in Table 1.

Table 1. Forest area

	Croatia	England	Germany	Italy	Serbia	Spain
Forest area in ha	2,580,000	1,294,000	11,419,124	10,467,533	2,252,400	18,600,000
Percentage of land area	46%	9.9%	32%	35%	29.1%	37%
Proportion of: conifer	7%	34%	56%	11.2%	9.3%	35%
mixed	31%			15.7%	2.4%	20%
broadleaf	62%	66%	44%	56.8%	88.3%	45%
other forested land				16.3%		
Coppice as percentage of total forest	39 %	No data	0.7%	41%	64.7%	11.8%

References: England: National Inventory of Woodland and Trees (2014); Germany: Thünen-Institut (2014) - National Forest Inventory BWI3; Italy: National Inventory of Forests and forest Carbon pools (2005)

International and European Policy Context

Coppice forest management is very rarely mentioned in international and European forest policy documents. In 34 key documents, traditional coppice is only mentioned in one, 'State of Europe's Forests 2011: Status and trends in sustainable forest management', in the context of (a) regeneration types and (b) cultural and spiritual values. This document also mentions SRC, as do a number of others.

Corresponding Author: Debbie Bartlett, d.bartlett@gre.ac.uk

While the forest area is around a third in most countries, except England, the figure for coppice varies considerably. In Croatia, Italy and Serbia most of the broadleaf forests are coppice, while in Germany very little is managed in this way. In many countries there is no legal definition of coppice, but it is generally agreed to be trees/woodland/forest originating from shoots from stumps or roots; this may be combined with standard trees. Italy and Germany have official definitions in their National Inventories. The German inventory defines coppice as less than 40 years old.

The policy context is set nationally in Croatia, England, Italy and Serbia, but is devolved in Germany and Spain. Most of the forest related national policy documents do not mention coppice; the most important documents that include specific references to coppice are listed in Table 2.

Table 2. National policy documents specifically mentioning coppice

Croatia	• The Forest Act (2005) is the most important policy document affecting coppice • Coppice is mentioned in subordinate regulations e.g. Ordinance for making forest management plans (2015), which defines silviculture and rotation periods
England	• Forestry Commission England's Corporate Plan 2014-15 mentions coppice. • The UK Forestry Standard: The Governments' Approach to Sustainable Forestry (2011) refers to both traditional and SRC. • The Woodfuel Strategy for England (2006) included traditional coppice and SRC
Germany	• Forest Strategy 2020 (2011) and the National Strategy on Biological Diversity (2007) both mention traditional coppice positively in the context of biodiversity, nature conservation, and recreation. However, the former also states that coppice does not play a noteworthy role in forest regeneration methods. • Forest Report of the Federal Government (2009) and Energy for Tomorrow Opportunities for Rural Areas (2009) both mention SRC
Italy	• The Framework Programme for the Forest Sector (2008) identifies priorities, including maintaining and preserving the social and environmental functions of the forest, as well as the economic aspects • FPFS (2008) refers to the conversion of coppice into high forest • The National Strategy on Biodiversity (2010) Industry Plan 2012-2014 • Bioenergy Sector Plan (2014) SRC Wood
Serbia	• The Law on Forests (2010) ensures the resources are available for priorities including conversion of coppice to high forest • Forestry Development Strategy (2006) identifies the unfavourable condition of coppice forests • National Strategy for Sustainable Development (2008) • Biomass Action Plan 2010-2012 SRC
Spain	• The Spanish Forestry Plan (2003-2032) suggests transformation of coppice into high forest • Energy crops are mentioned in Renewable Electricity Laws, but coppice is not

The Current Situation for Coppice in Each of the Case Study Countries

In many countries physical and biological variation combined with land use result in forest – and therefore the potential for coppice management – being regionalised. There is a divergence of opinion as to whether rotational coppice, or what is referred to as 'close to nature' high forest is the best option for combining commercial productivity and wildlife protection. This is likely to be context specific. Sustainable forest management requires a diversity of both species composition and age structure. If forest areas are large enough it is possible to achieve this with high forest management: however, where areas are small and widely dispersed, these criteria can only be met by rotational management such as coppicing. This is the situation in countries such as the UK. In much of Europe there is a policy of converting coppice to high forest. In cases where coppice is locally important for social, environmental and economic reasons then it may be permitted to remain. Realistically, conversion is a labour intensive process and is not likely to be achieved without significant investment and the availability of subsidies.

Croatia Traditional coppice management was linked mostly to rural areas where indigenous tree species, such as oaks, chestnut, hornbeam, and beech, are tolerant of coppice management. This also applies to some introduced species, for example black locust. Wood products from coppice were primary used for private purposes and rarely marketed. Traditional products from coppice were used in agriculture and for firewood. With rural emigration and the appearance of new materials, intensive coppice management ceased. As a result of abandoning coppice forest management combined with the general opinion that high forest has higher biodiversity, the focus of national and European funds for subsidies strongly support conversion of coppice to high forest of mixed native species.

England Historically the majority of England's woodland was broadleaf. Until the introduction of motor manual felling, the smallest diameter material possible was harvested due to the amount of effort involved. This has resulted in ancient coppice stools still producing poles that, until recently, supplied the lucrative markets for hop poles and mining bars. In south and south east England coppices have remained as they are effectively far more profitable than alternative land uses (i.e. clearance for agriculture or high forest). As a silvicultural system they require virtually no input and continue to yield profit, at the low end from firewood and at the higher from chestnut fencing products. The coppice industry is mostly 'under the radar' of the forestry authorities as, due to small stem size, no permission is usually required for harvesting and national forestry surveys do not accurately include it. The workers, particularly in the chestnut sector, tend to be from a family tradition of coppice work and the same can be said of many of the larger landowners as a significant quantity of coppice is on large estates. Coppice woodland is valued not merely for profit, when the right to cut is sold annually, but also in terms of rural livelihoods, the landscape, recreation, cultural heritage and for wildlife and game. Woodland management, which includes coppice, is more widely taught than forestry, a subject found in very few Universities in England / the UK.

Germany Coppice forest management was previously of major importance in terms of personal use, rural livelihoods and industry, but only very few areas are currently under active coppice management. Main factors for this change include the widespread availability of other forms of energy or materials, a lessened dependence of individuals on rural resources, as well as the currently dominant view and corresponding legislation in which 'close to nature high forest' is proclaimed as most desirable. However, with its continuing decline there has been an increased interest in the services or value provided by coppice outside of the provision of materials, such as biodiversity, erosion protection, recreation and cultural heritage.

Serbia Coppice forest and coppice with standards are the most dominant category in small scale private forests. This form of management is the best way to meet the needs of private forest owners for a regular supply of fuel wood for their households as well as saw logs for local marketing to improve cash flow in budget deficit situations. One of the main policies in the country relating to coppice forest is to support both public and private owners to begin conversion of coppice to high forest. During recent decades a movement of young private forest owners from rural areas to cities or abroad has been recorded. This has changed the approach from fuelwood production to more selling of the right to cut standing wood or lack of harvesting in recent years.

Italy Over the past 80 years, the coppice surface in Italy has remained practically unchanged, whereas the total forest surface has increased due to the abandonment of agricultural activity. The average age of coppice has increased so that now more than 50% is over 30 years old. The main reasons for the extent of coppice is, on one side, the strong relationship with agriculture (e.g., chestnut poles for vineyards, firewood for rural communities and for cooking in typical restaurants in the cities, the distribution of the seasonal workforce), and on the other, social factors (e.g. property: 75% of coppice is privately owned), climate and territorial characteristics (e.g., Mediterranean climate and forest species, distribution of forests in mountain regions).

Although the current paradigm for efficient and sustainable forest management favours conversion of coppice into high forest to increase certian ecosystem services, the observed trend is the slow "natural" evolution of coppices through ageing on less favourable sites. However, on more favourable sites utilisation continues and can, in some cases, lead to over-exploitation. Current legislation tends to emphasize the landscape and environmental aspects of forests, thus stimulating innovation in management and utilisation systems, including coppice.

Spain Coppice was a very important source of firewood for the rural population and small industries in past centuries. There were strict and detailed rules in some places, regulating firewood logging because of the high demand. Today coppice is mainly abandoned because of a decreasing demand for firewood (rural migration and the appearance of fuel alternatives). Currently, coppice is only the topic of some silvicultural research and forest management plans. This concept has disappeared from the National Forest Inventory and other national data bases. Owner associations and logging companies do not have a strong interest in maintaining or transforming coppice.

The current paradigm of good silviculture is the conversion treatment. In 2006 renewable energy had a strong impact on forest policy makers; they thought coppice could be productive again. However, following electricity fee cutbacks (2012) this powerful driver has disappeared. The firewood logging that remains is performed by small logging companies or non-professionals for their own use. Coppice does remain in Spain, but the trend is for it to decrease.

Coppice in Management Plans

Some countries have landscape scale management plans that cover forest, but the majority have plans that specifically focus on wooded/forested areas. While larger owners and public forests are likely to have management plans, the situation for privately owned forest is more complex. In Croatia and Serbia these plans are compulsory for all ownerships. In Spain, if the forest is recognised as having a protective function, it must have a management plan, and in England these are essential if subsidies are being sought. All plans are formulated according to national and regional legislation, and in most cases must be formally approved. In Croatia and England the process has a participatory element. Coppice, if present, may be covered by these plans.

In Croatia, England and Germany, the owner has freedom of choice regarding the management aims for their forest. Permission is required to cut trees managed as coppice, except in England and Germany. In Croatia and Serbia coppice must be marked by an authorised person before it can be cut. There are restrictions on the size of the area cut at any one time, although in Spain all species on rotations of less than 20 years can be cut without a specific management plan. In England no felling license is required for material less than 15cm dbh (diameter at breast height). In Italy a specific number of trees must be retained per ha.

Other areas managed as coppice include energy SRC that has been extensively planted in Italy. In northern Spain, eucalypts managed on a 12-year rotation for paper pulp have increased. In England native trees planted as screens on transport corridors are managed as coppice. In all countries naturally regenerating woody broadleaved material under power lines, along rivers and roadsides are regularly cut and are effectively coppiced.

A significant management issue in many countries is deer browsing, which prevents regeneration of coppice and can necessitate capital expenditure on fencing and/or control if coppice is to persist.

Coppice Ownership

In general coppice is more frequent in private ownership. Many of the forests, particularly those in private ownership, are small (see FACESMAP for details). These tend to be a mix of traditional rural/farming and non-farming/new rural landowners, particularly in England. Owners get advice from a variety of sources such as State/Regional forestry advisory service, private land managers, websites and peer groups. In England farming associations such as the National Farmers Union and the Country Landowners Association[1] include woodland; there is also the Small Woodland Owners Group (SWOG) representing the non-farming faction and the Royal Forestry Society (RFS). In other countries there are specific forestry owners' groups. In Croatia, Germany, Italy, Serbia and Spain there are multiple owner associations, most of which have national umbrella federations enabling them to contribute the Confederation of European Forest Owners.

[1] Still commonly known by this name although the full name is the Country Land and Business Association

None are specific to coppice and membership is apparently low, which restricts effective communication. In some countries there is a tradition of common ownership of some areas of coppice with a formal system of allocating harvesting rights to different people. In Germany this is now in decline as the entitlement, if not used, ceases to exist and there is no automatic transfer of rights. In Serbia, while some regional private forest owners associations exist their activities and the support they provide for private forest owners are very limited. Most were established externally, with international project money, and so do not reflect the interests of owners in the region.

In Croatia, England and Serbia, most small scale owners have some coppice; in Germany and Italy the proportion is very low and in Spain the picture is not clear. There is little data on the gender balance of owners although it is generally thought that the majority are male. Research carried out in Western Serbia corroborated this, revealing 82.4% of owners to be men. In Bavaria, Germany, 8% of owners were found to be women and it has been estimated for Germany as a whole that 20% are female (FACESMAP Germany Country Report).

In some countries, such as Croatia, Italy and Spain, there are significant areas of forest, including coppice, with unknown ownership as a result of split inheritance and rural emigration; abandonment can contribute to fire risk. Fragmentation is recognised as a problem for cohesive management and in some countries incentives are offered for consolidation, combining small parcels into a single ownership. Conversely, in southern England the persistence of large estates, with a long tradition of family ownership, significantly influences the persistence of coppice management.

In the past, the management of coppice forests under common ownership was important in some countries, such as Germany. Examples can still be found, but most have been converted to another form of ownership and frequently to another forest type. Systems of common ownership regulated harvesting and use of the coppice area, and often included unique local customs for allocating harvesting rights. One specific regulation, found in several German examples, is that the right is lost if not used and a federal law forbids the transfer of these rights.

Other Issues Affecting Coppice Management

Traditionally coppice existed to provide small diameter roundwood for a variety of markets. Many of these are now met by alternatives, or have disappeared, although coppice is still valued for multiple reasons. The current issues affecting coppice are outlined in the following section.

Markets for Coppice Products

The main influences for continuation of coppice management include demand for fuel wood, biomass, landscape, natural and cultural heritage and recreation. While profit from coppice is limited, it is low input and can make a positive contribution to rural livelihoods. Although firewood markets are generally good in some countries coppice biomass is not economically viable without subsidies.

- There are some specific markets driving coppice management, for example the demand for small diameter chestnut for fencing and poles. There are a wide range of other products produced from coppice serving local niche markets.

• Some markets require products to be certified, and coppice can be certified. This requirement may be stipulated in purchasing policies, particularly those of public authorities and larger companies. Certification is less important for local markets, such as firewood. The cost of certification may be an issue for small scale owners.

• The price of forest managed as coppice is low in comparison to agricultural land or high forest. The exception is where it is sold in small plots for recreational use, for example in the UK.

The Coppice Workforce

Where there is coppice, with ownership willing to manage it, and demand for the product, this will only be realised if there are workers available to carry out the necessary tasks.

• In most countries forestry contractors cut coppice as part of their job, these contractors may be State owned or private companies of various sizes. They may be members of Forestry Contracting Associations; in Italy there are workers co-operatives.

• In England many coppice workers work alone or in small, often family, groups; this structure contributes to the burden of overheads. The product from these workers may be collected and sold on via a coppice merchant who acts as the intermediary between the workers and the market place. There is at least one co-operative specifically representing coppice workers.

• Where seasonal restrictions are limiting, for nature conservation considerations, linked to the hunting season, or fire risk, then agricultural or landscape alternatives may be taken during the summer months. For some workers there is a move to processing or moving material cut in winter to market.

• Small scale owners, particularly those who are farmers, produce firewood for personal consumption and local markets during the winter. This may include those with common ownership rights and, in some cases, coppicing may be undertaken by volunteers.

• A lack of skilled coppice workers has been identified, specifically in England and Germany. Various training schemes have been considered in England, but with limited success. This may be due to this sector being less attractive than larger scale forestry.

• Capital investment in this sector is probably limited to national rural development programmes, for example for firewood processing equipment. In England there are coppice specific subsidies available to landowners in some areas.

• It can be difficult to harvest coppice on steep slopes. Access may be difficult, for example on water retentive soils, where forest is fragmented and surrounded by farmland or where, as in Germany, the paradigm is conversion to high forest when land is productive, effectively marginalising coppice to less favourable areas where mechanisation is not possible.

Coppice in the UK (Photo: Debbie Bartlett)

Conclusions

The research undertaken to produce this factsheet has highlighted that coppice generally falls outside strategic forestry frameworks at international and national levels, other than where there is an explicit policy for conversion to high forest. It has also revealed a variety of governance approaches at regional and local levels and that there are significant areas of uncertainty, not least the lack of valid statistics on the area of coppice and the extent of active management.

In order to determine the place for traditional coppice management in addressing future ecological, economic and social challenges for the European forest sector it is suggested that the following questions will need to be considered:

- Will the prevalence of the policy to convert to high forest impact on small scale private owners as well as public ones?
- To what extent will this trend towards conversion be influenced by the availability of funding?
- Does the apparent lack of coppice specific policy at national level originate in the regional, rather than general, distribution of coppice?
- How significant is the demand for fire/fuel wood and specialist products?
- What effects do nature conservation, landscape, amenity and ecosystem service provision agendas have?
- What effects will the increasing interest in ecosystem services at international/national and local levels have on coppice?
- How effective are the knowledge transfer networks, for example between owners, coppice workers, extension services and the end market?

References

FACESMAP http://facesmap.boku.ac.at/

National Inventory of Woodland and Trees (2014) http://www.forestry.gov.uk/forestry/infd-86xc6c

National Inventory of Forests and forest Carbon pools (2005) http://www.sian.it/inventarioforestale/jsp/home_en.jsp

Thünen-Institut, Dritte Bundeswaldinventur - Ergebnisdatenbank, https://bwi.info, Aufruf am: 1.12.2016, Auftragskürzel: 69Z1JI_L343of_2012_L344, Archivierungsdatum: 2014-8-21 17:4:38.353, Überschrift: Anteil der Waldfläche (gemäß Standflächenanteil) an der Gesamtfläche Wald+Nichtwald [%] nach Land und Bestockungstyp Laub/Nadel, Filter: Jahr=2012

The Potential Barriers to Persistence and Development of Small Scale Coppice Forest Management in Europe

Debbie Bartlett, Rubén Laina, Miljenko Županić and Eulalia Gómez Martín

This paper is based on original research into the factors influencing coppice management carried out during the COST Action FP1301 *EuroCoppice: Innovative management and multifunctional utilization of traditional coppice forests – an answer to future ecological, economic and social challenges in the European forestry sector*. This involved several Working Groups, with WG5 focusing on governance issues and the role of the people who make decisions affecting coppice forests. These range from policy makers, at national and European level, to woodland owners and managers and those who make commercial decisions, woodland workers, processors and purchasers. A complex interplay of factors was revealed, with significant differences between countries.

The contents of this paper provided a basis for a presentation by Debbie Bartlett at the IUFRO 125th Anniversary Congress in the Session 82a "Traditional coppice: ecology, silviculture and socio-economic aspects".

1 Introduction

Coppice is considered to be the oldest form of sustainable forest management and is still abundant with an estimated resource of more than 20 million hectares of forest currently managed as coppice across Europe and even more was formerly managed in this way. In the past roundwood was important, particularly for fuel, but, from early in the 20th century the most prevalent form of management changed to favour high forest systems, driven by increased use of fossil fuels, demand for larger timber and advances in technology. As a result, many coppices were converted to high forest, over planted or abandoned. There has been a resurgence of interest in coppice management as a component of sustainable forest management and it is increasingly recognised that coppice provides a diverse range of products and services of value to society.

The COST Action FP1301 EuroCoppice set out to consider how this traditional practice could be developed into a modern multifunctional system to increase the benefits from this currently under-utilised resource with representatives from member states contributing to different working groups to consider how this could be achieved. This paper has been produced by members of Working Group (WG) 5, "Ownership and Governance" who had the task of looking at potential barriers to increasing coppice management and how these could be overcome. The first step towards achieving this goal was to find out the current situation regarding coppice management in the countries involved in the Action.

Corresponding Author: Debbie Bartlett, d.bartlett@gre.ac.uk

2 Method

Research began with a focused discussion between WG5 members at the first EuroCoppice conference, held in Florence, Italy, in February 2014. Data gathering began at the second conference, held in England in November 2014, entitled 'People and Coppice'[1]. This brought together academics and practitioners to explore the issues for different stakeholders, stimulating discussion of the differences and similarities between countries. All the delegates were asked to engage in participatory exercises during the event to provide information about coppice management by country.

2.1 Data collection at the 'People and Coppice' conference

All delegates were asked to identify the key issue(s) for coppice in their country on a flip chart as part of the registration process, before the formal conference events began. The rationale was to begin to get an overview of what the barriers to development in the sector might be.

The conference was organised into three sessions: the coppice resource, access to this resource, and the people involved. There were speakers from the government agencies concerned with policy and implementing legislation, the perspectives of different ownership groups (traditional large estates as well as small woodland owners) and – perhaps unusually – from woodland workers and processors. Everyone attending was given a form listing all the talks and with spaces for comments to be filled in after each presentation. These were not completed by all delegates but a significant amount of data was generated and analysed.

2.2 The Fact Sheet

Working Group 5 members collaborated to produce a 'Fact Sheet' exploring in depth the socio-economic issues and providing the context for coppice forest management in Croatia, England, Germany, Italy, Serbia and Spain (EuroCoppice Working Group 5, 2017; see the previous article of this volume, 'Socio-Economic Factors Influencing Coppice Management in Europe' for an updated version of this document). Analysis of these six examples provided information on some of the constraints and opportunities that apply when considering the way forward to develop a modern, multi-functional, coppice sector.

2.3 Modelling future scenarios

A Short Term Scientific Mission (STSM), funded by the COST Action FP1301 EuroCoppice, enabled a member of WG5 to study the potential for using Agent Based Modelling (ABM) as a tool to explore the relative importance of different factors affecting coppice (Gomez-Martin 2017). ABM uses computational models to simulate the actions and interactions of autonomous agents between themselves and the environment. They can be used to predict the likely effect of any action, or changes in interaction(s), on a system (Bonabeau 2002). Once the structure of a complex system has been accurately captured then the model can be manipulated to stimulate the dynamic evolution of actions over time. This approach has been receiving increasing attention as a tool in land use decision-making and environmental management, as it has the capacity to dynamically link social and environmental processes (Matthews et al., 2007).

[1] For details, including presentations, please see https://www.eurocoppice.uni-freiburg.de/conferences/2014inChatham

3 Results

These are recorded with the same headings as in the method section.

3.1 Data collection at the 'People and Coppice' conference

Delegates' responses to the question 'what is the key issue for coppice in your country?' are given in Table 1.

Table 1. The key issues for coppice in different countries

Country	Key issues for the coppice industry
Albania	50% of forest area; traditional working system
Belgium	small scale; expensive; biofuel high price compared to fossil fuels; land costs and harvesting
Bulgaria	legislation restricts coppicing; small sized forest ownerships
Denmark	no problems
Estonia	high cost of transport/harvesting; falling prices of woodchip and logs
Finland	cost of biofuels and harvesting technologies; competition of existing natural forests
Germany	coppice on low productivity land; high cost of harvesting; no management plans; biodiversity concerns
Greece	low management standards; grazing; forest fires
Ireland	little coppice; few markets; lack of knowledge; farmers increasingly interested in firewood
Italy	mechanised felling; small ownerships
Latvia	coppicing is traditional; natural regeneration of deciduous forest
Lithuania	finance, resources and knowledge of such practice
Poland	coppicing is not traditional; rarely used
Romania	conversion of high forest to coppice; increase of willow/poplar SRC
S Africa	mechanical harvesting and planting of rotational coppice
Slovakia	sector under-developed; market drivers favour fossil/nuclear over biofuels; high investment needed to compete with fossil fuel and nuclear companies
Spain	mechanised felling is progressing and improving but is still far from profitable; overstood coppice; poor market; length of supply chain
Sweden	low product price; coppice not near e.g. railway; large producers buy small woods; mechanisation causing lack of skilled cutters

The responses to each of the sessions was recorded by participants on pre-prepared forms, printed on green paper to distinguish them from other papers in the delegate packs. A summary of the responses is included in Table 2.

Table 2. Summary of 'green sheet' responses

Session 1 The Resource

Ancient Woodland Policy (presented by Dr Keith Kirby)

How is the heritage value of coppice taken into account in your country?

Most responded that it is not. The few who responded that heritage value was taken into account related this to specific small areas. The only exceptions, from Italy and Spain, related the heritage value to sustainable supply of firewood.

Protection of Coppice for Biodiversity (presented by Christine Reid)

How is the biodiversity/natural heritage value of coppice taken into account in your country?

Responses to this question diverged widely. Some reported a high level of legislative protection particularly in, for example SACs, while others stated that no value was attached to coppice as biodiversity was associated with high forest systems. Approximately equal numbers were in either camp.

Landscape and Economy - Coppice in the landscape (presented by Sally Marsh)

How is the coppice woodland management valued as part of the landscape and local economy?

Again the responses varied between two extremes. Some reported that coppice was of no value; one delegate stated that it is costs money to harvest while others reported that it was very important to the local economy for fuel.

One alluded to non-timber forest products, such as mushrooms, being economically important. Few mentioned the landscape.

Session 2 Access to the Resource

Estimates of local woodland resource (presented by Matthew Woodcock)

How does your national forest service/government agency record coppice woodland?

The carrying out of regular forest inventories appeared to be the norm in most countries. However, many delegates seemed unclear as to how coppice was recorded and the precise definition of this woodland type.

On-going coppice survey (presented by Dr Debbie Bartlett)

(a voluntary initiative to try to establish how much coppice is in active management in Kent)

Do you have similar initiatives? Can you get figures for the area coppiced each year?

22 simply responded that they could not get this figure. Others were unsure. Four mentioned that some information could be derived from questionnaires sent to owners but these seemed to be small scale. Only one country (Albania) reported confidently that the Forestry Authority had the data.

Linking to Landowners – the agent's perspective (presented by Mike Bax)

(this presentation described the historical practice of selling standing coppice at auction and how this had now changed to a system of private contracts between the owner and coppice)

How do woodland owners and workers get together to achieve coppice management?

An interesting contrast emerged in the responses between those countries with large state owned contracting companies, those where coppice was small scale and harvested by the owners for their own use and those where there were effective owner associations that were able to arrange harvesting.

Session 2 Access to the Resource *(continued)*

The Local Woodland Register (presented by Alan Sage)
(an on-line resource listing those wanting wood and owners wanting their coppice cut)

Would this be an idea that would work in your country? Is there something similar already?
Representatives from Germany, Croatia, Bulgaria and Poland reported that there were databases of owners; some others mentioned there were people who put people in touch but it was a new idea to the majority. Some felt it would work while others felt the coppice resource was too small.

Session 3 The People Involved

Small Woodland Owners Group (presented by Judith Millidge)
It was at this point that responses began to trail off. Some pointed out most coppice was in public ownership, while others identified the problem that no owners can be traced for many abandoned coppices. The issue of restitution, where coppice is returned to private ownership, was also mentioned.
One comment was "this is too beautiful to be true!". 17 left this section blank.

Views of Small Woodland Owners (presented by Matt Pitts)
This revealed a marked contrast with many of the delegates, mostly forestry specialists in academic institutions, finding it difficult to believe that people would buy woodlands for recreational/pleasure reasons. The importance of production was emphasised by many, although a few recognised that the younger generation inheriting woodlands were more likely to appreciate the wider range of woodland services that coppice can deliver.

The Local Authority Perspective – managing publicly owned coppice for recreation and amenity (presented by Tim Bell)
This seemed a rather unusual idea to the forestry audience with few commenting. The idea of harvesting coppice in a public park was considered unusual and the comment made that such parks tend to be heavily subsidised.

Contracting issues in a range of woodlands – The view from a contractor working in East Sussex and Kent (presented by Nick Hilton)
Those that wrote comments in response to this presentation were highly complementary, mentioning entrepreneurial skills and the importance of this to the industry. One said "Practical presentation. This kind of people should be more invited to scientific conferences to show the big issues…".

Wood fuel manufacture and supply – view from a local log producer and supplier
(presented by Mike Gilman)
This generated some interest as an example of a highly organised approach to supply, however others felt that wood fuel production and marketing was small scale and happened without intervention.

Chestnut fencing manufacturing – the view from a long-established Surrey-based company
(presented by Steve Homewood)
This elicited a response from delegates from chestnut growing countries, although this type of fencing was new to them (demonstrated during the field trip).

Surrey and Sussex Coppice Group – coppice cutters working together (presented by Chris Letchford)
This produced few responses but the approach was not familiar to those who did comment.

The completion rate of these sheets declined dramatically as the day progressed (see Figure 1) and as the topics moved from conventional forestry topics into socio-economic areas that were perhaps less familiar to the delegates.

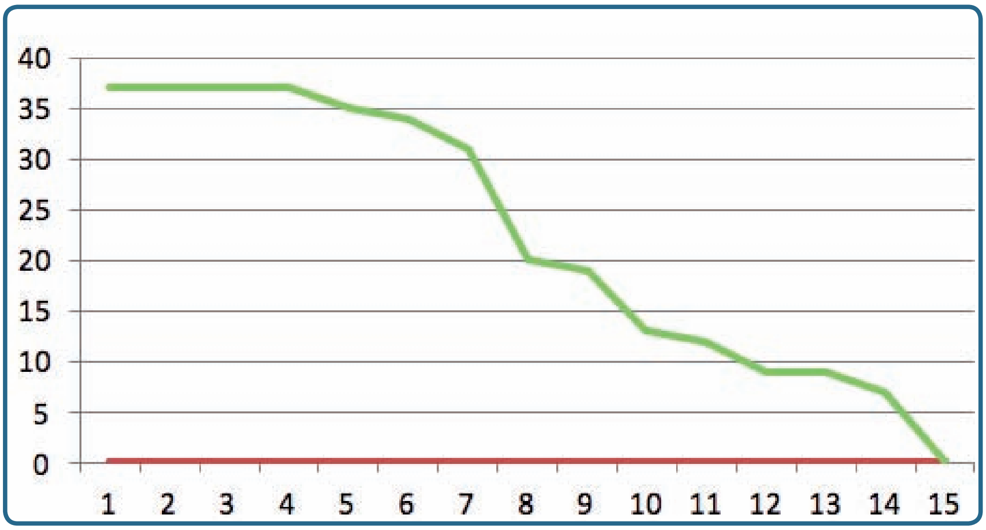


Figure 1. Number of responses to each of the presentations

3.2 The Fact Sheet[2]

The research undertaken to produce the factsheet identified that, in general coppice is not included in forestry frameworks at international or national level. The exception is in those countries where there is a policy to convert coppice to high forest. It also revealed significant areas of uncertainty, including a lack of robust statistics on the area of coppice and how much is actively managed. It was found that coppice was not always included in management plans and that key issues were coppice ownership, markets for coppice products and the coppice workforce (EuroCoppice Working Group 5, 2017).

3.3 Modelling to understand future scenarios

The initial work by WG5 clearly identified that complex factors influence decision making in coppice management and that the context varies considerably between countries. The first step in developing a model was to list these factors and classify them according to their likely impact (see Figure 2).

The next step was to identify and list all the potential interactions between agents (for information on terminology see Gomez-Martin, 2017). This process can enable the building of a model that enables the impact of manipulating different elements in the system to be seen. An illustration is provided in Figure 3.

[2] For the full fact sheet see https://www.eurocoppice.uni-freiburg.de/intern/pdf/deliverables/socio-economic

FACTORS INFLUENCING COPPICE MANAGEMENT		
Positive	**Negative**	**Context**
Subsidies to recoppice Subsides for equipment	Seasonal restrictions Subsides to convert into high forest Thought that high forest is more 'close to nature'	Policy context
Biomass fuel demand	New materials substituing small-diameter wood Alternatives sources of fuel	Demand
	Emigration to cities New owners with recreational focus Low price of coppice land compared with agricultural land	Ownership
Increase productivity/profitability	Damage to wildlife and cultural heritage Loans/interest rate burden (total labor costs: taxes, insurance…)	Mechanisation
Family groups Coppicing can be a 'life style choice'	Lack of skilled people Low wages Physically hard work	Workforce
Certification increases demand Local markets Co-operatives/Co-operative working	Cost of certification Distance to markets Low capital investment	Supply chain
	Deer browsing Novel diseases	Pest and diseases

Figure 2. Factors affecting coppice management
(Source: Gómez Martín, 2017)

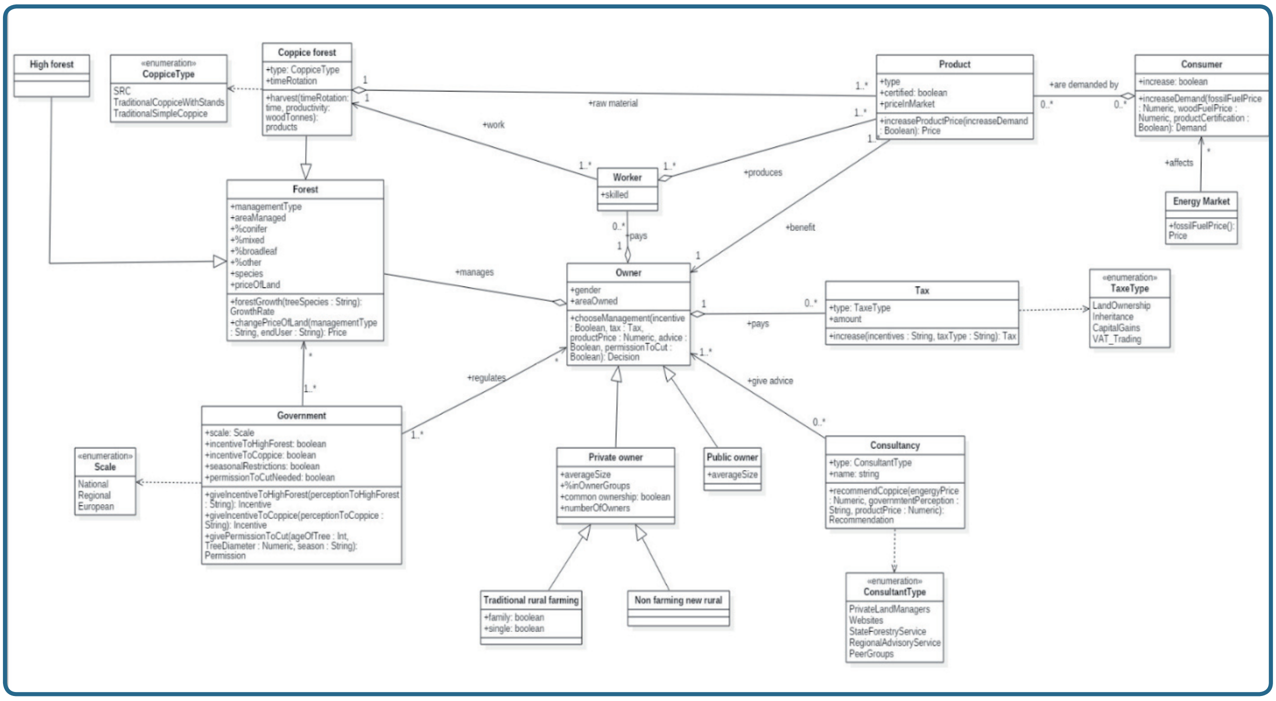


Figure 3. Class Diagram representing the coppice system
(Source: Gómez Martín, 2017)

4 Discussion

While the first meeting of Working Group 5, in Florence, Italy, provided the opportunity for an initial 'brainstorming' of ideas, it was the second conference, in Chatham, England, that was the first chance to begin to gather data. The programme was designed to demonstrate the levels of governance and begin to understand the context in which decisions affecting the coppice sector are made. The rationale was that understanding the current situation is vital as a pre-requisite for proposing any actions. The participatory element, the use of flip charts to identify the key issue for coppice in each country (Table 1) and the responses made by delegates to each of the presentations (Table 2) effectively demonstrated firstly, that there are significant differences between countries about virtually every aspect of coppice, and secondly, that basic information about the resource is lacking.

A detailed investigation into the issues affecting coppice was undertaken, focusing on the countries represented in the Working Group, and this further emphasised the differences between countries. However, there were some common features, notably the lack of significant reference to coppice legislation and policy, and uncertainty regarding statistics (EuroCoppice Working Group 5, 2017). The conclusion reached was that more information about governance issues would be needed to inform development of a modern multifunctional coppice system.

The fact sheet identified a list of questions, included below, as the basis for further research:

- Will the prevalence of the policy to convert to high forest impact on small scale private owners as well as public ones?
- To what extent will this trend towards conversion be influenced by the availability of funding?
- Does the apparent lack of coppice specific policy at national level originate in the regional, rather than general, distribution of coppice?
- How significant is the demand for fire/fuel wood and specialist products?
- What effects do nature conservation, landscape, amenity and ecosystem service provision agendas have?
- What effects will the increasing interest in ecosystem services at international/national and local levels have on coppice?
- How effective are the knowledge transfer networks, for example between owners, coppice workers, extension services and the end market?

While these questions are general and, if explored in depth, would increase the broad understanding of coppice forest management, specific research is also needed on a country by country (and potentially regional) basis. Agent Based Modelling was identified as a potential method to enable greater understanding of the governance issues and of predicting the impact of interventions. A basic model has been developed (Figure 3) but more work is required to develop this further and also create a sequence diagram describing how the objects interact over time. Models are only as good as the data put into them, and the next step is to develop a method of capturing accurate data about each aspect of the system in the class diagram. This will need to be done for each country separately and, on the basis of the gaps in information previously identified, this is not likely to be a simple task. However, this will enable different scenarios to be explored, and the impact of interventions assessed, to inform the future management of coppice forest in Europe.

5 Conclusion and Recommendations

A final output of COST Action FP1301 EuroCoppice was a paper intended to raise awareness among policy and decision makers of the unique characteristics of coppice forests and the valuable contribution these make to society, economy and the environment, by contributing to, for example:

Rural livelihoods: regular income, sustainable employment & resources

Low-carbon bioeconomy: renewable, sustainable, environmentally friendly biomaterials & fuels

Protective function: mitigates soil erosion, rockfall, landslides & avalanches

Sharing economy: community use & recreation

Provision: timber & non-timber forest products

Enrichment: biodiversity & cultural landscapes

See the 'Summary for Policy Makers', pages xiv-xv of this volume.

This paper has identified that, while endorsing the general characteristics of coppice, as stated above, there are wide differences between countries in the factors that affect decision making with respect to coppice.

The most significant barrier to development of coppice is simply the lack of robust data about coppice. Agent Based Modelling has been identified as a method that could enable greater understanding of the interactions inherent in the coppice system, such as the legislative framework, land ownership, markets and workers. It is recommended that this approach is developed, using sample countries as case studies, to identify potential barriers to persistence and development of small scale coppice forest management in Europe.

References

Bonabeau, E. (2002). *Agent-based modeling: Methods and techniques for simulating human systems*. Proceedings of the National Academy of Sciences, 99(suppl 3), 7280- 7287.

EuroCoppice COST Action (2017). *Coppice forests in Europe: A valuable and sustainable natural resource* available at https://www.eurocoppice.uni-freiburg.de/intern/pdf/deliverables/eurocoppice-policypaper-final-2017-05-23.pdf

EuroCoppice Working Group 5 (2017). *Socio-Economic Factors Influencing Coppice Management in Europe. COST Action FP1301 Reports.* Freiburg, Germany: Albert Ludwig University of Freiburg. Available at http://www.eurocoppice.uni-freiburg.de/intern/pdf/deliverables/socio-economic

Gomez-Martin (2017). *Assessing the feasibility of Agent Based Modelling to investigate the impact of governance interventions on the development of the coppice industry*. Available at https://www.eurocoppice.uni-freiburg.de/intern/pdf/stsm/stsm-report-gomez.pdf

Matthews R B, Gilbert N G, Roach A, Polhill J G & Gotts N M (2007). *Agent-based land-use models: a review of applications.* Landscape Ecology 22 (10) pp 1447-1459

APPENDIX - EXAMPLE OF GREEN SHEET RESPONSES

Ancient Woodland Policy (presented by Dr Keith Kirby)

How is the heritage value of coppice taken into account in your country?

Albania	Coppice forest, which covers about 60% of the land is traditional with great historical value.
Belgium	?
Bulgaria	By including them (or part of them) into Natura 2000
Croatia	Only small scale forest owners value coppice, as they use it for fuelwood, big owners and the state are not interested due to the lack of market for coppice products
England	On protected areas historic coppice landscape features (old stools and notable/veteran trees) are identified so future management does not damage them.
England	It is
Estonia	The main aim of coppice- to get firewood - has been maintained through centuries
Finland	Corylus avellana coppice in south Finland are considered to be part of heritage.
Germany	Few know what coppice is although widely used ~80 years ago the knowledge is lost
Germany	Experts/scientists have similar views as K Kirby but others believe it to be 'less valuable' as there are no big trees and that clear cuts of coppice is 'bad', destroying the forest
Greece	Those who moved to the countryside in search of a better career are reviving interest in 'traditional' products
Ireland	There is very little coppice in Ireland. I will check if any heritage areas have coppice
Italy	Most broadleaved woodlands could be classed as ancient but there is no institutional recognition or cataloguing
Italy	The heritage value of coppice is mainly at scientific level and not usually considered at all in practice; only some public forest managers consider this aspect.
Italy	Existing law regulation and voluntary protocols
Italy	Quite high. We have protective legislation firewood is very important coppice is considered for sustainable supply
Latvia	Huge in regeneration of deciduous trees forest. SRC as willow twigs for handicrafts. Small islands in meadows, river banks
Netherlands	Heritage is probably the most important value of Dutch coppice forests directly followed by biodiversity. This is not taken into account in management
Poland	Extensive form of FM (forest management?)
Poland	Heritage value of coppice is very low. It only exists in small protected areas (e.g. wetlands) with limited access
Poland	Coppice is not promoted and the values are not widely known and shared
Portugal	Coppice is view(ed) as a type of management to obtain small sized wood, originally around/close to rural communities (e.g. wood for fences, tools, firewood)
Romania	Almost lost. Coppice is not considered (except *poplar, salix* and *robinia)*. Forestry legislative framework is to convert to high forest
Romania	Coppice has been converted to high forest (except *Robina pseudoacacia*, *Salix* sp and *Poplar* sp) so there is no heritage value
Romania	Little coppice and the heritage value is not considered. The main need is for the wood production
S Africa	Essentially not. However recognised and understood by communities
S Africa	Not at all
Slovenia	There is no special value of coppice forests
Slovenia	I do not think the heritage value of coppice is taken into account at all in Slovenia
Spain	Most coppice is abandoned; accumulated biomass is an under-utilised natural resource
Spain	For centuries it has been our main source of fuel and heating so it is much appreciated
Sweden	Through nature conservation and restoration, small areas
Sweden	The heritage value of coppice has been lost; it is completely unknown as an important part of the traditional economic system. Only people with skills in the traditional alpine culture feel the importance in terms of heritage. Few remain in contact with traditional rural activities (vine cultivation, collecting firewood) and so continue to exploit little coppice areas
Sweden	The tradition was lost between 1960 and 2000, but it is now coming back strongly (especially in chestnut) due to the need of products such as poles and energy wood.
Sweden	I only know one small area of hazel that has been coppiced for cattle fodder.
Switzerland	Coppice/woodland is undervalued and largely forgotten. Woodland in general is neglected, over grazed, fragmented and unmanaged. Most woodland is even aged

More than a Century of Experience: The Community Forest Beočin in Serbia

Nenad Petrović

Introduction

Beočin is a town and municipality in the Vojvodina province in Serbia (see location map, Figure 1). The population is 7,839, whilst that of the Beočin municipality is 15,726 inhabitants. The Beočin Community Forest (in Serbian: "Šumska Zajednica Beočin"), is the oldest Association of private forest owners in Serbia. It was established in 1903, when farmers from the village of Beočin, and who also worked in this forest, bought it from three Austro-Hungarian noblemen. This area was, at that time, on the periphery of the Austro-Hungarian Empire, and so it was of little interest to these owners, however, to the indigenous people of Beočin work in the forest was almost the only source of income. Mr. Bogdan Glumac, the village teacher, invited all the farmers to a special meeting and suggested that they join together, combining forces to buy the forest. He declared: "Whoever wants to own the forest let him get up!" - and all the 79 farmers from Beočin stood up and the decision to buy the forest was made (Nas Vek, 2003). An Association was set up with the goal of helping members, who were mainly poor farmers, to secure some additional income and satisfy their household needs for wood through common management of the forest. Since then, this community forest has survived the many political changes that have occurred in Serbia, but has never stopped implementing forest management. An additional fact is that it is exceptional for an independent private forest to be located in the heart of a National Park.

Figure 1. Location map of the Municipality Beočin and Community Forest Beočin (Photo: https://www.researchgate.net/figure/278037557_fig1_Fig-1-Map-of-Vojvodina-Northern-Serbia-with-Novi-Sad-modified-after-Basarin-et-al)

Corresponding Author:
Nenad Petrović,
nenadpet@tehnicom.net

Method

This paper was prepared by intensive desk based analysis of the legal framework relevant to community forestry, as well as the scientific and other relevant literature including newspaper articles, and websites. The legal context is mainly based on the Law on Forests and the Law on Nature Protection, due to the fact that the Community Forest is located inside the Fruska Gora National Park (Figure 1). The governance framework for the management of the Community Forest, with the rights and obligation of members, is set out in the Statute of Association, updated in 2006.

Legal Framework - Community Forest Association

The umbrella document for the Community Forest is a Statute, adopted in 2006, that has provisions to regulate the management of the forest.

- **Article 1** defines the status of the Association, and states that: "The Association of private forest owners "Šumska zajednica" Beočin is a non-governmental, non-profitable association, established with no time limit to realise goals from the domain of forestry."
- **Article 8** is directed toward collective work defines this as follows: "Bodies of association are constituted and implemented on the basis of collective work, decision-making and responsibility. Programs of activity are created on the basis of the democratically expressed will of Association members."
- **Article 19** deals with family issues declaring that "owners of ideal forest parts and members of their families have the right of free recreational usage of the Community Forest complex, with the obligation to conserve natural beauty and to cherish them without causing any material damage (...)". The use of the term 'ideal' here, referring to part of the forest, indicated that, while the owner knows they own an area of a specific size, there is no way for them to identify where within the forest this is located.

This theme of responsible forest management is one of the most important issues, and it is repeated in several articles:

- **Article 23** states that "members of the Association are obligated to complete their knowledge on the basic terminology relating to the management of privately owned forests (...)"
- **Article 39** continues that "Members of Administrative Board (...) are obliged to become familiar with the forest areas covered by the Association, the external borders and inner division into sections in order to enable them to make appropriate management decisions and carry out the duties entrusted to them."
- **Article 34** enables the Administrative Board to "engage professional advisors as required to assist them, although these have no role in the democratic decision making process."

How the forest was bought

After the decision to buy this forest had been made, the legal aspects were entrusted to a lawyer named Dr. Jovan Jovanic. All of the farmers from Beočin assigned him a power of attorney to "represent them in all civil, legal and castigation matters, in front of the court, outside of the court and in front of political areas" (Nas Vek, 2003). Notably, the "lawyer is specifically authorised to sign the contract on behalf of the Association members with the original owners, namely Karl Kron from Novi Sad and Aleksandar Leopold and Ludvig Liht from Seksard". The sale contract was written in German, and comprised seven short paragraphs, as was the standard form of the time.

A deposit of 6,000 Crowns was paid directly to Kron, representing the Hungarian noblemen, with the remaining 54,000 Crowns handed over when the change of ownership was recorded in the land register, according to the contract. Two copies of the sale contract were signed by the forestry sellers (Kron, in Novi Sad, and Leopold and Liht in Seksardu), on February 27, 1903, with Dr. Jovanic signing on behalf of the villagers. These signatures were witnessed with a few sentences in Hungarian by the public notary in Novi Sad, who added his signature and seal. As the farmers were poor, they raised a loan from the "Srpska Banka" in Zagreb, with each of them pledging the entire property so having the same loan burden; this debt was repaid over the next 17 years.

During the Communist period, after the Second World War, the authorities demanded that agricultural owners renounce their property and contribute it to the Community, so the land was transferred into common ownership. This was exactly what had been done by the setting up of the Community Forest in 1903 so this was not an independent ownership, and the Beočin people managed to survive the communist system. From the very first day, the forest was managed equitably in exactly the way the Communists considered ideal, so there was simply no place for objections. Buying land from noblemen was considered as a successful example of effective class combat.

Figure 2. Names of the original members of the Association recorded on a panel on the outside wall of the Community building in Beočin (Photo: N. Petrovic)

Figure 3. The Community Forest Association Building (Photo: https://www.facebook.com/229624460582008/photos/a.229794097231711.1073741830.229624460582008/713793868831729/?type=3&theater)

Present Situation

The Beočin Community Forest is located within the zone of protection in the Fruska Gora National Park, and is covered by the Forest Management plan, in compliance with the National Park Spatial Plan[1] which, in turn, is set in the framework of the Law on Forests[2] and the Law on Nature Protection[3]. The members of the Community Forest Association are actively involved in the formulation of the plan, including the amount of wood they would like to harvest, and so respect the management prescriptions and comply with them while using the forest resource. There is, in addition, a specific plan for the Community Forest, considered as a distinct management unit (FMU "Forest community"), consisting of 8 separate compartments that are further divided into stands; the current management plan is for the period 2017-2026.

The composition of the forest is influenced by its geographical position on the southern rim of the Panonian plain on the Fruska Goramountain, as well as by the landform, geological and pedology diversity. In some parts there are stands of sessile oak, beech and, to a lesser extent, lime or hornbeam; mixed stands are mainly lime and beech or, more rarely, hornbeam and sessile oak. Pure beech and pure hornbeam are very rare. It is classified as sessile oak forest with butcher's-broom (*Aculeato-Querco Carpinetum serbicum* Jov.). The management was originally mainly coppice and mostly used for firewood.

The forest management strategy has not changed since the forest came under the ownership of the community. According to the data from the Forest Management Plan for the period 2007-2016, natural coppice stands of broadleaves covers 53.8% of forest area, while natural coppice stands of soft broadleaves covers 46% of area, which is in total 99.8%. Only 0.2% of forest area is covered with artificially established stands of conifers. Pure stands cover 18% of forest area, while mixed stands cover 82% of area.

Total yield planned for a ten-year period is 6,854.5 m^3, which amounts to 685.45 m^3 annually. Of the total yield, the quantity of main yield (from regeneration fellings) is 1,472.9 m^3, which is 21.5% of total yield, and the quantity of previous yield (from thinnings) is 5,381.6 m^3, or 78.5% of the total yield.

Concerning the assortment structure, having in mind that this is coppice forest, it is estimated that the amount of sawn wood is 30%, while the amount of firewood is 70%.

Expert technical tasks in the FC Beočin are performed by a forest technician, who is also a member of the Community. The Association is able to apply for State funding for constructing forest roads to enable efficient extraction; they do not own any equipment. The Community Forest comprises an Assembly and a Steering Committee; the majority of members (65%) live in Beočin and its surroundings.

Since nobody knows which specific part of the forest they own, there can be no independent harvesting. Individual shares can be sold, but only to community members, ensuring that this forest remains in the possession of the successors of original Beočin peasants (Figure 2) who invested everything they had in this forest. If there is more than one inheritor, the original

[1] Spatial Plan of the special purpose area of NP "Fruska Gora" to the year 2022. Official Gazette of Autonomous Province of Vojvodina Nr. 16/04

[2] Law on forests. Official Gazette of the Republic of Serbia, Nr. 30/2010, 93/2012 & 89/2015

[3] Law on Nature Protection. Official Gazette of the Republic of Serbia, Nr. 36/2009, 88/2010, 91/2010 - cor. & 14/2016

share can be split, into new equal parts. In this way no member can exclude themselves from the Association, nor can the right to timber be taken away, except when forbidden from participating in work of the Community as a result of failure to respect the special "code of conduct", which includes 30 items. The most interesting thing concerning this association is the provision that no owner is allowed to sell his/her part to anyone outside the community. An Assembly of members is held (Figure 3) to decide who can buy shares if they are offered for sale, and those with smaller shares have priority. If no one is interested, the Association will purchase them.

Every year approximately 1,000 m^3 is felled. 552 m^3 is divided into 46 integral parts, with each member receiving an allocation in accordance with their shares. The remainder of the timber is sold and the revenue is divided according to the same principle. Participation varies from 0.166 to 1.5 'ideal parts' (individual shares), depending on the participation of individuals in the original purchase of the forest, and how these have been divided up on inheritance or combined by purchase (Table 1).

In April 2003, the Community Forest "Šumska zajednica Beočin" celebrated a century of existence. This community represents a significant exception to the general principle of private forest management in Serbia. Its success and long survival demonstrates that good cooperation between forest owners is possible under such conditions.

It is interesting that, until the 1960s, inheritance was only through the male line. Until then, women were not permitted to own any part of the forest, so those in the line of succession were compensated either financially or with agricultural land, enabling the forest share to pass to their brother. As the result of societal change, this no longer takes place. However, it took a century from the date of establishment for a woman to be elected as the head of the Association. Today, more than half of the owners are women, and the president of the Community Forest is Mrs. Sonja Kokic, one of the owners.

Changes in lifestyle has resulted in a new type of owner, based in the city rather than the countryside and this is likely to result in changes in the way this forest is managed. Nevertheless, there is still a "critical mass" (Oliver, et al., 1985)

Table 1. Current participation of owners in total ownership of FC "Beočin"

Share	Number of owners	Number of 'ideal' parts	Part for distribution (m^3)	
			Per owner	Total
1.5	1	1.50	18	18
1.25	1	1.25	15	15
1	21	21.00	12	252
0.75	1	0.75	9	9
0.66	2	1.33	8	16
0.5	27	13.50	6	162
0.33	12	4.00	4	48
0.25	8	2.00	3	24
0.166	4	0.67	2	8
TOTAL	77	46.00	-	552

that is the driving force for all of the activities implemented in this forest and the widespread collective action within this community.

According to Schraml (2005) "forestry associations represent an important forest policy tool for overcoming the problems that often arise with small forest ownership". This community has survived for more than one century with no change in its internal organisation, other than in the legal constitution reflecting changes in regulations. According to Kittredge (2005), in the United States and many other countries a feature of community forestry, the association, is the main distributor of timber to market, which has a positive impact for the owners. These also benefit from joint management, enabling the production of larger quantities of timber and sharing the costs of harvesting and extraction. One of the largest benefits of the owners is that the Community Forest Association can negotiate a higher price of timber and other forest products than would be possible for individual forest owners.

As there are no boundaries between properties and owners don't know where their property is located, there are no barriers to cooperation and joint management. The management plan is based on the concept of 'close to nature' forest management, respecting the natural, cultural and economic context (Kittredge, 2005).

Conclusion

The Community Forest "Šumska zajednica Beočin" was established in 1903 and has remained active since then, despite all of the changes that have taken place in Serbia. This could be promoted as a successful example of cooperation.

The members of the Beočin forest community are volunteers driven by tradition, heritage and moral obligation towards their ancestors; this unique approach should be supported to enable it to continue into the future.

References

Assembly of the Autonomous Province of Vojvodina. 2004. *Spatial Plan of the special purpose area of NP "Fruska Gora" to the year 2022*. Official Gazette of Autonomous Province of Vojvodina Nr. 16/04

Kittredge, D.B. 2005. *The cooperation of private forest owners on scales larger than one individual property: international examples and potential application in the United States*. Forest Policy and Economics 7 (2005) 671– 688

National Assembly of the Republic of Serbia. 2010. *Law on forests*. Official Gazette of the Republic of Serbia, Nr. 30/2010, 93/2012 & 89/2015

National Assembly of the Republic of Serbia. 2009. *Law on Nature Protection*. Official Gazette of the Republic of Serbia, Nr. 36/2009, 88/2010, 91/2010 - cor. & 14/2016

Oliver, P., Marwell, G, Teixeira, R. 1985. *A Theory of the Critical Mass*. I. Interdependence, Group Heterogeneity, and the Production of Collective Action, American Journal of Sociology

Our Century (Nas vek). 2003. *Special Edition Prepared for 100th Anniversary of Establishment of Forest Community in Beocin: 1903-2003*. ABM Economic, Novi Sad (24 p.)

Schraml, U. 2005. *Between Legitimacy and Efficiency: The Development of Forestry Associations in Germany*. Small-scale Forest Economics, Management and Policy, 4(3): 251-268

6 Thirty-Five Countries

Talk about diversity!

Let's see some facts and figures.

Maps are useful to display distribution.

How would one describe the coppice situation in country X?

Time to dive into the details – how is coppice regulated in a specific country?

Finally, a few summaries.

Visit this chapter for:

Introduction to the 35 Country Reports

Albania, Austria, Belgium, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, fYR Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom

Summary of Data from the 35 Country Reports

Introduction to the 35 Country Reports

Alicia Unrau, Peter Buckley, Dagnija Lazdiņa and Valeriu-Norocel Nicolescu

The following chapters feature elements on the past, present and future of coppice forests in 35 countries. They are a compiled of multiple, individual reports that were originally published in 2017 and have since been reviewed and updated.

The 35 countries covered in this chapter

The countries featured here were members of COST Action FP1301 EuroCoppice: Albania, Austria, Belgium, Bosnia & Herzegovina, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, fYR Macedonia, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom (Figure 1). Many key countries for coppice were involved from the beginning, while others joined later, when national experts became interested in the Action. Any country showing interest in the Action was encouraged to participate.

Of the 35 countries, two are not within the geographical boundaries of Europe, namely Israel and South Africa, while Turkey can be considered a transition country to Asia. Compared to the countries listed in the "State of Europe's Forests (SoEF) 2015" by FOREST EUROPE (2015), this chapter encompasses all of the countries who contributed 2010 data to Table 27 on coppice statistics, with the exception of Montenegro. Other countries in Europe that could be expected to have some coppice, despite not having submitted data on that type of forest to the SoEF 2015, but are not addressed in this chapter are: the Russian Federation, Belarus, Georgia, Moldova and Luxemburg.

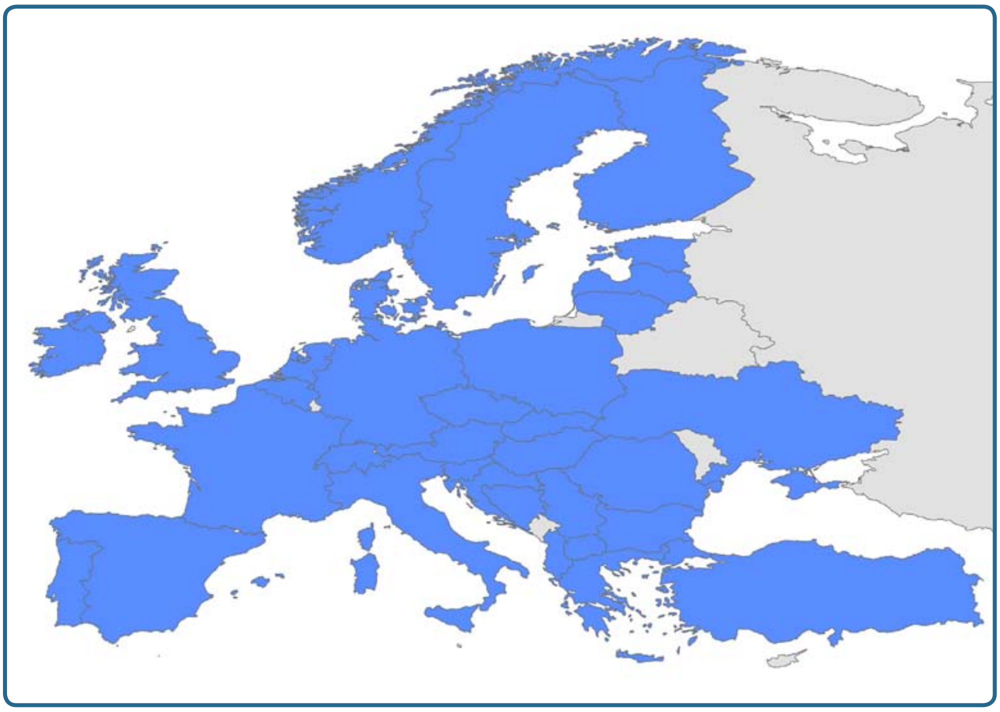


Figure 1. Map of the 33 European countries included in this chapter (in blue); it excludes two countries from outside of Europe; Israel and South Africa.

Encompassing the majority of European countries, this very broad base covers a range of coppice situations, for example: a long history of coppice, or none at all; different sizes and importance of current coppice area; active or neglected coppice; different environmental, social and economic functions; and various ways of governing coppice.

There are four sections in these country reports to which coppice forest researchers, practitioners and experts could have contributed: facts and figures, map, description and forestry regulations. Each country had different resources, expertise, and extent of coppice, so their reports vary in length and may not include all sections. The sections began as separate contributions, often by different authors - the details of this process are described in the following.

A compilation of separate reports from COST Action FP1301 EuroCoppice

In order to have a broad spectrum of information on coppice forests for the countries involved in COST Action FP1301, different themes were covered by Working Groups (WGs). Three of the five WGs independently collected information from EuroCoppice Members and/or their colleagues on most or all of the 35 EuroCoppice countries and published their results in separate booklets for each theme; they are the basis for the sections of the country reports that follow in this chapter.

Each of the original publications had its own group of editors and authors, which makes combining contributions a delicate matter. The main editors of the reports are the authors in this article, while all of the original editors are listed below. The country report authors appear under their respective section, but also as a group under the country title. The default policy was to list the authors as a group in the order of their appearance in the four sections. This policy was followed unless otherwise agreed upon by all authors. We are very thankful for the cooperation of the authors and the editors on this point.

When compiling the country reports, the contents of the original theme-related booklets were reviewed by editors and authors, proof-read and harmonised where necessary. There is still some overlap between sections within some countries, but the data or information should not be contradictory. Some of the most important aspects have been summarised in tables in the last article of this chapter.

Linking country report sections to original publications and editors

Of the four sections in the country report, three of them were originally published as individual booklets. To understand which sections were linked to which specific booklet, the original names and editors of the booklets are given here, along with some background information on each.

Section: Facts and Figures

Original title: National Factsheets on Coppice Forests
Original editors: Dagnija Lazdina and Santa Celma
Main Working Group: WG1 Definitions, History and Typology
Working Group Leader: Dagnija Lazdina, dagnija.lazdina@silava.lv

The authors were originally asked to fill in fields in an excel sheet, which was later compiled into a document by the editors. The responses in this section are, thus, often bulleted and brief, rather than descriptive. It is important to keep in mind that statistics on forest are difficult to compose in the first place, particularly so in the case of coppice. Many of the national forest inventories do not even collect data on coppice or hold relevant records. Furthermore, the definition of coppice greatly influences any data to be collected and/or interpreted.

Section: Map

This section was added after the end of the Action; all country report authors were offered the opportunity to submit a map for the updated country reports. Most countries do not have an official map of coppice, in some cases there simply is no data, so the maps included here are unique to each country and do not necessarily show coppice per se. Sometimes, for example, a map will illustrate the distribution of tree species that have the potential to be coppiced, such as in the Latvian report.

Section: Description

Original title: National Perspectives on Coppice from 35 EuroCoppice Member Countries

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

Main Working Group: WG2 Ecology and silvicultural management

Working Group Leader: Valeriu-Norocel Nicolescu, nvnicolescu@unitbv.ro

The authors of this section were given a great amount of freedom concerning the contents of their texts. This way they were flexible to choose topics that are important in their respective region. While describing coppice in their country, they were requested to keep to a limit of up to ca. two pages. Any overlap between this section and the first, Facts and Figures, was shortened if the repetition is quite lengthy, but was otherwise left in.

Section: Forestry Regulations

Original title: National Forestry Regulations Affecting Coppice Management in 27 EuroCoppice Member Countries

Original editors: Jenny Mills and Peter Buckley

Main Working Group: WG4 Services, protection and nature conservation

Working Group Leader: Peter Buckley, peterbuckleyassociates@gmail.com

This section is a compilation and evaluation of legal documents relating to the specific rules and legislation affecting coppice forests, including conservation and biodiversity issues. The text is frequently quite technical because of the content involved. In some cases, there is a little overlap with other sections, but these are typically only a few sentences in the introduction of the section.

References

FOREST EUROPE (2015). *State of Europe's Forests 2015*.

Lazdina, D., Celma, S. (Eds.) (2017). *National Factsheets on Coppice Forests*. COST Action FP1301 Reports. Freiburg, Germany: Albert Ludwig University of Freiburg.

Mills, J., Buckley, P. (Eds.) (2017). *National Regulations Affecting Coppice Management in 27 Euro-Coppice Member Countries*. COST Action FP1301 Reports. Freiburg, Germany: Albert Ludwig University of Freiburg.

Nicolescu, V.-N., Bartlett, D., Buckley, P., Rossney, D., Pyttel, P., Unrau, A. (Eds.) (2017). *National Perspectives on Coppice from 35 EuroCoppice Member Countries*. COST Action FP1301 Reports. Freiburg, Germany: Albert Ludwig University of Freiburg.

Albania

Abdulla Diku, Vasillaq Mine, Elvin Toromani and Luljeta Mine

Facts and Figures

Abdulla Diku, Vasillaq Mine and Elvin Toromani

Definitions

Coppice forests originate from sprouts and are governed by a short production cycle (rotation).

Coppice - a forest that has a sprout origin/background and that is destined to be regenerated by new sprouts, from which is derived wood material of small and medium sizes.

Pyjet cungishte e kane origjinen nga lastaret dhe qeverisen me cikel te shkurter prodhimi.

Cungishte (Korie, Zabel) - eshte nje pyll qe ka prejardhje lastarore dhe qe eshte paracaktuar te riperterihet po me lastar, nga i cili perfitohet material drusor me permasa te vogla dhe te mesme.

Legal Framework

Forest - an area of land with a dense group of forest trees greater than 0.1 ha, with a canopy coverage of not less than 30% of the area and with the potential to reach a height greater than 3 m, when forest has reached maturity.

Forest lands - areas with trees, shrubs, or other non-forest vegetation covering from 5 - 30%; bare surface; eroded and non-productive lands; sandy lands; forest roads that have not entered the register of the land property of agriculture lands that are ecologically linked and functionally related to the national forest fund.

Statistics

The total forest area in Albania is 1,052,237 ha, while the coppice forest area accounts for 295,440 ha (28% of total forest area) and has a standing volume of 5.3 million m^3 (Institute of Statistics, 2016; www.instat.gov.al/en/). Young coppice forests up to 20 years old cover approximately 73% of the entire coppice forest area and are widely spread in Albania. They mainly have a production function (about 273,045 ha) and are the main source of firewood supply for local communities in rural area.

Typology

Simple coppice	*Populus* spp., *Salix* spp., *Quercus* spp., *Alnus* spp., *Robinia* spp.
Coppice with standards	*Populus* spp., *Salix* spp., *Quercus* spp., *Alnus* spp., *Robinia* spp.
Pollarding	Not practised
Short rotation coppice	Mainly *Populus* spp.; there are efforts to cultivate *Paulownia*
Other types	A few cases aim at the conversion of oak coppice to high forests. This is considered a challenge. The normal coppice rotation age in Albania is up to 60 years old. The conversion is done through clearcutting in the entire forested area, leaving about 100-150 trees for seeds production. A few cases of mixed forest management forms (coppice with high forests) exist in Albania.

MAP

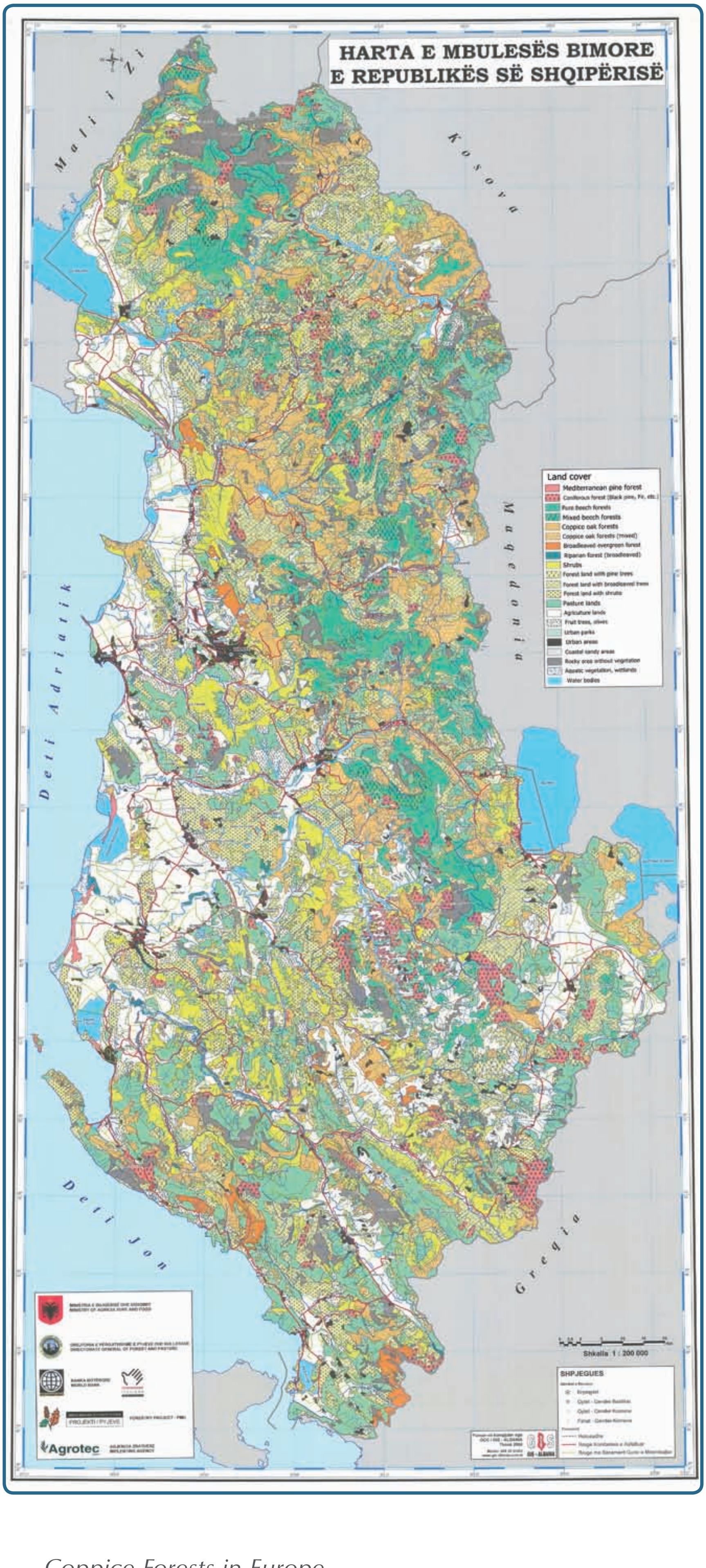
Abdulla Diku

Map of land use in Albania:

Oak coppice forests are displayed in light orange ( )

Mixed oak coppice forests are displayed in light orange with white tree-images ( )

Source: Albania National Forest Inventory



Images

Description

Abdulla Diku and Vasillaq Mine

As in all other countries, coppice forests in Albania represent a traditional system of forest management. For centuries, and 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 and industry, as well as livestock grazing, for example.

Figure 1. Oak coppice forest in Drini valley

Prior to 1944, Albania had a forest area of about 1,379,000 ha; of which ca. 300,000 ha 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 (Figure 1), but shrub species are also managed as coppice across the country. Generally, coppice forests are located in close proximity to residential areas. Most coppice forests in Albania are irregularly structured due to their disorganized management. In the past 10 years there has been a slight increase in the area of coppice forests, with coppiced oaks now extending to 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 approximately 32 $m^3 ha^{-1}$. 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 2.

The chart shows that 70% of coppice is 0-20 years old. Based on an analysis of ANFI data, the average annual growth of coppice forests in Albania is estimated at ca. 2.1 $m^3 ha^{-1} yr^{-1}$.

Even shrub species are historically treated as coppice forest, with this type comprising about 23% of the forest area of the country. In terms of volume they represent about 10%, with the average volume about 20 $m^3 ha^{-1}$, again demonstrating the very low quality of these forests.

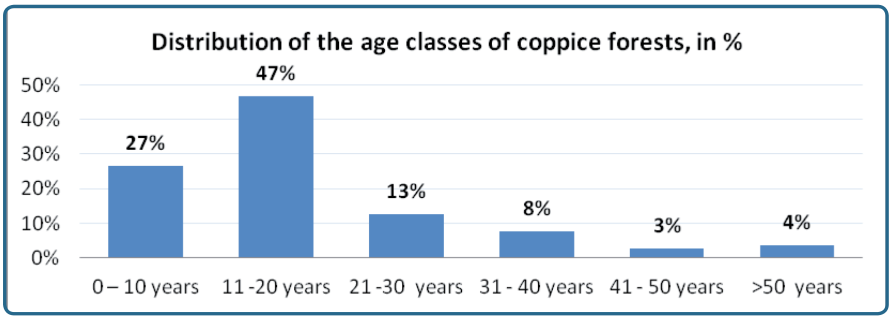


Figure 2. Distribution of the age classes of coppice forests in percent
Source: National Forest Inventory of Albania (2004)

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

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

Forestry Regulations

Abdulla Diku, Luljeta Mine and Vasillaq Mine

Albania has limited forestry resources due to extended periods of overuse, damage caused by fires and illegal cutting. According to the European Environmental Agency, losses of forestry stock volume in Albania during the period 1990-2010 were 2-5 times higher than the natural growth of forests.

The forest area in Albania is 1.05 million hectares, comprising 55.25 million cubic meters. Forests cover 37% of the country's territory. Forest areas consist of: (i) 36% high forests, (ii) 28% coppice forests and (iii) 36% shrubs.

We would like to highlight the fact that the majority of shrubs in Albania are managed as coppice forests. Considering this fact, coppice forests in Albania account for over 60% of the national forest area. In terms of forest volume, high forests represent 78% of the stock, coppice forests 15% and shrubs 7%. If we analyse the volume per hectare according to forest management forms, the situation is as follows: high forests have 114 m^3/ha, coppice forests 28 m^3/ha and shrubs 9 m^3/ha. Over the period 1961-2015, the national forestry area was reduced by 300,000 hectares, or approximately 25% of the total.

The Code / Kanun (XV-XX centuries)

This represents the oldest "law" in the country, which was applied in the central and northern part of the country during that period. It constituted the main legal basis for various issues of the communities' social and economic life. The Code states that "Every house with a smoking chimney shall have its own property". With regard to forests, there was a forest area known as "*kujrija*" that either surrounded the village or was located in the vicinity. While private forests or property were divided by boundaries, "*kujrija*" was not divided and all the households of the village were equally entitled to use it. "*Kujrija*" was mainly used for firewood production, building materials, livestock fodder, grazing and hunting and each village had its own forests ("*kujri*"). They were irregular coppice forests, mainly consisting of oak and hornbeam. In addition to "*kujrija*", the village had access to its own mountain and pastures. The mountain was composed of forests located further away from the village, in its most mountainous part, and were mainly high forests that were used for timber.

Law on "Forests and pastures" (1923)

Three major forms of forestry ownership were acknowledged: (i) State-owned, (ii) Communal and (iii) Private.

This Law provided a complete framework for the organisation and management of the forestry and pasture sector management in the country, placing the emphasis on their sustainable use.

An important element of this law was the care that should be taken with coppice forests used to produce charcoal or firewood, particularly with regard to their natural regeneration. After cutting for firewood and charcoal, livestock was prohibited from entering the area for ten years and grazing outside the defined area required an official permit. This allowed the forest the necessary time to regenerate. Firewood collection, logging and grazing took place in the coppice forests (oak trees, hornbeam trees, shrubs, etc.) located close to the village. In high forests located further away from the village, only the cutting of trees for building materials was allowed. Deforestation for the purposes of opening land for agriculture or pastures was not allowed. The law also prohibited pruning trees for the purpose of providing fodder for livestock. The law also stated that "…in the case of coppice forest composed with rare trees, or in slopes, the cutting of trees is not allowed", since these trees should be given the necessary time to produce seeds, in order to guarantee the forest's regeneration.

Law no. 3349 "On forests protection" (1961)

This law was aimed at converting coppice forests into high forests. Coppice forests could be maintained only to meet the needs of the rural population. Coppice forests could also be kept under certain ecological conditions. The exploitation of coppice forests under the age of 10 was prohibited. Cutting could only take place between October 1 and March 31. Grazing of livestock was prohibited until the naturally regenerated saplings reached a height of 1.5 m from the ground, while grazing by goats was prohibited.

Law no. 4407 "On forests" (1968)

This law underlined the major role of forests in providing firewood for the development of industry, for the construction of the country, and for their paramount role in moderating climate and protecting the land from the erosion. Pruning of forest trees was allowed only in certain areas, which were defined in advance. Agricultural cooperatives were allowed to exploit coppice forests to meet their own needs for firewood and building materials. Due to the low level of industrialisation in Albania over the period 1960-1990, approximately 300,000 ha of forests in the country were converted to open agricultural land. These were coppice forests (oak trees, hornbeam trees and shrubs) near and surrounding villages. In addition, since firewood was the only source of energy available to Albanian households for heating and cooking, forests were cut faster than their natural rate of growth.

Law no. 7623 on Forests and Forest Service Police (13.10.1992)

The law envisages:

(i) the overall preservation of forestry stock for its economic function and its special value in environmental protection, water reserves, cleaning of the atmosphere, land fertility, landscape, agro-tourism and infrastructure;

(ii) control over the cutting of timber, to keep it at a sustainable level that balances the natural growth of forests, defined through growth projects drawn up in compliance with this law;

(iii) control over the development of the entire forestry sector; and

(iv) ensuring the balance between society's interests as a whole and the interests of people with legal entitlement.

To increase the forest stock and its production capacities, the forest service is obliged to undertake afforestation. In such cases, fast-growing and highly economic varieties/strains have to be used. The law highlights that "it is prohibited to cut down or uproot trees in very steep places, in a strip of land 100 m wide at the upper boundary of vegetation; it is prohibited to cut down and uproot rare varieties of trees and shrubs, as well as the trees on both sides of national roads with an inclination over 30% and on strips of land of 20 m above and below roads, as well as in forests that have a protective and special function".

Grazing is prohibited in new forests, forests during their regeneration and in coppice forests under regeneration....

Law no. 9385 on "Forests and Forestry Service" (2005)

Pursuant to this law, the management of the national forestry stock is based on the principles of sustainable and multifunctional use of forests. This law classifies the ownership of forests as: (i) public or (ii) private.

Rehabilitation and use of national forestry stock requires protection and regeneration works to prevent or restrict harmful exploitation. Increases in the productivity of the national forestry stock should be accomplished through regeneration of exploited forests and improvement of existing forests by taking silvicultural measures. Furthermore, the afforestation of abandoned lands, barren and eroded plots is the duty of the administrators and users of these lands. Pursuant to this law, grazing and the transfer of livestock to public forests, newly afforested lands, exploited forest plots, those under regeneration and newly coppiced forests, etc., is only allowed in compliance with defined rules. As the previous law, this law also stipulates that: "it is prohibited to cut down or uproot trees and shrubs in very steep places...", due to their protective role.

Strategy for the development of forestry and pasture sector in Albania (2004)

The Strategy aims to ensure the sustainable and multifunctional development of forestry and pasturage resources. One of the objectives of the strategy is: "…the establishment of several forestry entities with regular oak coppice forests and their scientific growth as a basis for the conservation and preservation of valuable species of oak trees and their conversion into high forests…" The actions required to accomplish this objective are:

- Selection of areas with oak trees (irregular coppice forest) with the proper size and species contents, suitable for their conversion into regular coppice forest.
- Drawing up technical projects for these forestry entities and for the commencement of their implementation.
- Calculation of current and future annual productivity (when the entities will consist entirely of regular coppice trees) and conducting a study for the conversion of these entities into high forests.

To meet the needs of rural population for firewood and building materials, the strategy envisages: "The establishment of regular coppice trees within the territories of communal forests with sufficient area in order to meet the needs of communes for firewood and building materials and their unification into regular coppice forests entities for purposes of growth with short rotations." Also, another important activity to be undertaken is "the definition and separation of forests for producing firewood and building materials (from the regular coppice forests)."

Cross-cutting Environmental Strategy (2015-2020)

Its strategic objectives are:

(i) approximation and implementation of acquis communautaire in the field of forests and pastures;

(ii) increase of communal forest management capacities;

(iii) improvement of forestry information systems and databases;

(iv) strengthening forest-related research systems, technological development and innovation;

(vi) improvement of regional relations and unification of technologies and methodologies;

(vii) applications to ensure support for the development of forestry in the country;

(viii) inclusion of various climate issues in forestry stock management aspects.

The strategy also aims:

- To achieve the full transposition of acquis communautaire in forests by 2020
- To adopt a new law on forests
- To develop a national program for forests' revitalization
- To increase economic effectiveness and energy efficiency through the sustainable use of forests
- To afforest with short-rotation species to produce biomass and reduce the adverse effects of extreme natural events (floods, etc.) in pilot areas.

National strategy for development and integration (2015-2020)

As a forest-related strategic objective, the strategy values the strengthening of management and preservation of forest and pasture resources through:

- Reduction of illegal cutting by 2020;
- Developing growth plans for all forestry entities in the country;
- Rehabilitation of degraded areas.

Forestry literature regarding coppice forests

In Albania, Silviculture and Forest Mensuration are the main subjects taught at university that deal with coppice forests. Meanwhile there are various studies and monographies prepared by native authors for oak species features, silviculture treatment and their management. *Forest Growth and Silviculture* (Muharremi et al. 1990) is the main resource on forest management and handling. They provide major alternative management option for all forest types, including coppice. They mention that clear cutting should be restricted in coppice forests that have a density below 70% and on slopes, and that their conversion to high forests is desirable from a silvicultural point of view.

References

INSTAT 2015

Ligji per "Pyjet dhe Kullotat" date 27.01.1923

Ligji 3349, viti 1961 "Mbi mbrojtjen e Pyjeve"

Ligji 4407, viti 1968 "Ligji mbi Pyjet"

Ligji 7623 date 13.10.1992 për "Pyjet dhe Shërbimin pyjor"

Ligji 9385 per "Pyjet dhe Shërbimin pyjor", i ndryshuar.

Muharremi V., Habili D., Kasëmi P., 1990. *Mbarështrimi i Pyjeve*

Strategjia ndërsektoriale e mjedisit (2016-2020), draft

Strategjia Kombëtare për Zhvillim dhe Integrim (2015-2020)

Strategjia për zhvillimin e sektorit të pyjeve dhe kullotave në Shqipëri (2004)

http://agrbes.freehostia.com/KanuniiLekeDukagjinit.pdf

https://www.eea.europa.eu/data-and-maps/indicators/forest-growing-stock-increment-and-fellings/forest-growing-stock-increment-and-4

https://www.eea.europa.eu/data-and-maps/indicators/forest-growing-stock-increment-and-fellings/forest-growing-stock-increment-and-4

Austria

Martin Kühmaier, Eduard Hochbichler, Karl Stampfer, Jenny Mills and Peter Buckley

Facts and Figures

Martin Kühmaier

Definitions

Coppice: even-aged stands consisting of trees and shrubs that regenerate wholly or mainly vegetatively (sprout or root shoot).	*Niederwald: Gleichaltriger Bestand aus Bäumen und Sträuchern, die sich ganz oder überwiegend vegetativ (Stockausschlag, Wurzelbrut) verjüngen.*
Short rotation coppice: Plantation of fast-growing trees or shrubs, with the aim to produce wood as a renewable resource in a short rotation period.	*Kurzumtriebsfläche: Anpflanzung schnell wachsender Bäume oder Sträucher mit dem Ziel, innerhalb kurzer Umtriebszeiten Holz als nachwachsenden Rohstoff zu produzieren.*

Legal Framework

1. There is no specific legal framework for coppice forests in Austria.

2. Short rotation coppices (SRCs) with a rotation period of up to 30 years are not classified as forests (Austrian Forest Act 1975 in the amendment of 2002 § 1a. (5)).

3. Dibbling of forest plants and cuttings on previously agricultural land is not considered afforestation if the owner reports within one year after planting to the district administrative authority that these forest plants will be used in the short term with a rotation period of up to 30 years (Austrian Forest Act 1975 in the amendment of 2002 § 1a. (5)).

Statistics

Coppice forests	93,000 ha	2.3 % of forest area in Austria
Short rotation coppice *	2,236 ha	On agricultural land

Sources: BFW Waldinventur 2009, Agrarstrukturerhebung 2013

* SRCs are grown following the quantitative order: *Populus, Salix, Robinia* (Jürgen Kern)

Typology

Simple coppice	Traditional natural forest regeneration method still practised in the Eastern part of Austria. Large parts have been transformed into high forests in the past decades.
Coppice with standards	Same as above
Pollarding	Practised in historic wood pastures until the beginning of the 20th century as cattle fodder, especially *Fraxinus excelsior.*
Short rotation coppice	Practised as an agricultural alternative, using *Populus* and *Salix*.

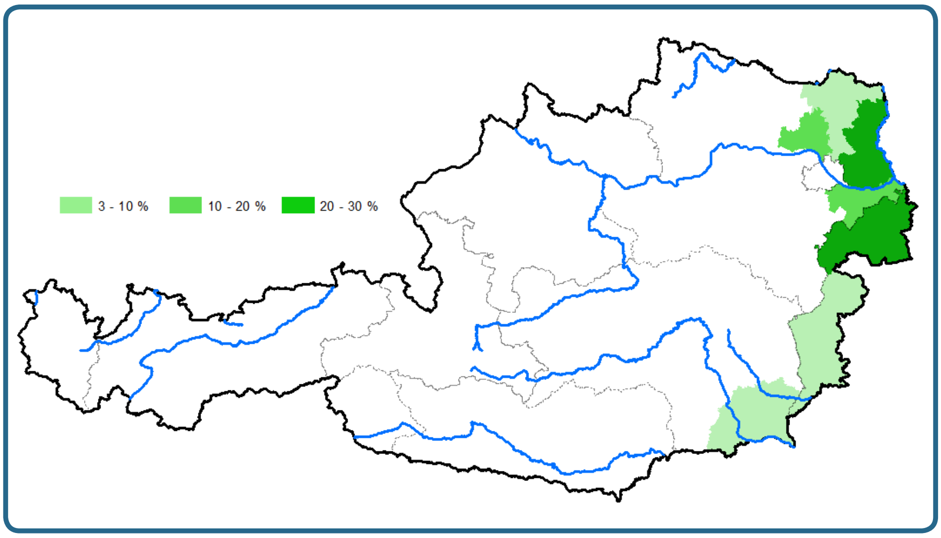
Images





Map

Martin Kühmaier



Map with the distribution of the most relevant coppice areas in Austria, shown as a percentage of the total coppice area (Data source: BFW Waldinventur 2009)

Description

Eduard Hochbichler and Karl Stampfer

In Austria, coppice forests presently cover an area of about 100,000 ha or 2.3% of the total forested area. Approximately 75,000 ha belong to the “land-coppice system” and 25,000 ha are part of coppice forests in the alluvial plains.

Approximately 90% of coppice forests are 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).

According to the site conditions, coppice (15–30 year rotation); coppice with reserves (underwood 20-30 year rotation; reserves 40-60 years) and coppice-with-standards management (underwood 20-30 years; overwood 100-120 years) have been a wide-spread 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 and performance of forestry systems (coppice system vs. high forest system) and decreasing demand for firewood and/or catastrophic events, such as the colonisation of the parasitic mistletoe *Loranthus europaeus*, have led to different structured stands in the forest enterprises over the last 40 years (Krissl and Müller 1989; Tiefenbacher 1996; Hochbichler 1997; Hagen 2005).

These trends have decreased the relevance of coppice and coppice-with-standards and fostered the promotion of valuable broadleaved trees other than oak. However, demand for valuable hardwood and 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, while for moderate sites (top height 18-24 m) a coppice with reserves and/or coppice-with-standards system is advised. For drier, less vigorous sites a simple coppice system is suggested. Silvicultural recommendations for coppice 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 and high forest) and operations (Hochbichler 2008; Hochbichler et al. 2013).

References

Hagen, R., 2005. *Verjüngung, Nährstoffsituation und Wildeinflüsse auf Eichenmittelwald-schlägen des Weinviertels unter besonderer Berücksichtigung von Vereschungstendenzen*. Diss. Univ. f. Bodenkultur. Wien. 323.S.

Hochbichler, E., 1993. *Methods of oak silviculture in Austria.* Ann. Sci. For. (50), pp 591-593.

Hochbicher E. and Krapfenbauer, A., 1987. *Behandlungsprogramme für die Werteichenproduktion im Wienerwald und Weinviertel*. Centralblatt Gesamte Forstw. 107, pp. 1-12.

Hochbichler E., 2008. *Fallstudien zur Struktur, Produktion und Bewirtschaftung von Mittelwälder im Osten Österreichs (Weinviertel)*. Österr. Gesellsch. für Waldökosystemforschung und experimetielle Baumforschung. Univ. F. Bodenkultur. 243 S. Habilitationsschrift.

Hochbichler E., Iby, H., Himmelmayr H., 2013. *Waldbauliche Empfehlungen für die Beirtschaftung der Wälder im Burgenland.* Burgenländischer Forsdtverein, Eisenstadt. 152 S.

Kilian, W., Müller, F., Starlinger, F., 1994. *Die forstlichen Wuchsgebiete Österreichs. Eine Naturraumgliederung nach waldökologischen Gesichtspunkten.* FBVA Bericht 82. 60S.

Krapfenbauer A., 1983. *Eichenmittelwald – Eichenmistelprobleme*. Informationsschrift zur Exkursion Hochleithenwald, Traun´sches Forstamt Wolkersdorf.

Krissl W. and Müller, F., 1989. *Waldbauliche Bewirtschaftungsrichtlinien für das Eichen-Mittelwaldgebiet Österreichs*. FBVA-Berichte 40, 134 p.

Tiefenbacher, H., 1996. *Laubholzwaldbau im Rationalisierungszwang.* Österr. Forstzeitg. 2, pp. 55-57.

Forestry Regulations

Jenny Mills and Peter Buckley

Austria's first comprehensive forest law in 1852 introduced the obligation to manage forests sustainably. The 1975 **Forest Act**, amended in 2002, includes general rules for sustainable forest management applying to publicly- and privately-owned forest and gives executive directives for the nine Austrian provinces.

Clearcuts of more than 2 ha are not permitted except under certain circumstances. In protection forests the maximum clearcut area permitted is 0.2 ha. Final cuts of immature trees of less than 60 years are forbidden, although a lower limit may be given for fast-growing trees. All clearcuts of more than 0.5 ha must be approved by the Forest Authority regardless of forest type, to limit detrimental effects on the soil and adjacent forest stands. Reforestation through natural regeneration should take place within 10 years, but can be extended in adverse conditions.

In addition to the Forest Act, some Federal Provinces have **forest ordinances**, which include regulations for timber production. There is **no national act on the protection of nature**, which is regulated through separate Acts for each of the nine provinces.

National Park Laws and **Hunting and Fishery Laws**, and the **Environmental Liability Law** also impact on forestry and biodiversity.

Austria's **Forest Development Plan (FDP)** covers all the country's forests and is used to assess forest functions in the public interest in terms of its key functions: economic, protective, beneficial, and recreational. The Plan is revised every 10 years by the forest authority and includes requirements for the treatment of forests during that period.

There is no general obligation for public or private forest owners to prepare a **Forest Management Plan (FMP)**, but most publicly-owned forests are likely to have one. All forest enterprises of over 1,000 ha need to submit an FMP if they want a subsidy from the rural development programme. FMPs are also required for public and private areas with special protection such as Natura 2000 sites, national parks and conservation areas. About 43 % of the Austria's **Natura 2000 sites** are in forest areas.

Both **FSC and PEFC certification systems** operate in Austria, but by far the largest area is certified under the PEFC scheme.

The Alps cover about three-quarters of Austria's total area. The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, BMLFUW) estimates that 19.3 % of Austrian forests serve a protection role.

Protection against torrents and avalanches is included in the Austrian Constitution as a responsibility of the Federal Government. The Forest Act ensures that this task is dealt with by the **Forest Engineering Service in Torrent and Avalanche Control** (Forsttechnischen Dienstes für Wildbach- und Lawinenverbauung, WLV, also known as die.wildbach), an office of BMLFUW, which analyses and assesses hazards and risks, plans and conducts preventive and protective measures.

A **Protection Forest Strategy** was adopted in 2002. The 'Protection through Forests Initiative' (Initiative Schutz durch Wald – ISDW) began in 2007. Tasks required by the Forest Act include the preparation of hazard zone plans, which describe the intensity and extent of all hazards due to torrents and avalanches as a basis for control measures. Engineering techniques are only used if necessary to ensure the success of the silvicultural methods adopted.

The 2002 amendments to the Forest Act redefined the term **'schutzwälder' (protection forest)** into two types:

'Standortschutzwalder', which protect the location on which they stand from erosion by wind, water or gravity and therefore require special treatment to protect the soil and vegetation and to ensure reforestation. These areas include forests on shifting sand and karst, sites liable to serious erosion or landslides, and forests on rocky ground or shallow soils where tree regeneration may be difficult.

'Objektschutzwalder' are forests that protect people, human settlements, infrastructure or agricultural land against natural hazards, such as avalanches, rocks, stones, landslides, or damaging environmental influences, and which require special treatment in order to achieve and secure their protective effect.

The owners of 'standortschutzwalder' must manage them in accordance with local conditions so that their preservation and stability is ensured. This can be financed by timber production, whereas the cost of the necessary management measures in 'objektschutzwalder' is financed by public funds or payments by those who benefit from the protection.

References

https://www.jusline.at/1_Nachhaltigkeit_ForstG.html (Forest Law)

Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2009) *Der österreichische Wald.* http://waldspiele-stmk.at/wp-content/uploads/2014/04/der-oesterreichische-wald_infobroschuere_deutsch-englisch_lebensministerium.pdf

European Commission (2014) *Forest Management Plans or equivalent instruments. Summary of Member States' replies to the DG ENV questionnaire.* http://ec.europa.eu/environment/forests/pdf/fmp_table.pdf

Hangler, J. (2012) *Governance and forest law enforcement – experiences and lessons learned in Austria.* http://www.foresteurope.org/sites/default/files/S3-3%20Johannes%20Hangler%20FE%20Workshop%20FLEG%20Budapest.pdf

Hochbichler E., (2008) *Case studies on structure, production and management of coppice with standards in the eastern part of Austria (Weinviertel)* Forstliche Schriftenreihe, Universität für Bodenkultur, Wien; Bd. 20, 246 S., Hrsg.: Österr. Gesellschaft für Waldökosystemforschung und experimentelle Baumforschung an der Univ. f. Bodenkultur. https://www.wabo.boku.ac.at/fileadmin/data/H03000/H91000/H91200/Schriftenreihe/Band_20.pdf

Ministerium für ein lebenswertes Österreich *Schutzwald-Aktivitäten - Rückblick.* http://www.bmlfuw.gv.at/forst/schutz-naturgefahren/schutzwald/Schutzwald6.html

Quadt, V., van der Maaten-Theunissen, M., & Frank, G. (2013) *Integration of Nature Protection in Austrian Forest Policy.* INTEGRATE Country Report for Austria. EFICENT-OEF, Freiburg. http://www.eficent.efi.int/files/attachments/eficent/projects/austria.pdf

Belgium

Kris Vandekerkhove, Stefan P. P. Vanbeveren, Reinhart Ceulemans, Hugues Lecomte,
Didier Marchal, Jenny Mills and Peter Buckley

Facts and Figures

Kris Vandekerkhove

Definitions

Coppice: one-storey forest structure, consisting of resprouts on stools and/or root suckers, occasionally with some trees from seedlings.

Coppice with standards: two-storey forest containing a upper canopy consisting of tall trees originating from seeds, and a lower canopy consisting of resprouts on stools and/or root suckers.

Taillis: une structure à un seul étage constituée de rejets de souches et/ou de drageons, avec éventuellement quelques rares tiges issues de semis.

Taillis sous futaie: peuplement constitué d'un étage supérieur composé d'arbres de futaie issus de semences et d'un étage inférieur issus de rejets de souche et /ou de drageons.

Definitions from the Walloon Forest Inventory

Legal Framework

Traditional coppice and coppice-with-standards forests are considered a legal management system in broadleaved forests. Short rotation coppices, e.g. of willow and poplar, with rotation periods of <8 years are legally not considered 'forest'. They are within the legislation of (agricultural) crops. Source: Bosdecreet 1991 (for Flanders); code forestier (for Wallonia)

Rotation Period

There are no legal restrictions on the rotation period; however the rotation period should be included in the management plan and should be in accordance with silvicultural rules of good practice for the management plan to be approved.

Rotation period generally varies from 8-12 years (alder, ash, birch), in some cases up to 20 years (oak, hazel, hornbeam). Exceptionally shorter (4-6 year in oak for bark stripping used in the tanning industry) and longer rotations (up to 30 years) were used in the past.

Statistics

In Belgium there are still approximately 115,000 ha of coppice and coppice-with-standards (15-20% of the total forest area). This area consists mainly of coppice-with-standards forests with oak in the standards, and hazel, hornbeam, maple, sweet chestnut and birch in the coppice layer.

Low coppice covers about 15,000 ha and consists mainly of black alder in wetland areas and birch and oak on dryer grounds. This type used to be much more common in the past: in 1895 coppice still covered over 100,000 ha. Many were transformed into conifer plantations or high forest of broadleaved trees.

Coppice with standards still cover about 100,000 ha (over 200,000 ha in 1895), mainly in Wallonia, but most of these stands are in gradual conversion towards high forest.

Typology

Simple coppice	'taillis simple', 'hakhout' - about 15,000 ha
Coppice with standards	'taillis sous futaie', 'middelhout' - about 100,000 ha
Pollarding	'têtards', 'knotbomen' - only in the open countryside (willow, poplar, ash)
Short rotation coppice	'korte omloop hout' (KOH) - considered an agricultural crop; not under forest legislation

Images


Coppice-with-standards: oak-hornbeam forest in Cerfontaine (Namur)

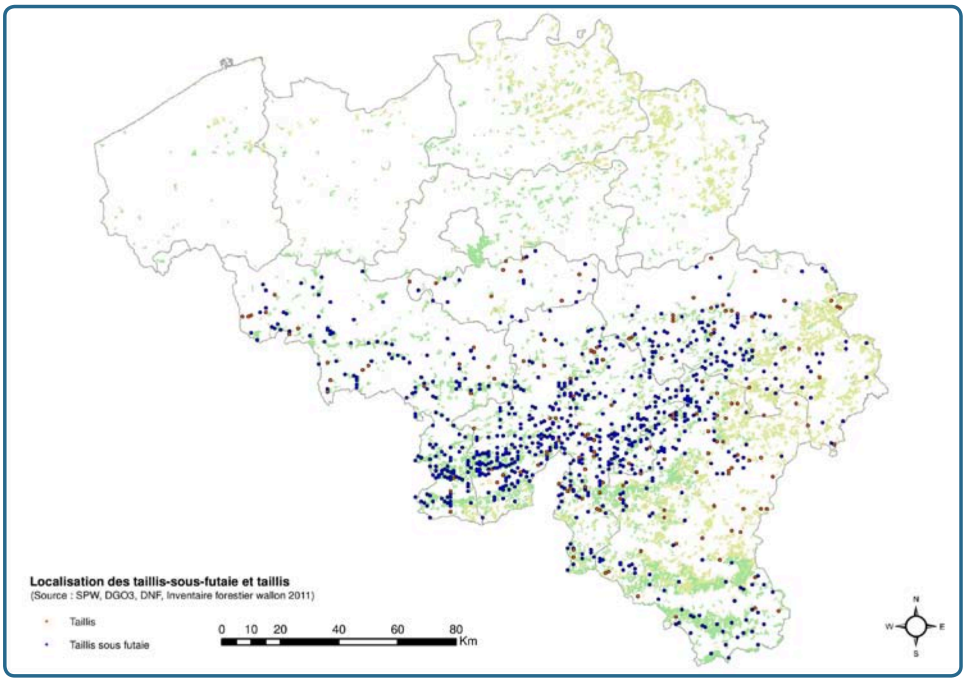
Experimental coppice-with-standards restoration in the Meerdaal Forest (south of Leuven)


Low coppice stands in Bierbeek (left) and Sinaai (right)

Photos: Kris Vandekerkhove and Peter Van de Kerckhove (right)

Map

Hugues Lecomte and Didier Marchal



Occurrence of coppice (orange dots) and coppice-with-standards (blue dots) in Belgium, based on the Walloon Forest Inventory plots (SPW, DGO3, DNF, Inventaire forestier wallon 2011). Operational coppice and coppice with standards forests in the northern part of Belgium (Flanders), are not shown in this map, but are very rare (only a few hundred ha). The background displays forest in Belgium: broadleaved in dark green, conifer in light green. Source: EFI forest map of Europe, version 2011 (Kempeneers et al. 2011; Päivinen et al. 2001; Schuck et al. 2002).

References

Kempeneers, P., Sedano, F., Seebach, L., Strobl, P., San-Miguel-Ayanz, J. 2011. *Data fusion of different spatial resolution remote sensing images applied to forest type mapping*, IEEE Transactions on Geoscience and Remote Sensing, in print.

Päivinen, R., Lehikoinen, M., Schuck, A., Häme, T., Väätäinen, S., Kennedy, P., & Folving, S., 2001. *Combining Earth Observation Data and Forest Statistics*. EFI Research Report 14. European Forest Institute, Joint Research Centre - European Commission. EUR 19911 EN. 101p.

Schuck, A., Van Brusselen, J., Päivinen, R., Häme, T., Kennedy, P. and Folving, S. 2002. *Compilation of a calibrated European forest map derived from NOAA-AVHRR data*. European Forest Institute. EFI Internal Report 13, 44p. plus Annexes.

Description

Stefan P. P. Vanbeveren and Reinhart Ceulemans

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 were the dominant management regime from the middle ages until the beginning of the 20th century. The early and more frequent 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* (Figure 1) 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 information available on productivity, stem wood values have been calculated at 2 to 7 m^3 ha^{-1} yr^{-1}.

The use of coppice cultures in Belgium declined in the 20th century as a consequence of a decrease in the demand for firewood and oak bark and an increase in management costs. 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; this proved, however, 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

Figure 1. An experimental SRC culture in Lochristi (East-Flanders, Belgium) with *Populus* (genotype Bakan, *P. trichocarpa* Torr & Gray (ex Hook) x *P. maximowiczii* Henry).

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, which requires protection from wildlife and control of competing understorey growth.

Reference

Den Ouden, J., Jansen, P., Meiresonne, L. & Knol, R., 2010. Chapter 24: *Hakhout en middelhout*. In: *Bosecologie en bosbeheer*. Den Ouden J., Muys B., Mohren F. & Verheyen K. (editors). ISBN 978-90-334-7782-9, Acco, Leuven, Belgium, 674 pp.

Forestry Regulations

Jenny Mills, Peter Buckley and Kris Vandekerkove

Flanders

1990 Forest Decree (Bosdecreet)

The law on Flemish forest management and is valid both for state and private forests.

1997 Nature Decree (Natuuurdecreet)

Aims to maintain, restore and develop the natural environment through protection and management measures.

While the forest management regulation of the Forest Decree still applies, the 1997 decree embodies principles that guide the government not to authorise or accept any management operation or plan that will degrade either the quality or quantity of the natural environment. These 'stand still' precautionary principles are embodied in the guidelines for forest management plans (bosbeheerplans) and felling permits (kapmachtiging) issued by the **Agency for Nature and Forest (Agentschap Natuur & Bos - ANB)**, which are applicable to all forests. The possible conservation impact must be assessed in all planned operations and avoidable damage must be prevented.

The Nature Decree deals with nature reserves, Natura 2000 Special Areas of Conservation, and also sets up the Flemish Ecological Network (Vlaams ecologisch netwerk; VEN) and Integral Interweaving and Supportive Network (Integraal Verwevings- en Ondersteunend Netwerk; IVON), an ecological network of linked, protected and other valuable areas to facilitate species migration. Although the main management aim is nature conservation, other activities, such as recreation, agriculture, forestry, military activities or the extraction of drinking water, are allowed in the VEN and IVON provided they do not jeopardise conservation.

In 2003 the Flemish Government established the **Criteria for Sustainable Forest Management** that include various goals and restrictions that are mandatory for all public and private forests within the VEN.

There are three levels of restrictions:

1. A basic level that applies to all forests

These restrictions are included in the directives for the evaluation of felling permit applications and management plans:

- Deforestation is forbidden (unless with special exceptional permit and procedure).
- No felling or harvest operations are allowed unless described in an approved management plan or in a felling permit authorised by the ANB. For an owner of several scattered small areas that collectively have an area exceeding

five hectares, but are each individually less than 5 ha, there is no obligation to draw up a management plan, but one can be drawn up voluntarily.

- Forest ownerships of >5 ha should have a (limited) management plan covering a 20-year period.
- Clearcutting is to be avoided. Where necessary, the maximum size of clearcuts for poplar and exotic tree species is 3 ha. For native broadleaved woodland, the maximum size is 1 ha, unless transforming homogeneous stands to more mixed stands, when the area may be enlarged to 3 ha.
- Clearcuts should be spread over the forest, at least 100 m apart.
- No felling and harvesting can take place from April 1 - June 30. (This can be extended, shortened or cancelled depending on local ecological conditions.)
- In thinning operations, maximum thinning intensities can be imposed (in % of stem number or basal area).
- Thinning that leads to degradation of the stand quality or structure (removing all quality trees) will not be allowed.
- Coppicing is allowed in appropriate stands and species, with a minimum rotation time of 8 years.
- Specific measures to prevent soil damage may be imposed if the conditions of the felling permit (e.g. fixed skidding tracks, avoiding certain areas).
- Other preconditions can be connected to the felling permit by the forest administration, e.g. pertaining to certain valuable trees or species to be spared.
- Successful regeneration must be established within 5 years after final felling. This can be by natural or artificial regeneration (to be planted within 3 years after final felling).

<u>All regeneration and transformation should follow the 'stand-still' principle:</u>

- Native trees cannot be replaced by exotics.
- Native broadleaved cannot be replaced by native coniferous forest (Scots pine).
- Mixed stands cannot be replaced by homogeneous stands.
- The owner is encouraged to keep and increase levels of dead wood and old trees, but there is no strict target.
- Planting subsidies are given to switch to indigenous tree species and there is a subsidy scheme for public access.
- When applying for a kapmachtiging, ANB decides if felling is permitted within sixty days of submission and under what conditions. If there is no reply within that period, the kapmachtiging is considered granted.
- In private forests, fellings can take place for urgent safety reasons without a kapmachtiging, but ANB must be notified in writing within 24 hours. If felling is necessary for sanitary reasons, a fortnight's notice should be given. Within 6 months after these types of felling, a proposal for rehabilitation measures must be submitted to ANB.

2. 'Criteria for Sustainable Forest Management'

This is compulsory for all forests (both state and private) inside the VEN. Outside VEN areas, forest owners can decide to join voluntarily, in which case they are also eligible for financial incentives and other opportunities (certification) related to CSFM.

In CSFM forests, the basic level restrictions are still in force, but some points are more stringent: it aims for 'continuous improvement' on some points, rather than 'stand-still'.

<u>The following requirements and restrictive measures are applied:</u>

- An extensive management plan is required, with a detailed inventory of elements valuable for nature conservation and specific management operations to conserve them (e.g. old habitat trees, streams, archaeological sites)

- Choice of tree species: 'stand still' plus a long-term goal for conversion of exotic stands to mixed indigenous on 20% of the surface area.
- Change all homogeneous stands to mixed stands (at least 30% admixture).
- Size of clearcuts: 1 ha, unless the plan is for transformation towards more mixed stands from homogeneous exotic plantations.
- Dead wood: A clear target, 4% of total stock, plus quality requirements: all sizes, standing and lying.
- Overmature trees: a certain number of trees/ha should be selected to be left unharvested.
- 5% of the forest should consist of, or be developed towards 'key habitats'. These can be ecologically valuable open spaces and/or semi-natural stands of mixed native woodland (a selective harvest of high timber value trees not detrimental to the quality is still allowed).

These CSFM criteria are very demanding and for many owners obligatory, but they also give the owner a certain legal security and other opportunities.

The CSFM are considered to be in accordance with the requirements for Natura 2000 habitats and also with FSC and PEFC(*)-certification standards, which makes all forests managed according to CSFM automatically eligible for individual or group-certification.

Some extra financial incentives are also provided:

- The owner is excepted from certain taxes and succession rights.
- Subsidy (per ha) for key-habitats and management of valuable open spaces.
- Subsidies for the production of an extensive management plan.

(*) No official Flemish PEFC-standard exists at this moment, but the CSFM is in accordance with global PEFC-standards, and the official standards of neighbouring countries or regions, like the Netherlands and Wallonia.

3. 'Management Vision for Public Forests'

This is applied to all public forests and is compulsory for State-owned Domanial forests. It includes very high standards of forest management, particularly for nature conservation; they are comparable to CSFM but go further for some elements. In particular, there are higher targets for tree species composition.

- The basic principle is close-to-nature forestry, with small-scale interventions, selective thinnings and abandoning of final cuts. Clearcuts (1 ha or more) are only allowed in exceptional cases.
- In the long term, the majority of forest stands in public forests should consist of mixed, uneven aged, indigenous forest stands and 80% of all stands should consist of indigenous species. There should be at least a 30% admixture of indigenous species in the remaining exotic stands.
- All stands must be mixed, meaning that no species should cover over 90% of the basal area.
- New afforestations are to be of indigenous species. Poplar clones may be used as a 'pioneer' generation, at most on 50% of the area.
- Natural regeneration is used whenever possible.
- Special attention and appropriate management is given to valuable non-forest biotopes in the forest complex (heathland, ponds, etc.). These permanent open spaces, together with transient open spaces with high conservation value, should cover at least 5-15% of the total forest area.
- Special attention is also given to rare and vulnerable species (hollow trees with bat colonies, breeding areas of rare bird species, etc.).

- Special attention is also given to rare local genotypes of trees and shrubs.
- No commercial harvesting (with heavy machinery) is allowed in valuable and vulnerable riparian forests and swamp forests.
- Changes in natural hydrology should be restricted to the absolute minimum.
- Old trees: some trees are spared to become old and die naturally. They can be spread over the stand or grouped. If spread over the stand, at least 10 trees/ha are to be spared (for very large trees and low stem numbers: at least 10% of the stand basal area). If clustered, areas of at least 5% of the stand are selected and remain unharvested.
- On dead wood, the same threshold is set as in CSFM: at least 4% of the standing stock, both standing and lying, in all decay classes, and representative for the species composition and size distribution of the stand.

As public forest management is not privatised (as in other countries), the forest administration is not eligible for any subsidies. They receive a yearly budget in order to realise these and other services, such as recreational infrastructure.

Forests within the Natura 2000-network

For forests within SACs there are no clear restrictions, but from the executive orders on Natura 2000 targets, it is clear that forests that adhere to a certain habitat type should at least comply with the CSFM if they want to reach the required favourable status of conservation.

A new nature management plan (natuurbeheerplan)

The ANB is working on the integration of the Forest and Nature decrees. When this new legislation comes into force, management of different types of natural areas will be covered by a single conservation plan. Individual management plans will continue, with some revisions to thresholds, limits, etc. This will not change current rules for specific points related to coppice, so coppice can be applied in 'appropriate' stands: the evaluation of the appropriateness will be done by the local official of ANB. In practice, this means that approval will be given in cases of 'continuation' or 'restoration' of previous coppice stands, and may be approved for young stands of broadleaved forest that are able to resprout to coppice (i.e. all except for beech). For old, well-structured broadleaved high forest stands, conversion to coppice may be regarded as a degradation of present natural values and a violation of the 'stand still principle', so may be refused. If these old, mixed stands are previous coppice-with-standards stands, permission will most probably be given for restoration of this type of management, under the prerequisite that ecologically valuable standard trees are to be spared.

References

Vandekerkhove, K. 2013. *Integration of Nature Protection in Forest Policy in Flanders (Belgium). INTEGRATE Country Report.* EFICENT-OEF, Freiburg.

ANB website pages: https://www.natuurenbos.be/beleid-wetgeving/natuurbeheer/beheerplan/het-nieuwe-natuurbeheerplan -and- https://www.natuurenbos.be/beleid-wetgeving/natuurbeheer/beheerplan/wetgeving

Wallonia

A new **Forest Code** (Code Forestier), covering private and public forests, was adopted by the Walloon Parliament in 2008. It replaced the former Code, which dated from 1854. Some of the objectives are to: produce wood of increased quality and quantity; fight climate change; safeguard biodiversity; fight fragmentation; diversify the forests; and ensure the social, recreational and educational role of the forest. The Code encourages the use of tree species adapted to local soil conditions, genetic conservation (rare tree species and local ecotypes), natural regeneration, an uneven-aged structure, and soil and water protection (limits on clear-cutting, drainage, etc.). Inheritance tax on standing timber has been abolished to encourage planting of species such as oak or beech rather than conifers.

Some of the regulations are:

- Except in urgent, authorized cases, it is forbidden to clearfell coupes over 5 ha in forests with more than 50% conifers. For areas with more than 50% broadleaves, the maximum clearfell allowed is 3 ha. This applies to all felling, which leaves an amount of woody material less than 75m^3/ha for standards and at least 25m^3/ha for coppice-with-standards of strong shoots.
- All requests for urgent and non-urgent coupes must be submitted to a section of the Department of Nature and Forests (Département de la Nature et des Forêts).
- The use of pesticides, herbicides and fungicides are prohibited, except in certain cases specified by the Government, in order to fight specific diseases and invasive species.
- All public forests contiguously larger than 20 hectares must have a management plan.
- Management plans are optional for small private forests. A simple management plan ("document simple de gestion"), mainly describing the planned harvests for the following 20-year period can be produced but is not obligatory.
- In the absence of a management plan, all harvesting requires an explicit authorisation from the administration.
- In public forests, at least one tree of exceptional biological interest (dead or damaged trees) must be retained for each 2 ha.
- In broadleaved stands, up to 2 dead or windthrown trees per ha with a diameter of 40 cm must be retained, unless they are dangerous or of high economic value.
- In conifer stands, 2 stumps of broken or dead trees should be retained per hectare, including those in clearfell areas.

References

Code forestier. http://environnement.wallonie.be/legis/dnf/forets/foret025.htm

Ministère de la Région wallonne: Direction générale des Ressources naturelles et de l'Environnement. *Le nouveau Code forestier.* http://environnement.wallonie.be/publi/dnf/codeforestierfr.pdf

Bosnia and Herzegovina

Ćemal Višnjić, Sead Vojniković and Besim Balić

Description

Ćemal Višnjić, Sead Vojniković and Besim Balić

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

The purpose of 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 the area of coppice forests divided into the above listed five classes, are shown in Table 1.

Productive coppice forests (class 1) are managed for timber production, the most important function (Fig. 1). The coppice forest classes 2 - 4 have more environmental and protective funtions, 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 have developed, differing widely in structure, quality of stems and species composition.

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.

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

Class	FBiH			RS			BiH (FBiH & RS)		
	State	Private	Total	State	Private	Total	State	Private	Total
1	217,300	164,000	381,300	221,000	284,900	505,900	438,400	451,300	889,700
2	86,200	52,400	138,600	53,200	27,200	80,400	139,400	80,000	219,400
3	400	400	800	4,800	400	5,200	5,200	800	6,000
4	1,200	800	2,000	2,000	1200	3,200	3,200	2000	5,200
5	52,700	21,200	73,900	23,200	34,800	58,000	75,900	56,000	131,900
Total	357,800	238,800	596,600	304,200	348,500	652,700	662,100	590,100	1,252,200

These categories are as follows:

1. good quality coppice forests (class 1)
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 under the coppice selection system. The most frequent rotation is 40-60 years, with felling cycles of 10 years.

In addition to the aforementioned types of coppice forests, Bosnia and Herzegovina also have pollards, sometimes as individual trees or in groups. These are evidence of cultural heritage; pollards located near the villages were used by locals as a source of small dimension building materials and firewood (Fig. 2).

Table 2. Area and average stocking of large timber of all available coppice forests of productive character according to 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 (FBiH & RS)		
	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
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 1. Productive, well developed coppice beech forest (central Bosnia)

Figure 2. Coppice beech forests with pollards (near Sarajevo)

Bulgaria

Ivailo Markoff, Grud Popov and Patrick Pyttel

Facts and Figures

Ivailo Markoff

Definitions

Forestry Act 2011: 88. (1) Forests are managed as high forest, conversion forest or coppice (Niederwald). (2) High forests are managed in a way to maintain their seedling origin. (3) Conversion forests are managed in a way that transforms them into high forest. (4) Niederwald is managed in a way ensuring its regeneration from re-sprouting.... (5) Not managed as forests are: ... 2. plantations of tree or shrub species for fast production of biomass;

§ 1. In the text of this Act: 54. “Niederwald” are forests of black locust (*Robinia pseudoacacia*), oriental hornbeam (*Carpinus orientalis*), manna ash (*Fraxinus ornus*) and honey locust (*Gleditsia triacanthos*) for coppice regeneration.

Чл. 88. (1) Горите се стопанисват като високостеблени, издънкови за превръщане в семенни и нискостеблени. (2) Високостеблените гори се стопанисват по начин, запазващ семенния им произход. (3) Издънковите за превръщане в семенни гори се стопанисват по начин, осигуряващ превръщането им в семенни. (4) Нискостеблените гори се стопанисват по начин, осигуряващ издънковото им възобновяване. (5) Не се стопанисват като гора: 2. плантации от дървесни или храстови видове, създадени с цел ускорено производство на биомаса;

§ 1. По смисъла на този закон: 54. “Нискостеблени” са акациевите, келяв габърови, мъждрянови и гледичиеви гори за издънково възобновяване. Чл. 104. (1) Забранява се: 1. провеждането на гола сеч във всички гори с изключение на тополовите, върбовите и нискостеблените гори;

Forestry Act 2011, last changed in 7.08.2015

Legal Framework

103. (1) ... Niederwald can be cut from Sept. 1st to Apr. 1st.

104. (1) It is prohibited: 1. to clear-cut a forest except poplar forests, willow forests and Niederwald.

Rotation Period

102. The age of regeneration cut can be not less than ... 2. 50 years for a conversion forest; 3. 15 years for a black locust forest and 20 for the other Niederwald species.

Statistics

Total forest area in Bulgaria is 3,833,640 ha. Conversion coppice takes up 1,351,815 ha, consisting mostly of oak (*Quercus* spp.; 1,025,571 ha), beech (*Fagus* spp.), hornbeam and linden (*Tilia* spp.). Conversion coppices have growing stock of 158,050,412 m^3.

Coppice forests take up 481,747 ha, mostly with oriental hornbeam (197,909 ha) and black locust (153,851 ha) and have stock of 18,665,335 m^3. Coppices mainly consist of trees older than 60 years.

Typology

Simple coppice	Only black locust plantations are still coppiced, rotation age 20 years. Oriental hornbeam can also be coppiced, but this is seldom done.
Coppice with standards	Not practised
Pollarding	Abandoned since the post-war years
Short rotation coppice	Not practised
Other types	1,351,815 ha (in 2015) of conversion coppice, of which 70% is oak and 15% beech, as well as hornbeam, linden etc. Rotation age is 60 to 100 years, aimed at seedling regeneration; most are ageing; the average age is 45 years.

Images


Oriental hornbeam coppice


Beech coppice


Oak coppice

Description

Ivailo Markoff, Grud Popov and Patrick Pyttel

Bulgarian coppice occupies 1,833,562 ha, or 48% of the country's forest area. Oaks are dominant (60% of the coppiced area), mainly sessile oak, Hungarian oak and Turkey oak (*Q. petraea, Q. frainetto* and *Q. cerris*), followed by beech (10%), black locust (9%), oriental hornbeam (8%), hornbeam (*Carpinus betulus*; 6%) and smaller areas of linden (*Tilia* spp.), aspen (*Populus* spp.), chestnut (*Castanea sativa*), pubescent oak (*Q. pubescens*), pedunculate oak (*Q. robur* L.), etc. Single trees and groves of the pedunculate oak have survived in cornfields.

Bulgarian coppices are the result of thousands of years of human pressure; uprooting for cornfields and pasture, in addition to the extraction of timber, charcoal and firewood. The number of coppicing rotations is irregular and not usually known, which makes it difficult to estimate their 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. Furthermore, all Bulgarian coppices have a large or small component of regeneration by seed; this improves their vitality but makes it even more difficult to evaluate their age.

Coppice is mainly found in the oak forest belt, the most densely populated part of the country. The average altitude is 450 m above sea level, rarely above 1000 m. Coppice forests are made up of 70% oak and 14% beech. One third (29%) are not owned by the state, of which half are private (14%) and the rest 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 gradually replaced by grasslands and shrubs. By 2080, depending on the climate change scenario, some 16% to 44% of them are expected to 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 the presence of exotic insects that were previously found only in the Mediterranean.

As a result of their abundance, Bulgarian coppice forests have never been subject to nature 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 coppice (74%) is in the process of conversion to high forest, with the remaining 26% maintained as simple coppice. Half of the simple forests are plantations of black locust, which are actually coppiced, the rest are natural stands of oriental hornbeam, which have been rather abandoned after decades of efforts to replace them with conifers. There are no coppice with standards areas in Bulgaria. In 1951 there were still 36,000 ha of pollarded high coppices, but since then pollarding has been abandoned. There is no short rotation coppice yet. Unlike Mediterranean countries, there is no maquis in Bulgaria. Deforested and devastated lands were afforested in the post-war years with nearly 1,000,000 ha of pine plantations, through 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 years, 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 being 16. It is difficult to set a rotation age for the oriental hornbeam, but its average age is 50 years.

There are two types of coppice conversion to high forest in Bulgaria: poor coppices are clear-cut and replaced with conifers, mainly pines, or the final cutting is postponed until the reproductive power of stools diminishes and in the meantime they are thinned for pit-poles and firewood. The replacement with conifers was, however, abandoned in 2006 because the suppression of stools is too expensive.

In Bulgaria, the conversion of coppice to high forest 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, mainly industrial wood and firewood. Sawlogs only 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. Although the firewood prices are also rising in Bulgaria, it is nevertheless the cheapest form of energy. All rural areas in Bulgaria use firewood for heating.

If biomass production is the aim of Bulgarian coppice management, an examination of mean increment shows that the optimal rotation time is about 20 years. At that age, the stands do not produce seeds and should regenerate by re-sprouting. However, resuming coppicing will be a silvicultural challenge because of aging and problems with oak regeneration. Recently, private forest owners often clear-cut their coppice, counting on regeneration by re-sprouting, but the aged coppice re-sprout badly. In addition, Bulgarian coppice forests are dominated by oak, which has a poorer regeneration 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 begins to decay. Thus, the oak coppices become unstable, shallow-rooted forests. In the lowland, their disappearance is a question of time; a large part of the oak coppices are currently in this threatened condition, especially the Turkey oak. 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 of 15 to 20 years. Where natural regeneration with seedlings is impossible, or has failed, acorns must be sown - in the autumn and after soil preparation, in order 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: although the idea to resume coppicing is very promising, it requires further investigation and experiments.

References

Anonymous, 2015. *Otčet na gorskija fond* (Annual report on the forests, in Bulgarian)

Glushkov, S., 2008. *Investigation of the possibilities for creation of sustainable usage of wood biomass for energy aims in Bulgaria*. Report for the World Bank.

Hinkov, G., Zlatanov, Tz., Pandeva, D., 2005. *Processes of degradation of the oak forests in the Middle Danube Plain.* 8th Symposium on the Flora of Southeastern Serbia and Neighbouring Regions, Niš, Serbia and Montenegro, June 20–24 2005, pp. 115–119.

Mirchev, Pl., Georgiev, G. Tsankov, G., 2001. *Studies on the parasitoids of Gelechia senticetella (Stgr.) (Lepidoptera: Geleciidae) in Bulgaria.* Journal of Pest Science, 74 (4), pp. 94-96.

Raev et al., 2010. *Program of measures for adaptation of the forests in the Republic of Bulgaria against the negative impact of the climate changes* (In Bulgarian). Part 3, IAG, Sofia.

Forestry Regulations

Ivailo Markoff

Bulgarian coppice forests cover an area of almost 2,000,000 ha, or 48% of the total forest area. There are no plans for their protection; however, an large percentage of these coppices is protected under the Natura 2000 network, a network which covers 60% of Bulgarian forests. Most coppice is state-owned (ca. 70%) or municipal (15%); privately owned coppice is characterised by very small plots belonging to millions of owners.

The main regulations affecting coppices are:

- Forestry Act + Implementation Rules
- Forest Management Ordinance
- Ordinance on Felling

They can all be downloaded from the website of the Executive Forest Agency.

Forestry Act

The act was issued in 2011 and amended many times afterwards. It has the following texts that affect coppice:

Art. 13. (1) Forest management plans shall be elaborated for state forests and municipal forests, with the exception of the territories provided for the needs of the national security and defense. … (3) Forest management plans or programs are developed for the forests owned by natural persons, legal entities and their associations. … (4) The forestry plans and programs shall determine the permitted use of the forest resources and the guidelines for achieving the management goals of the forest territories for a period of 10 years.

Art. 88. (1) The forests shall be managed as high forest, coppice for conversion into high forest or coppice (Niederwald). … (5): … 2. Plantations of wood or shrub species created for the purpose of accelerated production of biomass are not considered to be forests.

Art. 102. Final cuts shall be carried out at an age of not less than: ... 2. 50 years in the coppice forests for transformation into high forest; 3. 15 years for black locust plantations and 20 years for the other coppice forests.

Art. 104. (1): 1. Clearcuts are prohibited in all forests except for poplar, willow and low-stem (coppice) forests.

Art. 124. 3. Grazing is prohibited in forest plantations, young forest stands regenerated by seed and coppice until they reach a height of 3 m;

§ 1. … 9. "Clearcut" is a final cut where, for a period of not more than one year, all the trees of the mature stand on a given territory are cut. ... 54. "coppices" are forests of black locust, oriental hornbeam, manna ash and honey locust regenerated by shoots.

(Forestry Act) Implementation Rules

The Implementation Rules state the following usages:

Art. 89. ... (3) The use of wood after paying the stumpage price ... may be effected in: ... 4. cutting of coppice forests for conversion into high forest and coppice forests maintained as coppices.

Art. 109. The number of animals grazing in forests shall be determined according to productivity and conditions of the pastures and the grass cover, in compliance with the following limitations: ... 2. for coppices: up to 1 cow per hectare and up to 1 sheep or pig per 0.2 hectares.

Ordinance on Felling

The Ordinance on Felling gives many details on conversion.

Forest Management Ordinance

The Forest Management Ordinance regulates the elaboration of forest management plans and programs (a program is a simplified plan made for a small property). It provides details on rotation age in managed forests (covered by management plans), while the minimal cutting ages specified above are valid in all forests. The common rotation ages for the high forest conversions 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, 60, 40 and 40 years, respectively. The rotation age for black locust is 20 years.

References

Forestry Act and Implementation Rules (Закон за горите). Executive Forests Agency: http://www.iag.bg/docs/lang/1/cat/1/index

Forest Management Ordinance. Executive Forests Agency: http://www.iag.bg/docs/lang/1/cat/1/index

Ordinance on Felling. Executive Forests Agency: http://www.iag.bg/docs/lang/1/cat/1/index

Croatia 

Tomislav Dubravac, Martina Đodan, Damir Barčić and Miljenko Županić

Facts and Figures

Tomislav Dubravac and Martina Đodan

Definitions

Coppice forests are the result of deliberate or undeliberate degradation of high forests and are of vegetative origin (sprouts from the stump or roots - Dubravac and Krejči, 2001). A common feature of most coppices is the absence of any silvicultural activities throughout their development (Krejči and Dubravac, 2004). Since they were left to spontaneous development, a whole spectrum of coppices formed, from those with the highest quality, a relatively high wood volume, good structure and crown coverage to those of poor quality and low wood volume. In the past, coppices resulted from the growing needs for fuelwood and the lack of proper managerial interventions. Today, they are mainly a result of the unsuccessful regeneration of high forests. Tree species forming coppices are oaks (sessile, pubescent, holm), beech, hornbeam, chestnut, alder, black locust, etc.

Panjače su šume niskog uzgojnog oblika nastale namjernim ili nenamjernim procesima degradacije sastojina visokog uzgojnog oblika. Zajedničko obilježje većine panjača je izostanak bilo kakvih uzgojnih radova u mladosti i tijekom njihova razvoja. Kako su prepuštene spontanom razvoju, formirao se čitav spektar, od onih najkvalitetnijih s relativno visokom drvnom masom dobro sklopljenih i suvislo obraslih sastojina pa do onih nekvalitetnih, razbijenog sklopa, s kržljavim i kvalitetno lošim stablima male drvne mase. U prošlosti su nastajale iz potreba za ogrjevom i nestručnim gospodarenjem, u novije vrijeme nastaju kao posljedica neuspjele obnove visokih šuma. Glavne su vrste drveća koje tvore šume niskoga uzgojnoga oblika kitnjak, medunac, cer, crnika, bukva, obični grab, kesten, joha, bagrem i dr.

Dubravac, T., Krejči, V. (2001) *Pojavnost mladog naraštaja u sačuvanim panjačama hrasta crnike (Quercus ilex L.) – uvjet osiguranja budućih sjemenjača. Occurrence of young crop in preserved coppice forests of evergreen oak (Quercus ilex L.) – condition for future seed forests.* Research Paper: Science in Sustainable Management of Croatian Forests, Faculty of Forestry, University of Zagreb, Forest Research Institute, „Croatian Forests“ Ltd. page 43-52, Zagreb

Krejči, V., Dubravac, T. (2004) *Oplodnom sječom od panjače do sjemenjače hrasta crnike (Quercus ilex L.). From coppice wood to hight forest of evergreen oak (Quercus ilex L.) by shelterwood cutting.* Šumarski list (Journal of Forestry), Vol: 7/8, page 405-412.

Rotation Period

Rotation is determined by legal acts (Forest Management Rulebook).

Rotation for the coppice forests by species:

1. Oaks (*Quercus pubescens* Willd., *Quercus ilex* L., *Quercus petraea* (Matt.) Liebl.) - 80 years,
2. Beech (*Fagus sylvatica* L.) - 80 years,
3. European hornbeam (*Carpinus betulus* L.) - 40 years
4. Black locust (*Robinia pseudoacacia* L.) - 30 years
5. Soft deciduous (*Populus* sp., *Salix* sp., *Alnus* sp.) - 30 years.

Statistics

The area of coppice forests in Croatia amounts to 359,610 ha (14.4 % of forests in Croatia), while 192,986 ha (53.7 %) are managed by the state-owned company „Hrvatske šume" Ltd., 5,832 ha (1.6 %) of state-owned coppices are managed by other legal entities and 160,792 ha (44.7 %) are privately owned. The total growing stock of coppice forests is approximately 41.1 million m^3, with an annual increment of 1.09 million m^3 (Source: National Forest Management Plan 2016 – 2025).

Area of state owned coppices according to tree species: *Fagus sylvatica* L. (103,737 ha, 28.9 %), *Quercus pubescens* Willd. (95,640 ha, 26.7 %), *Quercus cerris* L. (41,845 ha, 11.7 %), *Carpinus betulus* L. (28,786 ha, 8.0 %), *Quercus petraea* (Matt.) Liebl. (22,959 ha, 6.4 %), *Quercus ilex* L. (21,217 ha, 5.9 %), other tree species (44,620 ha, 12.4 %).

Area of private coppices according to tree species: *Quercus ilex* L. (65,679 ha, 23.9%), *Quercus pubescens* Willd. (60,424 ha, 22.0%), *Carpinus betulus* L. (46,873 ha, 17.1 %), *Fagus sylvatica* L. (26,356 ha, 9.6%), *Quercus petraea* (Matt.) Liebl. (15,342 ha, 5.6%), other tree species (59,993 ha, 21.8%).

Typology

Simple coppice	The most common type in the country.
Coppice with standards	Ca. 15% of coppices can be regarded as coppices with standards.
Pollarding	Found in the northern part of Croatia, Istria and especially in the northern part of the island of Cres (oak and chestnut, but also suitable for: Mediterranean oaks, chestnut, mulberry, hazelnut, willows).
Short rotation coppice	*Populus* sp., *Salix* sp.

Images




Coppice forests in the northern part of Adriatic coastal area in Croatia. From left to right: holm oak coppice, pubescent oak coppice, Turkey oak coppice, holm oak coppice (photos Tomislav Dubravac)

Description

Tomislav Dubravac and Damir Barčić

The total area of coppice forest in Croatia amounts to 359,610 ha, of which 6.4% has a protective function, for example for soil and watercourses, and serves as a designated protected area (e.g. national parks) or another special purpose areas. Coppice forests in Croatia represent a significant source of wood products and provide a variety of forest services and functions. There is an almost equal distribution between private and state ownership, at 55.3 % and 44.7 % respectively.

Generally, coppice forests in Croatia can be divided into the Continental and Mediterranean parts of the country. Characteristic tree species in the Continental part are: European beech, hornbeam, sessile oak, chestnut, alder and black locust, while in the Mediterranean area one finds holm oak, pubescent oak and hornbeam.

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

Figure 1. View of the holm oak coppice forest on the Croatian Adriatic coast (Photo: D. Barcic).

Coppices were created by intention or accidentally, curtailing the development of a single-stemmed standard tree.

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 black locust stands, which can be renewed by clear cutting, reforestation and shoots.

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

1. Silvicultural activities on the clearing and thinning of coppice.
2. Silvicultural activities on the 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 2 for the distribution of these types by area.

Coppice rotation for species according to the 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* spp., *Salix* spp., *Alnus* spp.)

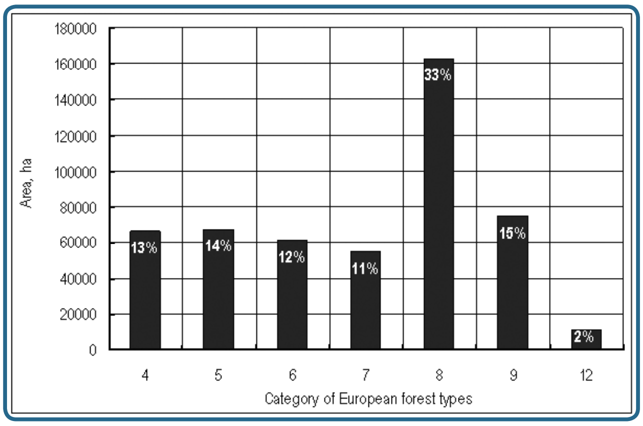


Figure 2. Area of coppice forests in Croatia by European forest types (Source: Dekanić et al, 2009)

Forestry Regulations

Miljenko Županić

The tradition of forestry and organized sustainable forest management in Croatia is more than 250-years old. Most of the forest in Croatia is in state ownership (76 %) and it has always been regulated at the national level.

At present, forest management and other forestry activities are regulated by several **laws and legal acts**, such as the:

- Law on Forests
- Forest Management Rulebook
- Laws on Physical Planning & Building
- Nature Protection
- Forest Planting Material
- Law on Fire Protection

In the actual management of state forests, the state-owned company **Croatian Forest Ltd.** (in Croatian, Hrvatske šume d.o.o.) has a key role. The company is obliged by Law to make detailed **Forest Management Plans** and to keep precise book-keeping records of growing stock for every **Forest Management Unit**.

Coppice is mentioned only in forest management plans or the management plans of protected areas.

All forest areas in Croatia are split into management units, which usually cover 2000-3000 ha and are divided according to ownership (state or private). Forest management plans are made for each unit for 10 years. State units have had these plans for 50 years, while around 70% of private units are covered in practice by the **Advisory service** (state agency) plans. This agency is also responsible for the administration of private forests. Forest management plans are made by licensed companies, during which all stakeholders are invited to share their opinions. Private owners may also have an input into management rules that form part of the plan (including coppice management), because these rules underlie applications for various projects and subsidies. Private owners who own more than 20 ha of forest can have a single ownership management plan. Each forest management plan must be approved by the Ministry, which may involve public discussion during the process of approval.

Currently, the most important policy document affecting coppice management is the **Law on Forests**, which is a national level regulation. Coppice is only mentioned as a silvicultural form in subordinate regulations – the **Forest Management Rulebook**; rotation periods are defined according to the management goals. These regulations incorporate EU timber regulations and Pan-European criteria and indicators for sustainable forest management.

According to these regulations, private owners must have permission to cut all types of forest, including coppice. Permission for cutting is given by the forest extension service on the basis that tree marking is done by a forester from a licensed company and proof of ownership is given to the court. If owners have to transport the wood products on public roads after cutting, they must obtain special delivery authorization, also issued by a licensed company, even if the owner uses the wood themself. All of these administrative procedures have some financial cost, so most new owners who don't need wood for themselves are not interested in cutting, as profits are not guaranteed.

For private forests that are included in protection areas, subsidies may be available to compensate limitations in management, but only when managed according to the protection rules included in the management plan.

The main challenges in private forests are their small scale, the heterogeneity of silvicultural forms, poor cadastre and land-registry records, indistinct parcel borders and degradation of forests (Čavlovic, 2004). However, the property rights as such remain the most important challenge, because this presents an obstacle to the consolidation of smaller properties.

References

Croatian forests Ltd. (2016) *General forest management Plan of the Republic of Croatia, 2016-2025, (in Croatian: Šumskogospodarska osnova područja za razdoblje 2016-2025 – Knjiga I).* Zagreb: Croatian forests Ltd.

Čavlovic, J. (2004) *Advancement of the State and Management of Private Forests in the Area of the City of Zagreb*. Forestry Faculty of the University in Zagreb

Čavlovic, J. (2010) *The First National Forest Inventory of the Republic of Croatia*. Zagreb: Ministry of Regional Development, Forestry and Water Management and Forestry Faculty of the University in Zagreb

Dekanić, S., Lexer, M. J., Stajić, B., Zlatanov, T., Trajkov, P., Dubravac, T. (2009) *European forest types for coppice forests in Croatia*. Silva Balcanica, 10(1):47-62.

Dubravac, T., Krejči, V. (2001) *Pojavnost mladog naraštaja u sačuvanim panjačama hrasta crnike (Quercus ilex L.) – uvjet osiguranja budućih sjemenjača. Occurrence of young crop in preserved coppice forests of evergreen oak (Quercus ilex L.) – condition for future seed forests.* Research Paper: Science in Sustainable Management of Croatian Forests, Faculty of Forestry, University of Zagreb, Forest Research Institute, “Croatian Forests” Ltd. page 43-52, Zagreb

Forest Management Rulebook (Pravilnik o uređivanju šuma), OG 111/2006 (amended in 141/2008)

Krejči, V., Dubravac, T. (2004) *Oplodnom sječom od panjače do sjemenjače hrasta crnike (Quercus ilex L.). From coppice wood to hight forest of evergreen oak (Quercus ilex L.) by shelterwood cutting*. Šumarski list (Journal of Forestry), Vol: 7/8, page 405-412.

Law on Forests (Zakon o šumama), OG 140/2005 (amended in 82/2006, 129/2008, 80/2010, 124/2010, 25/2012, 18/2013, 94/2014)

Law on Nature Protection (Zakon o zaštiti prirode), OG 15/2018

Zupanic, M. (2011) *Country report for the Forest Products Marketing Workshop*. p.10. Bled, Slovenia, 30.November - 1. December 2011.

Czech Republic

Petra Štochlová and Radim Hédl

Facts and Figures

Petra Štochlová

Definitions

(1) low coppice forest - forest management system in which trees originate from sprouts

(1) nízký les (pařezina) - hospodářský tvar lesa vzniklý výmladností

(2) coppice with standards - forest management system in which trees coming from sprouting and individuals originating from seeds are combined

(2) střední (sdružený) les - hospodářský tvar lesa vzniklý jako kombinace výmladkové složky a jedinců semenného původu

(1) & (2): Decree of the Ministry of Agriculture of the Czech Republic no. 83/1996 Coll. on elaborating regional plans of forest development and on specification of economic complexes

(3) stand of fast-growing trees (short rotation coppice; SRC) - cultivated agricultural land with permanent culture that is uniformly planted with at least one thousand woody plants per ha including handling area that cannot exceed 12 m on both sides of the rows and width of inter-row along the edge rows

(3) porost rychle rostoucích dřevin (výmladková plantáž) -zemědělsky obhospodařovaná půda s trvalou kulturou, která je rovnoměrně a souvisle osázena dřevinami, a to v minimálním počtu 1000 životaschopných jedinců na 1 hektar dílu půdního bloku, do plochy této zemědělsky obhospodařované půdy se započítává související manipulační prostor, který nesmí přesahovat 12 metrů na začátku a na konci řad a šířku jednoho meziřadí, v nejvyšší započitatelné šířce 8 metrů, podél řad po obou stranách rychle rostoucích dřevin pěstovaných ve výmladkových plantážích a netvoří součást cesty

(3): Government decree no. 307/2014 on land use records keeping

Legal Framework

Act no. 289/1995 on Forests defines forest as a forest stand with its environment and land designated for the fulfillment of forest functions. It defines the minimum age of trees to be felled (80 years); earlier felling is only possible with an exemption or in a special forest management sets of stands. Management sets are mean units used to differentiate between management methods in forests set out within individual natural forest areas and based on their function, natural conditions and state of forest stand. There are 24 management sets (and 3 for protecting forests); 6 of which include coppice.

Decree of the Ministry of Agriculture of the Czech Republic no. 83/1996 on elaborating regional plans of forest development and on specification of economic complexes - defines coppice forests and 6 forest management sets of stands where coppice forests can be grown and the age when they can be harvested.

Act no. 252/1997 on agriculture - SRC is defined as one of the crops that can be grown on agricultural land.

Act no. 334/1992 on protection of agricultural land resources - restricts growing SRC on agricultural land of I. and II. protection category; defines the maximum rotation length (10 years) and maximum growing period (30 years) for SRC; the land must be used in the different way 3 years after SRC removal.

Act no. 114/1992 on the Conservation of Nature and Landscape - growing allochthonous plants (mainly hybrid poplars) is possible only with permission; they are banned in protected areas.

Rotation Period

For (1) & (2): According to Czech law Act no. 289/1995 on Forests most forests cannot be felled before the age of 80. Simple coppice management is only allowed in six forest management sets of stands. Coppice forests with a predominance of hardwood trees are definitely preferred and have a recommended rotation length of 40 years (with a range between 30-50 years, in some cases 60 years). In coppice forests with a predominance of soft wood trees, the recommended rotation length is between 20 and 30 years. The recommended rotation length for willow forest cover and locust forest cover is 40 and 70 years, respectively, in specific forest management sets of stands.

For (3): Agricultural land can be used for growing woody plants of up to 10 years. However, SRC grown on agricultural land has a maximum of 30 years with rotation periods up to 10 years.

Typology

Simple coppice	Allowed in 6 forest management sets of stands. Species: alder, oak, hornbeam, maple, ash, elm, lime, poplar, willow (wild cherry tree, birch, rowan tree)
Coppice with standards	Mainly with sessile or common oak or common or narrow-leaved ash as standards
Pollarding	Not practised
Short rotation coppice	Mainly *Populus*, *Salix*, minimally *Alnus* or *Fraxinus*

Images

Simple Coppice

Coppice stools

Thinning of a coppice stand

Coppice stand vegetation
(Photos: Radim Hédl)

Short Rotation Coppice

Black poplar plantation in the first vegetation period

Black poplar plantation in the last vegetation period before 2nd harvest (6,061 plants per ha, 3 year rotation)

Sixth harvest in black poplar plantation (2,222 plants per ha, 3 year rotation)
(Photos: Petra Štochlová & Kateřina Novotná)

Map

Radim Hédl

Extent of coppicing in the Czech Republic

Currently, there are only six sites in the Czech Republic where coppicing has been restored in about the past decade (since 2007-2008). Altogether, they comprise up to 20 ha of freshly restored coppices and have only gone through one cutting (Fig. 1, black stars). Prior to that, there were no active coppices for the whole second half of the 20th century. Coppices were deliberately transformed to high forest by singling-out of coppice stools. This process was at its peak probably in the first two decades after WW II, but certainly exists at least since the 19th century. The coppicing abandonment had been an overall process started sometime between the end of the 18th to the early 19th century. Active coppices survived only locally until the 1930s–1940s (e.g. Müllerová et al. 2014).

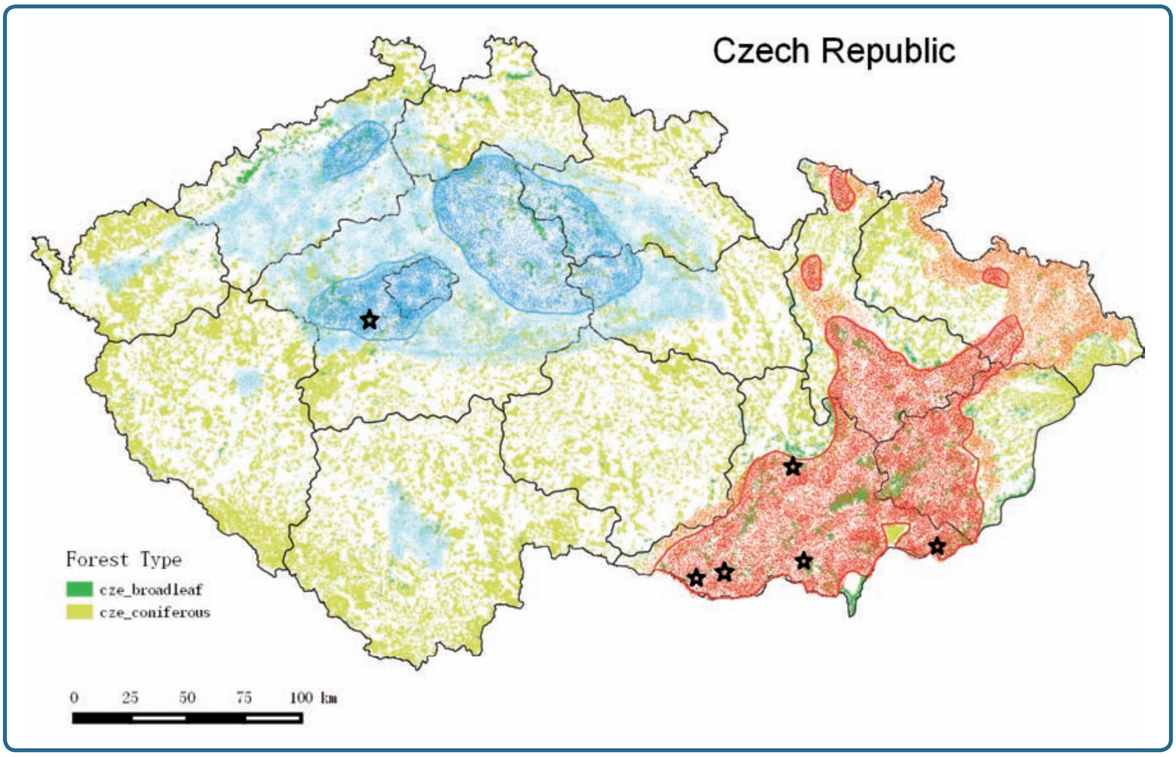


Figure 1. Extent of the historical and current coppicing in the Czech Republic. Map by R. Hédl.

Solid red boundary, red filling:
Core area of historically prevalent coppicing for Moravia and Silesia; based on an unpublished map by Szabó et al.

Orange area, no solid boundary:
Probable additional extent of the core area of historical coppicing in Moravia and Silesia; based partly on an unpublished map by Szabó et al. and my own estimate

Solid blue boundary, blue filling:
Core area of historically prevalent coppicing for Bohemia; based on a map for 1947 by Maděra et al. (2017)

Light-blue area, no solid boundary:
Estimated extent of the core historical coppicing area for Bohemia

Black star:
Sites of restored coppices in 2017; there are 6 sites altogether, some of which have 2 to 3 sub-sites; one such site has already been abandoned (not marked)

Background: Broadleaved forest in dark green, coniferous forest in light green
(Source: EFI forest map of Europe - Kempeneers et al. 2011; Päivinen et al. 2001; Schuck et al. 2002)

Coppicing can be traced back to the Middle Ages (14th century), based on the written evidence. There is, however, some dispute concerning terms and their exact meaning: "rubetum" versus "silva" (see Szabó et al. 2015). The archival data enabled modelling for the extent of coppicing in the Late Middle Ages for the whole Moravia (eastern Czech Republic; l. c.).

The area of the historical coppicing did not change much up until the 19th century. A precise reconstruction of the proportion of coppice forests at the level of cadastres (civil parishes) for the 19th century was made by Szabó et al. (unpublished map). It clearly shows an area with prevalent coppicing, however only for Moravia and small parts of historical Silesia. It is currently the best available reconstruction of the historical coppicing in the Czech Republic, because it is based directly on a large critical database of the historical archival information (www.longwood.cz).

For the western part of the Czech Republic, Bohemia, there is no such map. A predictive modelling was made for the whole country by Maděra et al. (2017), however the reliability of the historical source used for this prediction remains uncertain (digitalized descriptions for the so called Stable cadastre, available at http://archivnimapy.cuzk.cz). The same paper presents a map of the coppiced area in 1947, then already abandoned coppices. It generally conforms to the Szabó's map for the 19th century and can be used for the reconstruction of the historical coppicing in Bohemia.

To conclude, there are two "core areas" of coppicing (Fig. 1) in the Czech Republic. One in Bohemia, another in Moravia and parts of historical Silesia. They are highly correlated with lower elevations (up to 500 m a.s.l.) and high density of human inhabitation (since the Neolithic). In these areas, over 50% of all forest (often 80–90%) was regularly coppiced from at least the Middle Ages until the 19th century. Adjacent areas with less than 50% but probably no less than ca. 10% of coppicing can be estimated or predicted from the combination natural conditions, type of forest etc.

References

Kempeneers, P., Sedano, F., Seebach, L., Strobl, P., San-Miguel-Ayanz, J. 2011. *Data fusion of different spatial resolution remote sensing images applied to forest type mapping*, IEEE Transactions on Geoscience and Remote Sensing, in print.

Maděra, P., Machala, M., Slach, T., Friedl, M., Černušáková, L., Volařík, D., & Buček, A. (2017). *Predicted occurrence of ancient coppice woodlands in the Czech Republic*. iForest-Biogeosciences and Forestry, 10(5), 788.

Müllerová, J., Szabó, P., & Hédl, R. (2014). *The rise and fall of traditional forest management in southern Moravia: A history of the past 700 years*. Forest Ecology and Management, 331, 104-115.

Päivinen, R., Lehikoinen, M., Schuck, A., Häme, T., Väätäinen, S., Kennedy, P., & Folving, S., 2001. *Combining Earth Observation Data and Forest Statistics*. EFI Research Report 14. European Forest Institute, Joint Research Centre - European Commission. EUR 19911 EN. 101p.

Schuck, A., Van Brusselen, J., Päivinen, R., Häme, T., Kennedy, P. and Folving, S. 2002. *Compilation of a calibrated European forest map derived from NOAA-AVHRR data*. European Forest Institute. EFI Internal Report 13, 44p. plus Annexes.

Szabó, P., Müllerová, J., Suchánková, S., & Kotačka, M. (2015). *Intensive woodland management in the Middle Ages: spatial modelling based on archival data*. Journal of Historical Geography, 48, 1-10.

Description

Petra Štochlová

In the past, most of the forest cover in the lowlands, the warm hilly areas and highland areas of the Czech Republic 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 the singling-out of coppice stools, 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 Act no. 289/1995 on Forests, most forests cannot be felled earlier than the age of 80. Simple coppice management is only allowed in six forest management sets of stands. Coppice forests predominantly composed of hardwood 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 softwood trees are in the majority, the recommended rotation length 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.

References

Adamec, Z., Kadavý, J., Kneifl, M., Šplíchalová, M., Klimánek, M., 2014. *The response of basal area increment in old shoot-origin sessile oak (Quercus petraea (Matt.) Liebl.) trees during their conversion to a coppice-with-standards.* Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 62(5), pp. 837–847.

ÚHÚL, 2014. *Informace o stavu lesa (Information about the forest state)* [2015-06-08] Available on: <http://eagri.cz/public/app/uhul/SIL>

Forestry Regulations

Radim Hédl

Forests cover about 34% of the area of the Czech Republic. The long history of forest use in the Czech Lands has been paralleled by regulations applied from local to whole-country levels. Examples of popularly known historical milestones are laws imposed by the emperors Charles IV (14th century) and Maria Theresa (18th century). Countless regulations were applied historically within particular domains and properties, at least since the Middle Ages. After a long period of „traditional" forest management, the eventually prevailing trend was towards „modern" forestry has been in place since the end of 18th century. Originally from Germany, this rational concept aimed to produce the maximum yields of timber while securing the sustainable production of forest stands by applying strict measures protecting soil fertility and tree regeneration.

Consequently, all types of forest use interfering with timber-oriented forestry were suppressed and gradually replaced with highly standardized approach. This meant an end to the three formerly widespread non-timber forest uses, which were coppicing, wood-pasture and litter raking. Tree species composition shifted from mostly mixed and broadleaved stands to the currently prevailing plantations of Norway spruce (52%) and Scotch pine (17%), while broadleaved tree species make up only about 25% of forest composition in the Czech Republic.

The **Czech Act on Forests from 1995** declares its purpose as follows: „The purpose of this Act is to determine conditions for the preservation, tending and regeneration of forests as national riches forming an irreplaceable part of the environment, to enable the fulfillment of all their functions and to support sustainable forestry." An important rule is the 80-year limitation on forest stand felling: „It is prohibited to carry out planned main felling in forests under 80 years of age…" (Art. 33). However, the same article follows: „…in justified cases, during the course of approving the plan or preparing the guidelines or at the request of the forest owner, the relevant state forest administration body may grant exemptions from this rule." The exceptions from the 80-year rule are issued by the Ministry of Agriculture or Regional councils, based on the request of forest owners or on its own initiative.

The **Decree 83/1996 of the Czech Ministry of Agriculture**, provides recommendations on forest management in forest stand categories defined by dominant tree species and habitat conditions. Coppicing with a cutting period of 30 to 40 years is mentioned among recommended management types for several forest categories. Exceptions from the 80-year rule can therefore be plausibly applied in the form of coppicing. In still broader terms, **Article 8 of the Act on Forests** defines three main forest classes from the management perspective. „The class of Special Purpose Forests can be also applied to forests in relation to which a general interest in the improvement and protection of the environment or any other valid interest in the fulfillment of non-wood-producing functions of the forest is superior to the wood-producing functions." One category of **Special Purpose Forests** is defined as „forests necessary for the preservation of biological diversity", cf. letter (f) of the same article.

The Law is simple, its application difficult. Exceptions allowing shorter cutting periods required for active coppicing are granted on stands of fast-growing trees, such as willows, poplars or non-native black locust. In case of slow-growing species such as oaks, exceptions are given very reluctantly. It is largely because of historically-conditioned resistance of the great majority of forestry authorities and practicing forest managers towards short-cutting systems including coppices. The reasons should be sought in the historical development of forestry in the Czech Republic.

In the lowland areas, coppicing yielded most of the wood production in the past. Coppices („low forest“, adopted from German term Niederwald) and coppices-with-standards („middle forest“, from German Mittelwald) were very common both in hardwood and softwood stands. Coppicing was gradually abandoned during the 19th century, partly because of shift to fossil fuels, and completely ceased after the WW II. In the 1950s, during the early communist period of the then Czechoslovakia, coppicing was considered by many influential forestry researchers a „capitalist“ method, targeting at maximum wood production at the cost of depleting of soil nutrients and sustainable wood production capacity. This view basically conformed to the transformation from multiple-use towards timber-oriented forestry during the preceding century.

The second half of the 20th century witnessed a transfer of the remaining inactive coppices to high forest by the means of singling-out of the most dominant stems. This process was far from perfect, hence many today's forests still bear the original coppice structure. The area of these partially converted stands cannot be reliably established from the forestry log books, because the record on the management form is strongly biased towards high forest. Data on the current extent of coppice forests in the Czech Republic is therefore more or less a rough estimate. However, the tireless efforts of the past two hundred years have eventually led to the complete elimination of active coppices in the country.

Current revival of coppicing in the Czech Republic follows the development in western Europe. Relaxation of timber-oriented forestry and greater acknowledgement of ecological values of forests in the past two to three decades creates oppotunities for the return of traditional management forms, including coppicing. It is generally considered suitable for small- to mid-size owners, who would appreciate a regular supply of fuel wood. Another important argument for coppicing reintroduction is to provide support for biological diversity. It has been shown in many studies, both from abroad and directly from the Czech Republic, that coppicing abandonment has led to the decline of several groups of light-demanding organisms, including insects and vascular plants. Coppicing is therefore a relatively recently emerging strategy of nature conservation; it has been applied in several nature reserves. These forests are mostly protected in reserves established under the Czech law, or more recently, as a part of the EU Natura 2000 network.

References

Act on Forests, Law No. 289/1995 of the Czech Republic. Available at http://www.uhul.cz/images/ke_stazeni/legislativa_jazyky/Lesni_zakon_en.pdf

Decree No. 83/1996 of the Czech Ministry of Agriculture.

Lesnictví (Forestry), 1957, volume 3, issue 2; special focus on coppice transformation.

Müllerová, J., Hédl, R., & Szabó, P. (2015). *Coppice abandonment and its implications for species diversity in forest vegetation*. Forest Ecology and Management, 343, 88-100.

Müllerová, J., Szabó, P., & Hédl, R. (2014). *The rise and fall of traditional forest management in southern Moravia: A history of the past 700 years*. Forest Ecology and Management, 331, 104-115.

Szabó, P., Müllerová, J., Suchánková, S., & Kotačka, M. (2015). *Intensive woodland management in the Middle Ages: spatial modelling based on archival data*. Journal of Historical Geography, 48, 1-10.

Denmark

Pieter D. Kofman, Kjell Suadicani, Jenny Mills and Peter Buckley

Facts and Figures

Pieter D. Kofman and Kjell Suadicani

Definitions

Coppice – silvicultural method where the regeneration is vegetative as the shoots come from the stumps and form the new forest. The rotation cycle is short, usually 1-40 years, which means that the trees never reach their full height. In coppice forestry tree species with good ability to stump shoot formation are used, for example, willow, oak, hazel and alder. In Denmark coppice forestry is not very widespread.

Lavskov, skovdriftsform, hvor skovforyngelsen sker ved stævning (vegetativ foryngelse), idet støddene fra de fældede træer sætter stødskud, der vokser op til ny skov. Omdriftstiden er lav, som oftest 1-40 år, hvorfor træerne aldrig når deres fulde højde. Til lavskov benyttes træarter med god evne til stødskudsdannelse, fx pil, eg, hassel og rødel. I Danmark er lavskovsdrift kun lidt udbredt. Se også skovdyrkning og stævningsskov.

Coppice forest - forest that regenerates through shoots from the stump of the felled tree. In Denmark coppice was formerly a common silvicultural system in alder, oak and ash. The system was particularly widespread in Funen and among small forest owners. The system allows for a continuous, steady production of firewood, poles, fencing and similar assortments from even a small piece of forest.

Stævningsskov, skov, der forynges gennem stødskud, dvs. skud fra stubben af det fældede træ; d.s.s. lavskov. I Danmark var stævningsskov tidligere en almindelig driftsform, bl.a. i rødel, eg og ask. Driftsformen var særlig udbredt på Fyn og blandt småskovsejere. Driftsformen giver mulighed for et løbende, jævnt udbytte af ved til brænde, pæle, hegnsmateriale og lignende småeffekter fra selv et lille stykke skov.

In Denmark coppice is now rare, but, for example, in large parts of Europe coppice is widespread. Mechanized coppice forestry has been introduced as energy forest has been established.

I Danmark er stævningsskov nu sjælden, men fx i store dele af Europa er stævningsdrift vidt udbredt. Mekaniseret stævningsdrift har fået fornyet aktualitet i form af energiskov.

Energy forests are plantations of hardwoods with rapid juvenile growth, harvested for use as wood fuel. In Denmark willows are the most used species and the rotation is commonly three years. Energy forests have mostly been planted on former agricultural land. The production is approximately 7 tonnes of dry matter per ha. In 1995 there were approx. 500 ha of energy forest in Denmark.

Energiskov, plantage af løvtræer med hurtig ungdomsvækst, som høstes til brug ved energiproduktion. I Danmark anvendes piletræer, der hugges til flis hvert tredje år, hvorpå de vokser op igen. Energiskove plantes bl.a. på braklagte jorder. Produktionen udgør årligt ca. 7 t tørstof pr. ha; i 1995 var der ca. 500 ha energiskov i Danmark.

Gyldendals large lexicon, translated:
http://www.denstoredanske.dk/Natur_og_ miljø/Skovbrug/Skovdyrkning

Legal Framework

There is a definition of short rotation coppice in the COMMISSION REGULATION (EC) No 1120/2009 of 29 October 2009 on the implementation of the single payment scheme in Title III of Council Regulation (EC) No 73 / 2009, which establishes common rules for the direct support schemes available to farmers:

"Short rotation coppice" means areas planted with those tree species of CN code 0602 90 41 that consist of woody, perennial crops, the rootstock or stools remaining in the ground after harvesting, with new shoots emerging in the following season and that are contained in a list to be drawn up by Member States from 2010 of the species which are appropriate for use as short rotation coppice and their maximum harvest cycle.

(http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:316:0001:0026:EN:PDF)

Statistics

In the Danish forest statistics, ancient management forms cover about 22,000 ha. The proportion of coppice is estimated to be about 6,000 ha of which only few hundred ha is managed the traditional way. Some plantings along roads and railroads are managed as coppice, but we don't have statistics on these areas.

Typology

Simple coppice	Limited use
Coppice with standards	Not practised
Pollarding	Limited use
Short rotation coppice	*Salix*
Other types	Narrow wind break barriers (2-4 m) that are harvested every 30-40 years

Images

Description

Kjell Suadicani and Pieter D. Kofman

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 was not a result of there being 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.

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 supplier of cuttings, planting and 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.

References

Buttenschön, R.M. and O.L. Klitgaard, 2002. *Stævningsskove I Danmark.* Videnblade Skovbrug 3.1-3. University of Copenhagen. 2 pp.

Gram-Jensen, J. and J.R. Stockholm, 2012. *Drift af stævningsskove.* In Skoven 4/2012. pp. 171-175.

Klitgaard, O.L. and R.M. Buttenschön, R., 2002. *Stævningsdrift*. Videnblade Skovbrug 3.1-4. University of Copenhagen. 2 pp.

Larsen, J.B. and A.B. Nielsen, 2006. *Stævningsskov – Skovudviklingstype 91*. Videnblade Skovbrug 3.1-27. University of Copenhagen. 2 pp.

Worsøe, E., 1996. Stævningsskov og stævningsdrift I Danmark. In *Lövtäkt och stubbskottsbruk. Människans förändring av landskapet – boskapsskötsel och åkerbruk med hjälp av skog DEL II*. Kungl. Skogs- och Lantbruksakademin. Stockholm. ISBN 91-87562-89-8. 464 pp.

Forestry Regulations

Jenny Mills, Peter Buckley, Pieter D. Kofman and Kjell Suadicani

There are approximately 610,000 ha of forest in Denmark covering about 14.5% of the land area (FRA 2015). Conifers take up 50% of total forest land and deciduous species just over 46%; the remaining forest land remains bare of trees or the types of trees are unspecified. Sixty-eight percent of the forest area is privately owned and there are about 29,000 forest owners in Denmark. A survey in 2000 showed that 91 % of properties are less than 20 ha in size. Danish state forests (110,000 ha) are managed by the **Nature Agency (Naturstyrelsen)**, which is part of the Danish Ministry of Environment and Food (Miljø- og Fødevareministeriet). It also manages 90,000 ha of light, open areas such as meadows and moors. It has 18 regional offices that supervise private forests to ensure compliance with the Forest Act and to administer grant schemes.

Uncontrolled felling reduced forest cover to 2-3% in Denmark by the early 1800s. A **Forest Act** was adopted in 1805 which banned forest clearance and encouraged afforestation. A forest reserve obligation (fredskov) was introduced to secure future wood supplies. This led to the majority of private forests and all public forests in Denmark being designated as forest reserves, in total about 90% of Danish forests. These are regulated by the Forest Act under a sustainable forest management regime that pays regard to economic, ecological and social factors. The 2002 **National Forest Programme** advocated close-to-nature management and this has been the practice in all Danish state forests and many municipal ones since 2005, replacing the previous age-class forestry management method. However this type of management has not been so readily accepted in privately-owned forests. State-owned forests are **certified** according to both the FSC and PEFC standards.

In the transition to close-to-nature management, **19 'forest development types'** have been described that set objectives for the composition and structure of individual stands.

These include **4 historic types**:

- coppice forest
- forest pasture
- forest meadow and
- unmanaged forest

There is a tradition of coppicing and pollarding in eastern Denmark, particularly on Funen, Langeland, Lolland and Als where there are different types of very species-rich coppice forests. Hazel coppice occurs frequently but over 40 species of trees and shrubs can be found. In Jutland, oak scrub with some aspen has been used in the past for grazing and pollarding. Many oak forests were cut down during WW2 and no felling has since taken place although there is some scrub that is still pollarded.

The latest version of the Forest Law (Legislative Decree no. 678 of 14 June 2013, with changes imposed by § 3 of Law no. 86 of 28 January 2014) prescribes the use of forest reserve land. Guidance on the interpretation of the Law is given on Naturstyrelsen's website (https://www.retsinformation.dk/forms/r0710.aspx?id=175267). The Law does not require forest management planning at the level of individual properties, although this will, presumably, be carried out when applications are made for PEFC or FSC certification. Owners are not required to apply for logging permits or to notify the authorities before logging begins.

Some of the Forest Law provisions are:

- Areas must be stocked with trees that form, or within a reasonable period of time (up to 10 years) will form, a connected forest of standard trees. This excludes areas needed for forest management, such as roads, storage spaces, loading docks, firebreaks, forest nurseries, etc. and the other exceptions mentioned below.

- Harvesting, except thinning, may not take place before the vegetation or the individual tree has reached the age or dimension where it is mature and ready to harvest. This applies to single trees in uneven-aged forests or to stands of even-aged trees. Exceptions to this rule are mentioned below. Clear-cuts should be avoided where possible. A border of deciduous trees and shrubs on the external edges of forest reserve areas must be preserved; the width of these will vary depending on local circumstances. Safety considerations will dictate treatment of forest which also has a role as 'protection forest', e.g. for railways and roads.

- Coppicing can be carried out on up to 10% of a forest reserve without a derogation. Animal husbandry is prohibited, but forest grazing is permitted on 10% of a forest reserve provided any fencing does not prevent public access where the Nature Protection Act allows it. It is expected, although not required by the Law, that such operations are carried out where there is a historical tradition for this type of forestry or for cultural reasons. This applies to species, such as hazel, alder, ash and oak but also to other suitable species where they have been traditionally coppiced locally and also includes pollarding of willow.

The 10% is calculated from the total area of each forest reserve including any non-vegetated areas. One owner's property may contain several forest reserve areas and in such cases the 10% applies to each individual area. However, if they are physically separated from each other, the 10% areas cannot be aggregated and the coppicing or grazing carried out in only one of them.

A dispensation to allow coppicing or forest grazing on more than 10% of a forest reserve area may be given if traces of this type of management can be found on the forest reserve area. This could be the case for many properties with old coppice that dates back hundreds of years and where it is desirable for whole forest areas of, typically, 1 to 5 ha to be coppiced.

The 10% rule also applies to growing Christmas trees and other greenery, as long as this is short-term, i.e the trees must not be grown to maturity. The area to be planted must not affect valuable or vulnerable habitats and they must be surrounded by a belt of hardwood trees.

In addition to the areas that can lawfully be without woodland, **open natural areas** can be established for up to 10% of a forest area in order to promote nature and landscape values, cultural and biological diversity. This could include forest meadows or protected natural areas, and areas under natural succession but it excludes areas planted with agricultural crops, fruit trees, berry bushes, flower production, etc. Any deforestation necessary to open a natural area may be subject to an **Environmental Impact Assessment** if it might significantly affect important habitat areas. There is an obligation to report any proposed deforestation for EIA screening, regardless of whether it is on a forest reserve or not. Other open areas may be permitted if required by the **Nature Protection Act** or the **Buildings Preservation Act**.

The Forest Law includes provisions to conserve oak scrub forest (4,725 ha), which is found especially in central and western Jutland. Alder carrs may be subject to the Nature Protection Act and designated as a priority habitat under the EU Habitats Directive. Also, lakes, bogs, heaths, salt marshes, meadows and biological commons that belong to the forest reserves and are not covered by the Nature Conservation Act must not be drained, planted or otherwise altered.

The Forest Act and Nature Protection Act require that some operations in **Natura 2000** areas, which would otherwise be allowed under the Forest Act, be notified to the relevant authorities before implementation, so that an assessment can be made as to whether they could lead to habitat deterioration or disturbance to species for which the site has been designated. This includes coppicing. If necessary, conditions will be agreed with the owner if possible or imposed if not. The obligation to notify is independent of whether there is a Natura 2000 plan or management plan. Activities that require a derogation from the Forest Act or other legislation need not be notified because an assessment in relation to Natura 2000 protection will be made when the derogation application is processed.

References

Act on forests https://www.retsinformation.dk/forms/r0710.aspx?id=175267

Ministry of Environment & Food of Denmark Agency for Water & Nature Management Facts on Danish Forests http://eng.svana.dk/nature/forestry/

Jensen, C. L. (2012) *Forests and forestry in Denmark – Thousands of years of interaction between man and nature.* http://www.nordicforestresearch.org/wp-content/uploads/2012/07/ForestandforestryinDenmark.pdf

Larsen, J. B. (2012) Close-to-Nature Forest Management: The Danish Approach to Sustainable Forestry 3. Close-to-nature forest management in Denmark. In: *Sustainable Forest Management - Current Research* (eds. J. Martin Garcia and J. J. Diez Casero) In Tech http://cdn.intechopen.com/pdfs/36975.pdf

Estonia

Katrin Heinsoo, Indrek Jakobson, Jenny Mills and Peter Buckley

Facts and Figures

Katrin Heinsoo and Indrek Jakobson

Definitions

Coppice forests are considered a traditional form of passive silviculture that involves: (1) repetitive felling on the same stump (2) the meanings of "coppice" and "short-rotation coppice" are considered to be the same. Coppice is very common, but not undertaken as a form of silviculture.	*Lühikese raieringiga metsandus*

Legal Framework

Coppice forestry, as with all of other forestry, is mainly regulated by two legal acts:

1) Estonian Forestry Law

2) Estonian Forestry Development plan 2012-2000.

Typology

Simple coppice	Historically common method of forest regeneration, but losing ground
Coppice with standards	No special standards for coppice
Pollarding	Only on roadsides and on islands
Short rotation coppice	Short Rotation Coppice is managed on agricultural lands Willow, Hybird Aspen, Grey Alder
Other types	Very few stands for environmental projects and scientific purposes (Estonian University of Life Sciences) Water cleaning in Tartumaa and Lääne-Virumaa counties, Hybrid aspen etc.; plantations

Images

Description

Katrin Heinsoo

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

Coppice forest management has never been a cultural tradition in Estonia; re-sprouting of stools occured simply as a result of use. Due to the cold climate, firewood has always been needed in large quantities. Typically this was collected manually during wintertime from the low quality forest areas, mainly wet sites dominated by broadleaf trees (alders, aspens or willows) (RMK, 2016). Usually clearcuts were not performed; instead older, unhealthy, too dense or dead trees were cut (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 in which coppiced trees can be found, is one specific type of semi-natural grasslands – wooded meadows (NATURA 2000 type 6530*). Historically, the main aim of this particular management form was to provide the cattle of the landowner with grass during grazing period or hay during wintertime (Talvi, 2010). Pruning of bushes and trees was also an option during years of poor biomass production. The main aim of the trees in this landscape was to provide the cattle with shelter, as well as increase soil fertility and moisture through the deeper root-system of the 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 over 20 years ago we planted the first experimental Short Rotation Coppice (SRC) plots with different willow species in different parts of Estonia in order to promote the local economy and renewable energy production. Since then we have performed different studies on the usage of SRC for woodchip production (Heinsoo et al., 2002), the purification efficiency of SRC vegetation filters (Holm and Heinsoo, 2013) and other ecosystem services that can be provided by SRC (Poplars and willows, 2016). However, due to legislative limitations on the establishment of SRC, the lack of a 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 1. Examples of coppice and short rotation coppice in Estonia

References

Eesti statistika, 2016. http://www.stat.ee/metsamajandus

Heinsoo, K., Sild, E. and Koppel, A., 2002. *Estimation of shoot biomass productivity in Estonian Salix plantations.* Forest Ecology and Management, 170, pp. 67-74.

Holm, B. and Heinsoo, K., 2013. *Municipal wastewater application to Short Rotation Coppice of willows – Treatment efficiency and clone response in Estonian case study.* Biomass and Bieoenergy, 57, pp. 126-135.

Keskkonnaministeerium, 2016. http://www.natura2000.envir.ee/?nodeid=26&lang=et

Paal, J., 2000. L*oodusdirektiivi" elupaigatüüpide käsiraamat.* Eesti NATURA 2000.

Isebrands J.G. and Richardson J. (Eds.) 2016. *Poplars and willows: trees for society and the environment.* http://www.fao.org/forestry/ipc/69946@158687/en/RMK, http://loodusegakoos.ee/puuri-uuri/metsanduse-ajalugu/sae-kasutuselevott

Talvi, T., 2010. *Eesti puisniidud ja puiskarjamaad,* Keskkonnaamet.

Valk, U. and Eilart, J., 1974. *Eesti metsad*. Valgus, Tallinn.

Forestry Regulations

Jenny Mills, Peter Buckley and Katrin Heinsoo

The area of Estonia is 45,227 km^2. Just over half of the country is covered with 2.2 M ha of forest of which 1.6 M ha is manageable forest. Deciduous trees account for 51% of stands; 49% are conifers. The most common tree species are Scots pine, Norway spruce, Silver and Downy birch, aspen, Black alder and Grey alder. 47% of the forest area is in private ownership, the state owns 41% and 12% is still "subject to privatization". State forests are managed and marketed by the **State Forest Management Centre** (Riigimetsa Majandamise Keskus, RMK) and overseen by the Ministry of the Environment (Keskkonnaministeerium). A forestry development plan is prepared every 10 years and approved by the Estonian Parliament (Riigikogu). The principal goals of the **'Estonian Forestry Development Program until 2020'** are to safeguard forest productivity and viability and ensure the varied and effective use of forests. At least 10% of forest land is under strict protection.

Coppice management is not practiced, except in Short Rotation Coppice willow, poplar and alder plantations, but it has been used in the past in traditional wooded meadows, which are species rich and classified as a **European priority habitat** (6530 Fennoscandian wooded meadows). As well as hay harvesting and collection of wood for fuel, branches with leaves were coppiced or pollarded and dried for winter fodder. It is estimated that wooded meadows covered nearly 19% of Estonia's surface area at the end of the 19th century, but only approximately 8400 ha now remain, of which about 2700 ha are protected.

Since the early 1990s there have been several **Forest Acts**, each with amendments. The current Act does not apply to detached plots of forest land of less than 0.5 ha, or land where the average age of trees does not exceed 10 years and is not registered as forest land - even though it may comply with other definitions of forest land (at least 0.1 ha with woody plants at least 1.3m high and with canopy density of at least 30%). Estonian forestry is supervised by the Environmental Board of the Ministry of the Environment who give consent for felling operations.

Some of the provisions of the most recent Act are:

- A forest survey is carried out to receive data on the condition of forest and the volume of growing stock, to advise forest owners and to plan long-term forest management activities. The guidelines give the requirements for forest mapping; the objectives and methods of forest inventory; requirements for planning forest management; the methods of calculating the prescribed cut; and the requirements for preparation of forest management plans. The inventory data in force is mandatory for an improvement cutting, thinning and selective cutting. A forest management plan will be prepared for a forest owner together with forest inventory, unless the forest owner does not wish it.

- The following types of cutting are permitted: regeneration cutting, including clear cutting and shelterwood cutting; improvement cutting, including cleaning in stands with the average DBH of up to 8 cm, thinning in stands with the average DBH of 8cm and larger, and sanitary cutting; track cutting, including the cutting of 'quarter' or boundary lines; the cleaning of an existing ride or road shoulder, ditch bank or ditch shoulder from trees with the average DBH of more than 8cm; formative cutting in a protected area to attain a goal complying with the protection management plan, an action plan for the protection and control of a species, or for the purpose of preservation and improvement of the status of the protected area or key habitat.

- A forest owner must replant clear-cut areas over 0.5 ha within 2 years after cutting, although this is not necessary if natural regeneration with a suitable species composition and number of plants on the whole area is sufficient.

- Regulation of the water and nutrition regime of forest soil is permitted, but fertilisation of forests, except forest nurseries, with mineral fertilisers is prohibited.

- The minister responsible will establish the rotation age at which clear cutting is permitted per tree species and quality classes, making certain that it is: 90-160 years for pine and hard broadleaved tree stands; 80-120 years for spruce; 60-80 years for birch and black alder; 30-50 years for aspen.

- When clear cutting, all trees should be cut from the cutting area within 1 year after the beginning of the cut except for: 20 to 70 pines, white birches, ashes, oaks, black alders, European white elms or Scots elms per hectare, dispersed or in small groups, which are left as seed trees, and viable undergrowth. Seed trees will not be left if there are no trees suitable or if viable undergrowth of the tree species suitable for the forest site type exists in the cutting area for reforestation and is preserved when cutting.

- Old crop trees, i.e. trees necessary to ensure biological diversity, or the preserved standing parts of such trees, should be left so there is a total volume of stem wood of at least 5 solid cubic metres per hectare, or in the case of a cutting area sized over 5 ha, at least 10 cubic metres per ha.

- Key habitats: areas up to 7 ha needing protection and where there is a high probability of finding endangered or rare species. In state forests, the state forest manager organises the protection of key habitats in accordance with a ministerial directive. Protection of a key habitat is by a contract with the owner which gives the Ministry of the Environment a right of use for 20 years which may restrict economic activities. The forest owner must ensure its preservation. About one third of forests are covered with management restrictions.

- Protective forest: In forest designated by a plan for the protection of a settlement or residential building against air pollution, noise, strong wind or snowstorm or for reducing the fire risk or prevention of the spread of forest fire, the local authority may, by agreement with the landowner, establish restrictions as to the type of cutting for regeneration cutting and to the size of the cutting area and the rotation age in the event of clear cutting.

- A cutting right (raieõigus) is necessary to prove the legality of cutting, delivery of timber, etc. The right is established by an entry in the land registry, a transfer deed for the cutting right or timber, permission from the Environmental Board or a forest notification in the state register of the forest resource and an identity document.

- A forest owner, or his representative, must submit a forest notification to the Environmental Board concerning planned cuttings, except cleaning; or serious forest damage. The Environmental Board verifies the compliance of the planned cutting with the legislative requirements, valid inventory data or data about the condition, age, basal area and forest resources if the inventory data does not reflect the actual situation. If the planned activity does not comply with the legislation, the Environmental Board has the right to ban the activity, and making recommendations for bringing the activity into compliance with the legislation.

- A forest owner may cut, without submitting a forest notification or without registering with the state register of the forest resource, up to 20 solid cubic metres of wood per 'immovable' (a particular type of property) per year.

Forest certification

Both PEFC and FSC schemes are used in Estonia. PEFC is most commonly used in private forests; about 110,000 hectares of private forests are certified. State forests are certified by both PEFC and FSC.

Natura 2000

N2000 sites in Estonia are protected under the 2004 Nature Conservation Act. Management plans are compiled and approved by the Environmental Board (Keskkonnaamet). About 18% of total forest area is covered by Natura 2000.

References

Forest Act from the 2015 English translation: https://www.riigiteataja.ee/en/compare_original/525032015010

Marek Sammul, Kaili Kattai, Kaire Lanno, Vivika Meltsov, Merit Otsus, Liggi Nõuakas, Dora Kukk, Meeli Mesipuu, Silja Kana and Toomas Kukk (2008) *Wooded meadows of Estonia: conservation efforts for a traditional habitat*. Agricultural and Food Science 17: 413-429.

Republic of Estonia Environmental Board: http://www.keskkonnaamet.ee/eng/acivities/forestry/

http://www.keskkonnaamet.ee/eng/acivities/nature-conservation/

Finland

Jyrki Hytönen, Jenny Mills and Peter Buckley

Facts and Figures

Jyrki Hytönen

Definitions

Woodland that has been regenerated from shoots formed at the stumps of the previous crop trees, root suckers, or both, i.e., by vegetative means. Normally grown on a short rotation for small material, but sometimes, to a substantial size.

Vesametsä. Kanto- tai juurivesoista vegetatiivisesti syntynyt metsä. Vesametsiä kasvatetaan tavallisesti lyhyellä kiertoajalla mutta joskus tavoitteena voi olla myös ainespuun tuotanto.

Typology

Simple coppice	Not practised (however, birches of stump sprout origin are accepted in regeneration areas to fill in the plantation)
Coppice with standards	Not practised
Pollarding	Only in gardens and parks
Short rotation coppice	Mainly small scale plantations with *Salix, Alnus incana, P. tremula x tremuloides, Betula pubescens*

Images

Examples of Short Rotation Coppice

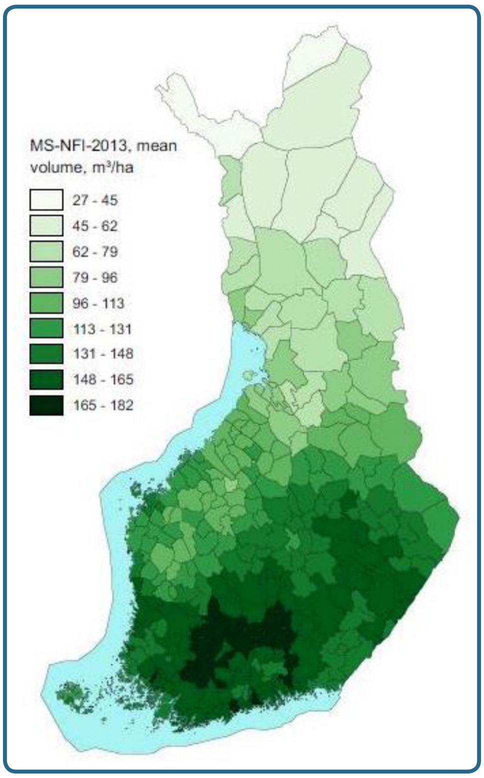
One-year-old hybrid aspen

Grey alder in Central Finland

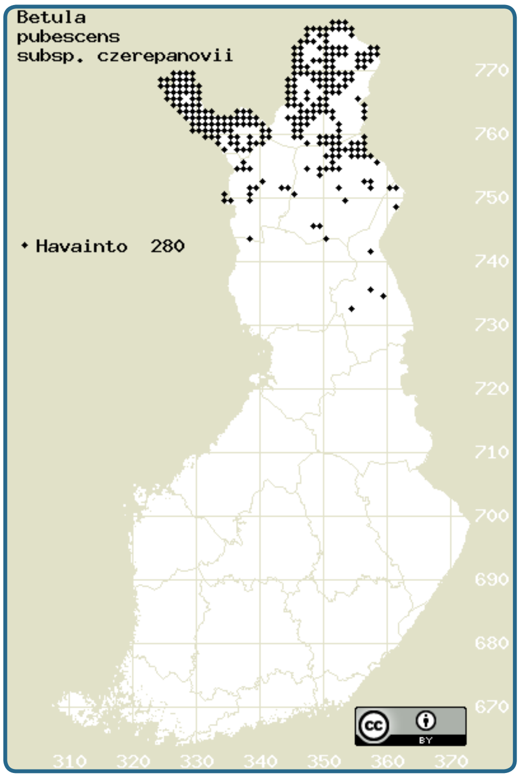
Downy birch in Lapland

Maps

Jyrki Hytönen



The mean volume of growing stock on forest and less productive forest land by municipalities in Finland (Mäkisara et al. 2016)



Mountain birch is most common in Finland's three northernmost municipalities; this species was coppiced in the past (Lampinen and Lahti 2017)

Mäkisara, K. Katila, M., Peräsaari, J. & Tomppo, E. 2016. *The Multi-Source National Forest Inventory of Finland – methods and results 2013*. Natural resources and bioeconomy studies 10/2016. http://urn.fi/URN:ISBN:978-952-326-186-0

Lampinen, R. & Lahti, T. 2017: *Kasviatlas 2016*. University of Helsinki, Finnish Museum of Natural History, Helsinki. http://www.luomus.fi/kasviatlas.

Description

Jyrki Hytönen

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% Norway spruce (*Picea abies*), 16% birch (*Betula pendula* and *B. pubescens*) and 4% 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, there have been recommendations to coppice 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. Pollarding was used in small areas 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), growing 'energy forests' may become economically viable in the future. Energy plantations based on fast growing deciduous tree species, grown in dense stands and renewed by coppicing, have been studied in Finland, with a focus on short-rotation willow. This research was begun in Finland in the late 1970s with extensive studies of cultivation methods. However, due to the combination of falling oil prices and 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.

Due to Finland's northern location, other native deciduous tree species have been the subject of short-rotation coppice (SRC) research. The rotation for coppicing native birches, alders and aspens is between 20 and 30 years, which

Figure 1. One-year growth of energy willow in south Finland (left) and four years old downy birch coppice in northern Finland (right)

is considerably 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.

Forestry Regulations

Jenny Mills, Peter Buckley and Jyrki Hytönen

About 20% of the total growing stock volume in Finland (2 357 mill. m^3) is of broadleaved species, the other 80% is composed of Norway spruce and Scots pine. Birches (silver birch and downy birch) constitute 83% of the growing stock of broadleaved species. There are no traditionally-managed coppice forests in Finland today, although coppicing was historically carried out on a very small scale in the south of the country. However, some trees of coppice origin can still be found in normal forests.

New forest legislation to ensure sustainable forestry came into force in 2014 including amendments to the 1996 **Forest Act** (metsälaki) and provisions for protected forests in the **Nature Conservation Act** (luonnonsuojelulaki). The amendments to the Forest Act aim to increase the freedom of choice of forest owners in managing their own forest property, to improve the profitability of forestry and operating conditions of the forest industry, and to enhance the biodiversity of forests. One important objective in the reform was to have less detailed regulation on the treatment of forests and to clarify the legislation. The most important changes include allowing uneven-aged forest stands, abolition of age and diameter limits in regeneration, a more diverse range of tree species, and an increase in habitats of special importance. Notification of the establishment of seedling stands is no longer required and supervision is targeted at the results of regeneration, for which new minimum limits have been specified.

The **Finnish Forest Centre** (Suomen metsäkeskus), a state-funded organisation, enforces forestry legislation. It also promotes forestry and related livelihoods, advises landowners on how to care for and benefit from their forests and ecosystems, and collects and shares data related to Finland's forests. The Finnish Forest Centre operates under the guidance of the Ministry of Agriculture and Forestry (Maa-ja metsätalousministeriö).

The Ministry of Agriculture and Forestry prepares a **National Forest Programme**, the objective of which is to promote diverse use of forests in line with the principle of sustainable development. The Forestry Centre prepares a **Regional Forest Programme** in its own territory and monitors its implementation. The programme contains objectives for sustainable forest management, objectives to be set for measures referred to in the legislation on the financing of sustainable forestry and general objectives for the development of forestry in the region. Both processes are participatory and a wide range of interest groups are involved in them.

Some regulations of the Forest Act:

- When intending to carry out felling, the landowner should send a forest use declaration (Metsänkäyttöilmoitus) to the Forestry Centre no later than 10 days, but no sooner than 3 years, prior to the date on which felling or other operations are due to start.
- A forest use declaration is not needed for subsistence felling for household use, for small-sized trees of a mean diameter of up to 13 cm or if they are in the marginal zones of power lines and railways or felling for a ditch, water pipe or sewer line, small areas of road, electricity or other similar lines, unless the fellings are in a habitat of special importance.
- There are seven types of habitats of special importance for biodiversity mentioned in the Forest Act, but which are small in area. Forests in these habitats must be managed and utilised cautiously so that the characteristic features of

the habitats are preserved or reinforced. Among others, these include habitats near streams and ponds, various mire, fen and flooded habitats, herb-rich forest patches, which include natural or semi-natural tree and shrub stands, and heathland forest located in undrained peatlands or peatlands where the natural water economy has for the most part remained unchanged. Actions that must not be taken in habitats of special importance include regeneration felling, forest road construction, treatment of the soil surface that may damage vegetation characteristic of the site, ditch drainage, cleaning of brooks and rivulets and use of chemical pesticides.

- In habitats of special importance, cautious fellings can take place by choosing individual trees that preserve the stand in its natural or semi-natural state so that the natural or semi-natural water economy of the habitat does not change. No wood harvesting may be done in steep bluffs and the forest lying directly underneath. In sandy soils, exposed bedrock and boulder fields, cautious fellings can take place by choosing individual trees so that old, as well as dead and decaying trees, are preserved.

- Intermediate felling for the purpose of growing the remaining tree stand or that promotes the creation of new seedling material shall be done such a way that after the intermediate felling a sufficient and evenly distributed stand with growth potential is left in the treatment area. Matters to be taken into account in assessing the sufficiency of the stand to be left include the geographical location of the treatment area, site, method of implementing the intermediate felling and dominating height, which means the arithmetic mean of the one hundred thickest trees within a hectare. Intermediate felling involves a forest regeneration obligation if the volume and status of the remaining stand is not sufficient to create a new stand.

- Regeneration felling resulting in an open area except for the retention of seed or shelter trees to produce a new tree stand, involves a forest regeneration obligation if the exposed area exceeds 0.3 hectares. In forest regeneration, a seedling stand may be established with seedlings or seed of pine, spruce, silver birch, aspen, Siberian larch, maple, common alder, oak, European white elm, Scotch elm, small-leaved linden, ash and hybrid aspen of suitable provenance. According to the Decree on Sustainable Management and Use of Forests (1234/2010), regeneration of aspen and hybrid aspen by sprouting is also allowed. A seedling stand may be established with seedlings or seed of downy birch only in peatland, paludified sections of mineral soils and compact soils dominated by clay or silt. In other sites downy birch may be used as a supplementary tree species depending on its site and the geographical location of the area.

The Forestry Act is not applicable in, among other places, protected areas established under the Nature Conservation Act, areas purchased by the State for nature protection purposes, or other State-owned areas managed in accordance with a protection decision of the state forest administration, Metsähallitus, or other authority administering State lands, or in areas referred to in the Act on Wilderness Reserves other than the seven habitats of special importance mentioned above. The majority of nature reserves are located on state-owned land and maintained by Metsähallitus.

The **Ministry of the Environment** (Ympäristöministeriö) guides and monitors nature conservation in Finland. It prepares legislation to maintain biodiversity and is responsible for the general monitoring of the implementation of this legislation. The Ministry also prepares nature conservation programmes and establishes nature reserves under these programmes.

Furthermore, it approves the management and use plans of major nature reserves. The **Finnish Environment Institute** (Suomen ympäristökeskus) researches and assesses biodiversity, serving various public bodies and agencies, businesses and communities. It assesses the endangered status of organisms and habitats, conducts research on the management and restoration of different habitats, and on the importance of ecosystem services and their interaction with biodiversity.

Centres for Economic Development, Transport and the Environment

(Elinkeino-, liikenne- ja ympäristökeskukset - ELY Centres) promote and supervise nature conservation and landscape protection in their respective regions. They safeguard biodiversity, for example, by establishing nature reserves on privately owned land, acquiring areas for the state, for the purpose of nature conservation, approving proposals for protected areas and management and use plans for these areas, safeguarding natural values in land use planning and planning the management and use of Natura 2000 areas. If a felling operation is to be carried out in a Natura 2000 site, or in its vicinity, which could significantly damage the natural value of the area, a declaration must be made to the area's ELY Centre.

About 18% of Finland's forestry land is **protected** or under restricted forestry use. The share of strictly protected forests is almost 14%. About 95% of commercial forests are PEFC **certified**.

References

Centres for Economic Development, Transport and the Environment (ELY Centres). https://www.ely-keskus.fi/web/ely-en/environment;jsessionid=756C1339A1CDC83BEBF92D2B4ACBB69F

Ministry of Agriculture and Forestry. http://mmm.fi/en/forests/legislation

Ministry of Agriculture and Forestry. Forest Act. http://www.finlex.fi/fi/laki/kaannokset/1996/en19961093.pdf

Natural Resources Institute. http://www.metla.fi/metinfo/sustainability/SF-2-forestyr-and-environmental.htm

Nature Conservation Act. http://www.finlex.fi/en/laki/kaannokset/1996/en19961096.pdf

Finnish Forest Association. http://www.smy.fi/en/forest-fi/

France

Philippe Ruch, Jenny Mills and Peter Buckley

Facts and Figures

Philippe Ruch

Definitions

Simple Coppice: forest whose trees have been regenerated at the same time, by allowing regrowth from cut stumps or root suckers. Thus, all trees are even-aged and are about the same size (diameter and height).

Taillis simple: peuplement forestier composé d'arbres issus de rejets et drageons auquel est appliqué un traitement régulier. De ce fait, il est constitué d'arbres de dimensions (diamètre, hauteur) voisines et il est équienne.

Compound coppice with standards system: forest stand composed of high forest (broad-leaves or coniferous, even-aged or uneven-aged) and coppice, side by side or stacked.

Mélange de futaie et taillis: peuplement forestier constitué d'une futaie feuillue et/ou résineuse, régulière ou irrégulière, superposée ou juxtaposée à un taillis.

Delpech R. et al., *Typologie des stations forestières – Vocabulaire*, IDF, 1993

Short Rotation Coppice (SRC): rotation from 7 to 10 years, objective is to produce small trees (diameter 15 cm, height 15-18 m).

Taillis à Courtes Rotations (TCR): rotations de 7 à 10 ans, objectif produire de petits arbres (15 cm de diamètre, hauteur 15-18 m).

Very Short Rotation Coppice (VSRC): rotation from 2 to 4 years, objective is to produce small shoots (diameter 3 - 5 cm, height 4-8 m).

Taillis à très courtes rotations (TTCR): rotations de 2 à 4 ans, objectif produire beaucoup de petits brins (3 à 5 cm de diamètre; hauteur 4 à 8 m).

Berthelot A., *Produire de la biomasse avec des taillis de peupliers*, AFOCEL, 2007

Legal Framework

Forest-related activities naturally have to comply with the National (French) Forest Policies. Logging operations, which are not planned in a approved management document, are generally subject to an application for authorisation. It varies according to the situation of the forest and the size of the clear-cut.

Statistics

Simple coppice forest structures represent 1.7 million ha (11% of the French forests) and compound coppice with standards system 4.7 million ha (30%).

Source: National Forest Inventory, 2013. Les résultats des campagnes d'inventaire 2009 à 2013.

Short-Rotation Coppice (SRC) and Very Short Rotation Coppice (VSRC) cover merely a few thousand ha in France and are therefore quite marginal.

Typology

Simple coppice	Mediterranean coppices (*Quercus ilex* and *Quercus pubescens*): 52% of the simple coppice area and *Castenea sativa*, 13% of simple coppice; more locally, there are also coppiced *Fagus sylvatica* in the mountains, *Quercus robur* and *Quercus petraea* and more marginally *Alnus glutinosa* and *Robinia pseudoacacia.*
Coppice with standards	*Carpinus betulus, Quercus robur* or *Quercus petraea* coppices and standards of common oaks on clayey loam soils in central and northeastern France. Other species such as *Betula verrucosa, Fagus sylvatica* and *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.
Pollarding	Only in some rural regions (*Quercus* and *Fraxinus* mostly)
Short rotation coppice	SRC: *Populus, Eucalyptus, Robinia pseudoacacia* VSRC: *Populus, Salix, Robinia pseudoacacia*

Images

Description

Philippe Ruch

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 (*Q. pubescens*), which represent 52% of the simple coppice area; coppicing is still the main silvicultural system and firewood the 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 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 1980s. More recently (2008 to 2012), an attempt has been made 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 eucalypt SCR continues to be planted in the southwest of France.

Figure 1. Hornbeam coppice with pedunculate oak standard in northeastern France (left) and chestnut coppice in western France (right)

References

Corvol A., 2009. *Le taillis énergétique: le retour du passé.* Journée technique Les taillis à courte rotation: une biomasse pour demain. 4 p.

National Forest Inventory, 2013. *Les résultats des campagnes d'inventaire 2009 à 2013*, pp 20-34.

Forestry Regulations

Jenny Mills, Peter Buckley and Philippe Ruch

The **Code Forestier** contains the laws regulating French forests. Interpretation and implementation of the Code filters down through various levels of Government documentation including les Orientations Régionales Forestières (**ORF**), which describe the sustainable management objectives of forestry policy for regional administrative areas taking into account economic, environmental and social issues. They specify the broad guidelines to be followed by the entire forest industry and concern all public and private forests and sector participants (foresters, forestry companies, manufacturers and wood processors). The ORF sets forest policy at a regional level as well as general action programs for the **DRA** (Directive Régionale d'Aménagement des forêts domaniales), **SRA** (les Schémas Régionaux d'Aménagement des forêts communales), and, for private forests, **SRGS** (le Schéma Régional de Gestion Sylvicole).

If a forest-owner has an approved sustainable management document, then planned coupes and other management operations do not usually need separate authorisation. For public or community forests, the "aménagement" constitutes the sustainable management document.

In private forests, there are 3 principal types of sustainable management documents, depending on the size of the forest and the owner's choice:

PSG (plan simple de gestion)

Obligatory where the cumulative area of the owner's forest plots located in the same municipality is equal to or greater than 25 hectares (a continuous area or the sum of fragmented patches over 4 ha in nearby municipalities). The plan lasts for 10 - 20 years and is approved by the CRPF*. A voluntary PSG can be carried out for properties between 10 and 25 hectares.

*Centre Regional de la Propriété Forestière France is divided into 11 CRPFs, delegated from the Centre National de la Propriété Forestière, a public advisory and management service for forestry owners. They are administered by elected forest owners and run by a team of forestry engineers and technicians. They direct and promote improved management of private forests.

RTG (règlement type de gestion)

An optional management document that is intended to define management arrangements for owners of forest of between 10 and 25 ha. It is overseen by an 'organisme de gestion et d'exploitation en commun' (OGEC*) and leads to at least 10 years of commitment.

*An OGEC is an organisation of proprietors for communal forestry management and exploitation. It can be a cooperative or management syndicate or an association of forestry proprietors as defined by a specific law.

CBPS (code des bonnes pratiques sylvicoles)

An optional document for small properties, drafted by the Centre Régional de la Propriété Forestière (CRPF) and validated by the Prefect of the region, which includes the essential recommendations by type of stand consistent with sustainable management. The owners adhere to it for a period of at least 10 years.

What regulations must be followed if wood is to be harvested? In privately-owned forests, whatever the size of the property, 2 cases may apply depending on whether a management plan has been established or not.

i) If such a plan exists, its compliance with the regional directives has been approved by the authorised administration and a harvesting operation need only comply with the plan (i.e. it meets the management objectives).

ii) If there is no management plan, then the harvesting operation will fall under specific regulation. The most common situations are:

• If the size of the future operation is > 4ha† and more than half of the volume of the standing standards are to be harvested: the operation needs to be authorised by the county administration (DDT - la Direction Départementale des Territoires)

• If the operation is a final felling (or clearcut) > 1ha† in a forest larger than 4ha†: the stand must be re-established (regeneration or plantation) at the latest 5 years after harvest

• Moreover, some forests may fall under municipal jurisdiction: they are classified in EBC (Espaces boisés classés), areas that need to be preserved (clearcuts for coppice are only allowed if they are considered a "usual" harvesting operation, every operation has to be approved by the municipal council).

Independently of the existence of a management plan, the location of the forest can also be subject to specific environmental regulation according to the nature of the area (specific protection status such as, e.g. Natura 2000, water).

...

An exception is made for cuts that are for the owner's own domestic use for firewood or for his agricultural fencing requirements, but not for timber. Where the firewood is sold, or more than a third of it is given away, authorization is necessary. The relevant article in the Code Forestier (L312-10) does not indicate what quantity or diameter of wood can be cut for the owner's domestic use.

Cutting of poplar plantations is not affected by these regulations. Thinning necessary for the good management of softwood stands will be authorized.

From a general point of view, clear-cuts or stand regeneration will be allowed where the stand has reached or exceeded the minimum age of exploitability defined for that type of stand in the Scheme of Regional Woodland Management (SRGS). For younger stands, an analysis is made on a case by case basis.

Penalties

Cutting without authorisation is illegal according to articles L313-11 et L362-1 of the Code Forestier. The agent or proprietor will receive a fine of € 20,000 per hectare for the first two hectares and € 60,000 for each supplementary hectare.

Obligatory renewal after clearcutting

All stands of 1 ha† or more in one piece located in a forest larger than 4 ha†, regardless of stand type (standards, coppice-with-standards or simple coppice), belonging to one owner or tenant, must be restocked. This can be by regeneration or planting.

Zones where other legislation can apply

Some logging may also be subject to other regulations, for example, in wooded areas classified as an EBC*, and in, or near other protected environmental (including Natura 2000 sites), historical or architectural sites.

*Under Article L. 130-1 of the Town Planning Code (Code de l'urbanisme), a 'plan local d'urbanisme' (PLU) can classify a site as an 'Espace boisé classé' (EBC) in order to protect or create woods, forests, parks, individual trees, hedges and plantations. This also takes account of the 'Grenelle II' laws relating to the national commitment to the environment. Cutting

† Noted here are the most common cases; the actual figures are decided upon by the regional Prefect.

of mature coppice can be exempt from prior notification in an EBC as long as renewal is satisfactory and other restrictions on cutting of the standards observed.

Natura 2000 sites

There are no supplementary formalities for Natura 2000 sites for felling or woodland management, but these must be in accordance with existing regulations relevant to the site. Each Natura 2000 site has a 'document d'objectifs' (DOCOB), which sets out the management objectives for the site and how they are to be achieved, among other things.

A PSG or RTG cannot be approved for a Natura 2000 site if the coupes or forestry work affect the site's conservation status. The CRPF has the responsibility of assessing if the types of management proposed in the PSG or RTG are likely to have a significant effect on the Natura 2000 site. It is they who have to decide whether or not to approve the PSG or the RTG.

If the owner asks the CRPF if he can benefit from Article L.122 of the Code Forestier* and if there is no significant effect on the habitat of the Natura 2000, a PSG will be approved.

If it is judged by the CRPF that the Natura 2000 site will be significantly affected by the proposals, the CRPF will ask the owner to amend his felling and management plan, but if the owner does not want to comply with the amendments, the owner will, at his own cost, be required to carry out an environmental impact assessment. If not, the CRPF will refuse to approve the PSG.

* In the past an owner had to ask permission for every type of management that could make an environmental impact on the various types of environmental and other zoning. Articles L 122-7 and 8 of the Forestry Code now allow an exemption from this during the time a PSG is valid for all the management and coupes specified in it, providing an application requesting this is attached to the PSG application.

References

Le Code Forestier. https://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000025244092

CRPF Midi-Pyrénées Réglementation des coupes de bois et Obligation de reconstitution après coupe rase. La réglementation au service de la gestion durable des forêts. http://www.lot.gouv.fr/IMG/pdf/PlaquetteTechniqueCoupes_DDT46_CRPF-MidiPyrenees.pdf

Demander une autorisation administrative de coupe de bois. http://mesdemarches.agriculture.gouv.fr/demarches/proprietaire-ou-operateur/obtenir-un-droit-une-autorisation-43/article/coupe-du-bois-pour-les-forets-sous?id_rubrique=43

Germany

Gero Becker, Alicia Unrau, Patrick Pyttel, Achim Dohrenbusch and Christian Suchomel

Facts and Figures

Gero Becker and Alicia Unrau

Definitions

(1) Coppice: Even-aged stands consisting of trees and shrubs (mainly: *Quercus* spp., *Carpinus betulus, Alnus glutinosa*, occasionally *Fagus silvatica*), which regenerate wholly or mainly by vegetative means (sprout or root shoot) and are harvested in small clearcuts (0.5-1 ha) in short rotations of 20-40 years. In some cases combined with standards, which have longer rotation periods.	*(1) Niederwald (Stockausschlagwald): Gleichaltriger Bestand aus Bäumen und Sträuchern (hauptsächlich Quercus spp., Carpinus betulus, Alnus glutinosa, seltener Fagus silvatica), die sich ganz oder überwiegend vegetativ (Stockausschlag, Wurzelbrut) verjüngen und in kleinen Kahlschlägen (0.5-1 ha) und in kurzen Umtriebszeiten (20-40 Jahren) bewirtschaftet werden. In einigen Fällen kombiniert mit aus Samen entstandenen Bäumen im Oberstand ("Kernwüchsen"), die in längerer Umtriebszeit bewirtschaftet werden ("Mittelwald").*
(2) Short rotation coppice (SRC): Plantation of fast-growing trees (mainly *Populus* spp., *Salix* spp., and *Robinia pseudoacacia*), with the aim to produce in several short rotation periods (5-20 years each) wood as a renewable resource, mainly for energy.	*(2) Kurzumtriebsplantagen: Künstlich angelegte Monokulturen schnell wachsender Bäume (hauptsächlich Populus spp., Salix spp., und Robinia pseudoacacia) mit dem Ziel, innerhalb kurzer Umtriebszeiten (5-20 Jahre) mit mehreren Wiederholungen Holz als nachwachsenden Rohstoff zu produzieren, vor allem für energetische Zwecke.*

For National Inventory purposes, the definition is: "Coppice forests originate from vegetative regeneration (stool or root sprouts) and are max. 40 years of age" (BWI3 Guidelines, page 34).

Legal Framework

In Germany, the federal forest law only gives a general framework for legislation and provides no mention of traditional coppice. Forest issues are regulated in detail by regional authorities in 14 of the 16 states. They rarely mention traditional coppice and, if so, it is often indirectly. For example, in Bavaria there is mention of high forest ("Hochwald"), which implies that other types of forest exist as well, while in Rhineland-Palatinate they are generally considered "non-productive forests" and it is thus clear to all concerned that they fall under the legal category of "other forest" ("Sonstiger Wald"); neither case, however, explicitly mentions coppice ("Niederwald", i.e. low forest). In Bavaria there is another indirect link since remaining coppice forest stands can qualify as a historical land use practice, in which case they should be protected. Short rotation coppice ("Kurzumtriebsplantagen") is mentioned in federal and regional forest laws. They state that it is only regarded as "forest" if the rotations exceed 20 years; otherwise it is regarded as an agricultural crop.

Statistics

National statistics according to the third Bundeswaldinventur (National Forest Inventory) in 2012: Simple coppice 45,766 ha (0.42% of total forest area); coppice with standards 32,354 ha (0.30% of the total forest area) (BWI3). It should be noted that the definition of "Niederwald" in the BWI is limited to stands with a max. age of 40 years. Thus, older coppice stands are automatically defined as "Hochwald".

In some regions (Rhineland-Palatinate, parts of North Rhine-Westphalia) the proportion of coppice may be as high as 5-10%. A recent study carried out in Rhineland-Palatinate shows that 20% (83,000 ha) of the state and community owned total forest area originated from and still shows signs of coppice forest (Becker et al. 2013). The proportion in private forests may even be slightly higher.

There are approximately 6,000 ha of Short Rotation Coppice in Germany; the plots are mainly experimental (Hauk et al. 2014).

Typology

Simple coppice	Small clearcuts; rotation 20-40 years
Coppice with standards	20-50 standards/ha, mostly oak, rotation >60-80 years, combined with coppice on a rotation of 20-40 years
Pollarding	Not significant
Short rotation coppice	*Populus*, in some cases *Robinia pseudoacacia* and *Salix* spp.

Images

Typical German coppice forest, Baumholder, Rhineland-Palatinate

SRC Poplar and willow, second rotation period

SRC 1 year old *Salix* and GHG measuring chamber

Photos: C. Suchomel

References

Becker G., Bauhus J., Konold W. (Eds.)(2013): *Schutz durch Nutzung: ein Raum-Zeit-Konzept für die multifunktionale Entwicklung der Stockausschlagwälder in Rheinland-Pfalz.* (Culterra 62) Freiburg i. Br., Germany: Albert Ludwig University of Freiburg.

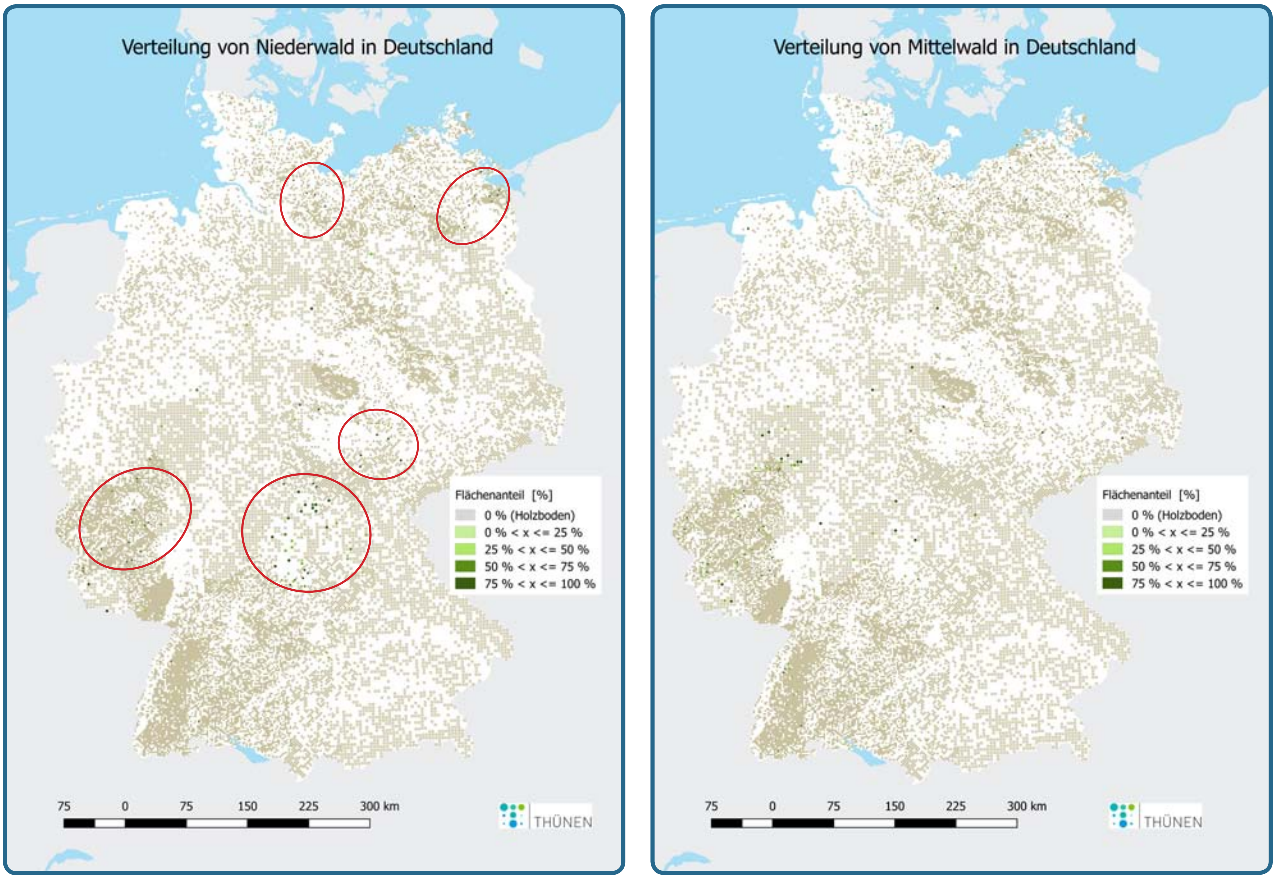
BWI3: Thünen-Institut, Dritte Bundeswaldinventur - Ergebnisdatenbank, https://bwi.info, Aufruf am: 1.12.2016, Auftragskürzel: 77Z1JI_L101of_2012, Archivierungsdatum: 2014-8-13 16:42:23.590, Überschrift: Waldfläche [ha] nach Land und Waldspezifikation, Filter: Jahr=2012

BWI3 Guidelines: https://www.bundeswaldinventur.de/fileadmin/SITE_MASTER/content/Dokumente/Downloads/AufnahmeanweisungBWI3.pdf 01.12.2016

Hauk S., Wittkopf S., Knoke T., (2014). *Analysis of commercial short rotation coppices in Bavaria, southern Germany. Biomass and Bioenergy*, 67, pps. 401 – 412. Cited: ZID: Bayerische Staatsministerium für Ernährung. Landwirtschaft und Forsted (StMELF). Zentrale InVeKoS Datenbank ZID. Available from: http://www.zi-daten.de; October 14, 2013.

Maps

Gero Becker



Plots with active coppice (i.e. < 40 years of age) identified during the 3rd German Forest Inventory (green); Simple coppice (Niederwald) on the left and coppice with standards (Mittelwald) on the right. Circled in red on the left are the main areas of coppice, in which overaged coppice is also common (estimate). Maps: Thünen-Institut, Dritte Bundeswaldinventur.

Description

Patrick Pyttel and Achim Dohrenbusch

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 ca. 75,000 ha of Germany, which represents 0.7% of the total forest area (BWI3, 2012), 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 overaged, 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 an 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, as being a potential source of fuel wood and are 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 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*. All forest managers should identify the basic situation, from stand to landscape level, at which coppicing is economically justified and needed in order to meet nature conservation objectives. It is important to conserve the remaining coppice forests and to continue their sustainable use and management.

Figure 1. Overaged coppice forests still dominate the landscape along the large Rhine and Moselle waterways

Forestry Regulations

Christian Suchomel and Patrick Pyttel

German forest law gives the framework for forest management in Germany. More specific laws are given by the federal states. Historic management forms are mentioned in the context of the national forest law, where it is stated that cultural heritage and heritage conservation should be taken into account (Bundesministeriums der Justiz und für Verbraucherschutz 1975).

In the **German National Strategy of Biodiversity**, which is a declared intention and not legally binding, historic management systems such as coppice, coppice-with-standards and forest pastures are explicitly mentioned for their high value in conservation and recreation. The aim of the strategy is to continue to manage in this way and expand if possible. Historic relicts of forest management (for instance coppice) are intended to be preserved (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2007). Another strategy at national level is the **German Forest Strategy 2020**. Here, unique historical management systems such as coppice, coppice-with-standards and wood pastures are again confirmed as important habitats for flora and fauna, which rely on their traditional and particular management. The strategy places a high emphasis on conservation (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz 2011).

The **state forest laws** regulate clearcuts and the rules for their reforestation. All but three states specify the maximum size of a clearcut, ranging from 0,3 to 2,0 ha. Since periodic clearcuts are a genuine traditional forest management practice, the application of clearcut rules to coppice is under debate. Recently, it has been discussed whether coppice forests violate the prescription in Natura 2000 areas that forbids a deterioration of the current ecological situation.

To elaborate on the rules and regulations of the federal states related to coppice forests and their management, we selected the six federal states (out of 16) that have the highest percentage of the total recorded coppice and coppice-with-standards in Germany: Bavaria (37%), Rhineland-Palatinate (17%), Mecklenburg-Western Pomerania (9%), North Rhine-Westphalia (8%), Thuringia (8%) and Hesse (5%) (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz 2005).

Neither German nor state laws contain specific guidelines concerning felling heights, maximum size of coppice areas or the number of standards.

Select Federal States

Bavaria

In the Bavarian forest law, coppicing or other historical forms of forest management are not specifically mentioned. The state strategy for the conservation of biodiversity only refers to regulations concerning voluntary contractual nature conservation measures (Bayerisches Staatsministerium für Umwelt und Gesundheit 2009). Here the establishment and maintenance of coppice and coppice-with-standards forests, as well as the resumption of coppicing, is permitted as a so-called compensatory measure. The same strategy refers to the need for action in forests. In the relevant paragraph, coppice and coppice-with-standards are mentioned as examples of forms of forest management which should be facilitated due to their special importance for biodiversity.

Rhineland-Palatinate

Rhineland-Palatinate is the federal state with the highest share of forest area. It is especially in this part of Germany that aged oak coppice forests are a substantial and omnipresent in many forest landscapes. Inventories in public forests, together with estimations in private forests, show that more than 160,000 ha are still covered by overaged coppice forests (these are not counted as coppice in the national forest inventory (BWI3) because they are over 40 years age). It is thus all the more surprising that neither historical forms of forest management, coppice nor coppice-with-standards forests, are considered in the state forest law. The law only indirectly mentions coppice, when it refers to non-productive forests, where special administrative regulations apply. However, coppice forests are explicitly mentioned in the state Strategy for the Conservation of Biodiversity (Ministerium für Umwelt, Landwirtschaft, Ernährung, Weinbau und Forsten Rheinland-Pfalz 2015). In this strategy, coppice forests are considered special habitats; their high nature conservation value should be given special consideration in the context of management.

Mecklenburg-Western Pomerania

The north eastern part of Germany belongs to the federal state of Mecklenburg-Western Pomerania. In the forest law of this federal state, coppice forests are only mentioned indirectly in the context of the so-called protection forests. Forests can be designated as protection forests if they are of importance for research, conservation of genetic diversity or the conservation of meaningful historical forms of forest management (Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg-Vorpommern 2011). Hence, coppice and coppice-with-standards could potentially gain specific protection status, but the selection criteria for these forests are not specified. The state forest law is supported by a governmental program for the conservation and development of biological diversity, where specific attention to historical forms of forest management is expressly requested until the year 2020 (Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg-Vorpommern 2012). In the relevant paragraph, coppice and coppice-with-standards forests are specifically mentioned in parenthesis. Both political instruments (Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg-Vorpommern 2011 and 2012) are presumably influenced by the state Forest Development Program, published by the Ministry for Agriculture, Food and Forestry in the year 2002. This program requires the promotion of historical forms of forest management, along with the conservation of native tree species and rare plants (Ministerium für Ernährung, Landwirtschaft, Forsten und Fischerei Mecklenburg-Vorpommern 2002).

North Rhine-Westphalia

In North Rhine-Westphalia, which is in north-west Germany, 6,000 ha of historical forests (coppice and wood pastures) are still actively managed. In the Biodiversity Strategy it is mentioned that these forests contribute in an important way to the preservation of biodiversity. One aim is to develop an immediate concept for the coppice area and a concept for forest edges to be managed as coppice-with-standards, so as to support light- and warmth-demanding species (Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen 2015). Coppice regeneration can be allowed by the administrators as a method by the forest law of North Rhine-Westphalia. Other clear cuts (max. 2 ha) must be reforested within 2 years (Ministerium für Ernährung, Landwirtschaft und Forsten des Landes Nordrhein-Westfalen 1980).

Thuringia

The Free State of Thuringia is located in central Germany. The forest law of this state explicitly mentions coppicing. Firstly, in the context of clear cutting, the relevant article allows clear cuts in coppice and aged coppice forests, independent of their age. In all other broadleaved forests, clear cuts are not allowed until the age of 80 years. Secondly, in the context of the fee-based management services of governmental employees in private and community owned forest, the article states that fees for the management of coppice forest (excluding aged coppice and coppice-with-standards forests) are reduced by two thirds (Thüringen Forst 2015). These articles are supplemented by the state Strategy for the Conservation of Biodiversity (Thüringer Ministerium für Landwirtschaft, Forsten Umwelt und Naturschutz 2012). The strategy proposes the conservation of historical forest management types to reinforce specific forest structures and compositions.

Hesse

Hesse is in the centre of Germany. The Hessian Biodiversity Strategy does not mention coppice, coppice-with-standards or any other historical management systems (Hessisches Ministerium für Umwelt, Klimaschutz, Landwirtschaft und Verbraucherschutz 2015). The state's forest law allows a maximum clear cut size of 1 ha. Coppicing is explicitly mentioned in the context of clear cutting. The relevant article allows clear cuts in coppice and aged coppice forests, regardless of their age. In all other broadleaved forests, clear cuts are not allowed until the age of 80 years (Hessisches Ministerium für Umwelt, Energie, Landwirtschaft und Verbraucherschutz 2013).

References

Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (2011): *Waldstrategie 2020: Nachhaltige Waldbewirtschaftung – eine gesellschaftliche Chance und Herausforderung*. 35 p.

Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (2005): *Die zweite Bundeswaldinventur – BWI2: Der Inventurbericht*. Bonn. 231 p.

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (2007): *Nationale Strategie zur Biologischen Vielfalt*. 178 p.

Bundesministeriums der Justiz und für Verbraucherschutz 1975: *Gesetz zur Erhaltung des Waldes und zur Förderung der Forstwirtschaft (Bundeswaldgesetz)*.

Hessisches Ministerium für Umwelt, Energie, Landwirtschaft und Verbraucherschutz (2013): *Hessisches Waldgesetz (HWaldG)*.

Hessisches Ministerium für Umwelt, Klimaschutz, Landwirtschaft und Verbraucherschutz (2015): *Hessische Biodiversitätsstrategie* 29 p.

Maps of German States (in green): By David Liuzzo [CC BY-SA 2.0 de (https://creativecommons.org/licenses/by-sa/2.0/de/deed.en)], via Wikimedia Commons

Mairota P, Buckley P, Suchomel C, Heinsoo K, Verheyen K, Hédl R, Terzuolo PG, Sindaco R, Carpanelli A (2016). *Integrating conservation objectives into forest management: coppice management and forest habitats in Natura 2000 sites.* iForest 9: 560-568 . – doi: 10.3832/ifor1867-009

Ministerium für Ernährung, Landwirtschaft und Forsten des Landes Nordrhein-Westfalen (1980): *Landesforstgesetz für das Land Nordrhein-Westfalen (Landesforstgesetz LFoG)*.

Ministerium für Ernährung, Landwirtschaft, Forsten und Fischerei Mecklenburg-Vorpommern (2002): *Gutachtliches Waldentwicklungsprogramm für Mecklenburg-Vorpommern*. 44 p.

Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen (2015): *Biodiversitätsstrategie Nordrhein-Westfalen – Die Biodiversitätsstrategie des Landes Nordrhein-Westfalen*. 153 p.

Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg-Vorpommern (2011): *Waldgesetz für das Land Mecklenburg-Vorpommern (Landeswaldgesetz – LWaldG)*. 50 p.

Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz Mecklenburg-Vorpommern (2012): *Erhalt und Entwicklung der Biologischen Vielfalt in Mecklenburg-Vorpommern*. 170 p.

Ministerium für Umwelt, Landwirtschaft, Ernährung, Weinbau und Forsten Rheinland-Pfalz (2015): *Die Vielfalt der Natur bewahren - Biodiversitätsstrategie für Rheinland-Pfalz*. 67 p.

Thüringen Forst (2015): *Das Thüringer Waldgesetz*. 47 p.

Thüringer Ministerium für Landwirtschaft, Forsten Umwelt und Naturschutz (2012): *Thüringer Strategie zur Erhaltung der biologischen Vielfalt*. 93 p.

Greece

Giorgos Mallinis, Ioannis Mitsopoulos, Petros Tsioras, Thomas Papachristou and Gavriil Spyroglou

Facts and Figures

Giorgos Mallinis, Ioannis Mitsopoulos, Petros Tsioras, Thomas Papachristou and Gavriil Spyroglou

Definitions

Forests that resprout after felling - Papachristou	*πρεμνοφυή δάση (premnofie dasi)*
Coppice forest, or paravlastogenes forest, is forest where regeneration is done by sprouts. - Mallinis	*Πρεμνοφυές ή παραβλαστογενές δάσος είναι το δάσος στο οποίο η αναγέννηση γίνεται με παραβλαστήματα.*

Legal Framework

Presidential Decree. 19-11-1928, 28-29.
Restrictions and guidelines regarding coppice forest harvesting.

Statistics

Coppice forests cover an area of approximately 1,930,000 ha (12% of the total country's area). The main species managed as coppice are broad-leaved oaks (1,105,339 ha), beech (337,000 ha), chestnut (33,000 ha) and other broadleaved species (88,000 ha). The management of these coppice forests is intensive, with a clear cutting cycle ranging from 20 to 30 years.

1.1. Area of forest and other wooded land and its changes

	1964		1992	
	Area (1000 ha)	Percentage (%)	Area (1000 ha)	Percentage (%)
Forest *	2 512	19.0%	3 359	25.5%
Other wooded land *	3 960	30.0%	3 154	23.9%
Forest and other wooded land	6 472	49.0%	6 513	49.4%
Other land uses	6 724	51.0%	6 683	50.6%
Total area	***13 196***	***100.0%***	***13 196***	***100.0%***

* Definitions are quoted in the Appendix I

1.1.1. Area of forest according to management type and its changes

	1964		1992	
Management type	Area (1000 ha)	Percentage (%)	Area (1000 ha)	Percentage (%)
High forest	872	34.7%	1 166	34.7%
Coppice forest	1 206	48.0%	1 612	48.0%
Coppice forest with standards	434	17.3%	581	17.3%
Total	***2 512***	***100.0%***	***3 359***	***100.0%***

Source: a) Distribution of Forests in Greece 1964, General Secretariat of Forests and Natural Environment (GSF&NE), Ministry of Agriculture
b) First National Inventory of Forests 1992, GSF&NE, Ministry of Agriculture

Images



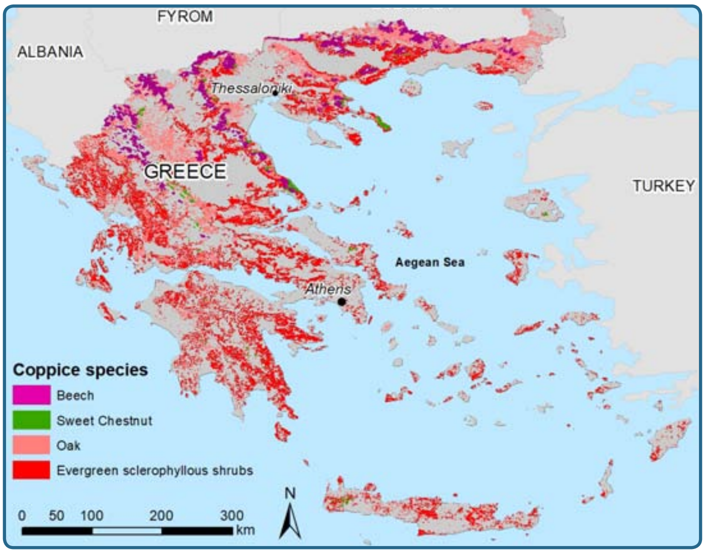
Coppice Oak forest in Northern Greece

Typology

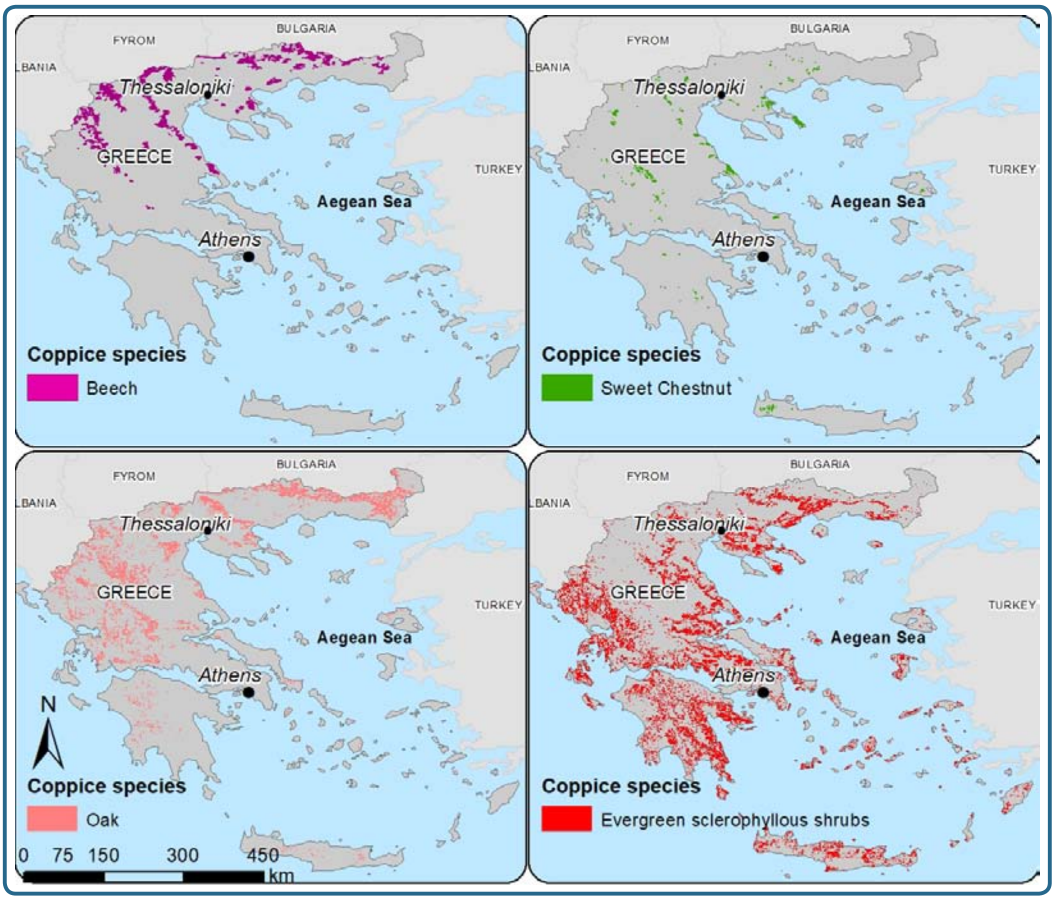
Simple coppice	Used to be applied to all broadleaved species in the past. Today almost all of the beech has been converted and much of the oak coppice forests are being converted into high forests by extending the rotation and altering the method of stand tending. All evergreen broadleaved species forests (maquis) are managed as simple coppice.
Coppice with standards	Used to be applied traditionally in oak and chestnut coppice forests but in the nineties and after the chestnut blight infestation it was prohibited to manage chestnut coppice forests with standards in order to prevent the expansion of the disease. As an alternative it was suggested to extend the rotation time or to leave standards in groups, not individual trees. Coppice with standards management is applied regularly in all oak coppice forests of the country.
Pollarding	Practised locally in rather limited cases; not practised systematically. One exception is the pollarding of white mulberry trees for feeding the silkmoth in sericulture or silk farming, but only on privately-owned mulberry plantations. Some livestock growers in rural Greece also occasionally use tree pollarding for animal fodder, but it is rather extensive and cannot be considered typical.
Short rotation coppice	Short rotation coppice is not officially applied in Greece. There is no law or other legal document for this particular management method specifically for energy purposes. One small exception of short rotation coppice concerns the basket willow (*Salix viminalis*), which was the raw material for the traditional basket making but today it is limited in very few places and the production is very small.
Other types	Coppice conversion into high forests: (1) coppice with standards can sometimes be implemented as an indirect method of conversion where a number of standard trees are retained individually or in groups at each rotation time and after several rotations the forest becomes uneven-aged and can be regenerated by seeds; (2) the extension of rotation time and stand tending by thinning is another indirect method of conversion.

Maps

Giorgos Mallinis and Gavriil Spyroglou



Overlaid map - range of the four main species that are coppiced in Greece (beech, sweet chestnut, oak and evergreen sclerophyllous shrubs)



Single maps - range of the four main species that are coppiced in Greece
(beech, sweet chestnut, oak and evergreen sclerophyllous shrubs)

Data source: First National Inventory of Forests in Greece, 1992. GSF&NE, Ministry of Agriculture

Description

Gavriil Spyroglou

Coppice forests in Greece make up 65% of the forested area and 12% of the entire country (Ministry of Agriculture 1992). The main species are oaks (*Quercus* spp.) followed by chestnut (*Castanea sativa*), beech (*Fagus* spp.) 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, i.e. to provide an economic use (wood production), a protective function against soil erosion and aesthetic benefits. However, the great contribution of these forests is in mitigating climate change (Chatziphilippidis and Spyroglou 2004).

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. In the past, coppice management was 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 the 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 trees that regenerate 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 (Dafis 1966; Stamou 1981). Indirectly, by extending the rotation time so it equates to that of a high forest and managing the coppice stand as if it was of seedling origin. Alternatively, it 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 and to develop a new strategic plan for a modern holistic approach that will meet today's challenges.

Figure 1. Typical coppice forest in Taxiarchis, Chalkidiki

Mediterranean ecosystems in general, and coppice forests in particular, have been used over time for resources other than woody products. 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, maintaining biodiversity and its associated economic values, ecosystem functions and services and last – but not least – are of considerable cultural importance.

References

Chatziphilippidis Gr. and Spyroglou G. 2004. Sustainable Management of coppice forests in Greece. In Anderson, F., Birot, Y., and Pāivinen, R., (eds) *Towards the sustainable use of Europe's forests – forest ecosystem and landscape research: Scientific challenges and opportunities Proc 25-27 June 2003 Tours, France*. EFI Proceedings No 49, pp. 61 -70.

Dafis, Sp. 1966. *Standorts-und Erttragskundliche Untersuchungen in Eichen-und Kastanien-niederwaeldern der N.O. Chalkidiki Thessaloniki*. [In Greek with German summary].

Ministry of Agriculture 1992. *Results of the first National Forest Inventory*. Ministry of Agriculture, General secretariat of forests and natural environment, General directorate of development and protection of forests and natural environment, Athens, p. 134.

Stamou, N. 1981. *Le Taillis simple de chênes en Grèce et ses traitements futurs, aspects économiques, conversion et enrésinement*. Foret Méditerranée III(2).

Hungary

Norbert Frank

Facts and Figures

Definition

Coppice forest is a forest (woodland) regenerated by vegetative shoots (stump or roots), depending on the species.	*Coppice forest = Sarjerdő*

Legal Framework

Stands can be regenerated by coppice – in the absence of a different decision by the forest authority, on forests with the primary function of the soil protection, shelterbelt, the river bank protection, as well as forests with low canopy closure – in the case of alder, black locust, native poplar, as well as willow.

Black locust and native poplar can be regenerated by coppice through root shoots – with the exception of 100% state-owned forests and in the absence of the different decision of the forest authority.

The conditions of the declaration of the forest regeneration for established forest must be insured in the case of regeneration by coppice within 5 years after the obligation to regenerate the forest was formed.

Sources:

Act No. XXXVII of 2009 on forests; the protection and management of forests
Regulation 61/2017 on forests; the protection and management of forests

Description

Hungary is situated in the middle of Europe, at the central and western parts 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 400 m 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 can 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. They 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 the protection and management of forests – enables coppicing of alder, native poplar, willow (stumps coppice) and black locust (root suckers).

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. 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 Europe put 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}, the average volume at harvest is 190 m^3 ha^{-1} and the average harvest age is 31 years. Black locust forests in Hungary have been established on a range of sites; however, only sites with an adequate moisture supply, well-aerated and loose-structured soil that is rich in nutrients and humus can produce good quality timber. Black locust stands are often regenerated by coppice (from root suckers). 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}.

Figure 1. Hornbeam (*Carpinus betulus*) middle aged forest of coppice origin

Table 1. Comprehensive facts on forests in Hungary

Registered forest management area	1,000 ha	2,060.8
Area of forest sub-compartments	1,000 ha	1,940.7
Forest share based on forest management area	%	22.2
Growing stock	million m^3	378.5
Gross annual increment	million m^3 yr^1	13.0
Total felling	million m^3	7.4
Final cuts	million m^3	5.0
Regeneration per year	1,000 ha	17.0
Afforestation per year	1,000 ha	0.3

Black locust are not only regenerated naturally from root suckers, but also artificially, i.e., with seedlings. The latter is also used for the establishment of new black locust plantations (stands). 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 easily 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 difficult to uproot (Führer and Rédei, 2003).

Table 2. Coppice in Hungary by ownership (in ha)

State ownership	root coppice	102,775.63
	stump coppice	184,988.49
Public ownership	root coppice	3,056.65
	stump coppice	2,917.50
Private ownership	root coppice	165,609.18
	stump coppice	112,835.70
Mixed ownership	root coppice	5,229.82
	stump coppice	4,006.69

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

- 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, in a pit manually prepared, or by tractor-mounted borer. Coppicing by root ripping provides abundant root suckers due to the root wounds. 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 at least 3 m in height and consist of non-forked healthy trees, regularly distributed (Führer and Rédei, 2003).

Figure 2. Black locust (*Robinia pseudoacacia*) mixed stand (coppice and high forest)

References

Führer, E., Rédei, K., 2003. *Site Requirements and Stand Establishment Techniques for Black Locust (Robinia pseudoacacia L.) Stands in Hungary* (http://www.fao.org/docrep/ARTICLE/WFC/XII/0320-B2.htm).

Rédei, K., 2012. *Influence of Regeneration Method on the Yield and Stem Quality of Black Locust (Robinia pseudoacacia L.) Stands: a Case Study.* Acta Silvatica and Lignaria Hungarica. Vol. 8, pp. 103-111.

Ireland

Ian Short

Facts and Figures

Definitions

"Coppice" means a forest crop raised from shoots produced from the cut stumps of the previous crop.
Forestry Act 2014

Legal Framework

Forestry Act 2014 (http://www.irishstatutebook.ie/eli/2014/act/31/enacted/en/pdf)

The felling of trees in Ireland is regulated under the Forestry Act 2014. Most trees that are felled require a Felling License. There are some exemptions. Short rotation coppice of willow or poplar species and maintained solely for fuel is exempt.

The felling of coppice requires a felling license unless it is on an agricultural holding, is being removed for use on that holding, and that the total volume felled does not exceed 15 cubic meters in any period of 12 months.

Rotation Period

There is very little coppicing done in Ireland. Therefore there are no standard rotation periods. Short rotation coppice of willow or poplar species (predominantly willow) is on a 2 or 3 year rotation.

Typology

Simple coppice	Very little in Ireland; some for conservation/habitat and a little for craft
Coppice with standards	Not practised
Pollarding	Only in gardens, roadsides and urban streets
Short rotation coppice	Willow for biomass

Description

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 practised 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).

Figure 1. 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.

Today there is little coppicing being practised 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 practised with biodiversity and conservation objectives in mind. In a survey of native woodlands conducted during the period 2003 - 2008, 18 % of the 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).

References

Bosbeer, S., Denman, H., Hawe, J., Hickie, D., Purser, P. and Walsh, P. 2008. *Review of Forest Policy for the Heritage Council.* May 2008. https://www.heritagecouncil.ie/content/files/Forest_Policy_Review_05-08.pdf [Accessed May 2018].

Cross, J. 2012. *Ireland's native woodlands: A summary based on the National Survey of Native Woodlands.* Irish Forestry 69(1&2), pp. 73-95.

Government of Ireland, 2013. *National Forest Inventory – Republic of Ireland – Results.* Covering the National Forest Inventory, 2009 to 2012.

http://www.agriculture.gov.ie/media/migration/forestry/nationalforestinventory/2012/NFI%20Ireland%20Results_v12%20V%20Final.pdf

Jones, M. 1986. *Coppice wood management in the eighteenth century: an example from County Wicklow.* Irish Forestry 43(1): 15-31. McCracken, E. 1971. The Irish Woods Since Tudor Times: Their Distribution and Exploitation. David and Charles (Publishers) Ltd., Newton Abbot.

Neeson, E. 1991. *A History of Irish Forestry.* The Lilliput Press: Dublin.

Nisbet, J. 1904. *Interim Report Regarding Inspection of Woods and Plantations in County Wicklow. Dublin.* Cited in Carey 2009. If Trees Could Talk. Wicklow's Trees and Woodlands Over Four Centuries. COFORD, Dublin. pp. 58.

O'Sullivan, A. 1994. *Trees, woodland and woodmanship in early Mediaeval Ireland.* Botanical Journal of Scotland 46(4), pp. 674-681.

Rackham, O. 2010. *Woodlands*. Collins, London.

Short, I. and Hawe, J. 2012. *Possible silvicultural systems for use in the rehabilitation of poorly performing broadleaf stands – Coppice-with-standards.* Irish Forestry 69(1&2), pp. 148-166. http://t-stor.teagasc.ie/handle/11019/317

Tighe, W. 1802. *Statistical Observations Relative to the County of Kilkenny Made in the Years 1800 and 1801.*

Tomlinson, R. 1997. Forests and woodland. In *Atlas of the Irish Rural Landscape*, Eds. Aalen, F.H.A., Whelan, K. and Stout, M., Cork University Press, pp. 122-133.

Young, A. 1780. *A Tour in Ireland: With General Observations of That Kingdom: Made in the Years 1776, 1777, and 1778. And Brought Down to the End of 1779. Vol. II. 2nd ed*. Printed by H. Goldney for T. Cadell, the Strand, London.

Forestry Regulations

The **Forestry Act 2014**, administered by the Forest Service (Department of Agriculture, Food and the Marine), outlines the legislative requirements for tree felling in Ireland. The provisions of the Act and the regulations (SI No 191 of 2017) came into force from 24th May 2017. A **felling licence** granted by the Minister for Agriculture, Food and the Marine provides authority under the Forestry Act 2014 to fell or otherwise remove a tree or trees and to thin a forest for management reasons. The Forestry Act 2014 provides for a single licence process for tree felling. Felling licences can be valid for up to 10 years in duration, which may be extended for one or more further periods, up to a total of 5 years.

However, trees outside of the forest can be felled without a tree felling licence in certain circumstances.

For example, **a felling licence is not required for**:

- A tree in an urban area
- A tree within 30 metres of a building (other than a wall or temporary structure), but excluding any building built after the trees were planted.
- A tree less than 5 years of age that came about through natural regeneration and removed from a field as part of the normal maintenance of agricultural land (but not where the tree is standing in a hedgerow).
- A tree of the willow or poplar species planted and maintained solely for fuel under a short rotation coppice.
- Tree outside a forest — within 10 metres of a public road and which, in the opinion of the owner (being an opinion formed on reasonable grounds), is dangerous to

persons using the public road on account of its age or condition.

- Tree outside a forest — on an agricultural holding and removed by the owner for use on that holding, provided —
  — it does not form part of a decorative avenue or ring of trees,
  — its volume does not exceed 3 cubic metres, and
  — the removal of it, by the owner for the foregoing purpose, when taken together with the removal of other such trees by the owner for that purpose, would not result in the total volume of trees, on that holding and removed by the owner for that purpose, exceeding 15 cubic metres in any period of 12 months.

  Note: Under sub-section 2 of Section 19 this exemption does not apply in certain cases.
- Tree outside a forest — of the hawthorn or blackthorn species.
- Tree outside a forest — in a hedgerow and felled for the purposes of its trimming, provided that the tree does not exceed 20 centimetres in diameter when measured 1.3 metres from the ground.

Penalties for illegal felling can be severe, on summary conviction ranging from fines of up to a maximum of €200 per tree (total penalty not to exceed €5,000) and/or imprisonment for up to 6 months to, on conviction on indictment, a fine up to €1,000,000 and/or imprisonment for up to 5 years.

References

http://www.irishstatutebook.ie/eli/2014/act/31/enacted/en/print

https://www.agriculture.gov.ie/forestservice/treefelling/treefelling/

https://www.teagasc.ie/crops/forestry/advice/timber-harvesting/felling-of-trees---legal-requirements/

Israel

Orna Reisman-Berman

Description

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 three main climatic and three phyto-geographic 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 river-beds 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. However, some main traditional practices are small scale coppice. Several examples are:

The species *Ficus sycomorus* was first brought to Israel by man during the dawn of history, 6,500 years ago, perhaps even 10,000 years ago. It re-sprouts and the trunk elongates 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. Its widespread use led to re-sprouting and its management as coppice. The species is found in the coastal plans, on sand dunes above aquifers.

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 firewood beginning from the Upper Paleolithic Period, 25,000 years ago, until today. The Romans used the timber of this species in the construction of a giant siege tower with a battering ram, built for their assault on the fortification of Masada in 73 CE.

A third example is the *Faidherbia albida*, originating in the sub-tropical savannas, but found in Israel in fragmented distributions along the southern shore and 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 trait allowed traditional practices such as small scale clear-cutting, grazing and the use of fire to encourage herbaceous species growth. Small scale clear

Figure 1. Resprouting that allowed the production of beams; *Quercus ithaburensis* (Photo: Orna Reisman-Berman)

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, traditional practices such as small scale clear-cutting were excluded, whereas the chaparral expanded, becoming a dense thicket.

A large scale experiment was conducted along the gradient in Long-Term Ecological Research (LTER) stations on the effect of clear-cutting on ecosystem biodiversity. The results demonstrated that patchiness of herbaceous and woody species is of importance, and that both small scale clearcutting and grazing help 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 60s very few plantations of *Populus nigra* were planted for the production of matches. However, in spite of the extensive irrigation and fertilization that the saplings received in agricultural soil, they did not yield even one quarter of the expected production. At the beginning of the 21st century, there was a nationwide 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 trial failed and did not reach an industrial capacity.

Figure 2. Resprouting that allowed the production of beams; *Ficus sycomorus* (Photo: Neot Kdumin archive)

References

Agra, H., G. Ne'eman, M. Shachak, M. Segoli, O. Gabay, A. Perevolotsky, A. Arnon, B. Boeken, E. Groner, M. Walczak, Y. Shkedy, S. Cohen, and E. D. Ungar. 2015. *Canopy structure of woody landscape modulators determines herbaceous species richness along a rainfall gradient.* Plant Ecology 216:1511-1522.

Reisman-Berman, O., L. Rojo, and P. Berliner. 2011. *Afforestation to combat desertification in arid zones requires a concerted endeavor.* Pages 145-150 in Y. Birot, C. Gracia, and M. Palahi, editors. Water for Forests and People in the Mediterranean - A Challenging Balance. European Forest Institute, Joensuu, Finland.

http://www.wildflowers.co.il/english/

http://www.kkl.org.il/

Italy

Paola Mairota, Francesco Neri, Davide Travaglini, Rodolfo Picchio,
Pier Giorgio Terzuolo, Pietro Piussi and Enrico Marchi

Facts and Figures

Enrico Marchi and Davide Travaglini

Definitions

General definitions

(1) Simple coppice without standards ("simple coppice" hereafter): At each rotation (approx. 8-10 years), all shoots are removed by clear cut. This kind of coppice system is in general permitted for certain species (e.g. black locust, poplar, willow, common hazel) depending on local (regional) forest law. Short rotation coppice theoretically fall under this definition, even though these are no longer considered (Ordinance (D.lgs.) n. 34/2018) under forestry.

(1) Ceduo semplice senza matricine: Ad ogni rotazione (circa 8-10 anni) tutti i polloni sono rimossi con un taglio raso. Questo tipo di ceduo è consentito solo per alcune specie (a esempio, robinia, pioppo, salice, nocciolo) a seconda dei regolamenti forestali regionali". In questa definizione sono teoricamente compresi i cedui a turno breve (SRC), che il D.lgs. n. 34/2018) non considera una forma di selvicoltura.

(2) Simple coppice with standards ("coppice with standards" hereafter): When coppice is felled a minimum number of standards per hectare is left depending on local forest law (e.g. 60 standards/ha in case of oak and beech coppice; 30 standards/ha in case of chestnut coppice).

(2) Ceduo semplice matricinato: Ad ogni rotazione il ceduo è tagliato a raso lasciando un numero minimo di matricine per ettaro a seconda dei regolamenti forestali regionali (a esempio, 60 matricine per cedui di quercia e faggio, 30 matricine per cedui di castagno).

(3) Uneven-aged coppice: coppice with shoots of different ages on the same stump (usually three age classes). Based on coppice selection system; the oldest (i.e. the biggest) shoots are cut every 6-8 years and a light thinning of the smaller shoots is also done.

(3) Ceduo a sterzo: cedui con polloni di età diversa sulla stessa ceppaia (solitamente di tre classi di età). Si basa sul sistema di selezione dei polloni, vale a dire che ogni 6-8 anni i polloni più grandi e di maggiore età vengono tagliati con un contemporaneo leggero diradamento dei polloni più piccoli.

(4) Compound coppice: forest managed with the aim to obtain a stand formed by a coppice and a high forest. It is characterised by the coexistence on the same area of a coppice, managed with clear cut, and a high forest managed with a selection system and therefore formed by trees of different age classes, that is approximately 2, 3 and 4 times (rarely more) the coppice rotation age.

(4) Ceduo composto: Il ceduo composto è una forma di governo rivolta a creare o a gestire soprassuoli formati da un ceduo ed una fustaia, in cui le due componenti si combinano sullo stesso tratto di terreno boscato. La componente a fustaia di solito è formata da matricine di età pari a 2, 3 e 4 volte (raramente di di più) la durata del turno del ceduo.

(5) Mixed management system: This category brings together very heterogeneous and widespread situations, originating from the historic compound coppice system (more precisely called as a high forest above coppice or coppice below high forest, according to the prevailing layer, or by silvicultural interventions varied over time). Mixed management stands are those stands made up of shoots (of vegetative origin) and a variable number of standards (of generative origin), generally of species different from those of the coppice. The latter, which are "older" than the shoots and are distributed in at least 2 diameter classes, must provide for 25% of the crown cover. Below this threshold the stand is classified as simple coppice with standards. If the standards cover exceeds 75%, the stand is then classified as high forest. Operationally, 40% standards' cover is pursued. In addition, if standards belong to just one diameter class or their number per hectare is less than 30, the stands has to be considered as a simple coppice with standards. On the contrary if standards' density is above 300 n/ha, the stand has to be considered as a coppice undergoing conversion to high forest. Finally, also those stands where standards consist of native conifer species are assimilated to mixed management system.

(5) Governo misto: questa categoria raggruppa situazioni assai eterogenee e diffuse, originate dallo storico governo a ceduo composto, più precisamente denominato come fustaia sopra ceduo o ceduo sotto fustaia, a seconda dello strato prevalente, o da interventi selvicolturali variati nel tempo. Si definiscono boschi a governo misto i soprassuoli costituiti da polloni (rinnovazione di origine agamica) e da un numero variabile di riserve (di origine gamica), generalmente di specie diverse da quelle del ceduo, in cui la copertura dei soggetti affrancati, di età (in pratica diametro) superiore a quella del ceduo e appartenenti ad almeno 2 classi di diametro, è compresa tra il 25% (al di sotto si ricade nel ceduo semplice matricinato) e il 75% (al di sopra si ricade nella fustaia) del totale. Nella pratica si consiglia il 40% di copertura dei soggetti affrancati. Se la classe di diametro delle riserve è una sola o se queste sono presenti in numero inferiore a 30 per ettaro di superficie, il soprassuolo viene considerato a ceduo semplice matricinato; se le riserve sono più di 300 per ettaro, si ricade nella forma del ceduo in conversione. I boschi cedui con presenza di conifere di specie autoctone sono assimilati ai boschi a governo misto.

Ciancio O., Nocentini S. (2004). *Il Bosco ceduo. Selvicoltura, Assestamento, Gestione [The coppice forest. Silviculture, Regulation, Management]*. Accademia Italiana di Scienze Forestali. ISBN 88-87553-06-8. Tipografia Coppini, Firenze, pp. 721. [in Italian].
Piussi P., Alberti G. (2015). *Selvicoltura generale. Boschi, societa e tecniche colturali [Silviculture. Forests, societies, and coltural techniques].* Compagnia delle Foreste, Arezzo, Italy, pp. 432. [in Italian].
Mairota P, Manetti Mc, Amorini E, Pelleri F, Terradura M, Frattegiani M, Savini P, Grohmann F, Mori P, Terzuolo PG, Piussi P (2016). *Opportunities for coppice management at the landscape level: the Italian experience.* iForest, p. e1-e8, ISSN: 1971-7458, doi: 10.3832/ifor1865-009

Definitions according to the 2nd Italian National Forest Inventory (2005)

(1) Coppice (simple coppice or coppice without standards): forest stand completely composed of shoots, or dominated by shoots, as opposed to trees originating by seed (less than 20 standards per ha).

(1) Ceduo (senza matricine): soprassuolo totalmente edificato da polloni o prevalenza di questi ultimi rispetto ai soggetti arborei di origine gamica (meno di 20 matricine/ettaro).

(2) Coppice with standards: forest stand composed of shoots and standards (the latter between 20 and 120 per ha; the age of the standards is equal to 1 or 2 times the coppice rotation age).

(2) Ceduo matricinato: soprassuolo costituito da polloni e matricine (queste in numero compreso tra 20 e 120 ad ettaro, ed età pari a 1 o 2 volte il turno).

(3) Compound coppice: forest stands composed of shoots and standards (the latter > 120 per ha; the age of the standards is not uniform, and can be greater than 3 times the coppice rotation age).

(3) Ceduo composto: soprassuolo costituito da polloni e matricine (queste in numero superiore a 120 ad ettaro e di diverse classi di età, anche superiore a 3 volte il turno.

(4) Coppice in conversion to high forest (in Italian forestry literature and jargon is called "transitory high forest"): forest stand completely composed of shoots, or dominated by shoots, as opposed to trees originating by seed; the signs of thinnings carried out to prepare the stand to regenerate from seeds are clearly evident).

(4) Fustaia transitoria: soprassuolo totalmente edificato da polloni o prevalenza di questi ultimi rispetto ai soggetti arborei di origine gamica; riconoscibili segni evidenti di taglio di conversione.

...where coppice is further divided into:

(1) Young coppice: the age of shoots is less than half of the customary coppice rotation age.

(1) Ceduo giovane: con riferimento al turno consuetudinario praticato localmente o in aree limitrofe ai cedui semplici o matricinati di quel tipo forestale, fase in cui l'età dei polloni non supera la metà del turno.

(2) Adult coppice: the age of shoots is close to the customary coppice rotation age.

(2) Ceduo adulto: fase in cui l'età dei polloni è prossima al turno.

(3) Old coppice: the age of shoots is clearly greater than the customary coppice rotation age.

(3) Ceduo invecchiato: l'età dei polloni è chiaramente superiore a quella del turno consuetudinario.

(4) Coppice in the regeneration phase: forest stand after the final cut; the cut was carried out in the current year or the year before; the shoots reach the height of 1.3 m.

(4) Ceduo in rinnovazione: stadio immediatamente successivo ad un intervento di taglio eseguito nell'anno in corso o in quello precedente; i ricacci, se presenti, raggiungono 1,3 m di altezza.

(5) Uneven-aged coppices: presence of shoots of different stem sizes (age) on the same stump.

(5) Ceduo a sterzo: compresenza di polloni di dimensioni (età) differenziate sulla stessa ceppaia.

Gasparini P., Di Cosmo L., Floris A., Notarangelo G., Rizzo M., 2016 – Guida per i rilievi in campo. *INFC2015 – Terzo inventario forestale nazionale*. Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Unità di Ricerca per il Monitoraggio e la Pianificazione Forestale (CREA-MPF); Corpo Forestale dello Stato, Ministero per le Politiche Agricole, Alimentari e Forestali. 341 pp. https://www.inventarioforestale.org/it/node/72. Last accessed on June 4th, 2018.

Legal Framework

There are several definitions of Forest, depending on local (regional) forest law. For instance:

- The National Forest Inventory has adopted the FAO-FRA definition of forest: Land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ.
- In Italy (D.lgs. 34/2018) forest is defined as: land spanning more than 0.2 ha with a tree canopy cover of more than 20%.

Restrictions for coppice forests are mainly based on: size of cutting area; rotation period; number of standards. These restrictions can vary in the different administrative regions, depending on local forest regulations. For instance, in the Tuscany region the following restrictions are provided:

- maximum cutting area = 20 ha;
- minimum rotation period: 8 years for chestnut, black locust, poplar, willow, alder, common hazel; 24 years for beech; 18 years for oak and other species;
- maximum rotation period: coppice forests older than 50 years must be converted to high forest;
- number of standards: in the case of coppice with standards, a minimum of 60 standards/ha must be left in the forest (a minimum of 30 standards can be left in case of chestnut forest); in the case of compound coppice, a minimum of 150 standards/ha must be left in the forest, with at least 75 standards older than twice the rotation period.

Although there are differences among the 21 administrative regions/autonomous provinces, simple coppice (coppice without standards) can only be applied to certain species, such as *Salix* spp., *Robinia pseudoacacia* (L.), *Populus* spp., *Alnus* spp., *Corylus avellana* and *Castanea sativa*. In addition, some restrictions refer to the size of the maximum cutting area, which is usually equal to 20 ha, as in the Tuscany region.

Rotation Period

The rotation period varies depending on forest species and administrative region. However, the most common minimum rotation periods are the same as in Tuscany (see above). In most regions, when the coppice is not cut for 40 years it takes the legal status of high forest.

Typology

Simple coppice	Traditional natural forest regeneration method
Coppice with standards	*Fagus sylvatica, Quercus petraea, Q. pubescens, Q. robur, Q. cerris, Q. frainetto, Q. trojana, Q. ithaburensis* subsp. *Macrolepis, Castanea sativa, Ostrya, Carpinus, Q. ilex, Q. suber*, Hygrophilous forest, other (evergreen-) deciduous forest
Pollarding	No longer used
Short rotation coppice	*Populus* spp., *Salix* spp., *Robinia pseudoacacia*, *Eucalyptus* spp., *Alnus glutinosa*, *Platanus*, *Ulmus* spp., *Castanea sativa*
Other types	Compound coppice; Coppice in conversion to high forest (esp. *Fagus sylvatica*); Uneven-aged coppice (limited to *F. sylvatica* and *Q. ilex*)

Images

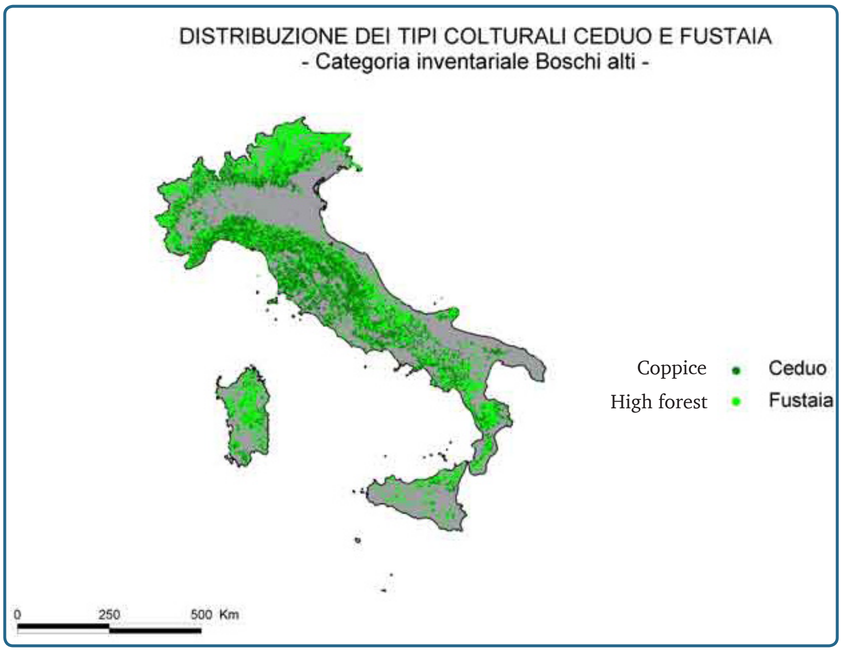
Uneven aged coppice; beech (both of above)

Coppice with standards: chestnut (upper left), downy oak (upper right), holm oak (lower left), turkey oak (lower right)

Mixed management systems

Coppice conversion to high forest; beech (left), oak (right)

Map



Map of coppice in Italy (dark green). Source: INFC (2005)

Reference

INFC (2005) Ministero delle Politiche Agricole Alimentari e Forestali - Corpo Forestale dello Stato Consiglio per la Ricerca e la Sperimentazione in Agricoltura (CRA-MPF) http://www.sian.it/inventarioforestale/img/cartogrammi/ceduo_fustaia.jpg

Description

Paola Mairota, Rodolfo Picchio, Francesco Neri, Pier Giorgio Terzuolo and Pietro Piussi

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 3,666,310 ha) (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 XIXth 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. Among the coded coppice silvicultural systems (i.e., simple coppice, coppice with standards – Matthews 1989, Nyland 2002, and compound coppice – Nyland 2002), coppice with standards 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 approximately 19% of coppice in the EU28, which in turn represents 83% and 52% of coppice in Europe and at a global level, respectively (UN-ECE/FAO 2000).

Negative environmental impacts of coppice are 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, and 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, including grazing, litter collection and tillage for food crops during the 2-3 years after final harvesting, dictated by need and various physiographic, economic and social constraints (Fabbio 2010). Over time, regulations have been issued to limit activities and disturbances, without which the benefits derived from the coppice system hindered what has 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 mechanisation levels (Pentek et al. 2008; Marchi et al. 2016; Venanzi et al. 2016). In both coppice and coppice thinned during conversion 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 and poles, as well as in some cases 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 includes a higher density of standards than was traditionally used, which has 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 coppice with standards into stands with a high density of overstood coppice 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) (Figure 1), 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 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.

Figure 1. Over-aged beech coppice in Pollino national Park, Southern Italy (Photos: P. Mairota)

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 coppice), 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, Motta et al. 2015). 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 of these approaches, capable of enhancing stand stability, soil protection and biodiversity, can be combined at the landscape level, thus introducing a 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 that 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, grazing by sheep, goats and wildlife, pest outbreaks), suggesting 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. Particularly the ecological and hydrological effects of the spatial arrangement of standards within the stand (i.e. uniform vs group distribution; both envisaged in the technical prescriptions of the majority of regions, i.e. the Prescrizioni di Massima e Polizia Forestale, Annex on Legislation framework) deserves further investigation, even if it has been considered in European forestry literature (e.g. Perona 1891, Huffel 1927, Perrin 1954, Cantiani et al. 2006, Fiorucci 2009, Piussi & Alberti 2015).

Finally, the great heterogeneity of prescriptions across species and forest types in Italy (see Annex on Legislation framework), in some cases 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.

References

Abrami A. (2009) *Legge Galasso e legislazione forestale [Galasso law and forest legislation]* Aestimum 17:221-229 [in Italian]

Amorini E, Fabbio G (2009). I boschi di origine cedua nella selvicoltura italiana: sperimentazione, ricerca, prassi operativa [Coppice woodlands in Italian silviculture: experiences, research, operations]. In: *Proceedings of the "III National Silviculture Congress"*. Taormina (Messina, Italy) 16-18 Oct 2008. Accademia Italiana di Scienze Forestali, Firenze, Italy, vol. II, pp. 201-207. [in Italian]

Bastien Y, Wilhelm GJ (2000). *Une sylviculture d'arbres pour produire des gros bois de qualité [Single tree silvuculture to produce valuable timber]*. Revue Forestière Française 52: 407-424.

Becchetti M, Giovannini G (1998). *La matricinatura nei cedui di cerro: indagine in provincia di Perugia [Standards' retention in Turkey oak woodlands: survey in the Perugia province]* Sherwood - Foreste e alberi oggi 34: 21-27. [in Italian]

Bianchi L, Giovannini G (2006). *Observations on the felling of standards in oak coppices, Central Italy*. Forest@ 3 (3): 397-406. [in Italian with English summary] - doi: 10.3832/efor0390-0030 397

Bruckman VJ, Yan S, Hochbichler E, Glatzel G (2011). *Carbon pools and temporal dynamics along a rotation period in Quercus dominated high forest and coppice with standards stands*. Forest Ecology and Management 262: 1853- 1862. - doi:10.1016/j.foreco.2011.08.006

Cantiani P, Amorini E, Piovosi M (2006). *Effetti dell'intensità della matricinatura sulla ricostituzione della copertura e sull'accrescimento dei polloni in cedui a prevalenza di cerro. [Effects of standards release on the recovery of forest cover and on sprouts growth in Turkey oak coppice woodlands]* Annali dell' Istituto Sperimentale per la Selvicoltura Arezzo 33: 9-20 [In Italian, summary in English]

Conedera M, Pividori M, Pezzatti GB, Gehring E (2010). Il ceduo come opera di sistemazione idraulica: la stabilita dei cedui invecchiati [Coppice as an hydraulic management work: overgrown coppices stability]. In: *Proceedings of the "46° Course on Culture in Ecology"* (Carraro V, Anfodillo T eds). San Vito di Cadore (Belluno, Italy) 7-10 Jun 2010, University of Padua, Padua, Italy, pp. 85-96.

Coppini M, Hermanin L (2007). *Restoration of selective beech coppices: a case study in the Apennines (Italy)*. Forest Ecology and Management 249: 18-27. doi: 10.1016/j.foreco.2007.04.035

Del Favero R (2000). *Gestione forestale e produzione legnosa a fini energetici [Forest management and energy wood production]*. Sherwood - Foreste e alberi oggi 59: 5-9. [in Italian]

Fabbio G (2010). *Il ceduo tra passato e attualita: opzioni colturali e dinamica dendro-auxonomica e strutturale nei boschi di origine cedua [Coppice between past and present: cultural options and dendro-auxonomic and structural dynamics in coppice woodlands]*. In: Proceedings of the “46° Course on Culture in Ecology” (Carraro V, Anfodillo T eds). San Vito di Cadore (Belluno, Italy) 7-10 Jun 2010, University of Padua, Padua, Italy, pp. 27-45. [in Italian]

Fiorucci E, (2009). *Le matricine nei boschi cedui: le attuali regole di rilascio sono ancora valide? [Standards in coppice woodlands. Are current release prescriptions still effective?]* Forest@ 6: 56-65 [In Italian summary in English] [online: 2009-03-25] URL: http://www.sisef.it/forest@/.

Garadnai J, Gimona A, Angelini E, Cervellini M, Campetella G, Canullo R (2010). *Scales and diversity responses to management in Beech coppices of central Apennines (Marche, Italy): from floristic releves to functional groups*. Braun-Blanquetia 46: 271-278.

Holscher D, Schade E, Leuschner C (2001). *Effects of coppicing in temperate deciduous forests on ecosystem nutrient pools and soil fertility.* Basic and Applied Ecology 164: 155-164. - doi: 10.1078/1439-1791-00046

INFC (2007). *Le stime di superficie 2005 – Prima parte* Authors: Tabacchi G, De Natale F, Di Cosmo L, Floris A, Gagliano C, Gasparini P, Genchi L, Scrinzi G, Tosi V. Inventario Nazionale delle Foreste e dei Serbatoi Forestali di Carbonio [National Inventory of Forests and of Forest Carbon Pools]. MiPAF - Corpo Forestale dello Stato - Ispettorato Generale, CRA - ISAFA, Trento, Italy, pp 409. [in Italian] [online] URL: http://www.sian.it/inventarioforestale/caricaDocumento?idAlle=496

La Marca O, Bernetti G (2011). *Il ceduo in Italia aspetti colturali, produttivi, ambientali [Coppice woodlands in Italy, cultural, production and environmental aspects]*. Sherwood - Foreste e alberi oggi 173: 5-14. [in Italian]

Laschi, A., Marchi, E., González-García, S (2016). *Forest operations in coppice: Environmental assessment of two different logging methods*. Science of The Total Environment, 562: 493-503.

Mairota, P., Manetti, M. C., Amorini, E., Pelleri, F., Terradura, M., Frattegiani, M., Savini P, Grohmann F, Mori P, Terzuolo P.G & Piussi, P. (2016a). *Opportunities for coppice management at the landscape level: the Italian experience*. iForest-Biogeosciences and Forestry, 918.

Mairota P., Buckley P., Suchomel C., Heinsoo K., Verheyen K., Hédl R., Terzuolo P.G., Sindaco R., Carpanelli A. (2016b). *Integrating conservation objectives into forest management: coppice management and forest habitats in Natura 2000 sites.* IFOREST, vol. 9, p. 560-568, ISSN: 1971-7458, doi: 10.3832/ifor1867-009

Manetti MC, Amorini E, Becagli C (2006). *New silvicultural models to improve functionality of chestnut stands*. Advances in Horticultural Science 1: 65-69

Manetti MC, Becagli C, Sansone D, Pelleri F (2016). *Tree-oriented silviculture: a new approach for coppice stands*. iForest 9: 791-800. – doi: 10.3832/ifor1827-009

Manetti MC, Pelleri F, Becagli C, Conedera M, Schleppi P, Zingg A (2014). *Growth dynamics and leaf area index in chestnut coppices subjected to a new silvicultural approach: single-tree-oriented management*. Acta Horticolturae 1043: 121-128

Marchi E, Picchio R, Mederski PS, Vusić D, Perugini M, Venanzi R (2016). *Impact of silvicultural treatment and forest operation on soil and regeneration in Mediterranean Turkey oak (Quercus cerris L.) coppice with standards*. Ecological Engineering, 95: 475-484

Matthews JD (1989). *Silvicultural Systems*. Clarendon Press, Oxford, UK, pp. 284.

Mei G. (2015). *Vegetazione e Suolo nel corso del turno in un Orno-Ostrieto mesofilo sul Monte Nerone (Appennino centro-settentrionale). [Vegetation and Soil during the rotation in a Flowering Ash-European Hophornbeam stand (“Orno- Ostrieto mesofilo”) on Mt. Nerone (Italy, Central-Northern Apennines)]* MSc Dissertation, University of Padova, Italy [in Italian, abstract in English] https://www.google.it/url?sa=t&rct=j&q=&esrc=s&source=web&cd=12&cad=rja&uact=8&ved=0ahUKEwiywduN_pzRAhXI0xoKHY8iD6AQFghIMAs&url=http%3A%2F%2Ftesi.cab.unipd.it%2F46787%2F1%2FMei_Giacomo%2C_definitiva_da_sostituire.pdf&usg=AFQjCNFav6q90DdnXqEig4VmktqGKPzYNw&sig2=FBVcXgfC2DJGCW3ifodQYQ

Motta R, Berretti R, Dotta A, Motta Fre V, Terzuolo PG (2015). *Il governo misto [Mixed management]*. Sherwood - Foreste e alberi oggi 211: 5-9. [in Italian]

Nyland RD (2002). *Silviculture: concept and applications (2nd ed.)*. McGraw-Hill, New York, USA, pp. 682.

Pentek T, Poršinsky T, Šušnjar, M, Stankić I, Nevečerel H, Šporčić M (2008). *Environmentally sound harvesting technologies in commercial forests in the area of Northern Velebit-Functional terrain classification*. Periodicum biologorum 110: 127-135.

Perrin H (1954). *Silviculture*. Ecole Nationale des Eaux et Forets, Nancy, France, pp. 411. [in French]

Picchio, R., Maesano, M., Savelli, S., & Marchi, E. (2009). *Productivity and energy balance in conversion of a Quercus cerris L. coppice stand into high forest in Central Italy*. Croatian Journal of Forest Engineering, 30(1), 15-26.

Piussi P (1979). *Le traitement en taillis de certaines forets de la Toscane du XVIeme au XXeme siecle [Coppice treatment of certain forests of Tuscany during the XVI and XX centuries]*. Actes du Symposium International d'Histoire Forestiere. Nancy (France) 24-28 Sep 1979. ENGREF 1: 50-57.

Piussi P (2007). *Considerazioni sul governo a ceduo composto in Toscana [Considerations on the compound coppice silvicultural system in Tuscany]*. Sherwood - Foreste e alberi oggi 131: 5-12. [in Italian]

Piussi P, Alberti G (2015). *Selvicoltura generale. Boschi, societa e tecniche colturali [Silviculture. Forests, societies, and coltural techniques]*. Compagnia delle Foreste, Arezzo, Italy, pp. 432. [in Italian]

Piussi P, Puglisi S (2013). Copertura forestale e franosità: Cosa non funziona nella difesa dal rischio idro-geologico nel nostro paese? Analisi e rimedi [Forest cover and landslides: What's wrong in the control of the hydro-geological risk in our country? Analysis and remedies]. In: *Proceedings of the "Convegni Lincei"*. Accademia Nazionale dei Lincei, Roma, Italy, 270: 137-150. [in Italian]

Piussi P, Redon O (2001). *Storia agraria e selvicoltura [Agrarian history and silviculture]*. In: "Medievistica Italiana e Storia Agraria" (Cortonesi A, Montanari M eds) CLUEB, Bologna, Italy, pp. 179-209. [in Italian]

Piussi, P. (2006). *Close to nature forestry criteria and coppice management. Nature-based forestry in central Europe: alternatives to industrial forestry and strict preservation*. Edited by Jurij Diaci. Ljubljana, 2006, 27-37.

Sansone D, Bianchetto E, Bidini C, Ravagni S, Nitti D, Samola A, Pelleri F (2012). *Tree-oriented silviculture in young coppices. Silvicultural practices to enhance sporadic species: the LIFE+PPRoSpoT project experience*. Sherwood foreste e alberi oggi, 185: 5-10.

Terzuolo PG, Ebone A, Brenta P (2012). *Il faggio: Conoscenze e indirizzi per la gestione sostenibile in Piemonte [Beech: knolwedge and sustainable management options in Piemonte]*. Regione Piemonte, Blu Edizioni, pp. 136. [in Italian]

UN-ECE/FAO (2000). *Forest resources of Europe, CIS, North America, Australia, Japan and New Zealand (TBFRA-2000)*. ECE/TIM/SP/17, Geneva, Switzerland, pp. 466.

Van Calster H, Baeten L, De Schrijver A, De Keersmaeker L, Rogister JE, Verheyen K, Hermy M (2007). *Management driven changes (1967- 2005) in soil acidity and the understorey plant community following conversion of a coppice with- standards forest*. Forest Ecology and Management 241: 258-271. - doi: 10.1016/j.foreco.2007.01.007

Venanzi R, Picchio R, Piovesan G (2016). *Silvicultural and logging impact on soil characteristics in Chestnut (Castanea sativa Mill.) Mediterranean coppice*. Ecological Engineering 92: 82-89

Zanzi Sulli A (1995). *Parliamo ancora una volta di cedui e matricine [Once again on coppice s and standards]*. Sherwood Foreste e Alberi Oggi 7:7-11 [In Italian].

Forestry Regulations

Paola Mairota, Rodolfo Picchio, Francesco Neri, Pier Giorgio Terzuolo and Pietro Piussi

In Italy, from the 1970s onwards (Law n. 382 of 1975 and subsequent modifications), responsibilities for forest regulation are transferred to 19 administrative regions (NUTS2) and 2 autonomous provinces (NUTS3) (regions hereafter) in the case of organisation and management matters and delegated to these concerning landscape and environmental matters. National forest guidelines indicate important goals for the regions to consider in order to develop sustainable, multifunctional forestry, which include environmental protection, conserving and enhancing biodiversity and the forest's protective function, while promoting productivity and improving socio-economic and educational aspects of forestry. To achieve these goals, forest and land use planning is required at the regional, provincial and municipal levels.

The national legal framework relating to forestry consists of **Law n. 3267 of 1923, 'Reordering and reform of legislation on forests and mountainous terrain'** (Riordinamento e riforma della legislazione in materia di boschi e di terreni montani), and its **related Ordinance (Regio Decreto) n.1126 of 1926**, which were enacted for hydrological and soil-protection reasons. By this framework, **forest management plans** ('Piani economici dei beni silvo-pastorali') became mandatory for public estates. **Law n. 431 of 1985, the so-called 'Galasso law'** (later integrated within, and somewhat altered by Ordinance (D.lgs.) n. 490/1999), imposed constraints on various, larger areas for landscape and environmental reasons and *ope legis* included land covered by forests and woods. These two sets of norms greatly differ in the way forests and silviculture are considered (Abrami 2009). In L. 3267/1923, forests are considered in relation to their crucial role in soil-protection and watershed stability (and therefore forest activities need to be regulated). L. 431/1985 bears the legacy of a previous Law n. 1497 of 1939, which aimed to protect natural beauty and landscape from an aesthetic point of view, and considered forests as "good" *per se*. That is, forests (and indeed large chunks of the country's territory, of relevance for their environmental features) are worth protection in the light of the services (*sensu lato*) they can provide to human communities. Despite this stronger and wider "environmentalist" rationale, it has been recognized that this regulation is not actually intended to impede or prohibit silviculture (Abrami 2009).

Further national level rules are provided by **Ordinance (D.lgs.) n 34/2018 'Consolidated ordinance on forestry'** ('Testo unico in materia forestale'). This act was enforced to substitute and integrate **Ordinance (D.lgs.) n. 227 of 2001 'Orientation and modernization of the forestry sector'** ('Orientamento e modernizzazione del settore forestale') and will become effective as soon as implemented within regional regulations. It is compliant with international and EU conventions and recognizes the need for sustainable forestry management, reaffirms the definition of "bosco" (woodland-forest) where the terms woodland and forests are made equal (similar to the French Code Forestier). It also fosters forest strategic and tactical planning on the part of the regions according to the national and **EU (COM (2013 n. 659/2013) forest strategies**.

Finally, the **Ministry of the Environment's Ordinance DM of 16-06-2005** ('Linee guida di programmazione forestale') stipulates guidelines meant to assess the conservation status of forests with regard to biodiversity, delineating forest planning strategies and criteria to be implemented by the NUTS2 and the NUTS3 regions in charge at different scales (e.g. regional, territorial, local-estate).

Analysis of the laws and regulations issued by the individual regions in compliance with national rules reveals considerable differences. Some regions have no legislation at all with regard to forests and forestry (e.g. Valle d'Aosta, although this autonomous region has a primary authority on these matters), others have enacted framework rules and others partial rules.

Even in the deficiency or absence of regional rules, planning has been developed by most of the regions on the basis of national standards, sometimes supplemented by regional guidelines, issued without the support of a forestry law or drafted for specific public funding schemes.

Forest plans at the regional scale are in fact just broad programming tools that describe forests, strong and weak points, objectives and, in part, resources available for the advancement of the sector. Some regions also have a separate document on the state of forests, updated periodically. This planning level is prescribed by 17 NUTS2 regions. Almost all of these have actually developed such a plan, many have approved it and some have already revised it after its natural expiration. The duration of the regional forest plan varies from 3 to 15 years, and in some cases it coincides with the duration of the regional legislature (5 years).

The second level of territorial planning, developed for **sub-regional homogeneous areas** (e.g. mountain valleys, sub-provincial areas), includes a discussion on forests and their functions, regardless of ownership. It is provided for by 8 regions, which have implemented it on part of the territory, rarely (Piemonte) on an experimental basis and sometimes enforcing it as binding instrument.

Forest planning at the **estate level, individual or associated**, is provided by all the regions that have legislated on these matters, and also has been at least partially developed by the others. This is called a forest management plan, business plan, forestry-pastoral plan, forest estate plan etc., terms that can be more or less considered synonymous.

For some of the regions/provinces, namely Valle d'Aosta, the Provinces of Trento and Bolzano, Veneto, and Friuli Venezia Giulia, forest planning instruments also cover all or most of the **communal or collective estates**, or at least significant portions of the territory. These instruments are devoted to large public (seldom private) estates or, more recently, to those pertaining to associated parties favoured by rural development programs (RDP).

Forest planning in **protected areas** (nature parks and reserves) and in the **Natura 2000** sites is a complex issue, often not addressed at the legislative level, neither as part of the forest framework law, nor as regulations for the conservation of biodiversity. The latter, if enacted, sometimes explicitly provide for a Site Management Plan (PDG) (e.g. Piemonte provides it for all sites), in compliance with the Habitats Directive and the national implementing rules. Some regions/provinces have drawn up the local equivalent for many or all of the sites, in some cases already approved, while others have prepared them either for some sites, or approve site-specific Conservation Measures ('Misure di conservazione' MdC). This regulatory process should have been completed by 2016, at least at the level of site-specific conservation measures.

In any case, the forest management plans involving Natura 2000 sites must comply with such conservation measures and, according to article 6 of the Habitats Directive, must undergo Appropriate Assessment (AA) procedures.

Technical prescriptions

With regard to silviculture (including coppice silviculture), enacted regional regulations either directly provide technical prescriptions or refer to province (NUTS 3) level regulations 'Prescrizioni di Massima e Polizia Forestale' (PMPF). These have been issued for all the provinces under the national framework law (Law n. 3267 of 1923) according to national level guidelines originally (1927) defined by the Ministry of Economy (then Ministry of National Economy), revised in 1957 and again in 1963 by a panel of technicians and jurists (cf. Fiorucci, 2009). Such technical prescriptions for coppice silviculture mainly concern the number of standards to be released in coppice with standards and in compound coppice. It is interesting to note (cf. Zanzi Sulli 1995) that the rationale for the definition of the number and the age distribution of standards differs greatly between the earlier (1927) and later version (1963) of the national guidelines for PMPF, reflecting motivation for the release of standards (animal raising/timber production vs dead stool replacement, respectively). This in turn was mostly due to the need to improve the state of coppice woodlands by preventing traditional side-practices (e.g. grazing, litter collection) as well as the need to define strictly coded systems (i.e. coppice with standards vs compound coppice).

The technical prescriptions in force with respect to coppice silviculture as implemented through either regional or province level (NUTS 3, PMPF) regulations greatly differ across the country and, in particular, for what concerns:

- Possibility of avoiding standard release for some forest types (simple coppice);
- Minimum and maximum number of standards (coppice with standards);
- Minimum and maximum length of rotation;
- Prescriptions for biodiversity in coppice and/or in Natura 2000 sites.

Most regions allow simple coppice for *Alnus, Robinia, Corylus, Populus, Salix, Genista, Eucalyptus* (as well as others) and allochthonous/invasive forest types, with the exception of Valle d'Aosta, Piemonte, Emilia Romagna, Marche, Umbria and Basilicata.

With regard to the **minimum and maximum number of standards**, regions can be arranged in four groups:

1) Regions in which a PMPF derived from the 1957-1963 scheme are still in force (Valle d'Aosta, Molise, Puglia and Sicilia). In these regions, the average minimum number of standards to be released per ha^{-1} is 60 and the maximum is 120 (median values) for most forest types. These average values are close to the reference values provided in the scheme (50-140 ha^{-1}, as reported by Zanzi Sulli (1995)), where the maximum values are the threshold representing one of the attributes discriminating between the coppice with standards system and the compound coppice system, the latter having up to three standard tree age classes.

2) Regions in which PMPF have been revised between 1980 and 2003 (Veneto, Emilia Romagna and Campania) and in which, on average, a minimum of 70 and a maximum of 140 standards ha^{-1} have to be released for most forest types. The minimum is 40% higher than the 1957-1963 reference value for the PMPF scheme, as reported by Zanzi Sulli (1995).

3) Regions in which prescriptions are dictated by regional regulations (Friuli Venezia Giulia, Liguria, Toscana, Umbria, Lazio, Abruzzo and Calabria) in which, on average, a minimum of 60 and a maximum of 140 standards ha^{-1} have to be released for most forest types; the minimum is 20% higher than the reference.

4) Regions in which prescriptions are dictated by regional regulations (Lombardia, Trentino, Marche, Basilicata and Sardegna) where, on average, a minimum of 100 and a maximum of

200 standards ha^{-1} have to be released for most forest types, with the minimum and maximum exceeding the reference values by 100% and 43% respectively.

The sole exceptions are Alto Adige and Piemonte. In the first, no prescriptions are in force for coppices due to the very small share of forest cover under coppice (less than 3.5%). Piemonte's recent regulations have introduced the criterion of minimum forest cover provided by standards, instead of their number, to define standard density. This is deemed more effective for the purpose of a variety of ecosystem services (cf. also Fiorucci 2009).

For the particular forest types of sweet chestnut and beech, all regions, on average, prescribe the release of a minimum of 40 and 100 standards ha^{-1}, respectively. In addition, Friuli Venezia Giulia prescribes a minimum of 120 standards ha^{-1} for *Carpinus* forest types, while Umbria perscribes a minimum of 100 standards ha^{-1} for *Quercus ilex* forest types.

The situation is even more varied concerning the **minimum and maximum length for a coppice rotation**, which differs across regions and forest types. For beech, deciduous oaks and sweet chestnut, for example, their respective average values are: min 24±3, max 40±7 years; min 18±3, max 36±7 years; and min 12±2, max 33±13 years, which are well above the very low values of the past (8-12 years), thus overcoming one of the main drawbacks of the coppice system, i.e. the over-exploitation of soil and stools due to the high frequency of the rotations. Maximum values are more sensible nowadays: most regions discriminate by law between coppice and high forest systems and once the maximum rotation length threshold is exceeded, regulations prohibit the maintenance of coppice management and force the stand to be managed as a high forest - that is to resort, at the right time, to reproductive regeneration.

Finally, in the majority of regions ad hoc regulations concerning **nature conservation** dictate additional, yet varied, prescriptions (e.g. coupe size and spatial arrangement, dead wood and ageing trees retention). For example, the Natura 2000 sites in Puglia (DGR 2250/2010) allow silvicultural operations between October 1st and March 15th to avoid impacts on nesting habitats of protected bird species; the cumulative size of three consecutive years coupes must not exceed 10 ha; 120 standards ha^{-1} must be released in all forest types; and sporadic tree species (less than 10%) must be preserved. In another example, in the Natura 2000 sites of Lazio (Regulation 1/10, modification to article 53 of the Regulation 07/05), the appropriate assessment (AA) of plans and projects significantly affecting Natura 2000 sites, is explicitly prescribed in the absence of approved management plans, regardless of ownership type (i.e. public or private). This is mandatory for old coppices, as well as when the coupe size of regular coppice exceeds 10 ha (20 ha for sweet chestnut) or 0.4 ha in the case of forest habitat types 9180, 9210, 9220, 9340 of the Habitats Directive.

References

Abrami A. (2009). *Legge Galasso e legislazione forestale [Galasso law and forest legislation]* Aestimum 17:221-229 [in Italian]

Fiorucci E, (2009). *Le matricine nei boschi cedui: le attuali regole di rilascio sono ancora valide? [Standards in coppice woodlands. Are current release prescriptions still effective?]* Forest@ 6: 56-65 [In Italian summary in English] [online: 2009-03-25] URL: http://www.sisef.it/forest@/.

Zanzi Sulli A (1995). *Parliamo ancora una volta di cedui e matricine [Once again on coppices and standards]*. Sherwood Foreste e Alberi Oggi 7:7-11 [In Italian].

Latvia

Dagnija Lazdiņa, Santa Celma and Kristīne Štikāne

Facts and Figures

Dagnija Lazdiņa and Santa Celma

Definitions

Coppice – deciduous tree stand that develops from shoots. Development of coppice depends on shoot production and regeneration ability. Trees that can regenerate with shoots multiple times include grey alder, black alder, birch, aspen, ash, oak and willow. Shoot sprouting activity gradually increases with tree age until it reaches physical maturity. At this point tree has the highest ability to sprout and grow shoots. Therefore, it is important to set an appropriate felling age to fit trees maturity (40-60 years). Felling time influences natural regeneration as well. The second half of winter is considered the most appropriate time for felling, since tree stumps sprout productively in the next spring and they have enough time to mature before autumn frosts start.

Atvasājs — lapkoku audze, kas izveidojusies no atvasēm. Atvasāja veidošanās atkarīga no koku atvašu dzīšanas spējas. Vairākkārt un ilgstoši atjaunoties ar atvasēm spēj baltalksnis, melnalksnis, bērzs, apse, osis, ozols un vītols. Pieaugot koka vecumam, pieaug arī atvašu dzīšanas spējas, līdz koks sasniedz fiziskās gatavības vecumu. Tad kokam ir visaugstākā atvašu dzīšanas spēja. Tādēļ, lai pēc mātesaudzes nociršanas panāktu sekmīgu izcirtuma apmežošanos ar atvasēm, jānoteic koku fiz. gatavības laikam (parasti 40—60 g.) pieskaņots cirtmets. Dabiskā atjaunošanās atkarīga arī no koku ciršanas laika. Par izdevīgāko uzskata ziemas otro pusi, jo tad pavasarī celmi bagātīgi dod atvases un tās līdz rudens salnām paspēj nobriest.

J. Bisenieks
Meža enciklopēdija, Apgāds "Zelta grauds", 2005

Legal Framework

1. Short rotation coppice - as agricultural land if planted with *Salix* spp., *Populus* spp., *Alnus incana*, on rotations of no more than 5 years. No restriction for density.

2. Forest land - more than 20% cover and over 5 m height.

2.1. Plantation forests - no restriction for felling age.
Pine at least 1,000 plants/ha initially; oak - 800/ha; ash - 500/ha.

2.2. Forest - defined felling by age or dimensions, initial density 3,000/ha pine, other species 2,000. (www.likumi.lv). NB: "Natural regeneration" means that <50% of trees were planted/seeded.

Statistics

There are no official statistics for coppice. Species that can regenerate as coppice in Latvian forests (total area 2,903,413 ha) are: birch (1,001,737 ha), aspen (151,855 ha), black alder (121,770 ha), grey alder (32,502 ha), ash (18,529 ha), oak (8,846 ha), linden (1,982 ha) and beech (119 ha). Species managed as agricultural crops that were declared for common agriculture payments in 2016 are: willow (516 ha), aspens (174 ha) and grey alder (14 ha).

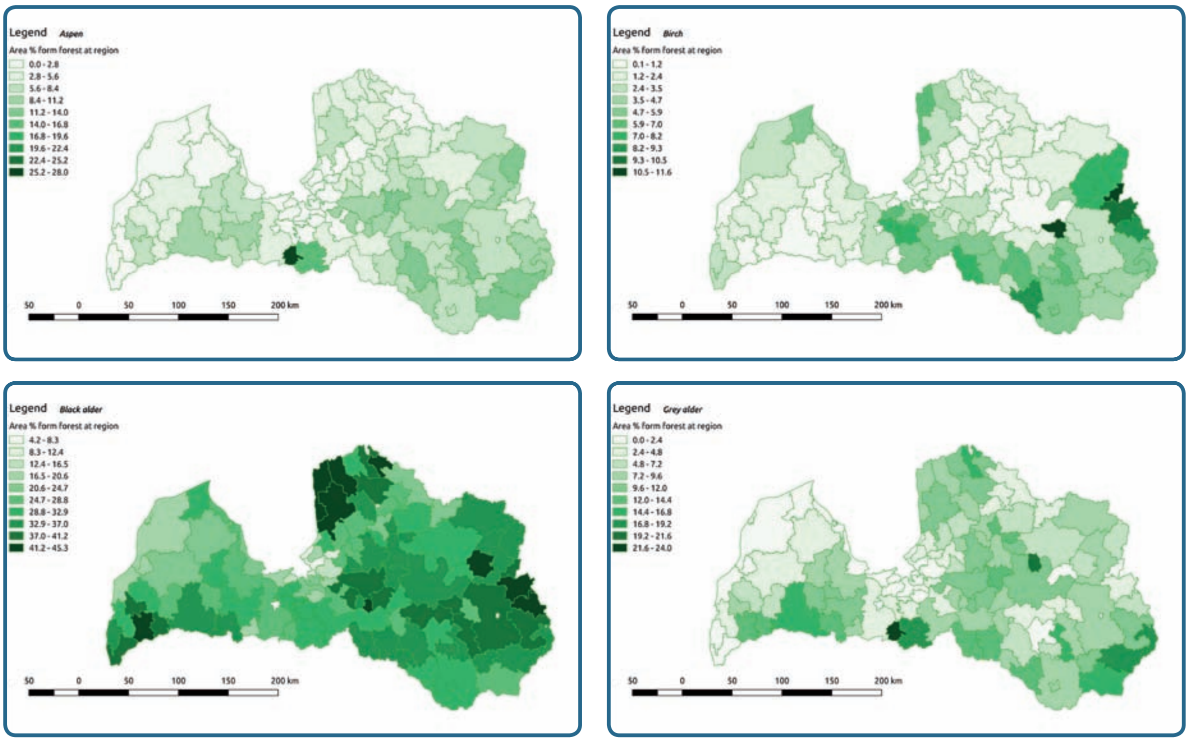
Typology

Simple coppice	Traditional natural forest regeneration method
Coppice with standards	Uncommon; *Populus, Alnus, Betula,* seldom *Salix*
Pollarding	Only on roadsides and in gardens
Short rotation coppice	*Populus, Alnus incana, Salix*
Other types	Few stands regenerated with poles or stakes (1.5 - 2 m)

Images

Maps

Dagnija Lazdiņa



Distribution of four tree species sometimes used for coppice in Latvia (species as % of forest in region): Aspen (upper left), birch (upper right), black alder (lower left) and grey alder (lower right). Data source: Latvia State Forest Service Statistic CD 2016

Description

Dagnija Lazdiņa

Coppice as a forest management system is not separated from forestry in general. 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, 516 ha of willows, 174 ha of aspens and 14 ha of grey alder received common agriculture payments.

Figure 1. Coppice in Latvia landscape and forests; willow on roadside (left), hybrid aspen stands (middle), black alder wetlands (right)

No statistics on coppice forests in Latvia are available. However, it is estimated that aspen, birch, alder, willow and osier are common coppice species in naturally regenerated and planted forest areas, where they have naturally sprouted from former forest stand tree stumps or root suckers (Fig. 1). Hazel, linden and ash are also at times naturally regenerated as coppice in some old wetlands. Coppice is more common in privately owned forests, which have a greater proportion of broadleaves than the state forests (Fig. 2). The proportion of private and state forests is close to 50:50.

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

Willows are mainly distributed near water reservoir banks, protected wetlands and "poorly managed" forest properties. 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.

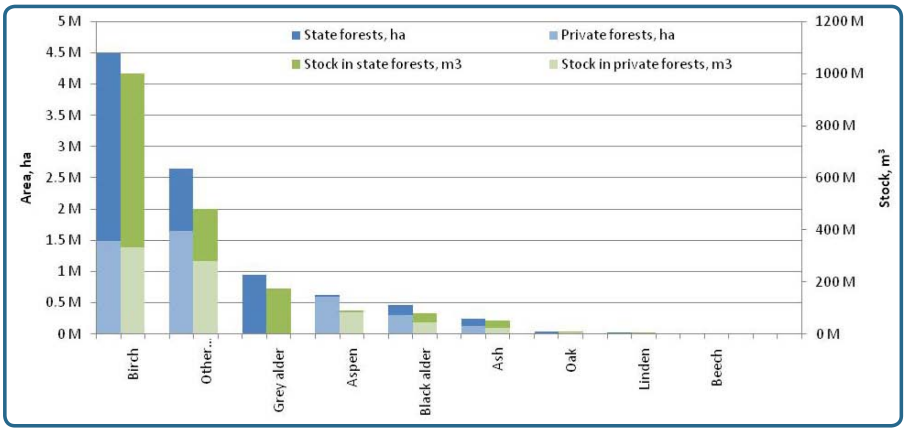


Figure 2. Growing stock (in millions – M) of traditional coppice forest species and area in Latvia forests (Source: VMD CD2016)

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

Forestry Regulations

Kristīne Štikane and Dagnija Lazdiņa

Latvia is situated in the boreo-nemoral zone, a transition between the temperate and boreal forest zones where mixed forests of broadleaves and conifers are common. Forests cover about 50% of the area of Latvia.

Basically, the three dominant tree species in the forests of Latvia are pine (*Pinus sylvestris*), spruce (*Picea abies*) and birch (*Betula pendula*). According to the 2010 National Forest Inventory (NFI) data, potential coppice species making up of the forest area of Latvia include birch (27.9%), grey alder (*Alnus incana* 9.8%), aspen (*Populus tremula* 7.7%), black alder (*Alnus glutinosa* 5.1%), ash (*Fraxinus excelsior* 0.8%) and oak (*Quercus* spp. 0.7%). There is no data available for willow (*Salix* spp.) because it is not widely planted as a main species in the forest.

After the restoration of Latvia's independence in 1990, the forestry sector has become one of the most important sectors in the country's economy. Since then, the forest area in the country has increased by around 60,000 hectares per year. That was the first time when representatives of the timber industry began to gather together in associations, so as to be able to defend their interests more successfully; not only in Latvia, but also in export markets. Exports of forestry products are more than 70 times higher than they were 20 years ago. Meanwhile, a list of specially protected environmental territories (IADT) was established in 1993.

On April 28, 1998, the government of Latvia adopted the **Forest Policy**, which has been developed to reach a compromise among all stakeholders interested in forestry. Prerequisites of a sustainable forest management are the targets defined and principles established in Latvia's Forest Policy. In 2000, the **Latvian Forest Industry Federation** was established to assist in the development and coordination of the activities of the various associations, in order to agree on fundamental principles aimed at preserving the national forest for future generations, as well as representing the interests of the timber industries at the international level. Since 2000, the **Ministry of Agriculture** performs the regulatory function laid down in the Forest Policy while the monitoring function is done by the **State Forest Service**.

In Latvia, considerable emphasis is placed on "planted forests", in which over 50% of trees were planted or sown, as opposed to having regenerated naturally, and this is reflected in the national regulations and definitions. The rationale is that improved planting material from tree breeding leads to a higher forest productivity and it is, thus, good practice to ensure as many trees as possible originate from such a source. It results in particular consequences for coppice, since for each shoot of stump or root origin, at least one additional tree should be planted or sown for the stand to achieve the desirable "planted forest" status.

The major part of the forest area possessed by the state is managed by the state-owned business operator; the **joint-stock company "Latvijas valsts mezi"** (Latvian State Forests) manages and administers 1.63 million ha of land, including 1.60 million ha of forest land, which incorporates 1.41 million ha of forest.

In 2004, when Latvia joined the European Union, it automatically became part of the unified **Natura 2000** network of protected territories in the EU. Among the species and biotopes that are listed in the EU's bird and biotope directives, Latvia protects 60 types of biotopes. There are several protected forest biotopes in Latvia which are listed in the relevant EU directive – boreal forests, primary forests along meandering rivers, certain coniferous forests, stands of oaks, forests on hillsides and in valleys, swampy forests, wet broadleaf forests, forests on river banks with oak and elm trees, dry fields of heather along seashore lowlands and other areas, wet fields of heather with crossleaved heath (*Erica tetralix*), as well as stands of juniper in calcified meadows.

There are many **forest habitats in Latvia protected by the EU directive**, which includes territories in which coppice tree species are common:

9010* Western taiga, which is typically dominated by pine, spruce, aspen and birch, or their combination.

9020* Fennoscandian hemiboreal communities of natural, old broad-leaved deciduous forests (of *Quercus, Tilia, Acer, Fraxinus* or *Ulmus*); rich in epiphytes. The tree layer typically is dominated by an admixture of ash, elm (*Ulmus* spp.), willow, lime (*Tilia* spp.), oak and aspen in different combinations, but with none of them dominant. A minor admixture of spruce, birch and pine is possible.

9080* Fennoscandian deciduous swamp forests are typically dominated by alder, ash, birch, or in admixture.

9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli community, typically dominated by oak, hornbeam and lime, or in admixture.

9180* Tilio-Acerion forests of slopes, screes and ravines where the tree layer is dominated by lime, ash, oak, elm, willow and maple (*Acer* spp.), or in admixture.

91D0* Bog woodlands are typically dominated by one or more species of pine, spruce and birch; occasionally aspen or alder are found in admixture, but these rarely dominate.

91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-padion, Alnion incanae, Salicion albae*) are protected under the EU habitat directive where the main species are ash, alder, elm (*Ulmus* spp.), willow, grey alder and bird cherry (*Prunus padus*). These are distinguished by an underlayer of brush and other various trees in admixture with a canopy dominated by aspen or birch.

91F0 Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*) typically dominated by oak, elm, willow, or ash, or in different combinations of these species.

References

https://www.zm.gov.lv/public/ck/files/ZM/mezhi/buklets/MN_20_EN.pdf Latvia's Forests

https://www.zm.gov.lv/en/mezi/jaunumi/the-land-forest-are-major-natural-resources-in-latvia?id=4100

https://daba.gov.lv/upload/File/Publikacijas/ROKASGR_biotopi_EN.pdf European Union protected habitats in Latvia

Lithuania

Marius Aleinikovas, Mindaugas Škema and Julija Konstantinavičienė

Facts and Figures

Marius Aleinikovas

Typology

Simple coppice	Small amount, only in private forests
Coppice with standards	Ash, birch, grey alder
Pollarding	Only on seedling plantation
Short rotation coppice	Willow, aspen, grey alder

Image

Description

Mindaugas Škema, Marius Aleinikovas and Julija Konstantinavičienė

In Lithuania, coppice and coppice with standards are very rare and the national forest inventory authority of Lithuania (State Forest Service) does not even register these types 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 an additional 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, as of 2015, 66% of willow plantation owners had 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 1),with later yearly increases of 13-60% (NMA, 2114).

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 again in 2007 (A. Pliūra, personal communication). Until 2007, approximately

Table 1. Statistics on short rotation energy plantations (SREP) and willow energy plantations (WEP)

Year	SREP total area (ha)	SREP increase (%)	WEP total 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

50 ha were cultivated both on forest and abandoned agricultural lands.

During the past decade, up to 400 ha of hybrid aspen short rotation plantations have been planted annually in Lithuania (Fig. 1) (Tullus et al., 2011; A. Pliūra, personal communication).

Breeding of hybrid poplars has also been started and the 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).

Figure 1. Short rotation plantation of hybrid aspen in Dubrava Forest Enterprise, Lithuania; it will become coppice forest in one rotation (after a clear cut at 20 years of age) (Photo: V. Suchockas and A. Pliura)

References

Konstantinavičienė, J. and Stakėnas, V., 2015. *Gluosnių energetinių plantacijų plėtrą Lietuvoje lemiantys veiksniai: plantacijų augintojų apklausos rezultatai.* Miškininkystė 1 (77), pp. 20–32 (In Lithuanian).

Konstantinavičienė, J., Škėma, M., Stakėnas, V. and Šilinskas, B., 2014. *Gluosnių (Salix viminalis L.) energetinių plantacijų antžeminės biomasės produktyvumas.* Miškininkystė 2 (76), pp. 29–37.

NMA (Nacionalinė mokėjimo agentūra prie Žemės ūkio ministerijos), 2014, 2015. *Pasėlių deklaravimo statistika pagal savivaldybių žemės ūkio skyrius* (SŽŪS) (In Lithuanian).

Pliūra A., Suchockas V., Sarsekova D. and Gudynaite V., 2014. *Genotypic variation and heritability of growth and adaptive traits, and adaptation of young poplar hybrids at northern margins of natural distribution of Populus nigra in Europe.* Biomass and Bioenergy 70, pp. 513-529.

Tullus A., Rytter L. and Tullus T. *Short-rotation forestry with hybrid aspen (Populus tremula L.×P. tremuloides Michx.) in Northern Europe*.

Forestry Regulations

Marius Aleinikovas and Mindaugas Škema

Lithuanian forests are a natural element of the Lithuanian landscape. They offer biodiversity, productivity and sustainability, and provide timber, green energy, food products and opportunities for healthy recreation of the urban and rural people. According to data from the Lithuanian Statistical Yearbook of Forestry (2016), the total forest land area is 2,186,000 ha, which is 33.5 % of the country's territory. The total growing stock volume is 537 million m^3, while the gross annual increment is 19.3 million m^3. Deciduous trees account for 56% of stands; 44% are conifers. The most common tree species are Scots pine (*Pinus sylvestris*), silver and downy birch (*Betula pendula* and *B. pubescens*), Norway spruce (*Picea abies*), black and grey alder (*Alnus glutinosa* and *A. incana*), aspen (*Populus tremula*) and oak (*Quercus* spp).

After the restoration of Independence in Lithuania, forest property rights were restored. The structure of **forest ownership** has changed due to an ongoing land reform process. All forestland was first transferred to the countrywide network of 43 state forest enterprises under the Ministry of Forestry. Currently, the private forest sector consists of 249,000 private forest owners, managing a total of 873,000 ha (LSYF, 2016), which is 39.9% of the total forest area. Forests belonging to the state cover 49.8 % and forest areas reserved for restitution amount to 10.3%.

State forest managers and private forest owners are obliged to manage and use their forests according to the **Forest Law** describing regulations on the management and use of forests, as well as other legal acts related to forest management, e.g.:

- Regulations for Forest Regeneration and Establishment (2008)
- Rules for Forest Sanitary Protection (2007)
- Rules for Forest Felling (2015)
- Rules for Forest Improvement Cuttings (2002), etc.

Forest management, reforestation and use are regulated in more detail in legal acts approved by the Minister of Environment. The main legal act is the **Law on Forests**, adopted in 1994. It regulates reforestation, protection and use of forests and specifies the legal preconditions for managing all forest ownership types upon equal sustainable forestry principles. According to the Law on Forests, the state forestry policy trends are defined by **Seimas** (Parliament of the Republic of Lithuania) by adopting appropriate laws. The state forestry strategy and state forestry programmes are prepared by the Ministry of Environment.

Forest sector development targets are guided through the **National Forestry Sector Development Programme for 2012–2020**, which was approved by the government in 2012. The document describes development trends and targets for the forestry sector. The major ones are to preserve Lithuanian forests and increase their area and resources, as well as to preserve the efficiency and sustainability of forest ecosystems, taking account of their ecological and social role and the impact of climate change.

At the beginning of 2016, the distribution of forests by functional groups was as follows.

- Group I (strict nature reserves): 26,500 ha (1.2%);
- Group II (ecosystem protection and recreational): 266,500 ha (12.2%);
- Group III (having protection status with regard to geology, geomorphology, hydrological and cultural merit): 333,400 ha (15.2%);
- Group IV (commercial): 1,560,300 ha (71.4%).

The Group IV commercial forests are split into:

a) commercial forests of normal cutting age, encompassing productive forest stands that continuously supply wood, following the requirements of environmental protection; and

b) forest plantations, where the objective is to grow as much wood as possible in the shortest period of time.

The latter are forests that consist of stands of fast-growing tree species with a cutting age of at least 15 years. Only stands with the same age class can be attributed to forest plantations. It is prohibited to plant forest plantations in non-plantation forest cutting areas. Coppice management is rarely practiced, except in short-rotation plantations of willow or poplar.

According to the Forest Law, forest managers and owners are obliged to follow certain mandatory parts of a **forest management plan** (i.e. the amount of wood allowed to be cut over a period of 10 years and reforestation within prescribed environmental protection requirements). Internal forest management projects for private forest holdings of less than 10 ha may be prepared for 20 years. If, over 10 years, the private forest owner does not cut all the permitted quantity of wood, the validity of the project can be extended for a further 5 years.

The preparation of an internal forest management project is not obligatory in the following cases:

1) final felling of grey alder, aspen and other low value stands;

2) private forest holdings of less than 3 ha.

Lithuanian Law states the mandatory reforestation of clear-cuts and the expansion of the forest area through afforestation of abandoned lands. Clear-cut areas should be reforested within 3 years after cutting. Unsuccessful natural and artificial regeneration should be reforested within 2 years. During the past 10 years, natural forests have expanded rapidly, by about 65,000 ha of new forest, as a result of both natural growth and planting on abandoned agricultural land. Furthermore, since Lithuania joined the EU, afforestation of agricultural land has been introduced using support from EU rural development funds and national funds.

The rotation age at which clear cutting is permitted is established in the **Rules of Felling**. For group IV in state forests it is:

- 121 years: oak
- 101 years: pine, larch, ash, maple, beech, elm
- 71 years: spruce
- 61 years: birch, black alder, lime, hornbeam
- 41 years: aspen
- 31 years: grey alder, sallow and willow

In private forests, for grey alder, aspen, willow and sallow the age of felling in group IV forests is not prescribed. Within forest groups II-IVa, at least 7 live trees/ha (of which at least 3 must be older or thicker than average trees in the forest) and at least 3 dead trees must be left, with a thickness of more than 20 cm in diameter at 1.3 m above ground, to ensure biological diversity.

Certification Schemes for forest products in State Forest Enterprises are certified under the rules of the Forest Stewardship Council (FSC) forest management and chain of custody. According to the United Nations Economic Commission for Europe (UNECE), State Forest Enterprises produce about 3.8 million m^3 of FSC certified round wood, 50 % of all the round wood volume produced in Lithuania. Lithuania has its very own system of protected areas, and long-standing traditions for the protection of natural and cultural heritage. Protected areas are established not only for the protection of natural and cultural values, but also for their adaptation to allow public use and access, be it for educational, recreational or other purposes. The Natura 2000 network covers about 13% of the total country territory.

References

The Republic of Lithuania Forestry Law. Available at http://extwprlegs1.fao.org/docs/pdf/lit38225.pdf

Ministry of Environment of the Republic of Lithuania. http://www.am.lt/VI/en/VI/index.php#r/206

Directorate General of State Forests at Ministry of Environment of the Republic of Lithuania. http://www.gmu.lt/en/

Mizaraite, D., Mizaras, S. (2015) *Forest Land Ownership Change in Lithuania*. COST Action FP1201 FACESMAP Country Report, European Forest Institute Central-East and South-East European Regional Office, Vienna. 35 pages. [Online publication].

http://www.europarc-nb.org/protected-areas/lithuania

fYR of Macedonia

Pande Trajkov and Ljupco Nestorovski

Facts and Figures

Pande Trajkov

Definitions

Coppice forest – a forest originating by vegetative means, i.e. by basal shoots, root suckers or both.

Нископстеблена шума – е шума настаната по вегетативен пат односно изданци од пенушки, ибојци од корења или на двата начини.

Legal Framework

1. Forest land with more than 20% cover and
2. Volume density of more than 0,3 (30% of "normal" stands)

Regulation for Forest Management Plans (http://www.mzsv.gov.mk).

Statistics

Total forest area in 2012: 989,000 ha

Managed forest: 902,000 ha

High forest: 276,000 ha

Coppice forest: 561,000 ha

Coppice with standards: 3,000 ha

Shrubs, maquis, etc.: 54,000 ha

Artificial forest (up to 20 years): 8,000 ha

Unmanaged forest: 87,000 ha

Main species: *Fagus moesiaca, Quercus petraea, Q. conferta, Q. cerris, Q. trojana, Q. pubescens* and *Q. coccifera.*

References

Forestry, 2012, State statistical office of the Republic of Macedonia, 2013. - 29 pages.

Forest management plans, state 2012: PE "Makedonski sumi" Skopje.

Typology

Simple coppice	Traditional, clearcuts, rotation 40-50 years
Coppice with standards	Very rare
Pollarding	Practised in the past; very rare today
Short rotation coppice	Not practised
Other types	Coppice in conversion process (oak and beech) with natural regeneration (seeds) or introduction of conifers (*Pinus, Abies, Picea*)

Images

Overaged oak stand with natural seeds regeneration (Goten Mountain)

Harvested oak plantation

Successfully regenerated sessile oak coppice stand (Bushava Mountain)

Beech coppice stand (Bistra Mountain)

Description

Pande Trajkov

Due to a combination of traditional forest management, extensive cattle breeding that was 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 to prohibit the breeding of goats (Nikolovski, 1955). The result was a rapid reduction in the goat population. 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, which has a low growth rate on poor sites and suffers damage from frequently occurring forest fires and pests (Trajkov, 2007). This history, along with a lack of knowledge on the growth of other species, has meant that only few coppice forests have actually been converted in recent decades.

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 these 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 also 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*).

Oak coppice forests (Figure 1) 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 oak 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. 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 under-storey 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. Thus, 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 comments negatively on large areas of clear cut near settlements, close to recreation centers or along roads.

Figure 1. Oak coppice stands in the regeneration stage

References

Mircevski, S. 1977. *Biostructural relations in the low trunk wood of the beech in Macedonia.* Forest Review, No. 3-4, pp. 12-26, Skopje (in Macedonian).

Nikolovski, T. 1955. *Situation of bushes and guidance for their management.* Forest Review, No. 1, Skopje (in Macedonian).

Nikolovski, T. 1958. *The forest vegetation types in Dub Mountain near Dojran Lake.* Forest Review, No. 5-6, Skopje (in Macedonian).

Nikolovski, T. 1960. *The conversions problem of degraded hardwood forest in PR Macedonia.* Forest Review, No. 5-6, Skopje (in Macedonian).

Nikolovski, T. 1964. *Low income forest in SFR Yugoslavia and possibilities for transformation into high income ones.* Forest Review, No. 3-4, Skopje (in Macedonian).

Nikolovski, T. 1966. *Contribution to the results of operation of the ban on keeping goats on the development of forest, soil and moderate erosion.* Forest Review, No. 3-4, Skopje, pp. 3-13 (in Macedonian).

Trajkov, P., Kolevska, D.D., Zlatanov, C., and Trajanov, Z. 2007. *Growth of artificial black pine (Pinus nigra Arn.) stands established in different climate-vegetation-soil regions in the Republic of Macedonia.* Proceedings of International Symposium Sustainable forestry – Problems and challenges, Ohrid October 2007 (in Macedonian).

Forestry Regulations

Ljupco Nestorovski

In the Republic of Macedonia, the **Law on Forest** (Official Gazette no. 64/09, and subsequent modifications from 24/11, 53/11, 25/13, 79/13, 147/13 and 43/14) gives instructions and specifies the responsibilities of stakeholders for the management of forests. These guidelines cover the most important goals for state and privately owned forest in order to preserve and further develop sustainable, multifunctional forestry, as well as the socio-economic welfare of stakeholders. Environmental protection and the promotion of other forest functions and values are partly covered within the same Law, and partly in the **Law on Nature Protection** (Official gazette no.53/05 and its modifications). Both Laws have provisions that concern topics such as forest management, forest planning, protection and silviculture.

Following a chain of historical, economic and political events, organised forest management and planning systems for forests in the Republic of Macedonia began after the Second World War. The first Law on Forests was adopted in former Yugoslavia in 1949 and it was subsequently revised several times (1956, 1974, 1986). After independence in 1991, the new Law on Forests was adopted in 1997 and became operational in 1999.

There are no special issues in this Law that treat coppice separate from high forest. Coppicing is considered a regular way of managing forests. The rotation depends on tree species (mostly different types of oak, ash, beech and hornbeam), and is usually done every 30-50 years. The most common treatment is traditional coppicing. To date there is no national inventory, but forest management plans are made for every unit (limited to a maximum of 5,000 ha). There are no differences in the treatment of private and state-owned forests. Private owners with an area of forest greater than 100 ha are obliged to make a **Forest Management Plan** (FMP) that must be approved by the Ministry of Agriculture, Forestry and Water Economy. This also applies to the Public enterprise "Makedonski sumi" that manages state-owned forests, in accordance with the provisions in FMP of the surrounding forests. The **Ministry of Agriculture, Forestry and Water Economy** is also responsible for licensing forest engineers to be able to plan activities in private owned forests.

References

Law on Forestry, Official Gazette 64/09

Law of Nature protection, Official gazette 53/05

Ministry of Agriculture, Forestry and Water Economy, Skopje, Republic of Macedonia

Ministry of Environment and Physical Planning, Skopje, Republic of Macedonia

Trajkov P, Nestorovski L, Tralanov Z.: *National Forest inventories, Assessment of Wood Availability and Use*, Chapter 36, The republic of Macedonia, Springer 2016.

UKIM, Faculty of Forestry, Skopje Republic of Macedonia

Netherlands

Patrick Jansen, Jenny Mills and Peter Buckley

Facts and Figures

Patrick Jansen

Definitions

Closed forest with vegetative regeneration by regrowth of the stools of deciduous species (not willow) with good regrowth capacity.	*Gesloten bos met vegetatieve verjonging door stronkopslag van loofboomsoorten (m.u.v. wilg) met een goed uitstoelingsvermogen.*

Legal Framework

Traditional coppice is considered forest in the Dutch Nature Conservation Act. The criteria are a minimum area of 0.1 hectare and a canopy cover of at least 60%.

Short rotation coppice is considered agriculture in the new Nature Conservation Act. It is defined as: plantation of willow, poplar, ash or alder with the aim to produce woody biomass. It is harvested at least every 10 years and contains at least 10,000 stools per hectare per unit. The short rotation coppice must have been established after January 1st, 2013.

Statistics

Forests in the Netherlands consisted mainly of coppice woodlands until approximately the end of the 19th century. Since then, most coppice woodlands have been converted to high forest through replanting, abandonment and singling. Approximately 1,500 hectares is still coppiced today.

Typology

Simple coppice	As forests and small plantings in open, agricultural area.
Coppice with standards	Currently not practised
Pollarding	On roadsides, waterways and as forests along rivers
Short rotation coppice	Mainly *Salix* (limited area)

Description

Patrick Jansen

Large parts of the Dutch forests, approximately 57%, were coppice woodlands until around 1850. 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. Longer production cycles were used for fuelwood, 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 (Figure 1) in wetter conditions. Due to the rise of cheaper tanning and fuel products and rising labour

Figure 1. Coppice management in alder coppice in The Netherlands (Photo: P. Jansen)

costs, the management of coppice woodlands declined in the second half of the 19th century. Thereafter, only a small proportion of the coppice woodlands were managed in the traditional way. During 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 or 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 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 used 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.

References

Jansen, P., Kuiper, L. 2001. *Hakhout; suggesties voor het beheer.* Stichting Bos en Hout, Wageningen, The Netherlands, 56 p.

Den Ouden, J., Jansen, P., Meiresonne, L. & Knol, R., 2010. Chapter 24: *Hakhout en middelhout.* In: *Bosecologie en bosbeheer.* Den Ouden J., Muys B., Mohren F. & Verheyen K. (editors). ISBN 978-90-334-7782-9, Acco, Leuven, Belgium, 674 p.

Forestry Regulations

Jenny Mills, Peter Buckley and Patrick Jansen

Some 10% (360,000 hectares) of the Netherlands consists of woodland, which is protected under the 1961 **Forestry Act** (the Boswet).

The legislation in the Act applies to planting areas greater than 1000 m^2, or when there are more than 20 trees in a row. Trees in urban areas are excluded; these are regulated under municipal law.

One month before felling is due to take place it must be reported, either by the owner or the contractor, to the Ministerie van Economische Zaken (Ministry of Economic Affairs) by means of a **kapmelding** notification. A topographic map (minimum scale 1:25.000) on which the trees are marked must also be submitted. Only 5 plots can be entered on each kapmelding and a separate one must also be sent for each municipality in which the trees are growing. Felling must take place with a year of submitting the kapmelding, otherwise it has to be re-submitted. An additional permit may be required under other legislation.

A receipt is given after submission of the kapmelding. If there is no response one month after submission, then the trees can be felled.

If the cut is prohibited (kapverbod), the owner is notified within a month of submission and this is also published in the Government Gazette. The reasons are always given. If the owner disagrees with the decision, an objection can be filed within 6 weeks. An appeal decision will be given within 6 weeks of the objection being made. When a landscape of exceptional natural beauty is threatened, the Ministry of Economic Affairs can prohibit felling, but this rarely happens.

After felling, there is a duty to **replant** (herplantplicht) within three years of felling. This also applies if trees have been lost through fire, windthrow or disease. This obligation is attached to the property and, if sold, the new owner has a duty to replant. High fines can be imposed if replanting does not take place. The Forest Act allows planting on a parcel other than that which was felled, but it must occur in a silviculturally acceptable way on a similar-sized area. Natural regeneration is not officially considered to be replanting, but in practice it is allowed if successful (within 6 years).

Thinning and coppicing do not usually include a duty to replant and therefore do not need to be notified by a kapmelding.

A judge adjudicates the difference between thinning and felling: if the canopy cover is reduced to below 60%, it is considered to be a felling.

A kapmelding notification is not required under the following circumstances:

- the trees to be felled are in urban areas and therefore under local authority regulations
- the trees are in gardens and other domestic areas
- the felling is to promote the growth of the remaining trees (thinning)

- coppice or withies are being cut periodically
- felling is taking place as part of an approved development plan
- an exemption has been granted in the Regulations on notification and replanting
- roadside plantations and single-row plantings of poplars and willows on, or alongside agricultural land.

Felling does not have to be reported for the following species: Poplar (*Populus spp.*), lime (*Tilia spp.*), horse chestnut (*Aesculus hippocastanum L.*) and willow (*Salix spp.*,) fruit trees and windbreaks around orchards, spruce up to 12 years old intended as Christmas trees. However, municipal legislation may still apply.

Further applicable legislation:

The 1988 **Nature Conservation Act** (De Natuurbeschermingswet) regulates the protection of areas that the Government has designated as protected natural monuments. It also protects areas in accordance with international agreements such as the Birds Directive (Vogelrichtlijn) and Habitats Directive (Habitatrichtlijn) and the Ramsar Convention, which protects wetlands. In 2005, the Act was amended to better integrate legislation on nature protection, forestry policy and obligations under the Habitats Directive.

For **Natura 2000** areas, special management plans must be developed, including an inventory listing the habitats to be protected. The management plan then provides an overview of the measures that will be taken to protect these habitats. Measures that are included in the management plan may be carried out without a licence, but permission from the province is needed for other activities if they have an impact on protected habitats or species.

The 2002 **Flora and Fauna Act** (Flora- end faunawet) protects designated species. Management, development, hunting, etc., only take place under strict conditions.

As from January 1st 2017 a new **Nature Protection Act** (Wet Natuurbescherming) replaces the Flora and Fauna Act, the Forest Act and the Nature Conservation Act. This will make it easier to apply the law to protect the Netherlands' flora and fauna, Natura 2000 sites and forests. Implementation and controls under the Act will mainly be carried out by each individual Province rather than the Government.

References

Rijksdienst voor Ondernemend Nederland (RVO.nl) http://www.rvo.nl/onderwerpen/agrarisch-ondernemen/beschermde-planten-dieren-en-natuur/natuur-en-landschap/bomen/bos-en-bomen-kappen

Van der Maaten-Theunissen, M. & Schuck, A. (2013) *Integration of Nature Protection in Forest Policy in the Netherlands*. INTEGRATE Country Report. EFICENT-OEF, Freiburg.

Norway

Giovanna Ottaviani Aalmo

Facts and Figures

Definitions

Coppice	*Styving, Lauving*

Legal Framework

Standard coppice does not exist in Norway as the Norwegian forestry sector is essentially dominated by conifers. On the other hand deciduous trees represent a very important part of the cultural heritage and the biodiversity and they are regulated under the "Naturmangfoldloven" (Diversity Act). Nowadays, coppicing is still performed in several counties i.e. Akershus, Rogaland, Sogn og Fjordane and Nord-Trondelag (see Map). 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 amounts to about 50 Euros/tree from the Regional Environmental Program for Agriculture (RMP) for keeping and managing as coppice the deciduous trees on their properties. The legal framework applies therefore to the procedure for registering the trees and obtaining the subsidies.

Typology

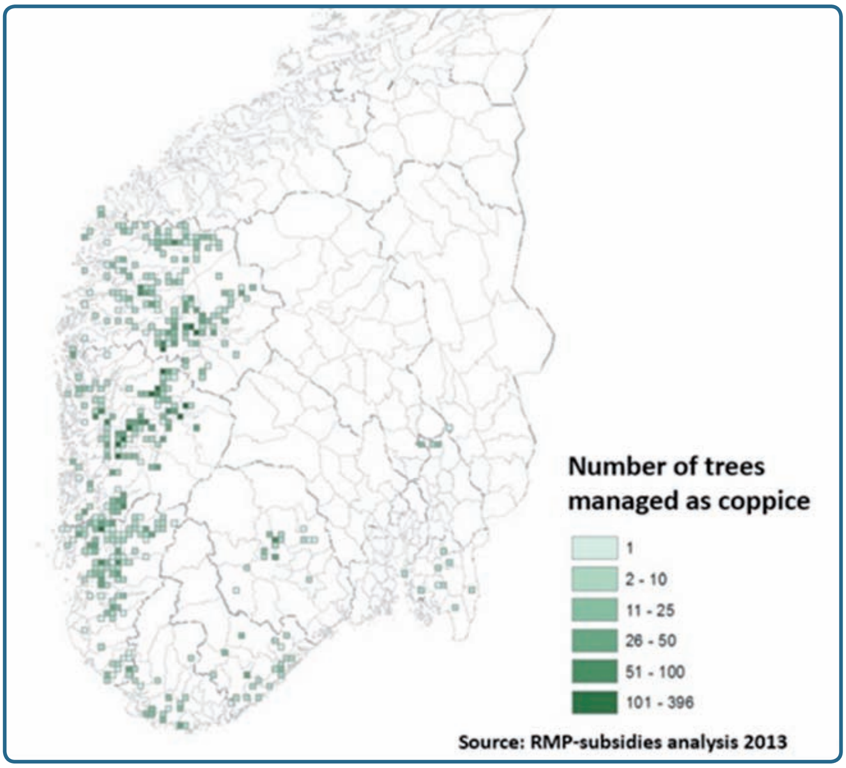
Simple coppice	Practised still in some areas as a cultural heritage. In the past bark was also harvested for tanning.
Coppice with standards	Not practised
Pollarding	Practised still in some areas as a cultural heritage for pastures or boundaries.
Short rotation coppice	Not practised

Images

Coppice managed tree: 1989 (left) and 2009 (right);
Photo by Leif Hauge and Oskar Puschmann;
Location: Arnafjord, Vik Sogn og Fjordane Norway

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

Map



Number of trees managed as coppice in Norway, 2013

Description

Standard coppice does not exist in Norway as the Norwegian forestry sector is essentially dominated by conifers, although, 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.

Using this old traditional technique, farmers cut the main branches of the trees to form several shoots, this increasing 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 (see Images; left).

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 started to grow larger. 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 (see Images; right).

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.

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

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.

References

Austad, I. & Hauge, L. 2003. Lauving-en driftsform med tradisjoner. I Austad, I, Braanaas, A og Haltvik, M (red.): *Lauv som ressurs. Ny bruk av gammel kunnskap*. HSF rapport nr. 4/03. Høgskulen i Sogn og Fjordane og Fylkesmannen i Sogn og Fjordane.

D. SKJØTSEL AV STYVINGSTRE jf. forskrifta § 10; *Tilskot til verdifulle element i kulturlandskapet* https://lovdata.no/dokument/SF/forskrift/2004-02-04-448? q=miljøtiltak%20jordbruket%20 tilskudd

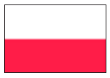
John Bjarne Jordal og Harald Bratli; *Styvingstrær og høstingsskog i Norge,* med vekt på alm, ask og lind Utbredelse, artsmangfold og supplerende kartlegging i 2011

Kari Stensgaard, *Rapport fra Skog og landskap 24/2011* KULTURMINNER OG KULTURMILJØER I JORDBRUKETS KULTURLANDSKAP Rapport for prosjektårene 2004–2008.

Morten Rasmussen; *Alm - mat- og fôrprodusent i 5000 år*

https://www.landbruksdirektoratet.no/no/miljo-og-okologisk/jordbruk-og-miljo/regionalt-miljo-program

Poland



Piotr Mederski, Martyna Rosińska, Mariusz Bembenek and Zbigniew Karaszewski

Facts and Figures

Piotr Mederski

Definitions

1) Coppice: Even-aged or uneven-aged stand consisting of trees (mainly: *Alnus glutinosa* Geartn., *Betula pendula* Roth) that regenerate wholly or mainly (at least 50%) vegetatively (sprout or root shoot). After 2 years, shoots are reduced to only 2 or 3, after 5 years one shoot might be promoted to high forest and felled at 60 years.

2) Short rotation coppice: Plantation of fast-growing trees or shrubs (mainly *Populus* spp., *Salix* spp.), with the aim to produce renewable wood biomass in several short rotation periods (5-20 years each), mainly used for energy.

3) Pollarding: cuts by which the tree trunks (*Salix* spp.) are cut at 2-3 m height from the ground in order to obtain coppice sprouts on the top of the tree.

1) drzewostany odroślowe: jednowiekowe lub wielowiekowe drzewostany (głównie olsza czarna i/lub brzoza brodawkowata) odnawiane wegetatywnie całkowicie lub częściowo (min. 50%). Po dwóch latach od odnowienia pozostawia się 2-3 pędy odroslowe (pozostałe są usuwane), po 5 latach pozostawia się tylko jeden pęd, który dorasta do wieku rębności (60 lat).

2) odroślowe plantacje drzew szybkorosnących: celem jest produkcja drzew lub krzewów (głównie Populus spp., Salix spp.) w krótkich kolejach rębu (5-20 lat); drewno wykorzystywane jest jako energetyczne.

3) ogławianie: usuwanie wierzchołkowej części pnia wierzby (Salix spp.) do ok. 2-3 m wysokości od ziemi w celu uzyskania krzaczastych odrośli w górnej części pnia.

Statistics

Forests cover almost one third of Poland, of which 7,094,696 ha is under the State Forest National Forest Holding management. The total area of coppice amounts to 21,477.57 ha and almost 89% belongs to the State Forest. 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 is black alder (*Alnus glutinosa* Geartn.); 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.

References

Maciejowski K. 1953. *Olsza (Alder).* Państwowe Wydawnictwo Rolnicze i Leśne. Warszawa, p. 27-28.

Szymura T. 2010. *Tradycyjna gospodarka odroślowa w Europie Środkowej i jej wpływ na różnorodność biologiczną (The traditional coppice management system in Central Europe and its impact on biological diversity)*. Sylwan 154 (8): 545−551.

Typology

Simple coppice	Traditional natural forest regeneration used mainly for alder and oak; after 2 years only 2-3 sprouts are left; after 5 years, only one stem is left
Coppice with standards	Alder and oak
Pollarding	For willow only; landscape beautification
Short rotation coppice	Willow and poplar
Other types	Black alder; rotation period 60 years

Description

Martyna Rosińska, Mariusz Bembenek, Zbigniew Karaszewski and Piotr Mederski

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 (Figure 1).

Coppice forests often grow 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., Figure 2), which is able to regenerate well vegetatively.

However, coppice trees are characterised by lower height, high tapering trunk, unilaterally formed crown and vulnerability 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 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

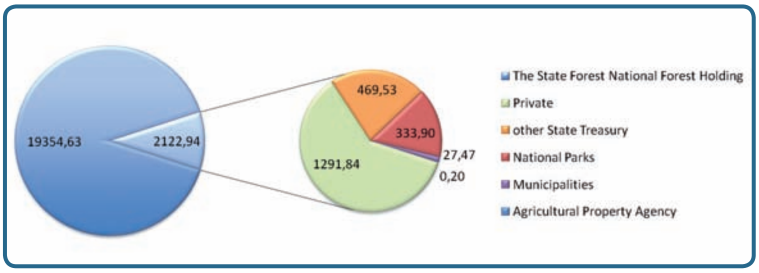


Figure 1. Coppice area (ha) in Poland by coppice owners (Bureau for Forest Management and Geodesy, 2016)

Figure 2. Black alder coppice in Pułtusk Forest District (Photo: M. Rosinska, 2015)

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.

References

Maciejowski K., 1953. Olsza (Alder). *Państwowe Wydawnictwo Rolnicze i Leśne.* Warszawa, pp. 27-28.

Szymura T., 2010. *Tradycyjna gospodarka odroślowa w Europie Środkowej i jej wpływ na różnorodność biologiczną (The traditional coppice management system in Central Europe and its impact on biological diversity).* Sylwan 154 (8), pp. 545–551.

Portugal

João Carvalho, Abel Rodrigues, Helder Viana, and Mário Costa

Facts and Figures

João Carvalho, Abel Rodrigues and Helder Viana

Definitions

Coppice is a system where trees originate from vegetative or asexual reproduction. Most coppice forests have been converted into high-forest in the last decades. This has involved oaks (*Quercus faginea, Q. pyrenaica, Q. robur, Q. ilex*) and chestnut (*Castanea sativa*). The aim is to produce better timber quality and for conservation purposes. In the case of holm-oak (*Q. ilex*), many areas have been managed as a sylvo-pastoral system known as montado. The most common coppice forests in the country involves *Eucalyptus* plantations for pulpwood production. The most usual species is *E. globulus* which is grown in rotations of 10 – 12 years.

Coppice
= Talhadia

Coppice with standards
= Talhadia composta

Legal Framework

The Forest Inventory considers forests of over 0,5 ha, minimum cover of 10% and width larger than 20 m. In general, there are no restrictions on clearfellings or on harvesting age. However, some natural parks might put some restrictions for certain species. Restrictions consider size of clearcuttings for species that are relevant for conservation and protection purposes (mostly oak species). Some species are protected by law in respect to harvesting. Cork-oak (*Quercus suber*) and holm-oak (*Q. ilex*) cannot be pruned or harvested without permission from the official authority (Institute for Nature Conservation and Forestry). In relation to forest establishment densities, there are some minimal densities if the afforestation is supported by a financed project. It depends on species: Pine and other conifers 1000 trees/ha; *Pinus pinea* (fruit) 200 trees/ha; broadleaves 600 – 800 trees/ha; cork-oak and holm-oak (sylvo-pastoral system) 250 trees/ha. Forest areas affected by fire cannot be used for another purpose (e.g. construction) and must be forested.

Short rotation coppice is considered in those cases where the rotation is between 2 – 5 years. In Portugal, short rotation coppices are not common.

Statistics

The coppice area is estimated around 863,000 ha. The *Eucalyptus globulus* area tended for pulp production, with a rotation period of 12 years, occupies an area of a 812,000 ha or ~ 26 % of total forest area (3,154,800 ha). Other types of coppicing have much longer rotation periods, such as oaks, *Castanea sativa* (20-50 years; eventually converted to high forest on a significant scale), as well as ash and poplar (20 year rotation), which are produced for timber.

Reference

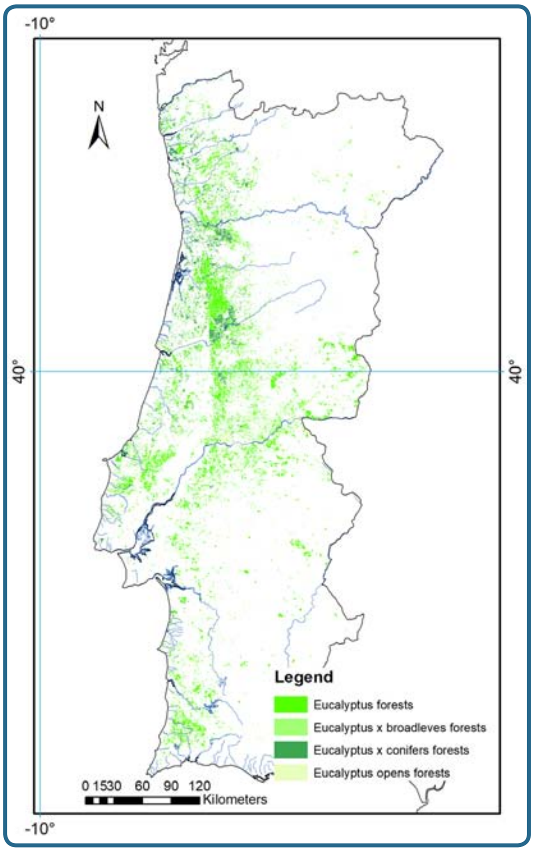
ICNF, 2013. *IFN6 - Áreas dos usos do solo e das espécies florestais de Portugal continental. Resultados preliminares*. Instituto da Conservação da Natureza e das Florestas, Lisboa 34 pp.

Typology

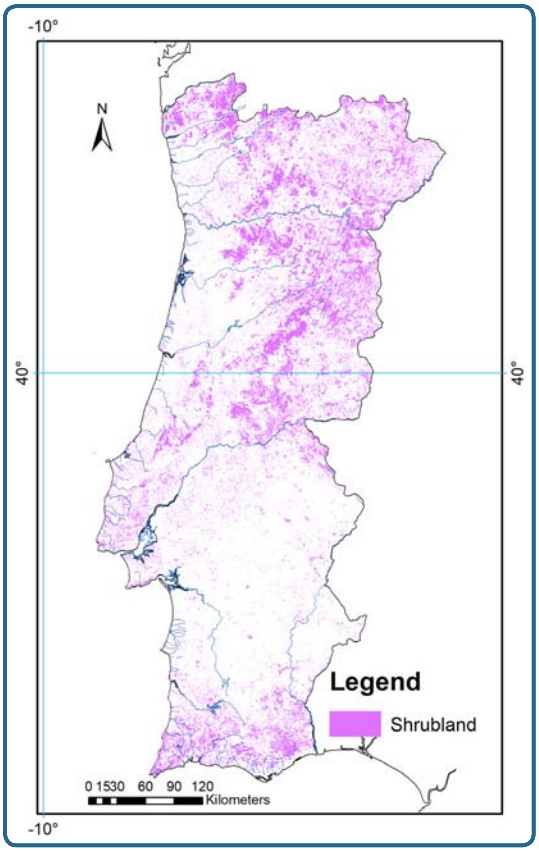
Simple coppice	*Eucalyptus* is the most common type of coppice forest in the country. The most usual species is *Eucalyptus globulus*, which is grown for pulpwood production. Areas with chestnut consist mostly of orchards for fruit production. Only small areas exist with coppice that was used in the past for the production of small sized wood. Some oak species are coppiced (*Quercus faginea, Q. pyrenaica, Q. robur, Q. rotundifolia*) for the production of firewood. Holm-oak (*Q. rotundifolia*) is the most common oak species used as coppice. Most coppice has been converted to high-forest for quality timber and conservation purposes.
Coppice with standards	*Castanea sativa, Quercus faginea, Q. pyrenaica, Q. ilex* subsp. *rotundifolia*
Pollarding	Pollarding may be found in some areas, mostly with ash (*Fraxinus angustifolia*) and poplar (*Populus nigra*)
Short rotation coppice	Hardly practised

Maps

Helder Viana and Abel Rodrigues



Map of the current extent of *Eucalyptus globulus* in Portugal; most of this species is coppiced



Map of shrubland in Portugal; this area has the potential to be converted to simple coppice

References
Albuquerque, J. de Pina Manique (1954). *Carta Ecológica de Portugal*. Ministério da Economia. Direcção Geral dos Serviços Agrícolas. Lisboa. 58pp.
COS2010 (v1.0). *Carta de Uso e Ocupação do Solo de Portugal Continental*. http://www.dgterritorio.pt/dados_abertos/cos/
ICNF, 2013. IFN6 - *Áreas dos usos do solo e das espécies florestais de Portugal continental. Resultados preliminares*. Instituto da Conservação da Natureza e das Florestas, Lisboa 33 pp.

Description

João Carvalho, Helder Viana and Abel Rodrigues

Coppice is a silvicultural system that has been commonly used in Portugal for centuries. It 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 eucalypt (mainly *Eucalyptus globulus*).

While coppicing of some species has declined over the years, eucalypt coppice, grown on 10 to 12 year rotations for pulpwood production, has expanded enormously in recent decades. *Eucalyptus globulus* (Fig. 1) is now dominant over approximately 812,000 ha (National Forest Inventory, 2013) and, as this is 26% 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.

The 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 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 eucalypt, as well as lignocellulosic crops such as reed canary grass (*Miscanthus*) and switch grass. Currently, short-rotation coppice (SRC) to produce raw material for energy purposes is 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 eucalypt (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 eucalypts (85% stands between 8 and 30) and 8 to 20 tons dry weight ha^{-1} $year^{-1}$ for poplar.

Figure 1. Eucalypt (*E. globulus*) coppice stands in Portugal

References

Abel, R., 2012. *Modelos potenciais de talhdia de curta rotação (SRC) para choupo e eucalipto em Portugal, no contexto do potencial global da biomassa.* INIAV, Oeiras.

Carvalho, J. and Loureiro, A., 1996. *Stool and root resprouting according to different cutting seasons in a Quercus pyrenaica Willd. coppice.* Annali Istituto Sperimentale Selvicoltura 27, pp. 83-88.

European Commission, 2014. *Communication from the Commission to the European Parliament and the Council, The European Economic and Social Committee and the Committee of the Regions. A policy framework for climate and energy in the period from 2020 to 2030.* COM(2014) 15 final, Brussels, Belgium.

National Forest Inventory, 2013. Autoridade Florestal Nacional, Lisbon.

Viana, H., Cohen, W.B., Lopes, D., Aranha, J., 2010. *Assessment of forest biomass for use as energy. GIS-based analysis of geographical availability and locations of wood-fired power plants in Portugal.* Applied Energy 87, pp. 2551-2560.

Forestry Regulations

Abel Rodrigues, Mário Costa and Helder Viana

The forest public service was first institutionalized in 1824, under the aegis of the Navy Ministry, with the creation of the **Royal Forest Administration**, which was subsequently transferred to the Ministry of Industry, Trade, and Public Infrastructures. In 1886, the first public institution was created, which aimed to reforest the Gerês and Estrela Mountains in Northern Portugal. In 1901, the forest regime code was implemented in a law that included the main legislation concerning the forest sector. In 1919, the **Forest Services** were put under the General Direction of Aquaculture and Forests (DGRFA), which developed forest engineering works such as torrent mitigation and the forestation of coastal dunes through the **Law of Forest Settlement** in 1938. Nowadays, the Forest Service's Extension is consolidated within the **Institute for Conservation of Nature and Forests** (ICNF), resulting from the merger of the former Nature Conservation Institute, part of the Environment Ministry, with the General Direction of Forest Resources from the Agriculture Ministry.

In Portugal, the forest area occupies about 35% of the territory (3.2 Mha), with an additional 1.5 Mha occupied by shrubland. Historical circumstances have dictated that more than 90% of the forest area is in private ownership, a very high percentage compared with privately-owned forest areas in other countries, e.g. 70% in Spain, Finland and Sweden; an average of 60% in the EU 27 countries; 55% in the USA and 8% in Canada. The main forest species in Portugal are managed or are potentially manageable under the coppice regime. Indeed, nowadays, the main forest species is eucalypt (*Eucalyptus globulus*) with an area of 812,000 ha, managed intensively as coppice for pulp production. These coppices run for 4 or 5 rotation cycles, with 8-12 years per cycle. On burnt sites, the ability of eucalypts to re-sprout from stumps enables their partial recovery. After maritime pine (*Pinus pinaster*) high forest, grown only for wood production, the third species in terms of area occupied is cork oak (*Quercus suber*), with 730,000 ha, followed by holm oak (*Quercus rotundifolia*), occupying around 330,000 ha. Other oaks (*Quercus faginea; Quercus rotundifolia; Quercus robur; Quercus pyrenaica*), and chestnut (*Castanea sativa*) cover around 66,000 ha, and 40,000 ha, respectively. The latter species is mainly managed for fruit as high forest, but an area of around 3,000 ha of chestnut is managed as coppice for wood production.

The aforementioned forest regime code of 1901 was replaced by the **Forest Code** under a law of September 2009, but revoked in 2012. Nowadays, in addition to the 1901 regime, forestry legislation includes the following:

- 1996 law on the basis of national forest policy;
- legislation from 1999 and 2009 concerning regional forestry plans (PROF),
- plans of forest management (PGF)
- specific plans of forest intervention (PEIF), which can be adapted to county, district and national levels
- legislation from 2001 for the protection of cork oak and holm oak
- legislation from 2005 on forest intervention zones (ZIF)
- regulation from 2013 on the juridical regime of forestation and reforestation.

The **National Strategy for Forests** (ENF), approved in 2015, is a vast document emphasizing biotic and abiotic risks in forestry, the economic relevance of the main forestry clusters and forecast scenarios of resource allocation and forest diversification until 2030. In 2017, the urgent need for reform in the forest sector, stimulated by political pressure to control forest fires, resulted in 13 legislative acts, with three awaiting ratification.

These **new acts enhance and complement previous forest legislation** with regard to the following relevant topics:

(i) The ENF, reviewing estimates of scenarios for climate change in Portugal, suggested a **reduction of the area suitable for eucalypts** leading up to the end of the 21th century. Taking into account the versatility of this species for production of goods and services, the ENF came up with a proposal to stabilize the actual area of 812,000 ha until 2030. In this context, legislation in 2017 imposed a strict control of eucalypt forestation, limiting the expansion of eucalypt coppices and allowing new plantations only in compensation for former areas of eucalypt previously abandoned, on condition that these abandoned areas should be cleared and left in a suitable condition for either agricultural or forest use. Moreover, if the total eucalypt area surpasses the ENF's threshold, an intervention for reducing the total area is made, prioritising projects or stands abridging existing eucalypt areas higher than 100 ha.

(ii) the establishment of the so-called **Entities of Forest Management** (EGF), i.e. corporations of forest owners or private agents operating within a specific juridical regime, aiming to manage forests larger than 100 ha, wherein 50% of land assets should consist of areas smaller than 5 ha. The main objective is to promote professional management in small forest properties, creating economies of scale under good practice codes, which allow for economic and sustainable feasibility of the available land assets to be achieved. In this context, the EGF is entitled to fiscal benefits and other forms of public support.

(iii) simplifying the process of establishing **forest intervention zones** (ZIF), defined in 2005 as continuous and delimited areas, subject to a plan of forest management approved by ICNF. Also, if necessary, ZIFs can define specific plans of forest intervention, regulated by ICNF, aimed to control biotic or abiotic risks such as soil erosion, biodiversity, phytosanitary conditions or fire protection. ZIFs are managed by a single private entity, with the necessary technical expertise and a commitment to follow the guidelines and objectives established for the ZIFs, scrutinized by the forest owners' council. Legislation in 2017 simplified the creation of ZIFs, establishing both maximum and minimum areas of 20,000 ha and 500 ha respectively, with no more than 25 necessary associates and 50 forest land properties within each intervention zone. There were provisions for consolidating forest properties from different counties. The ZIFs are covered by fiscal benefits that consider the specific kind of goods and services delivered by forests and agro-forest farms and the long-term returns from forest investment. The philosophy of the ZIFs and EGFs was to consider the prevalence of small private forests and to provide incentives for amalgamating forest and agro-forest farms and to promote professionalization in forestry and forest management.

(iv) the 2017 legislation changed the **juridical status of regional forestry plans** (PROFs), by delegating to municipal authorities the capacity to intervene on soil use, by transferring of some elements of the regional forestry plans to Municipal Directory Plans (PDMs). Municipalities will henceforward be able to include mandatory forestry components in their PDMs. Legislation of 1996 and 1999, actualized in 2009, allocated to ICNF the responsibility of forest planning. The objective was to establish a continuous process of decision-making over the use and conservation of forest areas and resources and to achieve medium and long term targets laid down in national strategies, particularly the National Strategy for Forests (ENF). Forest planning was designed to operate at three levels:

1) regional or supra-municipal, where the PROFs are elaborated in coordination with other public priorities of the regions

2) local, where plans for forest management (PGF) are coordinated with local practices of forest management

3) at a lower operational level, through specific plans for forest intervention (PEIF), dealing with local constraints such as biotic and abiotic risks, recovery of degraded soils, forest diseases, forest fires and improved water retention.

The preparation and execution of PGFs is obligatory in situations such as:

- public and community forests or agro-forestry farms,
- private forests or agro-forestry farms with areas equal or greater than those defined in the respective PROFs,

- candidate forest or agro-forestry farms for national or EU financial support, aimed to benefit forest production and commercially valorize the ZIF areas.

In the latter context, forest owners and economic agents who are committed to PGFs within ZIFs are exempt from the obligation of making their own PGF.

From 1996, national forest policy laws strictly regulate the cutting of trees, so that forest owners must communicate to ICNF the type and extent of scheduled tree cuttings. The **juridical regime of forestation and reforestation** of 2013 (RJAAR) requires forestation and reforestation operations with forest species be referred to ICNF. This legislation controls and evaluates forestation and reforestation operations that do not apply to urban or transport matters, which are regulated by other legislations. The RJAAR also exempts control operations in areas of less than 5000 m^2, with a width greater than 20 m.

Portugal is the premier cork producer in the world; the cork oak stands are traditionally managed as high forest, although the coppicing system operates in other Mediterranean countries. Indeed, as early as 1950, "Subericultura (Cork oak cultivation)", the *magnum opus* of Vieira de Natividade, promoted the environmental advantages of cork oak and holm oak coppice in protecting soil, using cycles of 10-15 years. This is no minor issue in the southern part of the country, where low fertility soils are prone to erosion; cork oak coppicing is then directed towards biomass production with a theoretical density of about 1000 stumps/ha.

The legislation concerning cork oak and oak dates from 2001; it allows for the conversion to coppice from high forest when thought necessary for technical and environmental reasons. Noteworthy additions to this legislation emphasize the need to protect these indigenous species, citing definitions of stand density (number trees/ha): 50 trees/ha for trees taller than 1m, with a perimeter at breast height (dbh) of less than 30 cm; 30 trees/ha, when the average dbh is between 30 cm and 79 cm; 20 trees/ha, when the average dbh of the trees is between 80 cm and 129 cm; and 10 trees/ha, when the average dbh is greater than 130cm. These trees can be rejuvenated when new poles grow from the stumps. An authorization from the ICNF is mandatory when cutting cork oak or holm oak trees, including thinning, which must be registered within a period of 30 days. Conversion from high forest to coppice, or phytosanitary pruning, also needs prior authorization. In cork and holm oak stands, deep soil cultivation is forbidden since it may affect tree root systems and natural regeneration. Soil cultivation is also prohibited on slopes between 10% and 25%, and also above 25% if not carried out along the contour lines. Among the remaining forest species (e.g. *Quercus pyrenaica* and chestnut) that are manageable as coppice, these are candidates for the necessary diversification of the Portuguese forest landscape. These species are subject to the common principles and objectives of the National Strategy for Forests, which aims to protect forest species with special ecological importance and vulnerability.

References

List of the Portuguese forest legislation [on-line] at: http://www.icnf.pt/portal (assessed at 24/07/2017)

Goes, E., 1991: *A Floresta Portuguesa*, 251 pps. Edt. Portucel (in Portuguese).

Pereira, J., 2014: *O Futuro da Floresta em Portugal*, 110 pps. Edt.FFMS (in Portuguese).

Louro, V., 2016: *A Floresta em Portugal, um apelo à inquietação cívica*, 268 pps. Ed. Gradiva (in Portuguese).

Natividade, J., 1950: *Subericultura*, 387 pps. Ed. Direcção Geral das Florestas (in Portuguese).

Romania

Valeriu-Norocel Nicolescu and Cornelia Hernea

Facts and Figures

Valeriu-Norocel Nicolescu

Definitions

(1) Coppicing (regeneration method) is the general way of managing a forest, based on vegetative propagation (Forest Law, 2015).	*(1) Regimul crângului constituie modul general de gospodărire a unei păduri, bazat pe regenerarea vegetativă (Codul Silvic, 2015).*
(2) Simple coppice (low coppice) - silvicultural system in which the old stand is exploited at young ages (under 30-40 years) by clear-felling, and the regeneration is accomplished by stump stools or root suckers.	*(2) Crâng simplu - tratament prin care arboretul se recoltează la vârste tinere (sub 30-40 ani) printr-o tăiere rasă, iar regenerarea se face prin lăstari sau drajoni.*
(3) Pollarding - cuts by which the tree trunks are shortened at 2-3 m height from the ground, to avoid the death by asphyxiation of the cut trees during flooding.	*(3) Crâng cu tăiere în scaun - tăieri prin care tulpinile arborilor se scurtează de la înălțimea de 2-3 m de la sol, pentru a feri suprafețele tăiate de asfixie în timpul inundațiilor.*
(4) Coppice with standards - intermediate regeneration method, between the two fundamental ones (coppice and high forest), in which the regeneration is accomplished by both seed and stools.	*(4) Crâng compus - regim intermediar între cele două regime fundamentale (crâng și codru), în care regenerarea se face atât din sămânță, cât și din lăstari.*

Legal Framework

In all Romanian forests, the only legal regeneration method (regime) is high forest.

The only forests in which coppicing is allowed consist of native poplars (black and white), willows, black locust, as well as alluvial forests (pure or mixed willow and/or poplar stands) (Forest Law, 2015).

Rotation Period

Black locust stands: from 20 years (5th yield class) to 35 years (1st yield class);

White willow: from 15 years (5th yield class) to 30 years (1st yield class)

Statistics

Coppice (low) forests cover only about 5% of national forestland.

Typology

Simple coppice	Legally performed only in black locust, native poplars (black and white) and native willow stands; size of logging areas: maximum 3 ha
Coppice with standards	Forbidden since 1948
Pollarding	Performed in white willow (*Salix alba*) stands along the Danube and major inner rivers
Short rotation coppice	Practised on a small scale, only for willows and hybrid poplars

Images

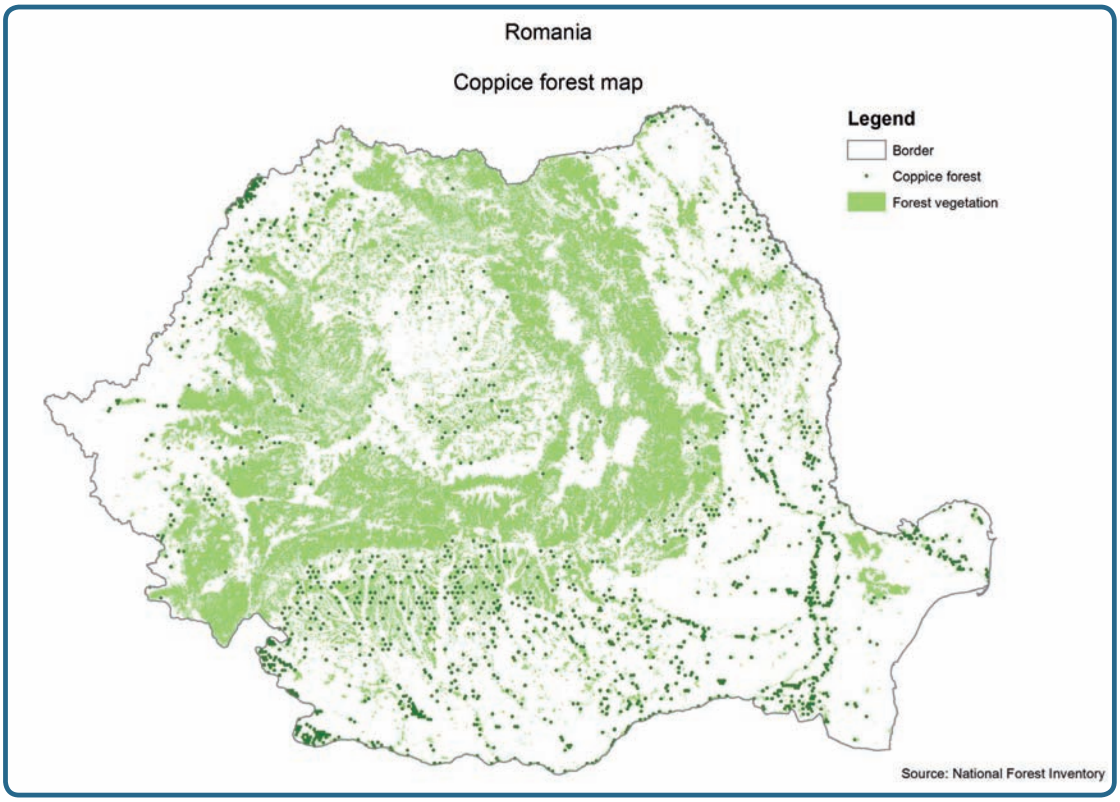
Low coppice, linden; since converted to high forest

Pollarding

Willow clone treated as short rotation coppice

Map

Valeriu-Norocel Nicolescu



Map of coppice forest (dots) and forest vegetation (green) in Romania
Source: National Forest Inventory of Romania, 2017

Description

Valeriu-Norocel Nicolescu and Cornelia Hernea

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

- the forests are historically dominated by broadleaved tree species, mainly oaks (e.g. sessile, pedunculate, Turkey, Hungarian, pubescent) and European beech, but also maples, ash, hornbeam, lindens, alders, poplars, willows, etc. Although their share has decreased in the past two millennia due to human transformations, broadleaves still cover over 70% of the national forest land.
- the country has one of the highest rural populations in Europe; this is still true despite its decrease from 89% in the mid-19th century to about 46% at present.

Before the nationalisation 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, with 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), willows in floodplain areas, and black locust forests. Yearly, approximately 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 (Figure 1), with a size of maximum 10 ha. The rotation of cutting in pollarding is 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 have been established.

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.

Since 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, which is mandatory according to the legal requirements, is a major challenge in technical

Figure 1. Pollards of white willow are a characteristic feature along the banks of Danube River.

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 would affect the ownership rights, as well as the freedom to manage them in a more dynamic and profitable way.

References

Costea, C. 1989. *Economia şi conducerea întreprinderilor forestiere.* Editura Ceres, Bucureşti, 339 p.

Ionescu, A.I. 1930. *Contribuții la studiul culturii și tehnicii crângurilor compuse în România.* Revista pădurilor, no. 12, pp. 1256-1282.

www.insse.ro/cms/files/Anuar%20statistic/14/14.Agricultura%20si%20silvicultura_ro.pdf

2015. Codul silvic.

Forestry Regulations

Valeriu-Norocel Nicolescu

Legal framework in relation to coppice

1. Law no. 133/2015 for the modification of Law 46/2008 (Forest Law)

Art. 28:

(2) The high forest regeneration system is applied to the regeneration of all forests.

(3) The exception from (2): stands of native poplars (black, white) and willow, in the floodplain areas, and black locust stands, where the application of a coppice regeneration system is allowed.

Art. 29:

(1) The size of clear-cutting (including coppice) coupes is a maximum of 3 ha.

2. Ministry of Waters, Forests and Environmental Protection 2000: Technical norms for the choice and application of silvicultural systems 3 (*Norme tehnice privind alegerea si aplicarea tratamentelor 3*). Ministerul apelor, padurilor si protectiei mediului, Bucuresti, 78 pp.

Low coppice

Its application is only allowed in native poplars, willow stands in the floodplain areas and black locust stands.

Regeneration is by coppice stools or root suckers.

Cutting is only during the dormant season, preferably close to its end.

Size of coupes: max. 3 ha. Interval between the cuttings in the same compartment: 2-3 years.

Cutting with axes (tree diameters less than 15 cm) or a saw (larger diameters or stools originating from old stumps); maximum height of stump is 5 cm.

The variant with regeneration by root suckers, after the removal of stumps and levelling of the ground: not allowed in sites with mobile sand dunes and with erosion problems.

After 3-4 generations of coppice (by stump stools), the stumps are removed and replaced with plants to avoid the degradation of low coppices.

Pollarding

The system is used for willow stands affected by repeated flooding, i.e. in the Danube Delta and Danube floodplain area.

Stumps are cut high, above the highest flooding levels over a long chronosequence, to avoid the stump being covered by the flood waters.

The old high stumps are removed after 2-3 generations of pollards and replaced by plantations with seedlings or rods (tall cuttings).

Size of annual coupes: 10 ha. Rotation of cuttings in the same compartment: 1 year.

Arrangement of coupes: perpendicular to the watercourse.

Coppice selection system

Can be adopted experimentally in some small-sized black locust stands, in stands located on ravine banks or on degraded lands.

Can be taken into account in small-sized private forests.

Note: even though it's part of the technical norms, this system is NOT included into the table used to choose the silvicultural systems for different forest vegetation formations/types!

3. Ministry of Waters, Forests and Environmental Protection 2000: Technical norms for forest management 5 (*Norme tehnice pentru amenajarea padurilor*). Ministerul apelor, padurilor si protectiei mediului, Bucuresti, 163 pp.

They include:

(i) Calculation of annual allowable cut for management units treated as coppice: for black locust stands (10-year period), as well as native poplar (black, white) and willow stands (5-year period).

(ii) 10-year management plans for:

- exploitable coppice stands, reaching the rotation age (coppice cuttings)
- non-exploitable or pre-exploitable coppice stands, with tending operations
- coppice stands to regenerate artificially.

(iii) Rules for converting coppice forests to high forests:

- conversion by coppice ageing (total cessation of coppice cuttings)
- conversion by coppice replacement and planting

(iv) Technical rotation age in stands/compartments treated as coppice, depending on the species and yield class:

Species	Technical rotation age per yield class...				
	I	II	III	IV	V
Black locust	35	30	25	25	20
Native poplars (black, white)	35	35	30	25	25
Willow (pollard)	30	25	20	20	15

(v) Intensity of thinning (% of standing volume) in coppice stands with canopy cover 90-100%, depending on the species and mean stand age:

Species	Mean stand age (years)	
	11 - 20	21 - 30
	Thinning intensity	
Black locust	35	35
Native poplars (black, white)	30	25

Serbia

Milun Krstić and Nenad Petrović

Facts and Figures

Milun Krstić and Nenad Petrović

Definitions

Coppice forest is a traditional silvicultural form that involves repetitive felling on the same stump, near to ground level, and allowing the shoots to regrow from that main stump or roots. Coppice forests in Serbia can be grouped into three categories based on their productivity: good productivity on a good site; low productivity on a good site; and low productivity on a bad site. Most common are productive coppice stands with valuable wood quality on a good site. The main silvicultural strategy in such coppice stands is indirect conversion towards high forest. Maximum rotation period is 80 years. Coppice is an important asset for private forest owners, especially for a regular supply of fuelwood from their small forest lots. The most abundant species are oak and beech.

Izdanačke šume – panjače su su uzgojni oblik šume obnovljene vegetativnim putem, kada su se nova stabla razvila iz panjeva ili žila posečenih stabala. Izdanačke šume u Srbiji se mogu grupisati prema produktivnosti u sledeće kategorije: Dobre na dobrom staništu, loše na dobrom staništu i loše na lošem staništu. Najzstupljenije su dobre izdanačke šume na dobrom staništu. Glavna mera u toj kategoriji izdanačkih šuma je indirektna konverzija sa ciljem dobijanja visokih šuma. Maskimalna ophodnja u izdanačkim šumama je 80 godinaIzdanačke šume igraju važnu ulogu u redovnom snabdevanju privatnih šumovlasnika ogrevnim drvetom za sopstvene potrebe. Najzastupljenije vrste su hrast i bukva.

Gajenje šuma – konverzija, melioracija i veštačko obnavljanje, 2006

Legal Framework

There is no direct legal framework, but coppice is mentioned in the classification of forests in the Regulation of the Ministry of Agriculture, nr. 453/2006 (coppice and high forest originated from coppice). Coppice is a stand of deciduous trees with re-sprouting ability from roots and tree stools, predominantly in the oak forest vegetation zones.

VÝMLADKOVÝ LES. Výmladkový les tvoria listnaté porasty obnovované koreňovou a pňovou výmladnou schopnosťou, väčšinou v oblastiach dubového vegetačného stupňa.

In the Forest law, 2016:

1. Coppice forest is a stand of coppice origin that has not overgrown the size of a pole stand. In coppice forests, the marking of trees is not mandatory.
2. Short rotation coppice is only allowed on agricultural land.

Statistics

Coppice stands occupy 1,456,400 ha, which is 64.7% of the total forest area. They are predominantly oak (42%) and beech (21%). Most coppice forests are in private ownership with 61.4%. The most common are preserved coppice stands with 76.3%. The share of insufficient stocked coppice stands is 21.3% over the area. Devastated coppice stands represent 2.4%. There is an unfavourable age structure: young (10%), middle-aged (78%) and mature (12%).

Source: National forest inventory of the Republic of Serbia, 2009

Typology

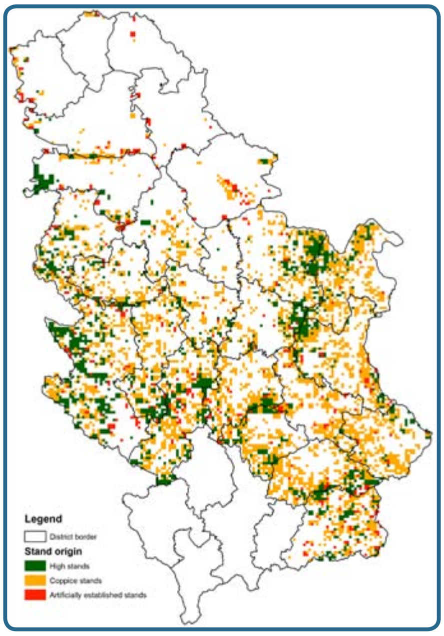
Simple coppice	Traditional natural regeneration methods
Coppice with standards	*Fagus* spp., *Quercus petraea, Q. cerris, Q. frainetto, Carpinus* spp.
Pollarding	Very rare
Short rotation coppice	*Salix* spp.
Other types	False coppice: *Fagus* spp., *Q. petraea, Q. cerris, Q. frainetto*; Very productive. This coppice type is scheduled by planning documents to be converted into high forests Preserved coppice: Dense to complete canopy (1.0-0.6), good health and good-quality trees, there is a favourable ratio of principal and minor tree species. Insufficiently stocked coppice: Incomplete canopy (0.4-0.6), good health and good-quality trees, but a less favourable ratio of principal and minor tree species. Devastated coppice: Characterised either by broken canopy (below 0.4), or by poor tree health and quality, or completely unfavourable tree species ratio (favouring of minor species).

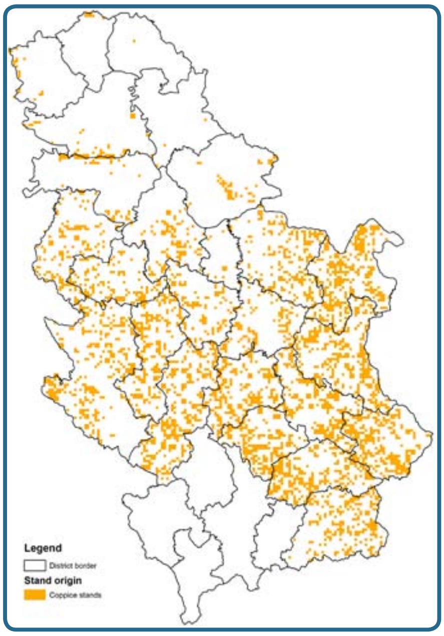
Images




Map

Nenad Petrović





Maps of coppice forests in Serbia (orange); compared to high forest (green) and artifically established stand (red) on the left and coppice on its own on the right (Data: National forest inventory of the Republic of Serbia, 2009)

Description

Milun Krstić

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% of those are dominated by oak and 25% by beech. 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 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.

Figure 1. A typical example of coppice in Serbia

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 of age.
- 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, planting of appropriate species of trees that can grow successfully under such conditions (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.

References

Aleksić P., Krstić M., Milić S., 2011. *Silvicultural needs and measures aimed the realization of the national forest action program of the Republic of Serbia.* First Serbian forestry congress – future with forest. Belgrade, Republic of Serbia, November 11-13. University of Belgrade, Faculty of Forestry, Belgrade. Congress Proceedings, pp. 87-96.

Krstić M., Stojanović LJ., Rakonjac Lj., 2010. *The tasks of siviculture in regard to the curent climate shange. International Scientific Conference "Forest ecosystems and climate changes".* Institute of Forestry, Belgrade, March 9-10th, Plenary lectures, pp. 117-130.

National Forest Inventory (NFI) – Presentation 2009, Belgrade (in Serbian).

Slovakia

Alexander Fehér

Facts and Figures

Definition

Coppice is a stand of deciduous trees that have the ability to re-sprout from roots and tree stools, predominantly in the oak forest vegetation zones.

VÝMLADKOVÝ LES. Výmladkový les tvoria listnaté porasty obnovované koreňovou a pňovou výmladnou schopnosťou, väčšinou v oblastiach dubového vegetačného stupňa.

Legal Framework

There is no direct legal framework, but coppice is mentioned in the classification of forests in the Regulation of the Ministry of Agriculture, nr. 453/2006. The classifications are coppice and high forest originating from coppice.

Statistics

The extent of coppice forests in Slovakia is 34,463 ha (1.8 % of the total forest area), as well as 76,216 ha (3.9 %) of high forests originating from coppice in the first generation (the latter category is 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 were still 208,438 ha of coppice. The Slovak legislation does not count on having a significant amount of coppicing in the future.

A total area of SRC on forest land of Slovakia is 520 ha; the potential area for SRC on forest land is 15,000 ha. According to estimations of the National Forest Centre, the theoretical potential for SRC on agricultural land in Slovakia is 45,000 ha (however currently there are only about 150 ha of SRC).

National Forest Centre. 2011. *Národný program využitia potenciálu dreva Slovenskej republiky (National program of wood utilization potential in Slovak Republic)*. Online: http://www.nlcsk.sk/nlc_sk/papvpdsr/n5ndur.aspx

Typology

Simple coppice	Traditional natural forest regeneration method, recently limited use only, in black locust, oak, hornbeam, beech, alder, willow and poplar forests
Coppice with standards	Oak, rarely others
Pollarding	Historically; now rarely on roadsides or in yards & parks; willow, mulberries
Short rotation coppice	Willow, poplar
Other types	Coppice in conversion to high forests (oak-hornbeam, beech etc.)

Description

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

After beech, oaks are the most important deciduous woodland trees in Slovakia; it is, however, usually more difficult to restore than the former. Oak forests are unstable and their abundance fluctuates depending on human activities, but when they are coppiced, it 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, preventing full canopy closure and the dominance of shade-demanding species, the oaks decline. Hornbeam, which is more shade tolerant, can proliferate and create 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, which also prevented effective natural regeneration of oak from seed. Therefore, the best way to support the oak is likely to be by coppicing, but this requires further study 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, requiring 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 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 the rare (and often protected) species would be retained. Furthermore, drier areas require simple management with thinning, while wetter forests require more frequent management.

Regulations do limit the planting of new black locust (*R. pseudoacacia*) forests, but they are not registered on the official list of invasive plant species (Regulation of the Ministry of Environment SR Nr. 158/2014).

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

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 of 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).

Figure 1. Aged coppice forest: *Quercus petraea* and *Q. dalechampii* at Nitra (SW Slovakia) (Photo: A. Feher)

Slovenia

Nike Krajnc, Matevž Mihelič and Anton Poje

Facts and Figures

Nike Krajnc, Matevž Mihelič and Anton Poje

Definitions

Coppice forest is forest with a short rotation period and is characterized by rejuvenation with stump shoots.

Panjevski gozd je gozd s kratko obhodnjo, ki se obnavlja s poganjki iz panja.

Legal Framework

1. Short rotation coppice is allowed only on agricultural land (Forest law, 2016).
2. Coppice forest is a stand of coppice origin that has not overgrown the size of a pole stand.

In coppice forests, the marking of trees is not mandatory (Forest law, 2016).

Rotation Period

Distinctively short rotation; felling age is between 12-30 years.

Statistics

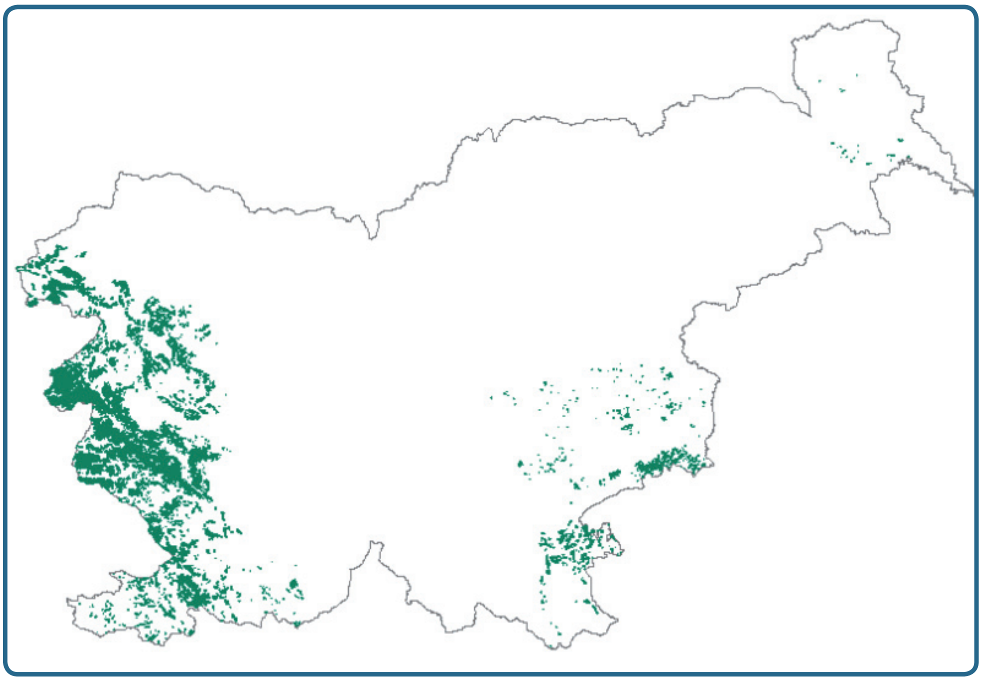
Coppice forests in Slovenia currently cover only 36,340 ha, which is less than 3,1 % of total forest area (Slovenian Forest Service, 2015). These forests are present in the west, south west, and south-east part of the country (see Map).

Typology

Simple coppice	Traditional natural forest regeneration method (beech, chestnut, black locust, oak)
Pollarding	Historically present in the south of the country
Short rotation coppice	Present on test plots – *Salix* spp.

Map

Nike Krajnc, Matevž Mihelič and Anton Poje



Map of coppice forests in Slovenia (in green)

Source: Slovenian Forest Service (2015)

Description

Nike Krajnc and Matevž Mihelič

Traditional coppice forests in Slovenia

According to official data from the Slovenian Forest Service, coppice forests in Slovenia (Figure 1) cover only 36,340 ha, which is less than 3,1 % of total forest area (Slovenian Forest Service, 2015). 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.

Figure 1. Coppice forests in Slovenia (Photos: N. Krajnc)

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

1. In the west, coppice was mostly used for production of poles and firewood. The main tree species used were *Robinia pseudoacacia, Quercus* spp. and to a lesser extent *Castanea sativa*.

2. In the south, coppice forests were mainly used for production of charcoal and are mostly dominated by beech. The high demand for charcoal originated from the ironworks and glass production that emerged at the end of the 18th century. However, this use of forests declined in the last century, which is why the share of beech coppice forest is decreasing; they have mainly been transformed into high forests.

3. Recently found evidence has indicated that coppice used to be heavily interconnected with animal grazing (Panjek, 2015). During the last 50 years, however, land use in the alpine region has changed and many grazing areas in mountain areas have been overgrown by natural vegetation (high forests).

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

Short rotation plantations

Besides traditional coppice forests, there has also been 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 accumulated biomass (absolutely dry) from these trials has been calculated as a product 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 the *Tordis* clone. The equivalent for the *Inger* clone gave lower values of 0.63, 3.49 and 9.17 dry tons ha^{-1}. The results are presented in Table 1.

Table 1. 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 per stool	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

References

Ara, P., Krajnc, N. (avtor, urednik), Jemec, T., Triplat, M. et al., 2014. *Demonstration plots with short rotation energy plantations: setting up of integrated strategies for the development of renewable energies.* [Ljubljana]: Slovenian Forestry Institute, Silva Slovenica, 3, str., ilustr. http://proforbiomed.eu/sites/default/files/Proforbiomed_PA_leaflet_1.6_web.pdf.

Panjek, A., 2015. *Kulturna krajina in okolje Krasa: o rabi naravnih virov v novem veku* [znanstvena monografija], 155 pp.

South Africa

Keith M. Little

Facts and Figures

Definitions

Various exotic eucalypts (and their hybrid combinations), which are grown for commercial timber production, resprout from the cut-stump (cut-surface ca. 5-15 cm in height) following harvesting, predominantly from epicormic buds, and/or lignotubers. For commercial production, these coppice shoots are selectively thinned over time and managed as a coppice stand for pulp wood, mining timber or poles. In general, the coppice shoots are reduced to the original stocking in two operations: the first to 2 or 3 shoots when the dominant height is about 4 m, and the second to the original stocking when the dominant shoot height is about 8 m. Rotation-lengths vary according to site productivity and/or product and range from ca. 7 -15 yrs. Increasingly, rurally-based small growers are managing eucalypt coppice stems for multiple products (droppers, laths, poles and pulp wood), with a higher management intensity in terms of repeat visits to remove product, and over a much shorter rotation (ca. 1 - 7 yrs).

Legal Framework

As *Eucalyptus* stands regenerated via coppicing are generally managed for commercial timber production, the same legal framework that applies to all exotically grown tree species would apply. As such, there is no direct legislation that applies specifically to the management of coppice stands.

Rotation Period

The rotation period will depend on the eucalypt grown, desired end-product and site productivity. For laths/droppers the rotation period may be 3 years, extending to 7-15 yrs for pulpwood and poles. The general rule is to "plant - coppice - replant - coppice" due to improved genetics, species and/or hybrid combinations (the idea being to only coppice once before replanting).

Statistics

Of the total land area, ca. 1.1% (1.275 million ha) is planted to exotic plantation forests. The main tree species planted for commercial purposes include pines (51%), eucalypts (42%) and wattle (7%). A rough estimate of the area managed for coppice would be 25 - 33% of the area planted to eucalypts at any one time, but this figure will fluctuate from year to year.

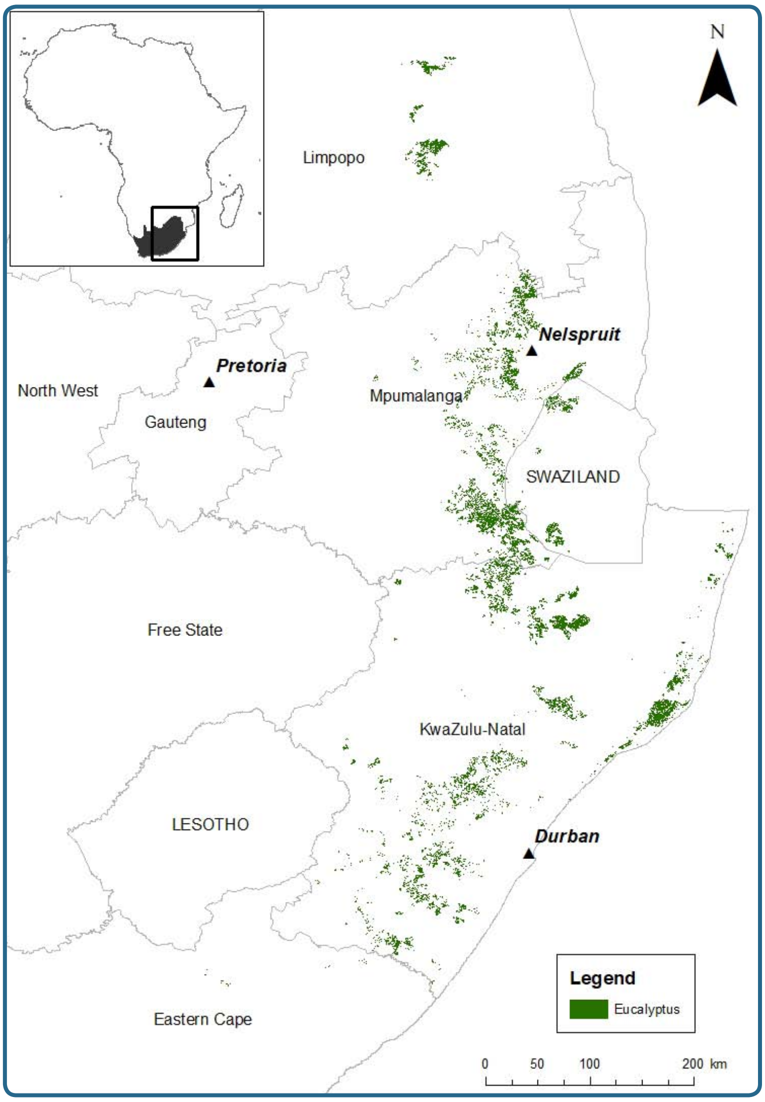
Most of the plantation forests are located within the summer rainfall region and along the eastern seaboard of South Africa (see Map section, following page).

Intensive silvicultural regimes are practised to maximise volume production, 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 1,300-1,600 sph.

Typology

Short rotation coppice	SRC using the "coppice selection system" Selected shoots (linked to product) are cut when needed, giving rise to uneven-aged stands. This system is used mostly by rurally-based growers on smaller areas (< 5 ha) planted to eucalypts. Mainly for the production of firewood, laths, droppers, poles and some pulpwood, with multiple cuts carried out within 1 – 7 year cycles. SRC using "singling" All shoots in a stand are felled, with the resultant regrowth "singled" to leave 1-2 stems per stump. Occurs in commercial plantations, mainly for the production of pulpwood and poles over 7 – 15 year rotations.

Map



Areas within the summer rainfall regions of South Africa within which various eucalypts and/or their hybrid combinations are planted (ca. 605 000 ha). Of this area, 25 - 33% of the eucalypts will be managed for coppice once felled, but this figure will fluctuate from year to year. Map source: Institute for Commercial Forestry Research, Pietermaritzburg, South Africa.

Description

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 (Figure 1). *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 7 to 15 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.

Figure 1. A coppiced stand of six-year-old *Eucalyptus grandis x E. camaldulensis* clones in the sub-tropical region of Zululand, South Africa.

Although eucalypts are planted at various inter- and intra-row distances, the target density at felling age is 1,300 to 1,600 stems 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 that 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.

Decisions as to whether to coppice or replant

Dependent on a number of factors, felled eucalypt stands may be coppiced once (seldom more than twice) before being replanted. Although stand regeneration through coppicing is more cost-effective than replanting, decisions as to coppice or replant specific stands takes into consideration a number of different factors, some of which include determining:

- whether the planted eucalypt has the ability to coppice (there is a range in terms of different eucalypts and their coppicing ability),
- 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 tolerance, snow tolerance etc.),

- whether trees were planted at the correct spacing (matching stand density to site productivity),
- or if rotation-end stocking of the originally planted stand is adequate.

Challenges

Current challenges in terms of coppice management centre mainly around issues associated with (1) increased mechanisation of forest operations, (2) the incidence of pests and disease, and (3) a change in land ownership.

1. Until recently, South Africa made extensive use of manual labour for both silvicultural and harvesting (motor-manual) 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.

2. The impact of recently introduced pests and disease into South Africa has meant that many of the 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.

3. Changes in the South African land reform policies has meant that ca. 50% of commercially afforested land is under "land claim". This will result in a change in ownership of existing areas under plantations from larger corporate companies to that of small-scale timber growers. In contrast to commercial companies, where maximising rotation-end product at lowest input cost is important, rurally based, small-scale timber growers require constant product throughout the rotation, either for personal use and/or cash-flow (for example droppers and poles for fencing, laths and poles for building, or as a source of firewood). Although the average size of each of these planted areas is small (ca. 1.5 ha), collectively the large number of growers provides an important source of timber to the commercial companies. Best management practices will need to be tested that support the needs of these small-scale growers, whilst still securing timber for South Africa's pulp-wood needs.

References

Edwards MBP. 2012. Introduction. In: *South African Forestry Handbook*. Eds. BV Bredenkamp and SJ Upfold. The South African Institute of Forestry, Menlo Park, South Africa. Pgs. 3-7.

Louw W. 2012. Brief History of the South African Forest Industry. In: *South African Forestry Handbook*. Eds. BV Bredenkamp and SJ Upfold. The South African Institute of Forestry, Menlo Park, South Africa. Pgs. 9-17.

Forestry South Africa. 2015. *South African Forestry & Forest Products Industry Facts (1980 - 2015)*. Available from: http://www.forestry.co.za/statistical-data/ [Accessed 30 July 2017]

Forestry South Africa. http://www.forestry.co.za/ [Accessed 30 July 2017]

Department of Agriculture Forestry and Fisheries: http://www.daff.gov.za/ [Accessed 30 July 2017]

Little KM. 2000. *Eucalypt Coppice Management*. ICFR Innovation 2000/01. Institute for Commercial Forestry Research, Pietermaritzburg, South Africa.

Forestry Regulations

As eucalypt stands regenerated via coppicing are generally managed for commercial timber production, the same legal framework that applies to all exotically grown tree species in South Africa would apply. Thus, there is no coppice-specific legislation that applies to the manner in which coppice stands are managed. Within South Africa, the protection of natural forests and the sustainable development of commercial timber is governed by a legal framework that covers a range of sector activities. This policy and legal framework is extensive and includes structures and policies that range from International Conventions to Government Acts that give effect to these, and the Regulations passed in terms of the Acts that enable their implementation. In general, these policies and supporting guidelines (in terms of criterion, indicators and measures) ensure sustainable forestry management in terms of:

- the protection of biodiversity within forest management units,
- the management of impacts such as erosion and alien invasive plant species,
- the management of outputs that reduce environmental quality such as waste,
- fair and appropriate labour practice,
- ensuring the health & safety of labour,
- the protection of heritage resources,
- the regulation of land tenure & rights

Although the two most relevant acts governing forest practices in South Africa are the National Forests Act (Act No. 84 of 1998) and the National Water Act (Act No. 36 of 1998), sections relating to forestry are also contained within other National Governmental Departments (for example Environmental Affairs, Labour, Rural Development and Land Reform, etc.).

References

Three websites that link directly to the Acts and Legislation regarding forests within South Africa:

http://www.daff.gov.za/daffweb3/Branches/Forestry-Natural-Resources-Management/Forestry-Regulation-Oversight/Sustainable-Forestry/Principles-Criteria-Indicators [Accessed 30 July 2017]

http://www.nda.agric.za/docs/media/Revision%205_Sept%202015_Draft%20Final.pdf [Accessed 30 July 2017]

http://www.forestry.co.za/government/ [Accessed 30 July 2017]

Spain

Míriam Piqué, Rubén Laina, Pau Vericat, Mario Beltrán, Eduard Busquets and Eduardo Tolosana

Facts and Figures

Míriam Piqué and Rubén Laina

Definitions

Management system applied to hardwood forests where regeneration is due to sprouting from roots or stumps after clearcutting.	*Método de beneficio aplicado a una masa forestal de frondosas que busca la regeneración mediante brotes de cepa o de raíz.*

Rubén Laina

Coppice forests - forest composed of trees originating from stump or root resprouts.	*"Monte bajo" - Masa arbórea compuesta por pies cuyo origen es un brote de cepa o raíz.*

Míriam Piqué

Legal Framework

There is no specific legal frame affecting coppice forest management in Spain. Management practices must follow "general good practices" in terms of proper rotation period (depending on species and objective), silvicultural criteria, as well as the organization and implementation of logging works. Harvesting plans are supervised and approved by the Government Forest Service to ensure that good management practices are included.

Rotation Period

1. 20-30 year rotation coppice of *Quercus ilex*, *Q. faginea* or *Q. pyrenaica*, with 1500-3500 trees/ha density and 10 to 20 m height.

2. 12-16 years *Eucalyptus* plantations, 600 trees/ha, three rotations before planting again.

3. Chestnut forest; several thinnings before clearcutting at 80 years.

Typology

Simple coppice	Most common type for obtaining fuelwood; evergreen oak (*Q. ilex*), deciduous oaks (*Q. faginea, Q.pubescens, Q. pyrenaica, Q. canariensis, Q. petraea, Q. robur*) and other species such as *Betula pendula/pubescens*, *Salix caprea*, *Eucalyptus* spp., *Castanea sativa*, *Platanus* and *Alnus*
Coppice with standards	*Quercus pyrenaica*
Pollarding	Was often used in the past with species such as beech, deciduous oaks, chestnut, ash, poplar, elm and willow in order to combine grazing with fuelwood or timber production; mostly abandoned nowadays
Short rotation coppice	*Populus*

References

Serrada R, Montero G, Reque JA, 2008. *Compendio de selvicultura aplicada en España*. Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Ministerio de Educación y Ciencia, Madrid. 1178 pp.

Vericat P, Piqué M, Serrada R (eds.). 2012. *Gestión adaptativa al cambio global en masas de Quercus mediterráneos*. Centre Tecnològic Forestal de Catalunya, Solsona. 172

Vericat P, Piqué M, Beltrán M, Cervera T. 2011. *Models de gestió per als boscos d'alzina (Quercus ilex subsp. ilex) i carrasca (Quercus ilex subsp. ballota): producció de fusta i prevenció d'incendis forestals. Sèrie: Orientacions de gestió forestal sostenible per a Catalunya (ORGEST)*. Centre de la Propietat Forestal. Departament d'Agricultura, Ramaderia, Pesca, Alimentació i Medi Natural. Generalitat de Catalunya, Barcelona. 166 p.

Images

Quercus ilex ballota low coppice (Photo: Pau Vericat)

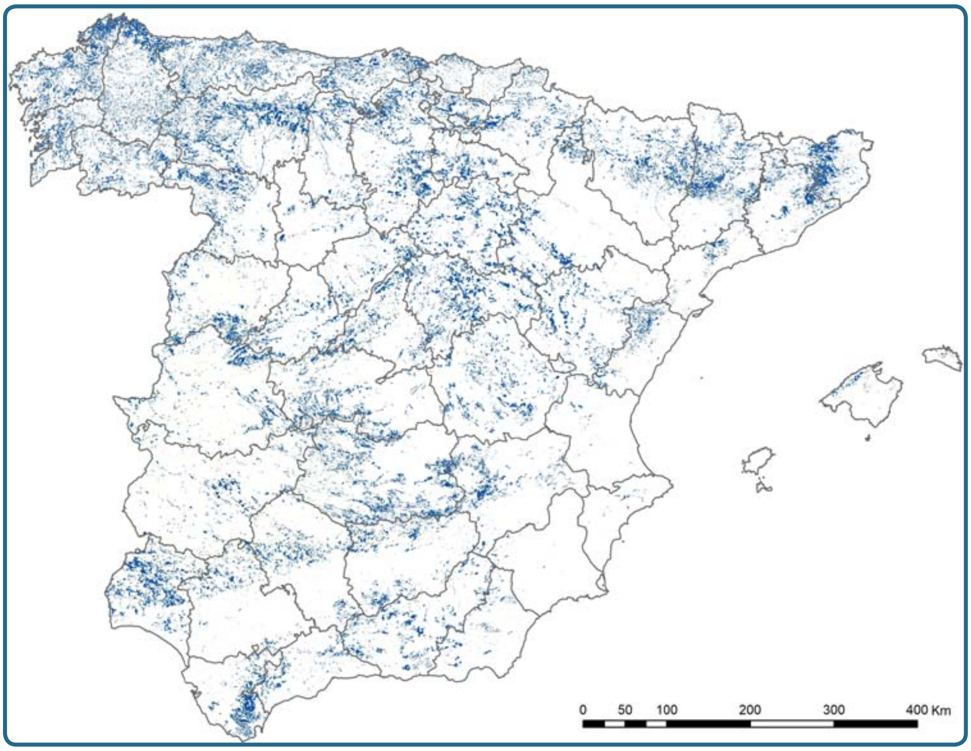
Quercus ilex ilex selection coppice (Photo: Pau Vericat)

Quercus humilis conversion to high forests (Photo: Míriam Piqué)

Quercus faginea abandoned conversion to high forest (Photo: Pau Vericat)

Map

Mario Beltrán, Pau Vericat, Eduard Busquets, Eduardo Tolosana and Míriam Piqué



Map of approximate areas of coppice forests in Spain, based on the official Forest Map of Spain (Spanish Ministry of Agriculture and Fisheries, Food and the Environment)

Description

Míriam Piqué and Pau Vericat

Coppicing has been widely applied for centuries in Spain to almost all hardwood species with re-sprouting ability. 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 method 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 (from 20 to 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 *Q. ilex* (Figure 1) and *Q. 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. *Q. ilex* in the North East, *Q. pyrenaica* in the North West and *Castanea sativa* in the North of Spain).

As a result 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 their ability to adapt to new scenarios. Furthermore, the dense and homogeneous stands resulting from abandonment become simpler in terms of structure and specific composition and so tend to be 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.

Therefore, in general, the priority is to renew 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.

Figure 1. *Quercus ilex* and *Quercus suber* uneven-aged coppice with standards in Catalonia, Spain.

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 in order to achieve a true 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.

Forestry Regulations

Mario Beltrán, Eduardo Tolosana and Míriam Piqué

The forest legal framework in Spain is characterized by the division of competencies between the Central State and the Autonomous Communities. General regulations are made by the Spanish Ministry in charge of forests, while the 17 Communities develop specific regulations adapted to their own characteristics. Furthermore, Communities are responsible for environmental issues in a broad sense and the State is only responsible for basic regulation, coordination and support.

Despite this division, the Spanish forest policy is usually introduced as a wide common framework subscribed to by all the public bodies of the forest sector, as a group. In this sense, the Spanish Forest Programme comprises legal regulations, forest planning tools and some general sustainable forest management tools. The main elements are the Spanish Forest Act (created in 2003; revised twice in 2006 and 2015), the Forest Act of each Community (where it exists), the Spanish Forest Plan (2002) and some of the Forest Plans of each Community.

The aim of the Forest Acts is to ensure the sustainability and conservation of forests. They establish a system of administrative guardianship concerning forest management, both in private and public ownership. The Spanish Forest Act makes the preparation of Forest Management Plans compulsory in certain cases for protective forests (private) and public utility forests. In all cases, the different administrations are in charge of enhancing and promoting forest planning. However, the Regional Forest Acts can extend the obligation to have a management plan to other cases, such as public forests larger than a certain area (depending on the region). The supervision of forest management actions is done through the management plans, or specified administrative procedures where plans are absent.

Regarding coppice forest management, there is no specific regulation; it is usually regulated as any other type of forest management. Nevertheless, the coppice system is described through different guidelines developed for certain species that are mainly managed as coppice (*Quercus ilex, Q. pyrenaica Q. pubescens, Q. faginea, Castanea sativa, Fagus sylvatica, Eucalyptus spp.* among others); hence, coppice management is allowed as a valid system for certain species. Some other regulations can affect coppice, especially those in relation to clear-cuts. In many regions, these clear-cuts are limited by areal extent and require a special administrative procedure.

As the regulation and descriptions of best practice for coppice forests in Spain are linked to certain species, the Autonomous Community has the direct responsibility for administering forest management. We describe below the case for two representative regions in Spain with managed coppice forests: Catalunya and Galicia. There are major differences between their species, ownership characteristics and forest management systems, as Catalunya is situated in the Mediterranean basin, while Galicia is situated in the very humid NW of Spain.

Catalunya

The Catalan Forest Act was published in 1988 and revised several times, while the Catalan Forest Plan was approved in 2014. These two elements form the main reference for the Catalan forest sector and they treat coppice as any other management system. Since 2011, some planning tools are available in order to ensure a common technical basis for forest management, known as the Sustainable Forest Management Guidelines for Catalunya (ORGEST). These include coppice management guidelines and provide silvicultural information for different coppice forests. Silvicultural models describe the treatments and management actions to achieve different objectives based on environmental conditions, always applying sustainable principles. Guidelines referring to resprouting species are focused on the coppice system, mainly oaks and chestnut. In Catalonia, forest practices related to plantations of short rotation broadleaved species are very uncommon.

Galicia

The Galician Forest Act, published in 2012, makes no direct reference to coppice management or to coppice species. Nonetheless, every domestic hardwood species, including those that are commonly coppiced (oak, holm oak, deciduous oak, beech and chestnut) are mentioned in an Annex and declared as priorities when planting in public forests. Forest owners applying for felling licenses for these species have to wait longer than *Eucalyptus* or softwood plantations' owners to get a specific licence prior to harvesting. In the stands composed of domestic hardwood species, planting with *Eucalyptus* is banned, even after harvesting or a wildfire.

Galician forest administrators must check and list every domestic hardwood stand greater than 15 ha, the owners of which are then obliged to have an approved management plan prior to harvesting. In order to write these management plans, the administrators may sign temporary agreements with the owners.

The Galician Forest Plan was approved in 1992, but is presently under revision. In 2014, the Galician forest administration created forest management guidelines and a code of best practice for Galician forests, again focused on the dominant species. Guidelines aimed at resprouting species focus on the coppice system. Plantations of broadleaved species are very common in Galicia, particularly of *Eucalyptus* or birch.

References

Catalan forest Act. Llei 6/1988, de 30 de març, forestal de Catalunya (DOGC 978, 15/04/1988). http://portaljuridic.gencat.cat/ca/pjur_ocults/pjur_resultats_fitxa/?action=fitxa&documentId=28548&language=ca_ES&textWords=forestal%2520catalunya&mode=single

Catalan Forest Management Guidelines, 2011-2017. ORGEST. http://cpf.gencat.cat/ca/cpf_03_linies_actuacio/cpf_transferencia_coneixement/cpf_orientacions_gestio_forestal_sostenible_catalunya/

Catalan Forest Plan, 2014. http://agricultura.gencat.cat/ca/ambits/medi-natural/gestio-forestal/planificacio-forestal/pla-general-politica-forestal-public/index.html

Galician Forest Act. Llei 7/2012, do 28 de xuño, de montes de Galicia (DOG 140, 23/07/2012). http://www.xunta.gal/dog/Publicados/2012/20120723/AnuncioC3B0-050712-0001_gl.html

Galician Forest Plan, 1992 (under review). http://mediorural.xunta.gal/es/areas/forestal/ordenacion/plan_forestal_de_galicia/

Galician Forest Management Guidelines, 2014. https://www.xunta.gal/dog/Publicados/2014/20140605/AnuncioG0165-280514-0001_es.html

Spanish Forest Act. Ley 43/2003, de 21 de noviembre, de Montes (BOE 280, 22/11/2003). http://www.boe.es/buscar/act.php?id=BOE-A-2003-21339

Spanish Forest Plan, 2002. http://www.mapama.gob.es/es/biodiversidad/publicaciones/pfe_tcm7-30496.pdf

Spanish Forest Policy Introduction. Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente. http://www.mapama.gob.es/es/desarrollo-rural/temas/politica-forestal/planificacion-forestal/politica-forestal-en-espana/index.aspx

Sweden

Magnus Löf, Ioannis Dimitriou, Tomas Nordfjell, Martin Weih, Jenny Mills and Peter Buckley

Facts and Figures

Magnus Löf

Definitions

Coppice forests - forest composed of trees originated from stump or root resprouts.	*Lågskogsbruk / skottskogsbruk*

Legal Framework

There is no specific legal frame for coppice forests in Sweden. Except for *Salix*, which is considered as a agricultural crop, coppice has mainly been practised historically and is very limited nowadays. Pollarding and coppice with some trees, such as alder, is sometimes practised.

Rotation Period

Rotation period is 3-5 years for *Salix*.

Typology

Simple coppice	Have been used historically, but not anymore
Coppice with standards	Have been used historically, but not anymore
Pollarding	Widespread historically, nowadays only for restoration purposes and along roads etc. in the southern most part of the country
Short rotation coppice	*Salix* plantations

Description

Ioannis Dimitriou, Magnus Löf, Tomas Nordfjell and Martin Weih

In Sweden there are limited areas where traditional coppice forest management has been applied, while coppice with standards does not exist at all. The national statistical authority of Sweden (Forest Statistics - Riksskogstaxeringen) does not record these types of forests, which is indicative of the status and condition of coppice forest management in the country.

The same concern regarding recording applies to pollards, although there are several sites in Sweden where there has been a recent restoration of pasture with pollarded trees of *Tilia cordata*, *Sorbus aucuparia* (mountain ash), *Fraxinus excelsior*, alder (*Alnus* spp.), aspen (*Populus tremula*), willow (*Salix* spp.) and 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 compared to 'conventional' forestry. The species used for simple coppice are alder (*Alnus* spp.), birch (*Betula* spp.), aspen (*Populus tremula*), willow (*Salix* spp.) and poplar (*Populus* spp.).

The most common coppice system in Sweden is willow (*Salix* spp.) short rotation coppice (SRC), which is used to produce biomass for energy. Today, approximately 11,500 ha 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 therefore unnecessary. 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 to clean soils, for example from 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 design new forms of production that produce biomass for energy and also enhance bio-diversity, 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. For example, trees in 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.

Forestry Regulations

Jenny Mills, Peter Buckley and Magnus Löf

In Sweden nearly 70% of the land area is covered by 28.1 million hectares of forest, 23 million hectares of which are productive. The forests are mainly of spruce and pine (82%). The remaining percentage includes broadleaf species such as birch, aspen, alder, willow and poplar, and, in the south, oak and beech. Even-aged forestry is the norm. Traditional simple coppice management and pollarding, which were very common in the past, are now rarely practiced and then only on very small areas of conservation interest. Pollarding is also still practiced near farms and in villages to keep the traditional scenery.

The **Forest Act** was first enacted in 1903 and covered only privately-owned forests, in 1979 it was revised to include all forests. The main forest policy of maintaining high levels of industrial wood production was amended in 1993 to include ecological provisions concerning environmental improvement and biodiversity and later to give regard to social values. The aim of Swedish forest policy is also to ensure sustainable forest management in line with international agreements. A **National Forest Programme** was established in 2014.

The **Swedish Forest Agency** (SFA, Skogsstyrelsen) is responsible for enforcing the Forestry Act and the 1999 Environmental Code where it affects forestry. On their website (http://www.skogsstyrelsen.se/en/forestry/The-Forestry-Act/The-Forestry-Act/) some of the provisions of the Act are summarised:

Reforestation

New forest must be planted or naturally generated after felling when the land's capacity to produce timber is not fully exploited. Planting or measures for natural regeneration must have been completed by the end of the third year after felling, or by the fifth year in northern areas where regeneration is slower.

Disused agricultural land must be reforested within three years of the land falling into disuse. This does not, however, apply to land to be protected for its natural characteristics or its cultural heritage.

Reliable methods and suitable species of trees must be used in the forestation work. Natural regeneration can be a good method if the site is suitable. Otherwise, the land must be sown or planted. Mechanical soil scarification is often a prerequisite for good results.

If there are insufficient numbers of seedlings, supplementary planting must take place before it is too late. Subsequent weeding and thinning may be necessary.

Felling

Thinning encourages forest development. Timber stocks after thinning must be large enough to utilise the production capacity of the land.

After thinning the trees must be evenly distributed on the area. Damage to trees and the ground must be avoided as far as possible.

Regeneration felling must not be carried out until the forest has reached a certain age. For predominantly coniferous forests, the age varies between 45 and 100 years, although this is much debated as it does not really apply to continuous cover forestry practices.

Regeneration felling is restricted on forest holdings larger than 50 hectares. Up to half of the land may be made up of finally felled areas and of stands less than 20 years old. Additional rules apply to holdings larger than 1,000 hectares.

Notification of regeneration felling

Regeneration felling of stem wood on 'productive forest land'* sites larger than a half hectare must be notified to the Swedish Forest Agency at least six weeks in advance of harvesting.

> *Defined as land outside protected areas and other than mountainous forest, and forest with noble broad leaved trees and that can produce no less than 1 m^3 $year^{-1}$ stem wood including bark and that is not used for any other purpose such as agriculture, buildings or infrastructure.

'Regeneration felling' replaces the term 'final felling', and includes all felling with the exception of thinning and cleaning. Notification is made on a special form (Timber Harvesting Notification, TFN*) available from the Swedish Forest Agency. The area to be felled and the regeneration methods to be used must be specified. A copy of a forestry map must be attached. A description of the intended natural consideration measures to be used, and measures to protect existing cultural heritage within the area, must also be stated.

> *The SFA inspects TFNs within a 6-week period using the Forest Agency's processing system, comparing the notifications to maps and register data. Local knowledge and staff expertise are also used. A proportion of the notified areas are inspected in the field before harvesting begins.

Notification must also be given if the land is to be used for purposes other than timber production, i.e. if forest fuel is to be removed, foreign tree species are planned be used, or in the event of protective ditching.

A permit is required for regeneration felling in mountainous areas in the interior of northern Sweden. Details of measures planned to secure regeneration and to safeguard the balance of nature, the cultural heritage and reindeer husbandry, must be given.

A permit is required for regeneration felling in forests that contain so-called 'noble broad leaved trees', i.e. stands of temperate broadleaved tree species of which at least 70 % of the basal area consists of broad leaved trees and at least 50 % consist of oak, beech, ash, lime, elm, cherry, maple and hornbeam. Regeneration and conservation measures to be taken must be stated. Normally, felled hardwood stands must be regenerated with a new hardwood species stand.

Insect damage

Insect pests breed in the bark of newly felled coniferous wood. Insect damage is controlled by removing damaged trees if they exceed 5 cubic metres per hectare. Unbarked conifers must not be stored in the forest or at the roadside during the summer.

Nature consideration & cultural heritage

Biological diversity in the forests must be preserved. At the same time, the cultural heritage must be safeguarded and social aspects must also be taken into consideration. Therefore, it is important that due care and attention is paid to all forestry measures. The conservation requirements must not be so far-reaching that they make on-going forestry activities significantly more difficult. Where there is a choice of methods to be used, the promotion of biological diversity must always be given priority.

Reindeer husbandry

The size and locations of felling areas in northern Sweden must be decided with due regard to reindeer husbandry. Further consideration can be shown by leaving groups of trees standing on felling sites and on non-productive land, such as migration routes.

Forest Management Plans (FMP)

These are voluntary in Sweden. In a response to a questionnaire from the EU's Directorate-General for the Environment in 2013 (European Commission 2014), Sweden reported that: "The obligation of having a FMP was taken away from the Swedish Forest Act in 1994. Instead a nationwide GIS database was established. The information in the database covers all forest properties and is available for forest owners and authorities, free of charge through the internet. The database includes information on Natura 2000 and other protected areas as well as other ecosystems with biodiversity and social values. All forest land is covered by regularly updated satellite imagery and aerial photography."

All past and planned (for the following 2 years) harvest activities are shown for each individual property, including the regeneration method used / planned, outtake of bioenergy, scarification method, environmental and cultural protection activities, etc. Forest owners must send harvest notifications to the Swedish Forest Agency, which is possible through the database. As the GIS database integrates data on Natura 2000 areas, other nature reserves, and areas with special considerations (hydrological, historical, biological, etc.), the SFA system for monitoring the implementation of the forest legislation is highly interactive and automated.

Most of the forest owners in Sweden have their own FMP, often offered by timber-buying companies as a service to the forest owners. FSC- and PEFC-certified forest owners are obliged to have a FMP due to certification requirements. An estimation is that for family forestry, approximately 8.5 M ha are covered by FMPs and for productive forest land 22.5 M ha, half under FSC, half under PEFC, with some overlap because of double-certified forest owners. An overall expert estimation is that >95% of forest land is covered by some sort of management plan in Sweden. In Sweden FMPs are considered a tool for forest owners and managers to plan their business activities in the medium-term (normally 10 years) and to plan environmental care in detail for each stand.

Adoption of Natura 2000 forest management plans in forests designated as Natura 2000 sites

In Sweden the County Administrative Boards have the overarching responsibility, at regional level, for Natura 2000 areas. Forest management plans are not normally used for Natura 2000 forest areas. The management of these areas are regulated through conservation plans as most Natura 2000 forest areas in Sweden are nature reserves. Currently, the Swedish Environmental Protection Agency is preparing guidelines for updating the existing Natura 2000 conservation plans.

The SFA is the responsible authority when it comes to forestry measures that could affect the environment in Natura 2000 areas. Consideration is given to forestry measures within designated areas and measures adjacent to, or in the vicinity of, designated areas. The County Administrative Boards are the competent authority for measures other than forestry operations taken in forested and other types of Natura 2000 areas. Permission needs to be obtained from the County Administrative Boards for measures that are likely to have a significant effect on the environment in Natura 2000 areas. In cases where the SFA is the competent authority – i.e. concerning forestry operations – the SFA evaluates whether or not a planned activity or operation needs permission. Thus, the SFA ensures that forestry operations that might affect a Natura 2000 area are not taken without prior consent from the County Administrative Board. The operator must evaluate if the planned activities need prior consent and seek permission from the County Administrative Board.

All forest owners have to notify the SFA when planning a final felling. The SFA then has six weeks to respond – i.e. giving detailed instructions on how and where certain activities should be conducted or if they are prohibited. In cases when a notification is received that concerns a Natura 2000 area or its vicinity, the SFA evaluates the planned activity regarding prior permission. The management restrictions included in the conservation management plans form the basis for that decision. If the planned activity does not need prior permission, it is treated like any other notification to the SFA. If it needs prior permission, the operator is informed in writing. An activity might be partially allowed or allowed under specific preconditions. If the County Administrative Board gives permission under certain preconditions, the SFA is responsible for checking that they are followed.

References

Swedish Forest Agency http://www.skogsstyrelsen.se/en/forestry/The-Forestry-Act/The-Forestry-Act/

The Royal Swedish Academy of Agriculture and Forestry (KSLA). *Forests and Forestry in Sweden*. http://www.ksla.se/wp-content/uploads/2015/08/Forests-and-Forestry-in-Sweden_2015.pdf

European Commission (2014) *Forest Management Plans or equivalent instruments. Summary of Member States' replies to the DG ENV questionnaire*. http://ec.europa.eu/environment/forests/pdf/fmp_table.pdf

K. B. Lindahl et al. (2016) *The Swedish forestry model: More of everything?* Forest Policy and Economy http://www.sciencedirect.com/science/article/pii/S1389934115300605

Switzerland

Josephine Cueni, Marco Conedera, Patrick Pyttel, Jenny Mills and Peter Buckley

Facts and Figures

Marco Conedera

Definitions

Coppice - Forest grown from coppice sprouts or root shoots with a short rotation period. Oldest form of regulated forest use, mostly to obtain firewood. This management system favours tree species that can develop coppice sprouts like chestnut, beech, hornbeam, and oak. Coppice forests are regularly clear-cut (every 10–30 years).

(German) Niederwald - Aus Stockausschlag oder Wurzelbrut hervorgegangener Wald mit kurzer Umtriebszeit. Älteste Form der geregelten Waldnutzung, vorwiegend zur Brennholzgewinnung. Die Bewirtschaftungsart begünstigt Baumarten mit der Fähigkeit zum Stockausschlag wie Edelkastanie, Buche, Hagebuche und Eiche. Niederwald wird in kurzen Zeitabständen (alle 10–30 Jahre) kahl geschlagen.

(Italian) Ceduo - Bosco cresciuto da polloni di ceppaia o radicali a turno breve. È la più antica forma di gestione regolamentata del bosco, finalizzata prevalentemente alla produzione di legna da ardere. Questo tipo di gestione favorisce lo sviluppo di specie arboree capaci di generare polloni, quali il castagno, il faggio, il carpino e la quercia. Il ceduo viene tagliato a raso a brevi intervalli di tempo (ogni 10–30 anni).

(French) Taillis - Forêt à courte rotation, issue de rejets de souche ou de drageons. C'est la plus ancienne forme d'exploitation forestière réglementée, qui sert avant tout à produire du bois de chauffage. Cette forme d'exploitation privilégie les essences pouvant donner des rejets de souche, comme le châtaignier, le hêtre, charme ou le chêne. Les taillis sont exploités à intervalles courts et réguliers (tous les 10 à 30 ans).

Legal Framework

Clearcuts are not allowed according to the law; exceptions can be authorised by the Kantone.

Statistics

See table below. No data for pollarded (high) coppice and short rotation coppice (in part because they are close to non-existant).

	Simple Coppice	Coppice with Standards
Area (ha)	25,800	9,400
Percent total Swiss forest (%)	2.1 %	0.7%
Average stem density (N/ha)	622	528
Average growing stock (m^3/ha)	189	267
Average growth rate (m^3/ha/yr)	5.5	6.7

Typology

Simple coppice	Coppicing of chestnut stands or alder stands close to the rivers (0.1 to 0.3 ha). Coppice forests in and to the north of the Swiss Alps are dominated by beech, oak, ash and alder. In the south, sweet chestnut is the main tree species.
Coppice with standards	This type has almost disappeared; it is only exceptionally practised in chestnut forests. Historically, there were forest stands composed of oaks from seeds (for masting) and hornbean from coppice (for firewood) in the north of the country.
Pollarding	Former chestnut orchards treated as pollards starting in the late 1960s; now abandoned. Willows were pollarded and used on yearly basis for fixing the yearly growth of grapevines.
Short rotation coppice	Not relevant in Switzerland at the moment

Images

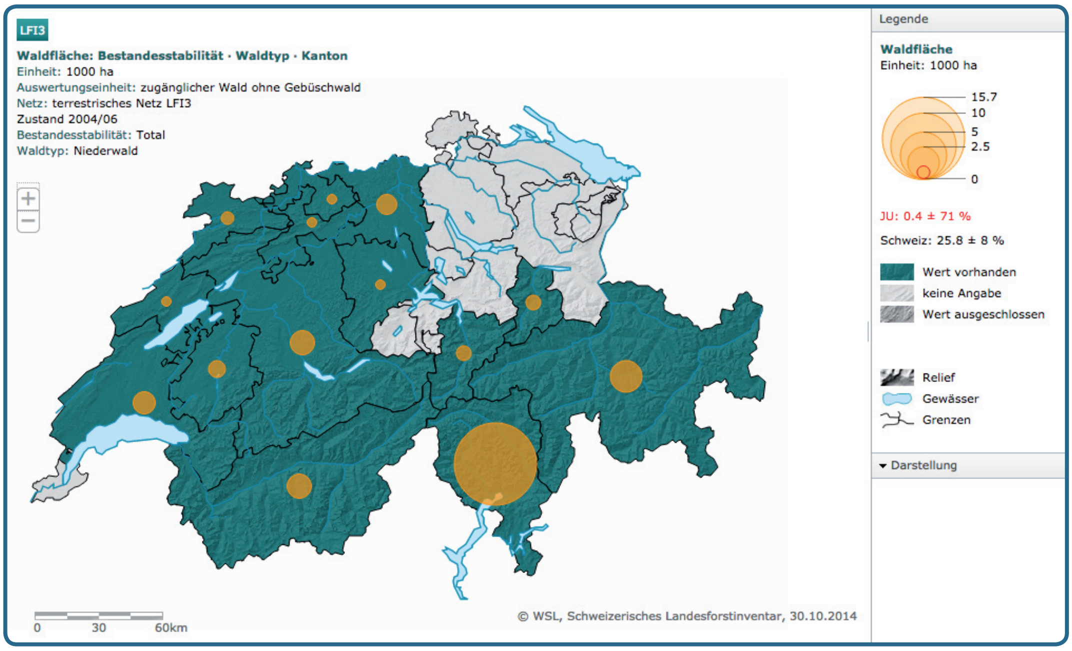
Ceduo samplice; chestnut simple coppice

Chestnut coppice with standards

Pollarded former orchard; chestnut

Map

Josephine Cueni



Map of the area of simple coppice in Switzerland per Kanton in 1000 ha
Source: LFI3, Abegg et al. 2014.

Abegg, M.; Brändli, U.-B.; Cioldi, F.; Fischer, C.; Herold-Bonardi, A.; Huber M.; Keller, M.; Meile, R.; Rösler, E.; Speich, S.; Traub, B.; Vidondo, B., 2014: Schweizerisches Landesforstinventar - Ergebnistabelle Nr. 137279: Waldfläche Birmensdorf, Eidg. Forschungsanstalt WSL https://doi.org/10.21258/1019053

Description

Josephine Cueni and Patrick Pyttel

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 19^{th} century (Schuler et al., 2000; Meier, 2007; Imesch et al., 2015).

Today, coppice forests (excluding coppice with standards) cover about 25,800 ha, which is 2.1% 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. There they make up 20% of the 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. Of the coppice forests in the Alps and in southern Switzerland, 71% and 86% serve as protection forests, respectively (Abegg et al., 2014). This management type is only thought to be suitable for this function under certain circumstances, i.e. when 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). Generally, coppice forests and short rotation plantations are not considered important for fuel wood since regional demand can be satisfied by day-to-day forest management and because of concerns regarding landscape aesthetics (Oettli et al., 2004; Meier, 2007; Ansprach 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 in Switzerland continue to be managed in this way. The exceptions are some study sites and 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 landscapes than for economic reasons. It is possible that increasing fuel wood prices will encourage more coppicing in the future.

Figure 1. Aged coppice forest on steep slopes in the Untersiggenthal, canton of Aargau (Photos: Pro Natura, Christoph Oeschger)

References

Abegg, M.; Brändli, U.-B.; Cioldi, F.; Fischer, C.; Herold-Bonardi, A.; Huber M.; Keller, M.; Meile, R.; Rösler, E.; Speich, S.; Traub, B.; Vidondo, B. 2014. *Fourth national forest inventory - result tables and maps on the Internet for the NFI 2009-2013 (NFI4b).* [Published online 06.11.2014] Available from World Wide Web <http://www.lfi.ch/resultate/>. Birmensdorf, Eidg. Forschungsanstalt WSL.

Ansprach, V.; Roesch, A. 2014. *Wirtschaftlichkeit der Energieholzproduktion durch Kurzumtriebsplantagen in der Schweiz.* GEWISOLA 2014. Poster Anlässlich der 54. Jahrestagung der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V. „ Neue Theorien und Methoden in den Wirtschafts- und Sozialwissenschaften des Landbaus".

Bachofen, H., Brändli, U.-B., Brassel, P., Kasper, H., Lüscher, P., Mahrer, F., Riegger, W., Stierlin, H.-R., Strobel, T., Sutter, R., Wenger, C., Winzeler, K., Zingg, A. 1988. *Schweizerisches Landesforstinventar. Ergebnisse der Erstaufnahme 1982-1986.* Eidgenössissche Anstalt für das forstliche Versuchswesen. Bundesamt für Forstwesen und Landschaftsschutz, Bern, 375 p.

BAFU (Bundesamt für Umwelt) (Hrsg.) 2011. *Handbuch Programmvereinbarungen im Umweltbereich.* Mitteilung des BAFU als Vollzugsbehörde an Gesuchsteller. Bundesamt für Umwelt, Bern. Umwelt-Vollzug Nr. 1105: 222 S.

BUWAL (Bundesamt für Umwelt, Wald und Landschaft) (Hrsg.) (2005): *Waldbericht 2005 – Zahlen und Fakten zum Zustand des Schweizer Waldes*. Bern, Bundesamt für Umwelt, Wald und Landschaft; Birmensdorf, Eidg. Forschungsanstalt für Wald, Schnee und Landschaft, 152S.

Castagnostyle, online 2015. Accessed 29.6.2015 over: www.castagnostyle.ch

Frehner, M., Wasser, B., Schwitter, R. 2005. *Nachhaltigkeit und Erfolgskontrolle im Schutzwald. Wegleitung für Pflegemassnahmen in Wäldern mit Schutzfunktion, Vollzug Umwelt.* Bundesamt für Umwelt (BAFU), Wald und Landschaft, Bern. 564 p.

Gerber, C., Elsener, O. 1998. *Geeignet oder nicht geeignet? Niederwaldbetrieb im Steinschlaggebiet. Mittelungen aus dem Gebirgswald.* Wald und Holz 14, pp. 8-11.

Häfner, R.; Hug, U.; Gordon, R.; Bettelini, D.; Hess, H. 2011. *Das Schweizerische Landesforstinventar aus Sicht einiger Kantone (Essay).* Schweizerische Zeitschrift für Forstwesen 162, pp. 282-289.

Imesch, N.; Stadler, B.; Bolliger, M.; Schneider, O. 2015. *Biodiversität im Wald: Ziele und Massnahmen. Vollzugshilfe zur Erhaltung und Förderung der biologischen Vielfalt im Schweizer Wald.* Bundesamt für Umwelt, Bern. Umwelt-Vollzug Nr. 1503: 186S.

Meier, U. 2007. *Die Rolle des Energieholzes in der Waldpolitik beider Basel (Essay).* Schweizerische Zeitschrift für Forstwesen 158 (7), pp. 201-205.

Meier, U. 2015. Personal communication. 17th June 2015.

Oettli, B., Blum, M., Peter, M., Schwank, O., Bedniaguine, D., Dauriat, A., Gnansounou, E., Chételat, J., Golay, F., Hersnere, J.-L., Meier, U., Schleiss, K. 2004. *Potentiale zur energetischen Nutzung von Biomasse in der Schweiz.* Forschungsprogramm Energiewirtschaftliche Grundlagen. Bundesamt für Energie (BFE), Bern, 293 p.

Schuler, A., Bürgi, M., Fischer, W. und Hürlimann, K. 2000. *Wald- und Forstgeschichte.* Skript zur Vorlesung 60-316. ETH, Eidgenössische Technische Hochschule Zürich, Departement Forstwissenschaften, Professur für Forsteinrichtung und Waldwachstum, Arbeitsbereich Wald- und Forstgeschichte. http://e-collection.ethbib.ethz.ch/view/eth:28539

WSL 2015. *Schweizerisches Landesforstinventar LFI. Spezialauswertung von Daten der Erhebungen 2004-06 (LFI3) und 2009-13 (LFI4b).* Urs-Beat Brändli 17.6.2015. Eidg. Forschungsanstalt WSL, Birmensdorf.

WSL, online: *Brennholz produzieren und Biodiversität fördern.* Last update: 15.9.2011. Accessed on the 30th of June 2015.

Zimmermann, N.E. 2010. *Biodiversität im Zeichen des Klimawandels.* Hotspot (21): S.18-19.

Zingg, A., Giudici, F. 2006. *Wertholzproduktion mit Kastanien-Niederwald.* Versuchsanlage und erste Ergebnisse. DVFF – Sektion Ertragskunde, Jahrestagung 2005.

Forestry Regulations

Jenny Mills, Peter Buckley, Josephine Cueni and Patrick Pyttel

A third of Swiss territory is forested, but coppice and coppice-with-standards now covers only small areas. However, the guidelines issued by the Swiss Federation BAFU in 2015 concerning biodiversity in forests indicates that there are noteworthy remnants of coppice-with-standards in the cantons of Baselland, Aargau, Zurich, Schaffhausen and Thurgau, where projects are taking place to boost coppice-with-standards management. Areas of relict coppice are located mainly in the canton of Fribourg, along the River Sarine, in the canton of Vaud along the foot of the Jura, in the canton of Bern along the Old Aar river, in the Grisons, and in the Rhine valley around Chur. The guidelines suggest that traditional coppice management to increase biodiversity could be reintroduced in a sustainable way in former coppice stands or be newly established in other places.

At the national level, the Swiss Confederation has passed a **Federal Act on Forest** and a **Forest Ordinance**, among other laws that relate to the environment. The aims of the Federal Act are to conserve the forest area and its spatial distribution; to protect the forest as a near-natural community, to ensure that the forest can fulfil its functions and to promote and maintain the forestry sector. One particularly vital forest function in Switzerland is the protection of human life and important material assets against avalanches, landslides, erosion and rockfall.

The **26 cantons which make up the Federation define plans and enact regulations** taking into account the forest functions, the requirements of wood supply, near-natural silviculture and respecting the federal law for nature protection and cultural heritage. They also have to take into account the **Swiss Biodiversity Strategy**, which was adopted in 2012 by the Federation.

Each canton therefore has its own forest law in compliance with the Federal Forest Law and the Forest Ordinance and, while also respecting other environmental laws and guidance, makes cantonal forestry plans, forestry development plans and maintains a forestry service. For ecological or landscape reasons, forest management does not always have to be carried out, but where the forest serves a protective function, the cantons must ensure a minimum level of management. Forest owners (corporations, private owners, political communes, cantons) must carry this out and in return they receive federal and cantonal subsidies.

Silvicultural measures are defined as all maintenance interventions that contribute to the conservation or restoration of the stability and quality of a stand. Measures to be carried out as part of young forest maintenance include maintaining regrowth in selection forests, in other multi-layered forests, in coppice-with-standards and coppice forests, as well as in multi-layered forest margins; protective measures against damage caused by game; and path creation in areas difficult to access. Thinning and regeneration measures are slash removal and creation of new stands with the necessary accompanying measures, wood harvesting and transport. For protective forests, interventions are restricted to ensuring the long-term stability of the stand; felled wood is used locally to improve the protection function or left on site, as long as it does not pose a risk.

Deforestation is prohibited but, exceptionally, permits may be issued by the Federal or cantonal authorities with reference to the Federal Office for the Environment (FOEN/BAFU/OFEV/UFAM) where necessary. Compensation in kind must usually be made for any deforestation but can also lead to revaluation measures in other ecosystems.

References

Federal Act on Forest (Forest Act, ForA). https://www.admin.ch/opc/en/classified-compilation/19910255/index.html

Ordinance on Forest (Forest Ordinance, ForO) of 30 November 1992. https://www.admin.ch/opc/en/classified-compilation/19920310/201503010000/921.01.pdf

Imesch N., Stadler B., Bolliger M., Schneider O. (2015) *Biodiversité en forêt: objectifs et mesures. Aide à l'exécution pour la conservation de la diversité biologique dans la forêt suisse.* Office fédéral de l'environnement OFEV, Berne. L'environnement pratique no 1503: 190 p.

Landolt, D., Zimmermann, W., Steinmann, K. (2015) *Forest Land Ownership Change in Switzerland.* COST Action FP1201 FACESMAP Country Report, European Forest Institute Central-East and South-East European Regional Office, Vienna. 24 pages. file:///C:/Users/User/Downloads/FP1201_Country%20Report_SWITZERLAND%20(1).pdf

Turkey

Halil Barış Özel and Murat Ertekin

Facts and Figures

Halil Barış Özel and Murat Ertekin

Definitions

Coppice - a forest that has a sprout origin/background and that is destined to be regenerated by sprouts, for harvests of small and medium-sized wood.

Halil Barış Özel

(1) Coppice Forests - Even-aged stands consisting of trees and shrubs (mainly: *Quercus* spp., *Carpinus betulus, Castanea sativa, Alnus glutinosa*) that regenerate wholly or mainly vegetatively (as sprouts or root shoots) and are harvested in small clearcuts (0.5-1 ha) in short rotations of 20-40 years.

(1) Baltalık Orman: Farklı yaştaki ağaç ve çalılardan (Meşe, Gürgen, Kestane, Kızılağaç) oluşan, meşcere bazında (0.5-1 ha) 20-40 yıllık periyotlarla tıraşlama kesimleri vejetatif (kök ve kütük sürgünü) yolla gençleştirilen ormanlardır.

(2) Short rotation coppice: Plantations of fast-growing trees or shrubs (mainly *Populus* spp., *Salix* spp., and *Eucalyptus* spp.), with the aim of producing wood as a renewable resource in several short rotation periods (5-15 years each).

(2) Kısa süreli baltalıklar: Hızlı büyüyen ağaç ve çalılardan (kavak, söğüt ve okaliptus) oluşan, odun üretimi amacıyla kısa rotasyon süreyle (5-15 yıl) işletilen plantasyonlardır.

Murat Ertekin

Legal Framework

There is a 40-50 year rotation for coppice of *Quercus petraea, Q. robur, Fagus orientalis*; oak coppice has a density of 2,500-4,200 trees per ha, and 15 to 25 m height.

Coppice forestry, as all other forestry, is regulated mainly by two legal acts:
1) Turkish Forestry Law
2) Forest Management Plan of Regional Directorate 2010-2020

Turkish oak forests cover 5,150,000 ha and are generally state owned; it is the main coppice species. The management of these coppice oak forests is intensive, with a clear cutting cycle of about 20 years.

Rotation Period

Minimum rotation period: 8 years for poplar, willow; 15 years for eucalyptus; 20 years for oak. Maximum rotation period: coppice forests older than 50 years must be converted to high forest. Short rotation coppice is seen as agriculture. It is defined as: Woody biomass plantation of willow, and poplar with the aim to produce woody biomass. It is harvested at least every 5-10 years.

Statistics

In 2010 there were 21,537,091 ha of forest in Turkey, 4,874,712 ha of which were coppice (23%). The growing stock of coppice was only 6% of the total for forest (78,509,363 m^3), while the annual increment of coppice accounted for 10% (3,881,926 m^3) of the total. The trend is clearly towards a decrease of coppice area, growing stock and annual increment.

Republic of Turkey Ministry of Forestry and Water Affairs (2013). *Forestry Statistics 2011*. Turkish Statistical Institute, Printing Division, Ankara ISBN 978-605-4610-18-1 https://www.ogm.gov.tr/ekutuphane/Istatistikler/Ormanc%C4%B1l%C4%B1k%20%C4%B0statistikleri/Ormanc%C4%B1l%C4%B1k%20%C4%B0statistikleri%202011.pdf

Typology

Simple coppice	Small clearcuts, rotation 20-40 years
Coppice with standards	Yes - standards often of oak
Pollarding	Only in gardens, roadsides and urban streets
Short rotation coppice	*Populus* spp., *Salix* spp., *Eucalyptus* spp.
Other types	Conversion of coppices to high forest, especially oak and beech

Images

Productive coppice of oriental beech (*Fagus orientalis* Lispky.) (left) and degraded coppice of European Hornbeam (*Carpinus betulus* L.) (right) in the Western Black Sea Region

Description

Halil Barış Özel

The main coppice product in Turkey is firewood, 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 pseudoplatanus, Robinia pseudoacacia, Carpinus orientalis, Carpinus betulus, Platanus orientalis, Quercus petraea, Quercus robur* and *Castanea sativa* (Fig. 1).

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 kitchenware, but this coppice type is currently in a degraded state.

Figure 1. *Castanea sativa* coppice in Turkey

There is no regeneration 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. However, 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 silvicultural 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.

Forestry Regulations

Murat Ertekin

The **General Directorate of Forestry** (GDF) was established in 1869. From this date, forests seen as a source of income were protected by the law; the GDF began to sell forests to domestic and foreign traders. Forestry directorates were established in the countryside with the aim of protecting forest and regulating sales. **Forestry Law No.3116**, enacted in 1937, was revolutionary in that private sector forest management was terminated and management by the state began. In this context, forestry directorates were subject to a new assessment: these were named “forest directorates” (32 units) in 1937 and the “forest infirmary authority” in 1944. Since 1937 “**Forest Sub-District Directorates**”, known as “forest district chieftaincy”, have been created under different forest directorates. The **State Forest District Directorate** was initiated within the framework of Law No.4767, enacted in 1945, in the provincial organization (Gümüs, 2013).

In 1956, the present **Forest Law** (numbered 6831) was enacted and has been modified many times since then. It defines the principles of forest land use and types of ownership and quality: forest ownership types are defined as State Forests, forests belonging to the public legal entities and private forests. In the Republic of Turkey, all affairs concerning State Forests or the places regarded as State Forests are handled or organized by the GDF. All forests owned by parties other than the State are subject to the inspection of the GDF in accordance with the provisions of the aforementioned Turkish Forest Law 6831. Articles 26 to 44 state that production and harvesting in forests can only be done by the State itself in State Forests and only in compliance to management plans.

General forest ownership for Turkey:

- Publicly owned forest: 21,678,134 ha (99.9%)
  ... of which simple coppice: 4,417,542 ha
- Privately owned forest: 18,000 ha (0.83 %)
  ... all of which is simple coppice: 18,000 ha

Turkey has some short rotation coppice forests of different species:

- 2,500 ha *Eucalyptus camadulensis* and *E. grandis* (publicly owned)
- 6,500 ha Poplar plantation (Privately owned)

Legal framework in relation to coppice

(1) **Coppice Forests:** even-aged stands consisting of trees and shrubs (mainly: *Quercus* spp., *Carpinus betulus, Castanea sativa, Alnus glutinosa*) that regenerate wholly or mainly vegetatively (as sprouts or root shoots) and are harvested in small clear cuts (0.5-1 ha) in short rotations of 20-40 years.

(2) **Short rotation coppice:** plantations of fast-growing trees or shrubs (mainly *Populus* spp., *Salix* spp., and *Eucalyptus* spp.), with the aim of producing wood as a renewable resource in several short rotation periods (5-15 years each).

Art. 298/2014 - Technical principles of silvicultural applications; prepared by Ministry of Forestry and Water Affairs, General Directorate of Forestry according to the Turkish Forest Law (Law 6831):

(1.1.2.2) The high forest (monoculture or mixed forest) regeneration system is applied to the natural regeneration of all forests.

(1.1.4) Exceptions to 1.1.2.2 are stands of short rotation coppice with fast-growing species, stands on floodplain areas, other coppice forest regeneration systems and those that apply artificial regeneration or the clear cutting system. The size of clear-cutting (including coppice) coupes is a maximum of 3-5 ha.

(1.1.4.1) and (1.1.4.2) Specifications include:

(i) Calculation of annual allowable cut for management units treated as coppice: 20 year period for *Quercus* spp., *Carpinus betulus, Castanea sativa, Alnus glutinosa* stands and 5-10 year period for poplar, eucalypt and willow plantations.

(ii) 20-year management plans for compartments treated as coppice for: exploitable coppice stands reaching the rotation age (coppice cuttings), or non-/pre-exploitable coppice stands with tending operations for coppice stands to regenerate artificially.

(iii) Rules for the conversion of coppice forests to high forests: conversion by coppice ageing (total cessation of coppice cuttings) and conversion by coppice replacement and planting.

References

Anon., 2012. *Orman Varlıgımız (In Turkish), (Forests of Turkey)* Booklet, Year: 2012 Published by: Orman idaresi ve Planlama Dairesi Baskanlıgı Yayın No: 115 Envanter Serisi No. 17, General Directorate of Forestry, Ankara, Turkey

ÇOB, 2004. *Türkiye ulusal ormancılık programı (National forestry program of Turkey) (2004–2023)*. Ministry of Environment and Forestry, Ankara, 95 p.

FS, 2012. *Forestry Statistics, Republic of Turkey Ministry of Forestry and Water Affairs*. A Publication of Official Statistics Programme, Publication Number – 01, Ankara 84 p.

GDF, 2012a. *1980–2012 Yılları Asli Orman Ürünleri Üretim Programı ve Gerçeklesmeleri (Timber Harvesting Program and Realizations Between 1800 and 2012)*. General Directorate of Forestry http://web.ogm.gov.tr/birimler/merkez/isletmepazarlama/

GDF 2012b. *The inventory of Turkish Forests*. General Directorate of Forestry in Turkey, Ankara, p 36

Gümüs, C., 2016. *Historical development of forestry education in the context of forest resources management in Turkey*. Turkish Journal of Forestry, 17(1): 93-98.

Law 6831. Http://www2.ormansu.gov.tr/osb/Libraries/Dok%C3%BCmanlar/6831_say%C4%B1l%C4%B1_Orman_Kanunu_1.sflb.ashx

Notification 298. *Technical principles of Silvicultural applications*. https://www.ogm.gov.tr/ekutuphane/Tebligler/Silvik%C3%BClt%C3%BCrel%20Uygulamalar%C4%B1n%20Teknik%20Esaslar%C4%B1.pdf

Ukraine

Ivan Sopushynskyy, Vasyl Zayachuk, Iryna Matsiakh and Volodymyr Kramarets

Facts and Figures

Ivan Sopushynskyy

Definitions

(1) Coppice: Even-aged stand consisting of trees and shrubs (mainly: *Quercus* spp., *Fraxinus* spp., *Betula* spp., *Carpinus betulus, Alnus glutinosa*, occasionally *Fagus sylvatica*) that regenerate wholly or mainly vegetatively (sprout or root shoot) and are harvested in small clearcuts (0.5-1 ha) in short rotations of 30-60 years. In some cases combined with standards that have longer rotation periods.	*(1) Перелiски - невеликi здебiльшого вузькi, витягнутi дiлянки лiсу, якi межують або чергуються з окремими полянами, полями або луками, сюди також вiдносяться рiдкостiйнi лiси, що з'єднюють лiсовi масиви. Гай - невеликий за площею лiс, сформований деревами однiєї породи близького вiку.*
(2) Short rotation coppice: Plantation of fast-growing trees or shrubs (mainly *Populus* spp., *Salix* spp.) with the aim to produce in several short rotation periods (5-20 years each) wood as raw material for weaving furniture and a renewable resource, mainly for energy.	*(2) Пiдлiсок - чагарники, рiдше деревнi породи, що не досягають висоти верхнiх ярусiв, не входять в основний деревний ярус i не здатнi утворити деревостан у даних умовах.*

Rotation Period

The rotation period varies depending on forest species. However, the most common minimum rotation periods are: 5 years *Salix*; 30-60 years *Quercus*, *Alnus, Betula, Alnus, Populus, Fagus,* and *Carpinus*.

Statistics

Coppice forests comprise about 16% of the Ukraine's 9573.9 thousand ha of forest. These are differentiated into natural coppice with rotations of up to 60 years and coppice with rotations of 2-5 years (wood energy plantations). The density of coppice plantations (up to 20 thousand trees ha^{-1}) has been established mainly with *Populus* and *Salix* species. 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* L., *Robinia pseudoacacia* L., *Fagus sylvatica* L., *Betula verrucosa* Ehrh., *Salix alba* L., *Salix caprea* L., *Alnus glutinosa* (L.) Gaertn., *Alnus incana* (L.) Moench, *Sorbus aucuparia* L., *Malus sylvestris* Mill., *Populus tremula* L., and *Corylus avellana* L.), while the uneven-aged standards were selected to produce timbers (e.g. *Quercus robur* L., *Quercus rubra* L., *Fraxinus excelsior* L., *Fagus sylvatica* L., *Alnus glutinosa* (L.) Gaertn.).

References

Sopushynskyy I.M., Vintoniv I.S., Kharyton I.I., Ostashuk R.V. (2015): *Some Features of Firewood Qualimetry* // Scientific Bulletin of UNFU, Issue 25.1: 162-166.

Forests in Ukraine. http://dklg.kmu.gov.ua/forest/control/uk/publish/category?cat_id=32867

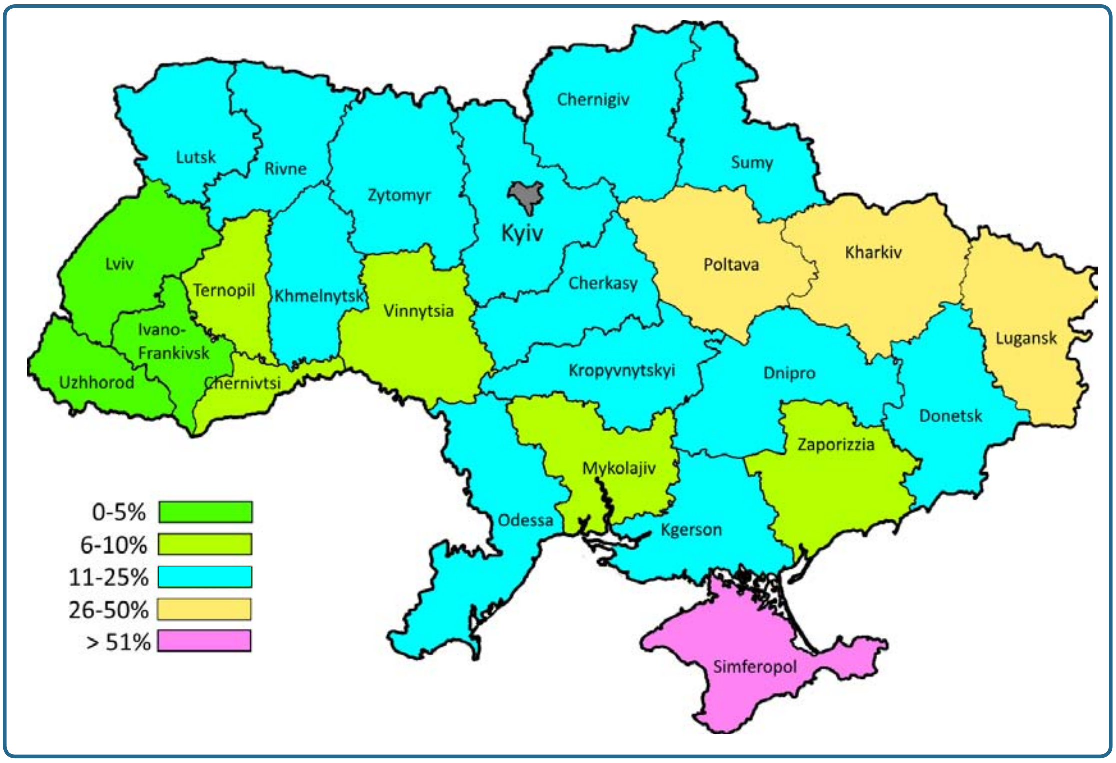
Typology

Simple coppice	Traditional natural forest regeneration method
Coppice with standards	*Populus, Alnus, Betula, Salix, Fraxinus, Quercus, Carpinus*
Pollarding	Only on roadsides and in gardens
Short rotation coppice	*Populus* spp., *Salix* spp.

Images

Map

Volodymyr Kramarets



Coppice forests in the regions of the Ukraine (in percent of the region's total forest area)

Description

Ivan Sopushynskyy and Vasyl Zayachuk

In the Ukraine, 9573.9 thousand ha are covered by forests; approximately 16% of this is coppice forest. Mixed broadleaved forests composed of pedunculate oak (*Quercus robur* L.), common ash (*Fraxinus excelsior* L.), hornbeam (*Carpinus betulus* L.), European beech (*Fagus sylvatica* L.), Norway maple (*Acer platanoides* L.), sycamore (*Acer pseudoplatanus* L.) and other tree species are dominant coppice tree species. They are differentiated into traditional coppice with rotations up to 60 years and wood energy plantations with rotations of 2-5 years.

The stands of coppice for wood energy were initiated in the past two decades and are mainly practiced for the economic reasons. The density (up to 20,000 trees ha^{-1}) of these coppice plantations has been established, mainly with *Populus* and *Salix* species. Short-rotation coppice is expected to expand with the predicted increase in demand for second generation biofuels.

The main products extracted from traditional 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. Coppice forests are often irregularly structured and disorganized.

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.

Traditional 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

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

In both tradtional 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.

Figure 1. Traditional mixed broadleaved coppice forests in the Ukrainian Subcarpathians

References

Forests in Ukraine. http://dklg.kmu.gov.ua/forest/control/uk/publish/category?cat_id=32867

Sopushynskyy, I.M., Vintoniv, I.S., Kharyton, I.I., Ostashuk, R.V., 2015. *Some Features of Firewood Qualimetry.* Scientific Bulletin of UNFU, Issue 25.1, pp. 162-166.

Forestry Regulations

Iryna Matsiakh and Volodymyr Kramarets

The forests of Ukraine are located in different natural zones: Polesia, forest steppe, steppe, and in mountainous regions (Carpathians and Crimea). The different topographical, edaphic and climatic conditions determine the main forest tree species distribution, their age, spatial structure and their productivity. Forests in Ukraine are not uniformly spread. The vast majority are concentrated in the Carpathians and Polesia regions. The largest forest areas are located in the oblasts (the admin divisions of the Ukraine) of Trans-Carpathia (51.1% of total land), Ivano-Frankivsk (41.0%), Rivne (36.4%), Zhytomyr (33.6%), and Volyn (31.0%). The smallest forest areas occur in eastern-southern regions: Kherson (4.1%), Mykolayiv (4.0%) and Zaporizzya (3.7%) oblasts.

Generally, Ukrainian forests are in state and communal ownerships; only 0.1% of the total forest area is found in private ownership. Forests are managed by institutions and enterprises that are **subordinated to more than 30 different Ministries and Departments**. The main forest users in Ukraine are the State Forest Resources Agency (65.2 % of the total forest area), the Ministry of Agrarian Policy and Food of Ukraine (5.5%), and the Ministry of Ecology and Natural Resources of Ukraine (1.6%). Communal forests (within local governments) comprise 12.5% of the forest area.

Data on State forests

The following data all refers to forests of the State Forestry Agency of the Ukraine:

Forests in Ukraine have long been exploited and still undergo intensive economic impacts. As a result, forest plantations dominate with 51.5% of the total forest area, while natural, seed-originating forests occupy 32.0% and coppice forests cover 16.5% of the forest area. The largest areas of coppice forests (155,800 ha, 67.8% of the total area of such forests) are found in the Autonomous Republic of Crimea. Coppice forests are also distributed in the Zhytomyr (111,600 ha), Volyn (93,500 ha), Kharkiv (92,300) and Rivne (90,200 ha) regions.

The eastern part of Ukraine (Luhansk, Kharkiv and Poltava regions) has the greatest distribution of coppice forests - in each of those oblasts more than 30% of the total forest area is of coppice origin. Compared with the western part of the country, there are small parts of coppice in Lviv, Ivano-Frankivsk and Trans-Carpathian regions, where coppice forests occupy only 3.8%, 3.7% and 2.0% respectively of the total forest area. Mature and over-mature coppice stands dominate, occupying 47.2% of all coppices, compared with only 8.3% in young categories.

Coppice forests in Ukraine developed without any clear intention to grow this type of forest. After World War II, part of the felled area remained as coppice, providing a fairly rapid supply of wood for heating and timber. In order to provide the best growing conditions for the main tree species (e.g. pedunculate oak, European beech, common ash, etc.), thinning of minor tree species such as hornbeam, silver birch and aspen was carried out. According to forest management plans, these stands are of seed origin, whereas they can contain up to 5-6 secondary tree species of coppice origin. This situation is typical in the forest enterprises of Poddilya and Lisostep (Tkach and Golovach 2009). Thinning favoured the main tree species, removing the secondary ones. Although a portion of these stands include a significant amount of coppice, unfortunately this factor is ignored in forest management activities.

Recently, it has been shown that the cultivation of coppice tree stands can have a number of advantages. In studies conducted in the Poltava region, comparisons of oak coppice forests with artificially planted oaks (Bojko 2006) indicated that: the time period of forest formation is decreased in coppices; a more complex structure develops than in oak forest plantations; coppices have higher productivity and a greater contribution to biodiversity conservation; and they reduce erosion and promote environment-specific functions (water and soil protection). Mature coppice oaks possessed a larger stock and a greater yield of small and medium-size wood than planted oaks. At the same time, the condition of coppice forests was often poor and a large share was affected by root and stem rot pathogens (Tkach 1999; Ustskiy and Bugayov 2014).

Usage of coppice stands for firewood production has a long tradition in Ukraine. Various species of willows were pollarded, for example, along with smaller amounts of poplar or other tree species. These willows were regenerated vegetatively using cut branch lengths, which quickly rooted up, on rich, wet soils along rivers or ponds. These were then periodically cut at 1.5-2.5 m above ground to aid the development of brushwood and sprouting. After several years, the willow branches were cut and used as firewood. Even nowadays, in many regions of the Ukraine local populations plant lines of willows along roads or in private gardens for firewood and heating, especially in the lowlands of Ukraine and in the Pre-Carpathian and Carpathian regions with a high forest cover. After the World War II, considerable attention was also paid to the selection of fast-growing poplar plantations (Shevchenko 1958), but this tree species is rarely used. Currently, biomass plantations to generate industrial energy are the subject of experimental research, but there are none on the territories of Forests Enterprises of the State Forest Resources Agency of Ukraine. Nevertheless, both the natural and economic conditions do allow fast-growing plantations for energy purposes to be established (Fuchylo et al. 2007).

Due to the problems concerning gas supplies from Russia and the war in the eastern part of Ukraine, where the coal mines are concentrated, our country faces the acute problem of finding alternative sources of energy. Thus, the **National Action Plan for Renewable Energy 2020**, approved by the Cabinet of Ministers of Ukraine on 01.10.2014, includes measures to promote bio-energy (National Action Plan 2014). The most realistic of these is the production of biomass for heating of private households, and for public, industrial and commercial consumers. There is also the prospect that biomass for energy production might be grown on an industrial scale. Private companies (Rika Biopalyvo, Eco-Energy) have made a commercial offer to establish energy plantations (Rakhmetov 2017), and the agro-energy company "SalixEnergy" is planning the cultivation of willow biomass for thermal and electric energy. On 1.05.2016, this company established 1,700 ha of energy plantations in the western part of Ukraine (Gnap 2016).

The growing and cultivation of energy crops requires support from the state and legislative regulators. The **Law of Ukraine "On Amending Certain Laws of Ukraine Concerning Ensuring Competitive Conditions for the Production of Electric Power from Alternative Energy Sources"** was adopted (04.06.2015) for the promotion of renewable energy, in particular:

- The "green tariff" for electricity generated from alternative sources (including wood) is approaching average world prices;
- If components of Ukrainian production are used to design and construct alternative energy sources, the remuneration is set as an allowance for the "green tariff";

- Stimulation of bioenergy is provided by setting the "green tariff" rate for electricity generated from alternative energy sources (including biomass).

The **Law of Ukraine "On Amendments to the Law of Ukraine "About Heat Supply" on Stimulation of the Production of Thermal Energy from Alternative Energy Sources"** (21.03.2017) promotes the production of energy for heating from alternative sources at local level. Moreover, domestic and foreign investments are guaranteed on the return of their investment, and can adjust the bioenergy tariff depending on the current gas tariff.

The tariffs for biological energy produced from alternative sources, including renewable resources (wood) for the local population and the state institutions, are set at 90% of the current tariff of heat produced from gas. Licensing activities for producing heat energy from alternative sources and setting tariffs is done at the local level, which allows for varying conditions in different regions within Ukraine and aims to stimulate small and medium businesses. In the new version of the **Law of Ukraine "About the Electricity Market"** (13.04.2017) considerable attention is paid to stimulating the production of electricity from renewable and alternative energy sources.

To summarize, the coppice forests of Ukraine result from a lack of effective forest management, especially after the World War II. However, there is a growing interest in the cultivation of fast-growing coppice tree species in plantations, which could become an important source of renewable energy in modern Ukraine. In addition, as shown above, domestic and foreign investors are given guarantees on returns from their investments in producing thermal energy from biomass, which in the future will further stimulate the cultivation of fast-growing coppice plantations.

Acknowledgement

We would like to thank M. Popovych, the Chief Specialist of the Department of Forest Protection from State Forest Resources Agency of Ukraine for information included in this report.

References

Law of Ukraine *"On Amendments to Some Laws of Ukraine Concerning Ensuring Competitive Conditions for the Production of Electricity from Alternative Energy Sources"* (04.06. 2015). Information from the Verkhovna Rada, 2015, No. 33:324. http://zakon4.rada.gov.ua/laws/show/514-19/page. In Ukrainian.

Law of Ukraine *"On Amendments to the Law of Ukraine" About Heat Supply "on Stimulating the Production of Thermal Energy from Alternative Energy Sources"* (21.03. 2017). Information from the Verkhovna Rada, 2017, No. 17:207. http://zakon2.rada.gov.ua/laws/show/en/1959-19. In Ukranian.

Law of Ukraine *"On the Electricity Market"* (April 2017, No. 2019-VIII). Information from the Verkhovna Rada. 2017. No. 26-27. http://zakon4.rada.gov.ua/laws/show/2019-19/page. In Ukranian.

Bojko S. V. 2006. *Comparative ecological & economical evaluation of coppices and artificial oak forests of river Sula water basin*. Forestry and forest melioration, 110: 67-71. [Бойко С. В. Порівняльна еколого-економічна оцінка природних порослевих і штучних дубових лісів на водозборі р. Сула. Лісівництво і агролісомеліорація. 2006. Вип. 110. С. 67-71]. In Ukrainian.

Fuchylo YA.D., Sbytna M.V., Derkach D.F. 2007. *The perspective of using of species of Salix L. for planting on energy plantations in Ukraine*. Ukrainian Phytosociological Collection. Kyiv, vol. 25: 97-102. [Фучило Я.Д., Сбитна М.В., Деркач Д.Ф. Перспектива застосування видів Salix L. для створення енергетичних плантацій в Україні. Український фітоценологічний збірник. Київ, 2007. Сер. С, вип. 25. С. 97-102]. In Ukrainian.

Gnap I. *Energy plantations: theory and practice in Ukraine*. [Енергетичні плантації: теорія і практика в умовах України]. https://www.salix-energy.com/energetichni-roslini. In Ukrainian.

National Action Plan for renewable energy for the period till 2020. Order of the Cabinet of Ministers of Ukraine No. 902-r dated October 1, 2014. http://zakon2.rada.gov.ua/laws/show/902-2014-%D1%80#n10. In Ukrainian.

Rakhmetov D. B. 2017. *Scientific and innovative potential of mobilization and use of new plant resources*. Bulletin of the National Academy of Sciences of Ukraine, 1: 73-81. [Рахметов Д. Б. Науково-інноваційний потенціал мобілізації та використання нових рослинних ресурсів. Вісник Національної академії наук України. 2017. No. 1. С.73-81]. In Ukrainian.

Shevchenko S. V. 1958. *Poplar and its cultivation in the western regions of the UkrSSR*. Lviv, 108 pp. [Шевченко С. В. Тополя та її культура в західних областях УРСР. Львів, 1958. 108 с.]. In Ukrainian.

Shilin I.S., Maurer V.M. 2015. *Some Features of Establishing Poplar Plantations in Western Polissya and Opillya*. Scientific Bulletin of Ukrainian National Forestry University, 25.6: 112-118. [Шилін І. С., Маурер В. М. Особливості закладання тополевих плантацій у Західному Поліссі та Опіллі. Науковий вісник НЛТУ України. 2015. Вип. 25.6. С. 112-118]. In Ukrainian.

Tkach V. P. 1999. *Plane forest in Ukraine*. Kharkiv: Law, 368 pp. [Ткач В. П. Заплавні ліси України. Харків: Право, 1999. 368 с.]. In Ukrainian.

Tkach V. P., Golovach R. V. 2009. *Modern condition of natural oak stands in the Left-bank Forest-steppe of Ukraine*. Forestry and forest melioration, 116: 79-84. [Ткач В. П., Головач Р. В. Сучасний стан природних лісостанів дуба звичайного Лівобережного Лісостепу України. Лісівництво і агролісомеліорація. 2009. Вип. 116. С. 79-84]. In Ukrainian.

Ustskiy I. M., Bugayov S. M. 2014. *Distribution of forest-pathological processes in the alder woodlands of Ukraine*. The Bulletin of Kharkiv National Agrarian University named after V.V. Dokuchayev. Seria “Soil science, agrochemistry, farming, forestry, ecology of soil”. No. 2: 106-111. [Усцький І. М., Бугайов С. М. Поширення лісопатологічних процесів у вільхових деревостанах України. Вісник ХНАУ ім. В. В. Докучаєва: Серія «Грунтознавство, агрохімія, землеробство, лісове господарство, екологія ґрунтів». 2014. No. 2. С. 106-111]. In Ukrainian.

United Kingdom

Debbie Bartlett, Peter Buckley, Jenny Mills and David Rossney

Facts and Figures

Debbie Bartlett and David Rossney

Definitions

Coppice in the UK really just means any tree that is cut at - or near - ground level, so that it regrows with multiple stems. These trees would then be described as 'coppiced'. Coppice woodland is woodland where this management technique has occurred and this may be carried out repeatedly, and so called rotational (or in rotation) coppice. We would refer to such woodland as managed by coppicing or in coppice management.

Debbie Barlett

Woodland comprising broadleaved trees, areas of which are clear felled, often regularly, and which then re-sprout (sometimes including suckering species). These sprouting root stocks will grow another crop of trees in the absence of grazing and browsing.

David Rossney

Legal Framework

There is no legal framework. In fact we have some problems defining woodland. Short Rotation Coppice is usually *Salix* spp., although chestnut can be managed on a wide range of rotations depending on end use, for example 3 years for walking sticks.

Debbie Barlett

There is no special legal framework for coppice, but it is mostly covered by general UK Forestry legislation and tree felling controls.

Coppice often grows in ancient semi-natural woodland which is itself subject to legal protection from damage. This does not mean that felling coppice cannot take place, but that the woodland must be allowed to re-grow again. This in effect means not cleared for building or agriculture and protected from grazing farm animals and wild browsing animals like deer.

David Rossney

Statistics

In 1999, total forest cover in the UK was over 2.6 m ha. Coppice and coppice with standards amounted to 0.9% of this total (24,000 ha). Historically this was higher and estimated at 1.5% in 1980 and 5.3% in 1947.

<u>Source</u>: Forestry Commission Research Report 2010

Much of the broadleaved woodland was, in the past, managed as coppice even if this practice has not been continued.

Typology

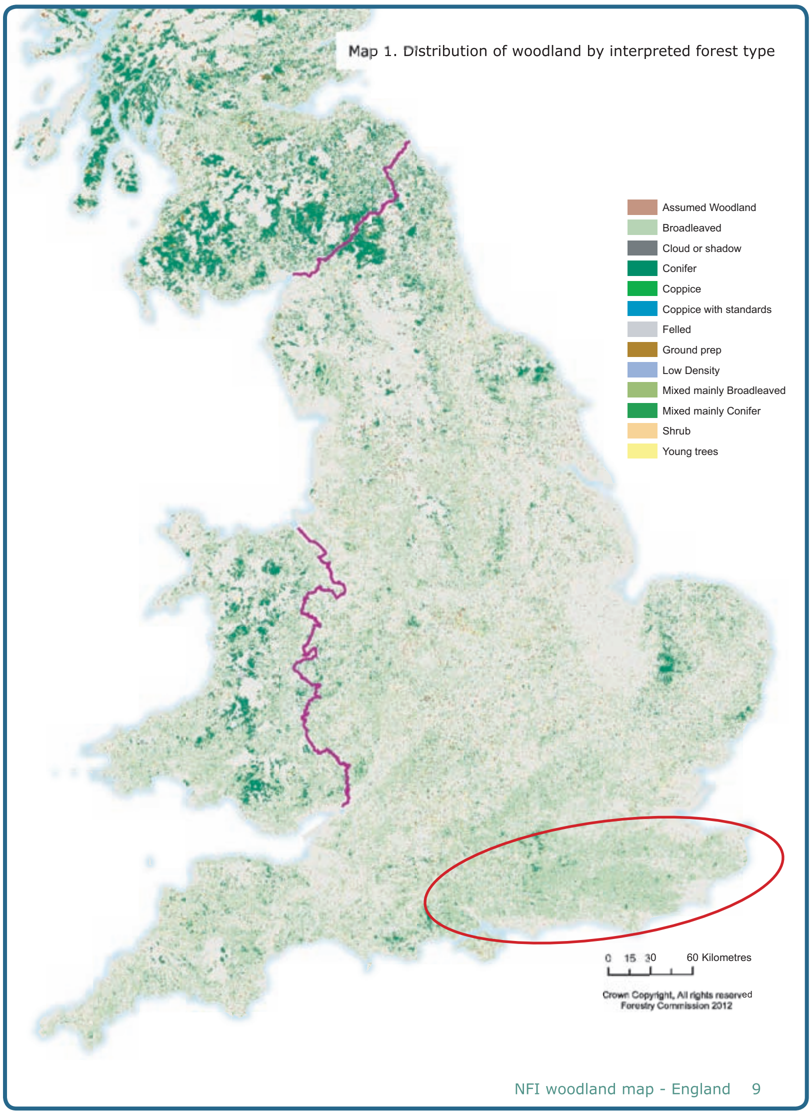
Simple coppice	Traditional natural forest regeneration method still practised, particularly in Southeast England, mainly sweet chestnut, hazel or mixed species and may include standards.
Coppice with standards	UK - Very common, usually with oak as the standard. This was, in times past, important for timber, particularly ship building. The recruitment of standards is no longer the norm, but is encouraged for biodiversity. England - standards often of oak.
Pollarding	UK - Practised in historic wood pastures and also within coppice areas as one way of marking boundaries between felling areas and changes in ownership, parish boundaries etc. England - historically - now regarded as archaeological features of cultural/biological significance.
Short rotation coppice	UK - Practised as an agricultural alternative to normal farmed crops. Not really part of the UK's woodland management heritage, unless counting hazel coppice cut on 7-9 year rotation. England - limited and considered as agriculture rather than forestry.
Other types	Self-seeded stands and newly planted coppice. A little new planting is still undertaken with the intention of creating new coppice woodland, particularly for sweet chestnut. Seed regeneration, especially of species such as silver birch, is often mistaken for or mixed in with coppice and is effectively managed in much the same way. After cutting, some stools will coppice, but with birch, most new trees come from self-seeding.

Images





Map



Map of the distribution of woodland in England by interpreted forest type, from the National Forest Inventory (NFI) 2011 (Contains Forestry Commission information licensed under the Open Government License v3.0). Coppice is currently a significant component of the landscape character in the south-east of England (circled in red).

Description

Debbie Bartlett

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.

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 1. An example of coppice with standards in the United Kingdom

Forestry Regulations

Jenny Mills and Peter Buckley

England, Scotland and Wales

There are 3.16 million hectares of woodland in the UK according to national forestry statistics published in 2016. This represents 13% of the total land area in the UK, 10% in England, 15% in Wales, 18% in Scotland and 8% in Northern Ireland. 1.35 million hectares of woodland in the UK is independently certified as sustainably managed. Conifers, mainly Sitka spruce and Scots pine, cover around 51% of the UK woodland area, although varying from 26% in England to 74% in Scotland. The main broadleaf species are oak, beech, sycamore, ash, birch, alder, sweet chestnut and hazel.

UK forestry statistics define woodland as land under stands of trees with a canopy cover of at least 20% (or having the potential to achieve this), including integral open space, and including felled areas that are awaiting restocking. There is no minimum size for a woodland or minimum height for trees to form a woodland at maturity; the definition therefore includes woodland scrub but not areas with only shrub species. During the 20th century, the area under working coppice in the UK greatly decreased; the last official estimate in 2011 was only just over 2,000 ha. This is distributed mainly in south-east England, where it represents approximately 1% of the forest cover (Forestry Commission, 2015).

The **Forestry Act 1967** and subsequent amendments regulate forestry in England, Scotland and Wales. Responsibility for administration and enforcement is vested in the Forestry Commission, Forestry Commission Scotland and Natural Resources Wales.

Under the Forestry Act, it is illegal to fell trees in the UK without prior approval, apart from the exemptions listed below. **Felling licences** are usually granted subject to restocking and maintenance for a period not exceeding 10 years. The Forestry Commission will discuss any proposed restocking condition with the applicant before a licence is issued. However, licences without the requirement to restock are issued for silvicultural thinning operations. They may also be issued if there are overriding environmental considerations, e.g. to restore important habitats, and such applications are assessed under the **Environmental Impact Assessment (Forestry) Regulations 1999**. It is recommended that a felling licence application is made at least 3 months before felling is planned to take place.

In England, Scotland and Wales, a felling licence is not required if the owner wishes:

- to fell less than 5 cubic metres in a calendar quarter, but only 2 cubic metres of this can be sold per quarter (i.e. can fell 20 cubic metres a year, but sell only 8)
- for trees that have the following diameters when measured 1.3 metres from the ground: 8 cm or less; 10 cm or less for thinnings; 15cm or less for cutting coppice

A licence is not needed if the owner has a current permission under an approved **Dedication Scheme** plan or planning permission granted under the Town & Country Planning Act.

A licence is not needed to fell dangerous or nuisance trees, diseased trees in accordance with a notice served by a Plant Health Officer, to comply with an Act of Parliament or to undertake duties as a statutory service provider (gas, water, electricity).

No licence is required for lopping, topping, pruning or pollarding unless the tree is covered by a **Tree Preservation Order** or by **Hedgerow Regulations**, in which case permission must be sought from the Local Planning Authority and they also have to be consulted if a tree is to be felled in a historical **Conservation Area**.

Application for a felling licence can be made on its own or as part of a management plan submitted to the Forestry Commission, Forestry Commission Scotland or Natural Resources Wales. An application to fell trees can be made as part of a grant scheme application. A separate felling licence application is not required as a felling licence will be issued with the grant scheme contract.

An offence under the **Wildlife & Countryside Act** (1981) may be committed if felling, and in particular, clear felling, is carried out during the breeding season of protected species, including all wild birds. A **European Protected Species** (EPS) licence may be required from Natural England under the **Conservation of Habitats and Species Regulations** (2010) if felling operations could adversely affect any EPS.

Natura 2000 sites in the UK are also designated as Sites of Special Scientific Interest (SSSIs). Consent for forestry operations, which include afforestation, planting, clear and selective felling, thinning, coppicing, modification of the stand or underwood, changes in species composition and the cessation of management, on these designated sites is required from Natural England, Scottish Natural Heritage or Natural Resources Wales as well as the Forestry Commission, unless statutory permission has been received from another public body such as the Environment Agency who have already consulted the national environmental body.

Within SSSIs, and so by association in all SACs (Special Areas of Conservation), lists of damaging operations notified by the above conservation organisations include the cessation of tree or woodland management, which in the case of coppice, could mean keeping the coppice within rotation. However, Natural England is not aware of any action being taken for sites where coppice is being neglected, even if it was being actively coppiced when listed.

Northern Ireland

The **Forestry Act (Northern Ireland)** passed in 2010 applies in this part of the UK. Owners of private woodlands of 0.2 hectares or more need a licence to fell trees from the Forestry Service of the Northern Ireland Department of Agriculture and Rural Development. They are required to re-establish the woodland under an approved felling management plan. The exemptions from the requirement for a felling licence are similar to the rest of the UK.

References

Forestry Act 1967 http://www.legislation.gov.uk/ukpga/1967/10

Forestry Commission (2015) *NFI 2011 woodland map England. National Forest Inventory report.* Forestry Commission, Edinburgh

Forestry Commission. *Forestry Statistics 2016* http://www.forestry.gov.uk/pdf/Ch1_Woodland_FS2016.pdf/$FILE/Ch1_Woodland_FS2016.pdf

Forestry Commission (2007) *Tree Felling: Getting Permission*. http://www.forestry.gov.uk/pdf/treefellingaugust.pdf/$FILE/treefellingaugust.pdf

Summary of Data from the 35 Country Reports

Alicia Unrau

Throughout the duration of COST Action FP1301, much coppice-related data and information was collected on the 35 countries involved. Each of the countries were featured in the previous sections of this chapter; a few of the key aspects are summarised below. First is a table on the amount of coppice in each country, followed by a list of the tree species. Finally, countries that offer coppice-related subsidies are highlighted. This summary is by no means all-encompassing, it is only meant to give a brief overview of some of the key information on coppice forests in Europe.

Coppice forest area

Table 1 lists the countries in this chapter by their reported area of coppice forests, from lowest to highest. The **data was extracted from the Country Reports**; if several figures were cited, generally the more conservative amount, closer to the amount of active coppice, was taken (e.g. the 1,351,815 ha of "conversion coppice" in Bulgaria are excluded) and for cases in which only a percentage as given (e.g. Romania), the area of coppice was calculated based on the share of the total forest area. The countries without figures have either a negligible and/or unknown (e.g. Latvia) amount of coppice.

The **figures on land and forest area** were taken from the State of Europe's Forests (SoEF) 2015 report (FOREST EUROPE 2015), from Table 1 and Table 2 of Annex 8, respectively. The "forest area (ha)" figures only include forest, not "other wooded land (OWL)". Coppice forests as a share of total forest area was calculated based on those figures.

It must be noted that there are the usual difficulties here in stating and comparing forest area statistics, which are in fact magnified for coppice due to its relative neglect as a forest management form. The figures cited here **can only be viewed as approximations**, since the definitions of coppice between countries vary, as do the inventory methods.

The figure of 29 million hectares of **total coppice forest area in Europe** is higher than other sources, such as Zlatanov and Lexer (2009), who cite the UN/ECE-FAO (2000) for over 23 million ha of coppice forests in Europe, as well as giving their own figures per country. In another source, the SoEF 2015 (FOREST EUROPE 2015), the sum comes to approximately 8.7 million ha of coppice. Concerning the latter, the countries with the largest variation in data compared to the Country Reports are France, Spain, Italy, Turkey, Greece, Serbia and Bosnia & Herzegovina, which are, apparently, underreported in the SoEF 2015 report by between 4.67 and 1.25 million ha, with some countries not having provided any data. Bulgaria is an exception, in which 1.29 million ha more are reported in the SoEF 2015 report than in Table 1 here (for the reason stated above, first paragraph).

Despite this comparatively high figure, the **area of forests of coppice origin, including overaged coppice, can be considered to be greater than reported here**, because of: the use of rather conservative estimates (see first paragraph above); overaged coppice is often not included in the forest inventory (e.g. in the German National Forest Inventory, forests are only considered to be coppice if they were cut within the past 40 years); and in many cases the OWL areas could be coppiced (e.g. Albania, in which 60 % of the total wooded area is managed as coppice, as opposed to the 38 % from forest cited here).

Table 1. Area of coppice forests in Europe based on data from the Country Reports, compared to total forest area (excludes the reports from Israel and South Africa).

	Land area (ha)*	Forest area (ha)*	Forest as share of land area (%)	Coppice forest area (ha)[†]	Coppice as share of forest area (%)
Ireland	6,889,000	754,000	11 %	-	0 %
Lithuania	6,267,500	2,180,000	35 %	-	0 %
Estonia	4,522,700	2,232,000	49 %	-	0 %
Latvia	6,218,000	3,356,000	54 %	-	0 %
Norway	30,427,000	12,112,000	40 %	-	0 %
Finland	30,389,000	22,218,000	73 %	-	0 %
Sweden	41,033,000	28,073,000	68 %	-	0 %
Netherlands	3,375,000	376,000	11 %	1,500	0.4 %
United Kingdom	24,193,000	3,144,000	13 %	2,000	0.1 %
Denmark	4,243,000	612,200	14 %	6,000	1.0 %
Czech Republic	7,721,600	2,667,400	35 %	11,703	0.4 %
Poland	30,622,000	9,435,000	31 %	21,477	0.2 %
Slovakia	4,810,000	1,940,000	40 %	34,463	1.8 %
Switzerland	4,000,000	1,254,000	31 %	35,200	2.8 %
Slovenia	2,014,000	1,248,000	62 %	36,340	2.9 %
Germany	34,861,000	11,419,000	33 %	78,120	0.7 %
Austria	8,243,500	3,869,000	47 %	93,000	2.4 %
Belgium	3,027,800	683,400	23 %	115,000	17 %
Albania	2,751,500	785,000	29 %	295,440	38 %
Romania	23,002,000	6,861,000	30 %	343,050	5 %
Bulgaria	10,856,000	3,823,000	35 %	481,747	13 %
Croatia	5,596,000	1,922,000	34 %	533,828	28 %
Macedonia	2,543,000	987,500	39 %	564,000	57 %
Hungary	9,303,600	2,069,100	22 %	581,420	28 %
Portugal	9,025,500	3,182,100	35 %	863,000	27 %
Bosnia & Herzegovina	5,120,000	2,115,000	41 %	1,252,200	59 %
Serbia	8,746,000	2,720,000	31 %	1,456,400	54 %
Ukraine	57,938,000	9,657,000	17 %	1,531,824	16 %
Greece	12,890,000	3,903,000	30 %	1,930,000	49 %
Italy	29,414,000	9,297,000	32 %	3,666,310	39 %
Spain	49,880,000	18,417,900	37 %	4,000,000	22 %
Turkey	76,963,000	11,943,000	16 %	4,874,712	41 %
France	54,766,000	16,989,000	31 %	6,372,000	38 %
TOTAL	611,651,700	202,244,611		29,180,734	

* Data from the "State of Europe's Forests 2015" (FOREST EUROPE 2015)

[†] Data from the 35 Country Reports in this volume, "Coppice Forests in Europe"

Table 2. Main tree species managed as coppice by country, according to data from the Country Reports and supplemented by feedback from the authors. Modified version of table in Lazdina and Celma (2017).

	Alder	Ash	Beech	Birch	Black locust	Elm	Eucalypt	Hazel	Hophornbeam	Hornbeam	Linden	Maple	Oak	Plane tree	Poplar/Aspen	Rowan	Sweet chestnut	Willow
Albania	xx	P	xP		xx	P		xx	P	xx	P	P	xx		xx			xx
Austria										xx			xx		S			S
Belgium	xx	xx		xx				xx		xx		xx	xx		S		xx	S
Bosnia & Herzegovina			xx										xx					
Bulgaria		x	xx		xx					xx	xx		xx				x	
Croatia	x		xx		x				xx	xx			xx		x		x	x
Czech Republic	xxS	xxS		x	x	x		xx		xx	xx	xx	xx		xxS			PS
Denmark	xx	x		x				xx				x	xx		x	x		x
Estonia	xS														xS			xS
Finland	S			xS				x			x				S	x		xS
France	x		x	x	xS		S			xx			xx		xS		xx	S
Germany	xx		x		S			x		xx	x		xx		S		x	S
Greece			xx										xx		S		xx	
Hungary	xx				xx										xx			
Ireland		xx						xx					xx		xxS			xxS
Israel													xx		x			
Italy	xS		xx		xS	S	S	x	xx	x			xx	S	S		xx	xS
Latvia	xxS	x		xx				x			x				xxS			xxS
Lithuania	xxS	xx		xx											S			S
Macedonia		xx	x						xx	xx		xx	xx		xx			
Netherlands	xx	xx	x	x		x					x		xx		S			S
Norway		xx		xx		xx					xx					xx		
Poland	xx		x	xx						x	x		xx		S			S
Portugal		P					xx						x		P		x	
Romania					xx										x			x
Serbia			xx		xx					xx	xx		xx					S
Slovakia	x	x	xx		xx					xx			xx		xS			PS
Slovenia			xx		xx								xx				x	S
South Africa							xx											
Spain	x			xx			xx						xx	x	S		x	x
Sweden	xx	P		xx							P				xx			xxS
Switzerland	xx	xx	xx					x		x	x		xx				xx	P
Turkey	xx		x				S			xx		x	xx	x	S		xx	S
Ukraine	xx	xx		xx	x			x		xx			xx		xxS	x		xxS
United Kingdom								xx		xx			xx				xx	S

xx = species used for coppice (current/historic) x = species less commonly used for coppice (current/historic)
P = species only/mainly used for pollarding S = species used for Short Rotation Coppice (SRC)

Tree species managed as coppice

The main tree species managed as coppice (Table 2) are taken from the sections of the Country Reports; the authors were subsequently given the opportunity to make further adjustments. Most of the tree species mentioned in the reports are listed, although there are a few exceptions, such as wild cherry (Czech Republic) and elder (Denmark).

The categories were kept rather open by using the common names that could encompass several species. In the reports, quite a few authors specify major species that are particularly important for coppice in that country, such as oriental hornbeam in Bulgaria and European hop hornbeam in Italy.

Subsidies for coppice forest management

Some of the Country Reports mention subsidies related to coppice forest management. These range in their aims and instruments, for example:

Croatia: subsidies are possible in protection areas and for conversion to high forest (the latter in Chapter five, "Socio-Economic Factors Influencing Coppice Management in Europe"); management plans are necessary when applying.

Denmark: subsidies were introduced in 1994 to support traditional silvicultural systems.

France: the replacement of coppice through conifers was strongly encouraged through subsidies in the second half of the 20th century.

Netherlands: 1955-65 conversion to high forest; current policy to protect coppice forests, with management subsidies of 2,563 €/ha/yr for coppice forests on wet soil, 394 €/ha/yr on dry soil.

Norway: 50 €/tree managed as coppice, Regional Environmental Program for Agriculture (RMP)

Switzerland: 4000 CHF/ha^{-1} per intervention for the restoration and tending of coppice forest with and without standards.

United Kingdom: some coppice-specific subsidies for coppice in some areas of England (in Chapter five, "Socio-Economic Factors Influencing Coppice Management in Europe").

Considering this diversity, a closer look at different subsidies related to coppice management could be an interesting topic for further research.

References

FOREST EUROPE (2015). *State of Europe's Forests 2015* (pp. 243, 244 & 273)

Lazdina, D., Celma, S. (Eds.) (2017). *National Factsheets on Coppice Forests. COST Action FP1301 Reports*. Freiburg, Germany: Albert Ludwig University of Freiburg.

UN/ECE-FAO (2000). *Forest resources of Europe, CIS, North America, Australia, Japan and New Zealand. Main Report.* Geneva Timber and Forest Study Papers 17, Geneva, Switzerland.

Zlatanov, T., Lexer, M.J. (2009). *Coppice forestry in south-eastern Europe: problems and future prospects*. Silva Balcanica 10(1), pp. 5-8.

7 Outlook

The end – or the beginning.

What historical patterns can we distinguish?

What could be done to support coppice in the future?

Visit this chapter for:

The Future of Traditional Coppice Forests in Europe: Lessons Learned and Actions to be Taken

The Future of Traditional Coppice Forests in Europe: Lessons Learned and Actions to be Taken

Gero Becker

Coppice forests are a result of human land use decisions and efforts to make the best use of a given eco-physical situation. Typical for coppice management is the intensive and continuous interaction with the existing forest resource, using their natural dynamic development to fulfil actual and future needs of rural societies for wood and non-wood products. Today, coppice forests in Europe represent a substantial natural resource in both forest area and wood production, but are also unique ecosystems with specific biodiversity features and heritage values.

The multitude of results of our coppice related research efforts reveal that it is impossible to give singular, uniform answers to the questions of how traditional coppice forests have developed, how they should be sustainably managed in the future and how they should be addressed at a European scale in forest and land use policy. Not only the eco-physical conditions, but also the historical developments and the socio-economic framework today is so diverse, that strict guidelines would not be feasible or appropriate.

Despite this diversity, some generalizations can be made on different situations of coppice in Europe and how they could develop in the future. Furthermore, due to their neglect in the past decades, it is also necessary to support coppice on a political level; some options for such support will be touched upon here.

Coppice in Europe: past, present and future developments

Since coppice forests are results of human decisions and interventions, their actual status and their role in the future can only be understood and discussed with a close look to their development in history, which is embedded in and closely linked to their respective socio-economic environment. When analyzing and comparing the development and the actual status of coppice forests and the related issues between European countries and regions, there seem to be some broad similarities in historical developments that have led to the differences in the current situations. The following four situations describe these developments, underline the coppice-related challenges of the present and formulate consequences and visions for the future.

1. Coppice forests resulting from traditional small-scale rural societies and economies

Historical development and current status

Household wood use in rural societies was the starting point of active coppice forest management in nearly all European countries. After clearing natural forests for farming, cattle grazing and housing, coppice management was introduced on the less fertile or difficult to access former natural forest areas surrounding the settlements, and intensively practiced to supply local communities with wood for energy, a variety of tools and non-wood products. Initially, in many cases these coppice forests were owned and managed by the community, with individual ownership developing later on.

This small-scale pattern of management and utilization of coppice forests was abundant until recently in quite a number European countries and regions, typically where there was a low degree of urbanization and industrial development, low incomes, primarily from agriculture, and poor public infrastructure. Even today, there are hot spots of actively practiced coppice management that can be identified in South-East Europe and in the Mediterranean countries, but, in many cases, the recent socio-economic developments there too result in a decreasing need and interest in active coppicing. Consequently, vast areas of coppice forests throughout Europe are no longer managed as coppice, resulting in neglected, overaged, and in many cases unstable broadleaved (oak, hornbeam, sweet chestnut, etc.) forests of low productivity.

Options for the future

Conservation and re-vitalization of active coppicing

In rural regions where coppice is still (or has been until recently) actively practiced by small-scale forest owners, who are often part-time farmers, it may be advisable to improve the circumstances that encourage the owners to continue with the traditional coppice forest management. This could result in positive short- to medium-term environmental and economic effects, while being less costly than conversion.

One inevitable precondition is the improvement of the existing, in most cases poor forest infrastructure (forest roads and strip roads). Technical and financial support from the public to make the related investment feasible is necessary. Furthermore, small-scale harvesting technology adapted to the specific conditions of coppicing has to be developed and introduced to facilitate the labor intensive and dangerous forest work in coppice. Finally, the development of local and regional markets for energy wood and other wood and non-wood products typical for coppice is a prerequisite for a successful revitalization of coppice forest management with positive effects for small-scale owners and their communities.

Successful examples of such a re-vitalization policy can be studied in a number of regional initiatives, for example in England and northern Italy.

Conversion to high forests

Since high forests deliver wood products, namely logs, that have a higher appreciation and price on the markets, conversion to high forests using the same or alternative tree species is an ecologically and economically viable option, especially on more productive sites and easy terrain. However, with significantly longer rotation periods than coppice (50 to 100 instead of to 20 to 30 years), it is likely very difficult for small private owners and rural communities to afford the initial investments in silviculture without the help of subsidies. Furthermore, barriers such as forest infrastructure (roads) and fragmented ownership patterns must be improved to make conversion effective. National and EU-wide programs offering financial support are therefore necessary to initiate these conversion efforts. In the long term, newly established high forests can create an improved wood supply and better income in rural areas, both of which are explicit objectives of national and European policy.

In Central Europe (e.g. France, Germany, the Netherlands and Belgium) a state-subsidized conversion policy was successfully introduced in the 1950s, which has resulted in significantly fewer abandoned and less productive coppice forests in those countries. In other European countries, such as Romania, the conversion of coppice to high forests with the objective to increase productivity and value is prescribed and enforced by forest laws, resulting in a low proportion of coppice forests.

2. Coppice forests resulting from early industrial development

Historical development and current status

Due to their specific biological characteristics and management features, coppice forests show a high productivity, especially during the first two to three decades of rotation. Consequently, they provide a substantial amount of wood within a short time, even if only as small dimensioned shoots.

Early industries such as mining, iron melting, steel forging, leather tanning, as well as glass, pottery and porcelain production, relied entirely on wood or wood products as a resource for their energy needs and processing requirements. Their high demand for wood first resulted in over exploitation of the surrounding natural forests. Subsequently, to secure supply, coppice systems were established on extended areas and utilized sustainably in short rotation cycles. This was organized by the industries, which often also owned the forests.

Only after fossil coal became widely available and could be transported with the newly installed canals or railway systems did the industries' demand for wood gradually drop, until wood was replaced completely towards the middle of the 20th century. In parallel, many coppice forests were converted to high forests, frequently supported by direct (financial) or indirect (technical support, tax relief) subsidies. This happened, for example, in Germany, Belgium and England in the 1950s. In other regions, e.g. Tuscany or central France, large areas with overaged coppice forests still exist.

Options for the future

These coppice forests are less fragmented than rural small-scale coppice forests, are often situated on easier to access terrain and have basic infrastructure, so conversion to high forests is one, but not the only option.

With regard to EU, national and regional political objectives to reduce the dependency on fossil energy, modern wood energy systems supplied by coppice forests can be a viable option with positive effects that are achievable in a shorter timespan compared to conversion. To support this option, modern specialized harvesting and logistic systems must be developed and introduced, and up-to-date power plants with conversion technology (furnaces) with low emissions are a must for long-term success. Since wood based energy systems typically release a substantial proportion of thermal energy, it is furthermore crucial to have year-round demand for heat close to the power plant; this could be agricultural or industrial customers. It is obvious that such complex energy systems require support for the investment and the initial operational phase. A combination of traditional coppice forests and "new" short rotation coppice energy plantations, established as "green field" land use activities on marginal agricultural soils, could increase both energy wood supply and productivity.

Similarly, the utilization of coppice and new short rotation plantations as a source of raw material for upcoming bio-economy projects is politically favorable, but, realistically, a longer-term project.

3. Coppice forests as a protective element of landscapes and in rural civil engineering

Historical development and current status

Following the widespread abandonment mentioned in the last two situations, some coppice forests were converted to high forest, but this took place most frequently on easy to access, productive sites. Other vast areas were simply neglected, which has resulted in an abundance of coppice forest on steep or otherwise difficult terrain. Such landscapes are often prone to soil erosion, landslides or avalanches. Other cases in which coppice grows in a vulnerable situation are parallel to infrastructures (roads, waterways, railway and power lines) or close to housing areas. Since traditional coppicing only allows the growth of small shoots above ground, but with a deep root system, actively managed coppice forests effectively protect the soil and the surroundings in such situations. If coppicing is abandoned, which is now often the case, trees become older and larger, while their root system tends to decay. This diminishes the protective function of these coppice forests over time, representing an additional risk.

Options for the future

In the vicinity of endangered landscapes and infrastructures, critical areas where coppice forests are necessary for safety reasons should be mapped and identified as protective coppice forests, and actively managed accordingly. Location, size, frequency and intensity of the periodical cuts should be prescribed to optimize the protective function. The related costs will be typically much lower than those of "artificial" civil engineering alternatives and are to be covered by the public or the institutions responsible for the infrastructures and their safety.

4. Coppice forests becoming a rarity: conserving hot spots of biodiversity and valuable cultural heritage

Historical development and current status

In areas of Europe where most coppice forests have been successfully converted to high forest in the past century or two, the scarcity of coppice forest management has led to an awareness for their unique biodiversity compared to high forest, as well as attention for their importance as a part of cultural heritage.

In terms of biodiversity, actively managed coppice forests result in specific eco-physiological conditions that are caused by the continuous and massive human interventions and usually lead to a very different ecological situation than high forest management. The periodical removal of canopy cover creates excellent growing conditions for light demanding species. The small-scale pattern of cuts with distinctively different tree coverage results in edge effects, which also favors otherwise rare species. Coppice forests on poor soils are particularly likely to have a great natural biodiversity. Overaged coppice forests tend to gradually shift to a more homogenous horizontal and vertical structure, through which they lose this specific diversity. In addition, abandoning the frequent removal of large parts of the above ground biomass when harvesting results in more fertile soil conditions, which can hinder certain species rich biotopes. These effects are even more pronounced if coppice forests are converted into high forests.

Concerning cultural heritage, it is clear from the previous historical descriptions that coppice forests were a typical element of rural landscapes throughout Europe. Shifting land use patterns, temporarily changing between field crops, pasture and coppice trees, were quite common. The daily life of our ancestors was closely linked to the intensive management of coppice forests and the utilization of the various products and services they provided. The introduction and cultivation of vineyards was, for example, closely linked to coppice forests, which provided the necessary poles, but also the wood for barrels. Basket making or tanning leather are other examples of how closely craftsmanship and coppice utilization were linked.

Options for the future

In countries and regions where coppice forests currently represent a very small proportion of total forest coverage, coppice should be "protected", which means actively managed, in order to meet biodiversity targets. This is especially important for coppice forests on poor sites. Somehow this seems contradictive to normal conservation policies, which usually aim at minimizing or excluding human interventions to protect the ecosystems in question. In the framework of EuroCoppice, an analysis of European Natura 2000 legislation and practice clearly revealed that the special case of coppice forests must be addressed in a specific way to ensure that coppice related biodiversity can be maintained in the future.

To preserve or to revive coppice forests and their active management, and to include the follow up utilization of selected products into integrated demonstration projects, would also contribute to preserve cultural heritage. Especially young people from urban areas could be informed and educated about the life of their ancestors and how they sustainably made use of the existing natural resources of their environment. Integrated coppice projects could also be an instrument to revive traditional craftsmanship and to stimulate rural tourism, which would contribute to the stability of rural communities.

Actions to support coppice forest management

Coppice is the oldest form of systematic utilization of natural forest ecosystems by humans throughout Europe and beyond. It provided for centuries a broad array of products, energy and services to rural communities, in most cases on a sustainable basis. Thus, coppice related traditions are deeply rooted in the common European history of land use and the respective knowledge and skills are a valuable part of European heritage.

Coppicing as a low input management concept is productive and aimed at an early yield of biomass. It allows a flexible orientation of forest production and products to the current needs of society and the economy. Coppice as an ecosystem is stable, resilient and adaptive to environmental impacts including climate change effects, and as a reservoir of biodiversity, giving a home to many rare and endangered species.

Due to changing market demands combined with the lack of adapted infrastructure and technology for their management and harvest, coppice forests have been neglected or even converted to high forests within the past decades. Cheap fossil resources and urbanization have contributed to this development, with a different pace and intensity throughout Europe.

To recognize the cultural heritage, preserve the valuable and unique coppice flora and fauna, benefit from the resistance and resilience of coppice forests in the context of climate change and to make use of this valuable natural and sustainable bio-resource for current and future industrial applications, actions to support coppice forest management must be taken on the European level, supported and supplemented by harmonized national activities, with emphasis on the following four domains:

Data collection and analysis

Coppice forests are not systematically addressed in national or EU-statistics and definitions and data are unclear or missing. Therefore, important information is not available, making it difficult to develop and implement targeted harmonized policies. It is thus strongly recommended, that guidelines for Forest Inventories, National Forest Programs and coppice forest related data in environmental databases are amended and updated with clear definitions of coppice relevant information and guidelines on how to collect, analyze and present the respective data on both national and EU levels. The terms and definitions elaborated and presented in this volume "Coppice Forests in Europe" may be useful for the design and implementation.

Research & development and education

During the collaborative work on coppice forests, it became obvious that research on coppice issues has not been a priority and has even been neglected in the agendas of national and international research on forests for many decades. Mainstream forest research is focused on high forests and their related issues. Practical knowledge and experience on coppice forest management on the regional and –in some cases– national level still exist, but this is not compiled systematically and is often not published in internationally accessible formats.

An analysis of curricula on a professional and academic level shows that coppice issues are neglected or even completely missing in education and training programs as well.

It is therefore strongly recommended that coppice related issues be explicitly addressed in EU-wide calls for R&D projects in the framework of, for example, Horizon 2020, INTERREG, LIFE and LEADER programs in the areas of forestry, landuse, rural development, bioenergy, nature conservation, biodiversity, climate change and sustainability.

Legislation

An analysis of the relevant official legal and policy documents on EU and national level revealed that coppice related issues are not adequately covered. In many cases, clear legal definitions are missing or contradictive, laws concerning forestry and nature conservation are not harmonized, just to mention some shortcomings. These undermine a harmonized development of the natural resources, for both utilization and protection.

It is therefore necessary that –in close connection with the first action, "data collection and analysis"– the relevant official documents are revised and amended.

Structural funds

The analysis of the current situation and of the future options for coppice forests in Europe clearly shows that, in most cases, positive development over the medium-term perspective will be unlikely without initial financial, technical and institutional support from EU structural funds.

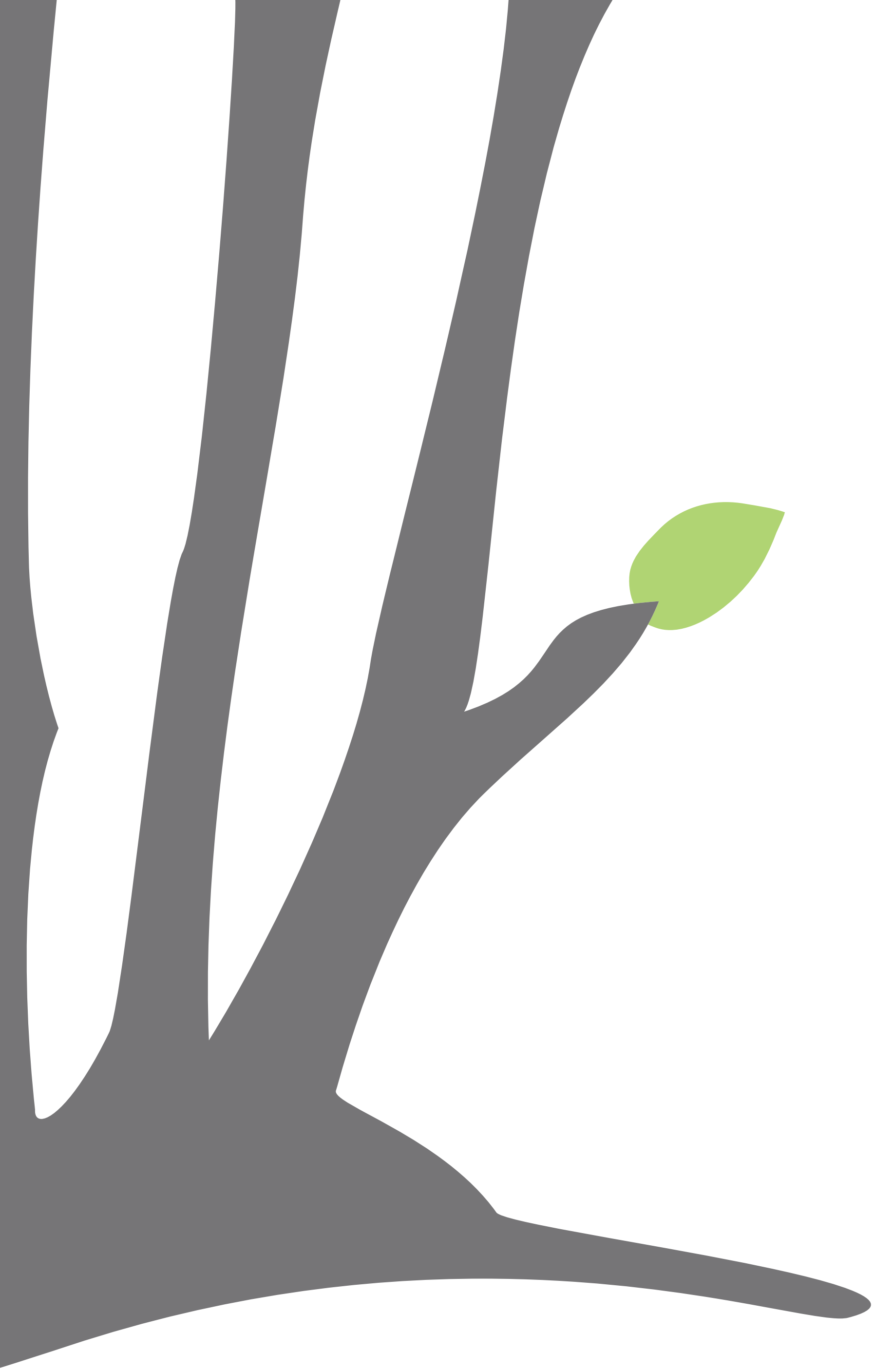
This is particularly the case for large, neglected areas of coppice that dominate rural areas. Infrastructure and business development, as well as market access must be supported to enable the rural population to manage their coppice forests with the perspective of economical sustainability.

For situations in which coppice is marginal, it should be protected and conserved for nature conservation and biodiversity, as well as cultural heritage value. Financial support from EU structural funds may be necessary to reach these objectives.

Conclusion

Since coppice-related issues and challenges are frequently cross sectional, touching on more than one single aspect or discipline, it is necessary to have a common understanding and integrated policy approach for the future management of these forests. They should be developed sustainably, encompassing a number of EU areas of policy, namely: Agriculture and Rural Development; Environment; Energy; Climate Action; Employment, Social Affairs and Inclusion; and Eurostat-European Statistics.

To put this vision into practice, officials, researchers and stakeholders are encouraged to read the articles of this volume and take advantage of the facts and findings presented.



8 Annex

In the background.

Four years of events and support for coppice topics.

The researchers, experts, emerging scholars involved in those activities.

The show will go on – a new global network on traditional coppice established in IUFRO.

Visit this chapter for:

COST Action FP1301 EuroCoppice: Activities

COST Action FP1301 EuroCoppice: Members

IUFRO Unit 1.03.01 – Traditional coppice: ecology, silviculture and socio-economic aspects

COST Action FP1301 EuroCoppice: Activities

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"), was active for four years, from October 2013 to October 2017. It was chaired and managed by the Albert Ludwig University of Freiburg and brought together international scientists, experts and young scholars to exchange and build on knowledge concerning coppice forests, form an international network on the subject, create awareness for and support capacity building on coppice and influence policy.

The Action was divided into five Working Groups that discussed ideas and deepened knowledge on particular topics concerning coppice, with each producing numerable reports throughout the Action duration. Each Working Group was represented in the Steering Group, which was responsible for the strategic planning, harmonisation of content and outputs, as well as guiding the implementation of the Action. The governing body of the Action, the Management Committee, comprised of one or two representatives from each of the 32 COST Member Countries, as well as Observers from two Near Neighbour Countries (NNC) and one International Partner Country (IPC).

EuroCoppice utilised the various COST formats to reach the aims of the Action. Multiple international Action Conferences were organised, with many of the presentations and posters later made publicly available on the website. Action Meetings were a valuable tool for discussing the specific content and publication of reports, as well as upcoming events. Two activities, Short Term Scientific Missions (STSM) and Training Schools (TS), were especially aimed at engaging and supporting young researchers. All Action Members were also involved in numerous additional Dissemination Activities, mainly in the form of publications and presentations.

The following tables summarise the framework of and main activities conducted by COST Action FP1301 EuroCoppice.

Countries involved

AL	Albania	EL	Greece	RO	Romania
AT	Austria	HU	Hungary	RS	Serbia
BE	Belgium	IE	Ireland	SK	Slovakia
BA	Bosnia & Herzegovina	IL	Isreal	SI	Slovenia
BG	Bulgaria	IT	Italy	ZA	South Africa
HR	Croatia	LV	Latvia	ES	Spain
CZ	Czech Republic	LT	Lithuania	SE	Sweden
DK	Denmark	MK	fYR Macedonia	CH	Switzerland
EE	Estonia	NL	Netherlands	TR	Turkey
FI	Finland	NO	Norway	UA	Ukraine
FR	France	PL	Poland	UK	United Kingdom
DE	Germany	PT	Portugal		

Working Groups (WGs)

Nr	Name	Leader	Vice-Leader
WG1	Definitions, History and Typology	Dagnija Lazdina	Pieter D. Kofman
WG2	Ecology and silvicultural management	Valeriu-Norocel Nicolescu	Halil Barýþ Özel
WG3	Utilization and products	Natascia Magagnotti	Janine Schweier
WG4	Services, protection and nature conservation	Peter Buckley	Florian Borlea
WG5	Ownership and governance	Debbie Bartlett	na.

Steering Group

Name	Role in the Action	Country	Organisation
Gero Becker	Chair	Germany	Albert Ludwig University of Freiburg
Raffaele Spinelli	Vice-Chair	Italy	CNR IVALSA
Alicia Unrau	Manager	Germany	Albert Ludwig University of Freiburg
Dagnija Lazdina	WG1 Leader	Latvia	Latvian State Forest Research Institute
Valeriu-Norocel Nicolescu	WG2 Leader	Romania	Transilvania University of Brasov
Natascia Magagnotti	WG3 Leader	Italy	CNR IVALSA
Peter Buckley	WG4 Leader	United Kingdom	Consultant
Debbie Bartlett	WG5 Leader	United Kingdom	University of Greenwich
Karl Stampfer	TS Coordinator	Austria	BOKU
Pieter D. Kofman	STSM Coordinator	Denmark	Danish Forestry Extension

Conferences

Title	Place	Date
Innovative management and multifunctional utilization of traditional coppice forests	Florence, Italy	Feb 26, 2014
People and coppice	Chatham, UK	Nov 5, 2014
Ecology and silvicultural management of coppice forests in Europe	Bucharest, Romania	Oct 19 - 21, 2015
Ecosystem services, protection and nature conservation	Antwerp, Belgium	June 15 - 17, 2016
Coppice forests in Europe: a traditional natural resource with great potential	Limoges, France	June 19 - 21, 2017

Training Schools (TSs)

Title	Place	Date
Silviculture of Coppice Beech Forests	Bosnia and Herzegovina	July 2014
Coppice Harvesting and Use of Products as a Source of Renewable Energy	Italy	May 2015
Coppice Economy - From Planning to Harvest	Czech Republic	April 2016
Coppice Management, Biodiversity and Services	Germany	July 2016
Establishment and tending of SRC	Latvia	March 2017

Short Term Scientific Missions (STSMs)

Guest Name	Host Institute	Guest Country	Host Country	Start Date	Title
Janine Schweier	CNR IVALSA	DE	IT	10/01/14	Harvesting of hardwoods with new machines
Antonio Scarfone	SLU	IT	SE	11/04/14	Monitoring systems in stored wood chip piles and energetic characterization of willow SRC
Debbie Bartlett	CNR IVALSA	UK	IT	02/06/14	Socio-economic structure in the chestnut coppice industry
David Rossney	CNR IVALSA	UK	IT	02/06/14	Knowledge Transfer in the Chestnut Coppice Industry - A Comparison of the Situation in Southeast England with Regions in Italy
Giorgos Mallinis	University of Sassari	GR	IT	02/07/14	Assessing differences in fire hazard over Mediterranean coppice and high forests
Murat Ertekin	University of Freiburg	TR	DE	21/07/14	Climatic change and silvicultural effects on the coppice forests of the Southern Black Forest
Cornelia Hernea	SLU	RO	SE	04/09/14	Management and implications of Short Rotation Coppice
Walter Mattioli	University of Sarajevo	IT	BA	14/09/14	Forest inventory concerning Bosnian old beech coppice in evolution to old-growth forest
Vladimir Corbic	University of Florence	CZ	IT	28/09/14	Surface fuel loads and biomass potential in coppice forests
Clara Valente	Politecnido di Torino	NO	IT	29/09/14	Sustainability assessment of chestnut and invaded coppice forests in Piedmont region
Giavanna Ottoviani	CNR IVALSA	NO	IT	26/10/14	Human factors in small scale forestry, the ergonomic advantage of using a new equipment for winching
Carolina Lombardini	University of Freiburg	IT	DE	11/11/14	Coppice Glossary and harvesting cost estimate for SRC
Srdjan Pejovic	University of Freiburg	RS	DE	15/01/15	The morphology, growth pattern and stem quality of multi-stemmed beech (*Fagus sylvatica*) trees in coppice forests
Milan Gazdic	University of Freiburg	RS	DE	15/01/15	Resilience of oak (*Querqus petraea*) coppice forests to drought
Kristaps Makovskis	MENDELU	LV	CZ	08/04/15	Technical operation of the glossary, terminology and overview of legal frame of coppice forests
Marko Stojanovic	GOZDIS	CZ	SI	25/05/15	Dendroecological study of sessile oak (*Quercus petraea* (M.) Liebl.) growth
Andrea Laschi	USC	IT	ES	01/07/15	Environmental impacts and energy balances in coppices: LCA on processes and products
Natascia Magagnotti	NMMU	IT	SA	01/07/15	Mechanised harvesting in coppiced *Eucalyptus* plantations
Martin Sramek	BAS	CZ	BG	05/07/15	The effect of coppice management on the tree growth
Vittorio Pasquino	NTNU	IT	EL	05/10/15	Hydraulic flow resistance and elastic behaviour of coppice in river beds
Matthew Everatt	UniFI	UK	IT	18/10/15	Evaluation of the potential of control options used in Italy for the management of the oriental chestnut gall wasp (*Dryocosmus kuriphilus*) in the UK
Stefan Vanbeveren	CNR IVALSA	BE	IT	08/11/15	The mechanised harvesting of short-rotation coppices
Zbigniew Karaszewski	AUT	PL	EL	09/11/15	Recognition of coppice wood quality
Abel Rodrigues	CNR IVALSA	ES	IT	25/01/16	Evaluation of Management techniques for Short Rotation Coppice (SRC) aimed at biomass production

Srdjan Keren	UAK	BA	PL	01/03/16	Case study from Bosnia and Herzegovina: Ecology and productivity of European beech coppice stands
Julija Konstantinaviciene	LSFRI	LT	LV	07/03/16	Harvesting and management of different clones of short rotation coppice in Latvia
Silva Senhofa	IGN	LV	DK	17/04/16	Growth of fast-growing coppice species in two environmental conditions at juvenile age
Ivailo Markoff	FH Erfurt	BG	DE	18/04/16	Short rotation coppices and traditional coppices in Germany
Abhishek Mani Tripathi	UNI Antwerp	CZ	BE	31/05/16	Assessment of leaf area index and gas exchange in short rotation coppice poplar cultures
Petros Tsioras	ITD	EL	PL	22/08/16	Mechanized harvesting of aged traditional coppice stands
Arta Bardule	MASARYK	LV	CZ	16/10/16	Impact of fertilization on trace element content in Hybrid aspen coppice tree rings
Lauma Busa	MASARYK	LV	CZ	16/10/16	Phytoremediation potential of different Poplar clone coppice plantation
Gianni Picchi	CTFC	IT	ES	16/11/16	An analysis of forest companies in the Catalonian Region: level of specialization and share of coppice forest in annual turnover
Eulalia Gomez-Martin	BCCC	UK	ES	08/01/17	Assessing the feasibility of Agent Based Modelling to investigate the impact of governance interventions on the development of the coppice industry
Jordi Garcia Gonzalo	ISA	ES	PT	22/01/17	Optimizing coppice management under climate change
Pere Navarro i Maroto	CNR IVALSA	ES	IT	22/01/17	An analysis of cable yarding in Toscana Region: effective production and work conditions
Ivan Sopushynskyy	POZNAN	UA	PL	26/02/17	Productivity and costs of harvester and chainsaw operations in alder coppice stand in Poland and Ukraine
Angela Blazquez	UEF	ES	FI	15/03/17	Modelling methodologies focussed on different machine learning using Rstudio for stand classification and productivity
Abhishek Mani Tripathi	SILAVA	CZ	LV	18/03/17	Measurement of tree height using lidar and gas fluxes by chamber methods
Giovanni Aminti	UPM	IT	ES	19/03/17	Study performance of a new coppice harvesting system
Ivaylo Tsvetkov	PLECO	BU	BE	02/04/17	Improving skills for ecophysiological and meteorological research applicable to poplar SRC
Abel Rodrigues	AU	PT	DK	03/04/17	A technical evaluation, through methodologies in field and laboratory, of poplar and willow SRCs biomass concerning its lifecycle, from production to thermal conversion

Peer-reviewed publications: co-authored by Action Members from two or more countries and acknowledging EuroCoppice

Jylhä P. & Bergström D. (2016): *Productivity of harvesting dense birch stands for bioenergy*, Biomass and Bioenergy, Volume 88, p 142-151. http://dx.doi.org/10.1016/j.bi

Magagnotti, N., Ottaviani Aalmo, G., Brown, M. & Spinelli, R. (2015): *A new device for reducing winching cost and worker effort in steep terrain operations*, Scandinavian Journal of Forest Research, 31:6, 602-610. http://dx.doi.org/10.1080/0282

Mairota, P., Buckley, P., Suchomel, C., Heinsoo, K., Verheyen, K., Hédl, R., Terzuolo, P.G., Sindaco, R., & Carpanelli, A. (2016): *Integrating conservation objectives into forest management: coppice management and forest habitats in Natura 2000 sites*. iForest, Vol. 9, pp. 560-568. 10.3832/ifor1867-009

Marchi E., Picchio R., Mederski P.S., Vusić D., Perugini M. & Venanzi R. (2016): *Impact of silvicultural treatment and forest operation on soil and regeneration in Mediterranean Turkey oak (Quercus cerris L.) coppice with standards*. Ecological Engineering, Volume 95, Pages 475-484. https://doi.org/10.1016/j.ecol

McEwan A., Magagnotti N. & Spinelli R. (2016): *The effects of number of stems per stool on cutting productivity in coppiced Eucalyptus plantations*. Silva Fennica vol. 50 no. 2 article id 1448. http://dx.doi.org/10.14214/sf.

Rodrigues, A., Vanbeveren, S., Costa, M. & Ceulemans, R. (2017): *Relationship between soil chemical composition and potential fuel quality of biomass from poplar short rotation coppices in Portugal and Belgium*. Biomass and Bioenergy, Vol 105, pp 66-72. https://doi.org/10.1016/j.biom

Schweier J, Spinelli R, Magagnotti N. & Becker G. (2015): *Mechanized coppice harvesting with new small-scale feller-bunchers: Results from harvesting trials with newly manufactured felling heads in Italy*. Biomass and Bioenergy (72): 85-94. https://doi.org/10.1016/j.biom

Spinelli, R., Cacot, E., Mihelic, M., Nestorovski, L., Mederski, P. & Tolosana, E. (2016): *Techniques and productivity of coppice harvesting operations in Europe: a metaanalysis of available data*. Annals of Forest Science. 73(4): 1125–1139. doi:10.1007/s13595-016-0578-x

Spinelli, R., Magagnotti, N. & Schweier, J. (2017): *Trends and perspectives in coppice harvesting*. Croatian Journal of Forest Engineering. 38. 219-230.

Tolosana, E., Spinelli, R., Aminti, G., Laina, R. & López-Vicens, I. (2018): *Productivity, Efficiency and Environmental Effects of Whole-Tree Harvesting in Spanish Coppice Stands Using a Drive-to-Tree Disc Saw Feller-Buncher*. Croatian Journal of Forest Engineering. 39. 163-172.

Vanbeveren, S. P. P., Magagnotti, N., & Spinelli, R. (2017): *Increasing the value recovery from short-rotation coppice harvesting*. BioRes. 12(1), 696-703. 10.15376/biores.12.1.696-703

Vanbeveren, S. P. P., Schweier, J., Berhongaray, G. & Ceulemans, R. (2015): *Operational short rotation woody crop plantations: Manual or mechanised harvesting?*. Biomass and Bioenergy, 72, 8-18. https://doi.org/10.1016/j.biom

Vanbeveren, S., Spinelli, R., Eisenbies, M., Schweier, J., Mola-Yudego, B., Magagnotti, N., Acuna, M., Dimitriou, I. & Ceulemans, R. (2017): *Mechanised harvesting of short-rotation coppices*. Renewable and Sustainable Energy Reviews, Vol 76, pages 90-104. https://doi.org/10.1016/j.rser

COST Action FP1301 EuroCoppice: Members

Name	Country	Organisation	WG	Email
Pierre A Ackerman	ZA	Stellenbosch University	3	packer@sun.ac.za
Karin Aguraijuja	EE	Estonian University of Life Sciences	3	karin.aguraijuja@emu.ee
Amaia Albizua	ES	Basque Centre for Climate Change (BC3)	5	amaiabc3@gmail.com
Marius Aleinikovas	LT	Lithuanian Research Centre for Agriculture & Forestry	3	marius.aleinikovas@mi.lt
Jürgen Aosaar	EE	Estonian University of Life Sciences	2	jyrgen.aosaar@emu.ee
Henrik Bach	DK	Ny Vraa Bioenergy I/S	3	henrik@nyvraa.dk
Alain Bailly	FR	Technology Institute FCBA		alain.bailly@fcba.fr
Besim Balić	BA	University of Sarajevo	2	balicbesim@yahoo.com
Anna Barbati	IT	Tuscia University	2	barbati.sisfor@unitus.it
Damir Barčić	HR	University of Zagreb	2	damir.barcic@zg.htnet.hr
Andis Bārdulis	LV	Latvia State Forest Research Institute	2	andis.bardulis@silava.lv
Debbie Bartlett	UK	University of Greenwich	5	d.bartlett@gre.ac.uk
Gero Becker	DE	Albert Ludwig University of Freiburg	3	gero.becker@fob.uni-freiburg.de
Mariusz Bembenek	PL	Poznan University of Life Sciences	3	mariusz.bembenek@up.poznan.pl
Lina Beniušienė	LT	Miškų institutas		lbenius@gmail.com
Dan Bergström	SE	Swedish University of Agricultural Sciences	2	dan.bergstrom@slu.se
Gheorghe F Borlea	RO	Banat University of Agriculture and Veterinary Medicine „King Michael I of Romania“ from Timisoara	4	fborlea@yahoo.com
Svetla Bratanova-Doncheva	BG	Bulgarian Academy of Sciences	4	sbrat@abv.bg
Viktor J Bruckman	AT	Austrian Academy of Sciences	2	viktor.bruckman@oeaw.ac.at
Peter Buckley	UK		4	peterbuckleyassociates@gmail.com
João Carvalho	PT	University Tras-os-Montes Alto Douro (UTAD) / Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB)	2	jpfc@utad.pt
Sinilga Černulienė	LT	Kaunas Forestry and Environmental Engineering College	2	s.cernuliene@kmaik.lm.lt
Reinhart Ceulemans	BE	University of Antwerp	3	reinhart.ceulemans@uantwerp.be
Enda Coates	IE	Waterford Institute of Technology	1	ecoates@wit.ie
H Oguz Çoban	TR	Süleyman Demirel University	3	oguzcoban@sdu.edu.tr
Marco Conedera	CH	Swiss Federal Research Institute WSL	1	marco.conedera@wsl.ch
Mário Costa	PT	Universidade de Lisboa	3	mcosta@ist.utl.pt
Imre Czupy	HU	University of Sopron	3	czupy.imre@uni-sopron.hu
Luc De Keersmaeker	BE	Research Institute for Nature and Forest (INBO)	4	luc.dekeersmaeker@inbo.be
Ger Devlin	IE	University College Dublin (UCD)	3	gerjdevlin@gmail.com
Abdulla Diku	AL	Diava Consulting shk	3	adiku@hotmail.com
Ioannis Dimitriou	SE	Swedish University of Agricultural Sciences	2	ioannis.dimitriou@slu.se
Martina Đodan	HR	Croatian Forest Research Institute	2	martinat@sumins.hr
Yonko Dodev	BG	Forest Research Institute - BAS		ionkododev@abv.bg
Achim Dohrenbusch	DE	Georg-August University of Göttingen	2	adohren@gwdg.de
Tomislav Dubravac	HR	Croatian Forest Research Institute	2	tomod@sumins.hr

Pavlos Efthymiou	EL	University of Thessaloniki		pnefthy@for.auth.gr
Mehmet Eker	TR	Süleyman Demirel University	3	mehmeteker@sdu.edu.tr
Murat Ertekin	TR	Necmettin Erbakan University	2	muratertekin@hotmail.com
Alexander Fehér	SK	Slovak University of Agriculture	4	alexander.feher@uniag.sk
Norbert Frank	HU	University of Sopron	2	frank.norbert@uni-sopron.hu
Christos Gallis	EL	Forest Research Institute, NAGREF		cgalis@fri.gr
Martyna Gierszewska	PL	Poznan University of Life Scienes	2	martynakaszuby@wp.pl
Tomo Gjorgjevski	MK		1	junpmtomo@yahoo.com
Sotir Glushkov	BG	Forest Research Institute - BAS	3	sotirgluschkov@abv.bg
Cori Ham	ZA	Stellenbosch University	3	cori@sun.ac.za
Radim Hédl	CZ	Czech Academy of Sciences	4	radim.hedl@ibot.cas.cz
Katrin Heinsoo	EE	Estonian University of Life Sciences	4	katrin.heinsoo@emu.ee
Cornelia Hernea	RO	Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara	2	corneliahernea@yahoo.com
Eduard Hochbichler	AT	University of Natural Resources and Life Sciences (BOKU)	2	eduard.hochbichler@boku.ac.at
Jyrki Hytönen	FI	Natural Resources Institute Finland (Luke)	2	jyrki.hytonen@luke.fi
Indrek Jakobson	EE	Estonian Private Forest Centre	5	indrek.jakobson@eramets.ee
Patrick Jansen	NL	Bosmeester	2	patrick@bosmeester.com
Rob Jarman	UK	University of Gloucestershire	1	robinajarman@gmail.com
Paula Jylhä	FI	Natural Resources Institute Finland (Luke)	2	paula.jylha@luke.fi
Zbigniew Karaszewski	PL	Wood Technology Institute	3	z_karaszewski@itd.poznan.pl
Selman Karayilmazlar	TR	Bartın University	2	selmankzku@yahoo.com
Tom Kent	IE	Waterford Institute of Technology		tkent@wit.ie
Jürgen Kern	DE	Leibniz Institute for Agricultural Engineering (ATB)	2	jkern@atb-potsdam.de
Karin Kikamagi	EE	Estonian Private Forest Centre	3	karin.kikamagi@eramets.ee
Radomír Klvač	CZ	Medel University	1	klvac@mendelu.cz
Pieter D Kofman	DK	Danish Forestry Extension	1	pdkofman@gmail.com
Lýdia Končeková	SK	Slovak University of Agriculture	2	koncekoval@gmail.com
Julija Konstantinavičienė	LT	Lithuanian Research Centre for Agriculture and Forestry	5	julija.konstant@gmail.com
Nike Krajnc	SI	Slovenian Forestry Institute	3	nike.krajnc@gozdis.si
Patrik Krebs	CH	Swiss Federal Institute for Forest	5	patrik.krebs@wsl.ch
Milun Krstić	RS	University of Belgrade	2	milun.krstic@sfb.bg.ac.rs
Martin Kühmaier	AT	University of Natural Resources and Life Sciences (BOKU)	1	martin.kuehmaier@boku.ac.at
Rubén Laina	ES	Technical University of Madrid	5	ruben.laina@upm.es
Juha Laitila	FI	Finnish Forest Research Institute (METLA)	3	juha.laitila@metla.fi
Dagnija Lazdiņa	LV	Latvian State Forest Research Institute "Silava"	1	dagnija.lazdina@silava.lv
Arvo Leinonen	FI	Technical Research Centre of Finland (VTT)	3	arvo.leinonen@vtt.fi
Krzysztof Leszczyński	PL	University of Agriculture in Krakow		rlleszcz@cyf-kr.edu.pl
Manfred Lexer	AT	University of Natural Resources and Life Sciences (BOKU)	2	mj.lexer@boku.ac.at
Keith M Little	ZA	Nelson Mandela University	2	keith.little@mandela.ac.za

Magnus Löf	SE	Swedish University of Agricultural Sciences	2	magnus.lof@slu.se
Natascia Magagnotti	IT	CNR IVALSA	3	magagnotti@ivalsa.cnr.it
Paola Mairota	IT	University of Bari "Aldo Moro"	4	paola.mairota@uniba.it
Kristaps Makovskis	LV	Latvian State Forest Research Institute "Silava"	1	kristaps.makovskis@silava.lv
Frantisek Malis	SK	Technical University in Zvolen	2	malis@tuzvo.sk
Giorgos Mallinis	EL	Democritus University of Thrace (DUTH)	4	gmallin@fmenr.duth.gr
Enrico Marchi	IT	University of Florence	1	enrico.marchi@unifi.it
Ivailo Markoff	BG	Bulgarian Academy of Sciences	1	imarkoff@abv.bg
Iryna Matsiakh	UA	Ukrainian National Forestry University	2	iramatsah@ukr.net
Andrew McEwan	ZA	Nelson Mandela University	3	andrew.mcewan@nmmu.ac.za
Piotr Mederski	PL	Poznan University of Life Sciences	3	piotr.mederski@up.poznan.pl
Matevž Mihelič	SI	University of Ljubljana	3	matevz.mihelic@bf.uni-lj.si
Stjepan Mikac	HR	University of Zagreb		smikac@sumfak.hr
Vasillaq Mine	AL	Agricultural University of Tirana	3	vmine@ubt.edu.al
Ioannis Mitsopoulos	EL	Ministry of Environment & Energy	4	i.mitsopoulos@prv.ypeka.gr
Blas Mola	SE	Swedish University of Agricultural Sciences	2	blas.mola@slu.se
Jana Müllerová	CZ	Academy of Sciences of the Czech Republic	4	jana.mullerova@ibot.cas.cz
Francesco Neri	IT	University of Florence	2	francesco.neri@unifi.it
Ljupco Nestorovski	MK	Ss. Cyril and Methodius University of Skopje	3	nestorovski@sf.ukim.edu.mk
Valeriu-Norocel Nicolescu	RO	Transilvania University of Brasov	2	nvnicolescu@unitbv.ro
Sylvestre Njakoudjomo	BE	University of Antwerp	5	
Tomas Nordfjell	SE	Swedish University of Agricultural Sciences	3	tomas.nordfjell@slu.se
Kateřina Novotná	CZ	Silva Tarouca Research Institute for Landscape and Ornamental Gardening	2	novotna@vukoz.cz
Juha Nurmi	FI	Natural Resources Institute Finland (Luke)	3	juha.nurmi@metla.fi
Pavol Otepka	SK	Slovak University of Agriculture	3	pavol.otepka@uniag.sk
Giovanna Ottaviani Aalmo	NO	Norwegian Institute of Bioeconomy Research	3	gio@nibio.no
Halil Bariş Özel	TR	University of Bartın	2	halilbarisozel@yahoo.com
Victor Dan Pacurar	RO	Transilvania University of Brasov	4	vdpacurar@unitbv.ro
Thomas Papachristou	EL	Hellenic Agricultural Organization	3	thomas.papachristou@fri.gr
Marko Perović	RS	University of Belgrade	2	marko.perovic@sfb.bg.ac.rs
Nenad Petrović	RS	University of Belgrade	5	nenad.petrovic@sfb.bg.ac.rs
Rodolfo Picchio	IT	University of Tuscia	4	r.picchio@unitus.it
Míriam Piqué	ES	Forest Science and Technology Centre of Catalonia (CTFC)	2	miriam.pique@ctfc.es
Mitja Piskur	SI	Slovenian Forestry Institute	3	mitja.piskur@gozdis.si
Anton Poje	SI	University of Ljubljana	3	anton.poje@bf.uni-lj.si
Patrick Pyttel	DE	Albert Ludwig University of Freiburg	2	patrick.pyttel@waldbau.uni-freiburg.de
Orna Reisman-Berman	IL	Ben-Gurion University	2	oreisman@bgu.ac.il
Abel Rodrigues	PT	INRB, IP	2	abel.rodrigues@iniav.pt

David Rossney	UK	Esus Forestry & Woodlands	3	esusforestry@btinternet.com
Philippe Ruch	FR	Technology Institute FCBA	3	philippe.ruch@fcba.fr
Liana Sadauskiene	LT		3	lsadauskiene@gmail.com
Patrick Schleppi	CH	Swiss Federal Institute for Forest	2	patrick.schleppi@wsl.ch
Uwe Schmidt	DE	Albert Ludwigs-University of Freiburg	1	uwe.e.schmidt@ifp.uni-freiburg.de
Janine Schweier	DE	Albert Ludwig University of Freiburg	3	janine.schweier@foresteng.uni-freiburg.de
Ian Short	IE	Teagasc	2	ian.short@teagasc.ie
Diana Simon	RO	Romsilva	2	simon.diana91@gmail.com
Ivan Sopushynskyy	UA	Ukrainian National Forestry University	3	sopushynskyy@nltu.edu.ua
Giulio Sperandio	IT	Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA)	5	giulio.sperandio@crea.gov.it
Raffaele Spinelli	IT	CNR IVALSA	3	spinelli@ivalsa.cnr.it
Karl Stampfer	AT	University of Natural Resources and Life Sciences (BOKU)	3	karl.stampfer@boku.ac.at
Petra Štochlová	CZ	Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Publ. Res. Inst.	2	stochlova@vukoz.cz
Kjell Suadicani	DK	University of Copenhagen	3	manne.suadicani@gmail.com
Christian Suchomel	DE	Albert Ludwig University of Freiburg	4	christian.suchomel@landespflege-freiburg.de
Bruce Talbot	NO	Norwegian Forest and Landscape Institute	3	bta@nibio.no
Eduardo Tolosana	ES	Technical University of Madrid	3	eduardo.tolosana@upm.es
Elvin Toromani	AL	Agricultural University of Tirana	2	etoromani@ubt.edu.al
Pande Trajkov	MK	Ss. Cyril and Methodius University of Skopje	2	ptrajkov@sf.ukim.edu.mk
Petros Tsioras	EL	Aristotle University of Thessaloniki (AUTH)	3	ptsioras@for.auth.gr
Ivaylo Tsvetkov	BG	Forest Research Institute	2	tsvet_i@yahoo.com
Alicia Unrau	DE	Albert Ludwig University of Freiburg	5	eurocoppice@fob.uni-freiburg.de
Stefan PP Vanbeveren	BE	University of Antwerp	3	stefan.vanbeveren@uantwerp.be
Kris Vandekerkhove	BE	Research Institute for Nature and Forest (INBO)	2	kris.vandekerkhove@inbo.be
Mats Varik	EE	Estonian University of Life Sciences	2	mats.varik@emu.ee
Kris Verheyen	BE	Ghent University	4	kris.verheyen@ugent.be
Pau Vericat	ES	Forest Science and Technology Centre of Catalonia (CTFC)	2	pau.vericat@ctfc.es
Helder Viana	PT	Polytechnic Institute of Viseu / Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB)	2	viana.h@gmail.com
Ćemal Višnjić	BA	University of Sarajevo	2	c.visnjic@sfsa.unsa.ba
Sead Vojniković	BA	University of Sarajevo	2	s.vojnikovic@sfsa.unsa.ba
Morgan Vuillermoz	FR	Technology Institute FCBA	3	morgan.vuillermoz@fcba.fr
Dinko Vusić	HR	University of Zagreb	3	vusic@sumfak.hr
Martin Weih	SE	Swedish University of Agricultural Sciences	3	martin.weih@slu.se
Axel Weinreich	DE	UNIQUE forestry and land use GmbH	2	axel.weinreich@unique-landuse.de
Terenzio Zenone	BE	University of Antwerp	2	terenzio.zenone@uantwerpen.be
Marko Zoric	HR	University of Zagreb	3	mzoric@sumfak.hr
Miljenko Županić	HR	Croatian Forest Research Institute	5	zupanicm@sumins.hr

IUFRO Unit 1.03.01 on Traditional Coppice

Unit 1.03.01 "Traditional Coppice: ecology, silviculture and socio-economic aspects" of the International Union of Forest Research Organizations (IUFRO) was founded as a direct result of COST Action FP1301 EuroCoppice and will ensure that international scientific efforts on traditional coppice will continue to have a platform for exchange and cooperation. The Unit was officially established in October 2016; information is available on the IUFRO website under: https://www.iufro.org/science/divisions/division-1/10000/10300/10301/

Broadening the European focus of the COST Action, this Unit is world-wide in scope and welcomes researchers from all areas of the globe working on traditional coppice.

If you are interested in joining the Unit please contact the Coordinator:
Norocel-Valeriu Nicolescu - nvnicolescu@unitbv.ro
https://www.iufro.org/who-is-who/officeholder/nicolescu/

Unit Description

The principle of coppicing is the ability of many woody plants (trees and shrubs) to regrow from cut or damaged stems or roots. Since prehistoric times, man has taken advantage of this characteristic to utilise woodlands and their products. In many regions, different and elaborate forms of coppice management have evolved over centuries, designed to produce specific resources from coppice systems of selected species cut on strict rotation cycles.

This Unit addresses all aspects related to this specific management of coppice, including ecology, silviculture, management, utilisation, landscape, ecosystem services, supply chain development, greening traditional value chains and further socio-economic issues. It aims to identify common principles and analyse specific regional differences of coppice regimes and to derive strategies for the future sustainable management of this type of forest.

There is a separate IUFRO Unit for industrial short rotation coppice plantations (1.03.00 Short-rotation forestry), with which cooperation has been established.

Scientific Session at IUFRO 125th Anniversary Congress

The Unit's first event, co-organised my EuroCoppice, was Session 82 a and b "Traditional Coppice: Ecology, Silviculture and Socio-economic Aspects" at the IUFRO 125th Anniversary Congress, held in Freiburg, Germany from September 18th to 22nd, 2017 (www.iufro2017.com). There were 13 presentations in total, 10 of which were by EuroCoppice members, while three of five posters were also presented by EuroCoppice members. Over 60 persons attended the Traditional Coppice Session and EuroCoppice dissemination material was available to the 2000 researchers attending the Congress.

http://www.eurocoppice.uni-freiburg.de/publications-folder/conferences/iufro-2017

Albania
Austria
Belgium
Bosnia & Herzegovina
Bulgaria
Croatia
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Israel
Italy
Latvia
Lithuania
fYR Macedonia
Netherlands
Norway
Poland
Portugal
Romania
Serbia
Slovakia
Slovenia
South Africa
Spain
Sweden
Switzerland
Turkey
Ukraine
United Kingdom

Coppice Forests in Europe - An Edited Collection

Over 100 experts, researchers and practitioners from **35 European and partner countries** came together to produce this volume on coppice forests and their management. A broad range of topics are addressed in **eight chapters**: (1) Overview, (2) Silviculture, (3) Utilisation, (4) Conservation, (5) Governance, reports on (6) 35 Countries, (7) Outlook and (8) Annex.

This publication is the last of a variety of activities carried out by **COST Action FP1301 EuroCoppice** (2013 - 2017), from awareness raising for coppice issues, to supporting the careers of young researchers.

A digital version of this edited collection, along with details on the outputs and events of FP1301 EuroCoppice, can be found on this website: www.eurocoppice.uni-freiburg.de

Contact
eurocoppice@fob.uni-freiburg.de

Become involved - global network IUFRO
Coppice topics will be explored further in the global organisation for forest research IUFRO (www.iufro.org) - interested parties are very welcome to participate.
Unit 1.03.01 "Traditional coppice: ecology, silviculture and socio-economic aspects"
Coordinator: Valeriu-Norocel Nicolescu, nvnicolescu@unitbv.ro