COST Action FP1301 EuroCoppice

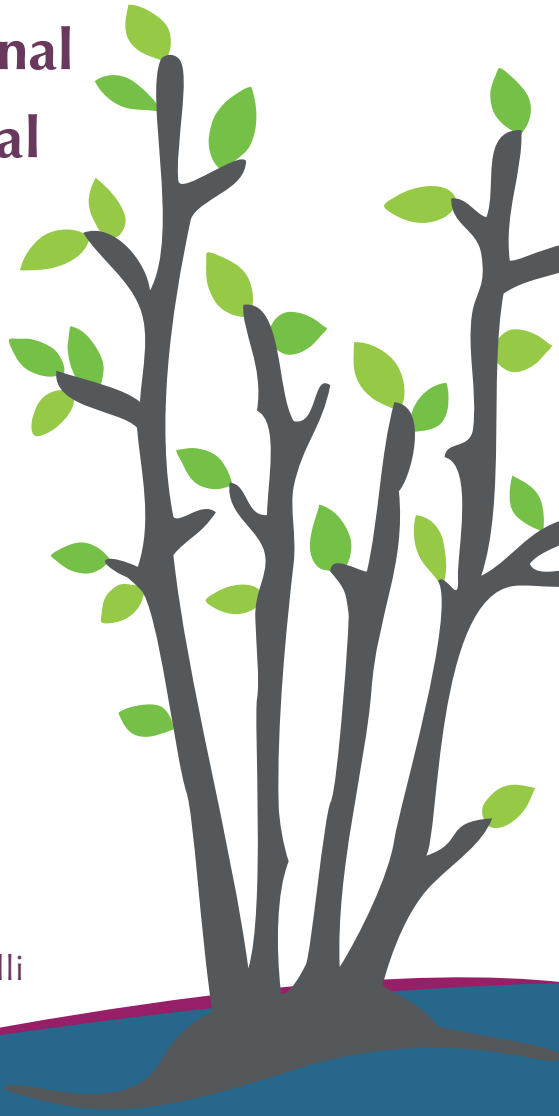
Innovative management and multifunctional utilisation of traditional coppice forests – an answer to future ecological, economic and social challenges in the European forestry sector

Coppice forests in Europe: a traditional natural resource with great potential

EuroCoppice Final Conference
19th - 21st June, 2017
Limoges, France

FCBA INSTITUT TECHNOLOGIQUE

Programme, Logistics & Abstracts



Editor Alicia Unrau

Scientific Committee Gero Becker, Emmanuel Cacot, Natascia Magagnotti, Raffaele Spinelli and Eduardo Tolosana

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COST is supported by the EU Framework Programme Horizon 2020

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Published by:
Albert Ludwig University Freiburg
Gero Becker, Chair of Forest Utilization
Werthmannstr. 6
79085 Freiburg
Germany

Printed by:
Albert Ludwig University Freiburg Printing Press

Year of publication: 2017

Editor: Alicia Unrau (DE)

Scientific Committee: Gero Becker (DE), Emmanuel Cacot (FR), Natascia Magagnotti (IT), Raffaele Spinelli (IT) and Eduardo Tolosana (ES)

Local Organisers: Emmanuel Cacot, Marin Chaumet, Laure Couvidat, Vincent Morillon, Philippe Ruch and Morgan Vuillermoz (FR)

Reference as: Unrau, A. (Ed.) (2017). *Coppice forests in Europe: a traditional natural resource with great potential. EuroCoppice Final Conference. Programme, Logistics and Abstracts. COST Action FP1301 Reports*. Freiburg, Germany: Albert Ludwig University of Freiburg.

Design & layout: Alicia Unrau

Cover acknowledgements: Simple coppice (grey) based on a drawing by João Carvalho;
Leaf vectors originals designed by www.freepik.com (modified)

Foreword

Coppicing is a very old and traditional form of sustainable forest management that can provide an array of products and services for households, industry and society. As a result of changing societal needs and the development of new technologies, coppicing became somewhat outdated in forest science and practice in many regions over the past century. Recently, however, there has been a renewed interest in coppice forests and coppice management. In the context of climate change policy, for example, coppicing can be an attractive way to sustainably produce a large amount of biomass in short time and at limited cost, as well as a resource base for the new bio-economy. Another area of interest is nature conservation and biodiversity, where coppice forests serve a protective function and provide a unique habitat for a variety of flora and fauna.

COST Action FP1301 EuroCoppice will end on October 15th 2017 after four years of intensive activities of scientific exchange, networking, dissemination and policy recommendations. Over 150 scientists and experts from 35 countries continuously contributed their knowledge and spirit to make EuroCoppice a collective success. While the first years of the Action were occupied by a detailed exploration of the current situation, the second step has been to raise awareness for coppice and providing recommendations to practitioners, experts and politicians regarding the future management of coppice forests throughout Europe and neighbouring countries.

This Conference "Coppice forests in Europe: a traditional natural resource with great potential", held in Limoges (France) from the 19th to 21st of June 2017, is the last major event in a series of activities organised by EuroCoppice since 2014, which have been hosted in numerous European countries. Located in the heartland of a traditional coppice forestry area of France, it begins with a full day excursion, where various aspects of coppice forestry management are presented and discussed with practitioners. The morning sessions of the subsequent scientific conference day have their focus on harvesting and utilisation of coppice forests, while the afternoon session widens the perspective to more general aspects of coppice forest management. These sessions are followed by a presentation on the results of EuroCoppice and a panel discussion with representatives of important target groups and stakeholders, which will contribute to the dissemination of major findings and conclusions to policy makers and a broader audience.

Foreword cont.

As Chair, Vice Chair and Manager of COST Action FP 1301 EuroCoppice, we would like to express our warmest thanks to our French colleagues, namely the scientists and staff of the FCBA who have organised this conference. We also appreciate all the effort that was invested by the members of our scientific committee in selecting contributions and compiling the program. Our sincere thanks is extended to the scientists who offered to share their knowledge and experience in many excellent presentations and posters. Last but not least, we are extremely grateful to the panellists for kindly agreeing to discuss our findings and share their specific view on coppice related issues.

Finally, we would like to express our gratitude to the COST Association and its staff for both the financial and organisational support that have made all the EuroCoppice activities and achievements possible. Additional support has kindly been provided by the Eva Mayr-Stihl Stiftung, for which we are also very grateful.

We wish all participants of the Conference a successful and insightful event!

With best regards,

Gero Becker	Raffaele Spinelli	Alicia Unrau
Chair	Vice-Chair	Manager

COST Action FP1301 EuroCoppice

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Programme & Map

Monday, June 19th, 2017: Action-Internal Meetings & Icebreaker

Conseil Régional Nouvelle Aquitaine (Regional Council of New Aquitaine)

27 boulevard de la Corderie – 87000 LIMOGES

Registration is open from 12:00 – 17:00

10:00 – 12:00	Steering Group Meeting (for SG members only)
13:00 – 13:30	Welcome and Introduction (for all Action members)
13:30 – 16:30	Working Group Meetings (for all Action members)
16:30 – 17:00	Coffee Break
17:00 – 18:00	Management Committee Meeting (for MC Members only)
19:30	Ice Breaker @ Bistrot Gourmand
	5 place Winston Churchill, 87000 LIMOGES
	The Ice Breaker is open to all Conference participants

Tuesday 20th June, 2017: Excursion

Boulevard de la Corderie, next to the Botanic Garden (see map)

Limousin is well-known for its coppice-based industry, particularly dealing with chestnut coppices. The field trip will allow the participants to discover all aspects from forest management (private ownership, social aspects, silviculture) to industrial wood uses (flooring, fences…), logging operations and the history of coppice in the region.

Registration for new arrivals prior to departure

Coppice forests and industry in the Limousin region (3 stops)

Presentations on harvesting, silviculture and conversion by:

- Dominique Cacot and Thierry Néquier, CRPF

Centre Régional de la Propriété Forestière (Regional Forest Estates Centres), www.cnpf.fr/nouvelle-aquitaine/

- Laure Dangla, PNR Périgord-Limousin

Parc Naturel Régional (Regional Nature Park), www.pnr-perigord-limousin.fr

- Eric Paillot and Samuel Riverain, CFBL

Coopérative Forestière (Forestry Cooperative), www.cfbl.fr

- Christophe Hémard, Hémard et Vignol

Company specialised in chestnut coppice, www.hemard-vignol.fr

--- Picnic lunch ---

Visit the Museum "Four des Casseaux" & the river Vienne

The museum "Four des Casseaux" explains the history behind the widespread occurrence of coppice around Limoges, which is tightly tied to the porcelain industry of the 19th Century. Afterwards the participants will visit an area on the river Vienne where all the logs arrived to the porcelain companies from the clear-cuts above Limoges.

--- Dinner on the riverside (Vienne) ---

Wednesday 21st June, 2017: Conference & Panel Discussion

- MORNING -

Bibliothèque Francophone Multimédia (French Multimedia Library)

2 place Aimé Césaire – 87000 LIMOGES

8:00 - 8:30	Registration & Poster Set-up
8:30 - 9:00	**Welcome and Introduction**
	Raffaele Spinelli, Vice-Chair of FP1301 EuroCoppice
9:00 - 10:30	**Session 1 – Coppice Harvesting**
	Moderator: Emmanuel Cacot, FCBA
9:00 - 9:15	Techniques and productivity of coppice harvesting operations in Europe: a meta-analysis of available data *Spinelli R, Cacot E, Mihelic M, Nestorovski L, Mederski P, Tolosana E*
9:15 - 9:30	Mechanised harvesting of short-rotation coppice: a review *Vanbeveren SPP, Spinelli R, Schweier J, Magagnotti N, Dimitriou I, Mola-Yudego B, Acuna M, Eisenbies M, Ceulemans R*
9:30 - 9:45	Bucking accuracy of alder and oak logs harvested in coppice stands during and after the growing season *Karaszewski Z, Mederski PS, Bembenek M, Tsioras PA, Rosinska M*
9:45 - 10:00	Manual and mechanized forest operations in Ukrainian coppicing: Products diversity and economic assessment *Sopushynskyy I, Ray CD, Zayachuk V, Ostashuk R, Sopushynskyy M*
10:00 - 10:15	The use of battery powered chain saw in coppice forest *Mihelic M, Poje A*
10:15 - 10:30	Forest operations sustainability: an overview on traditional coppices *Laschi A, Neri F, Picchio R, Cambi M, Marchi E*
10:30 - 11:00	*-- Coffee break -- Poster Exhibition*

11:00 - 12:30 **Session 2 – Coppice Products**

Moderator: Morgan Vuillermoz, FCBA

11:00 - 11:15 Economic evaluation of mechanized and motormanual options for selective felling of *Quercus pyrenaica* coppices in Leon (NW Spain)
Tolosana E, Laina R, Martínez-Ferrari R, Ambrosio Y, Martín M

11:15 - 11:30 Eucalypt coppice harvesting costs for stands of varying stump and stem densities, South Africa
Schwegman K, Little KM, McEwan A, Ackerman SA

11:30 - 11:45 Small scale pellet production from poplar (*Populus sp*) and aspen (*Populus tremula* L) timber: a case study
Makovskis K, Lazdina D, Arsanica A, Solodovniks V

11:45 - 12:00 Coppicing of oak and beech as seen from Bulgaria – a case study
Markoff I, Findeisen E, Popov G, Glushkov S

12:00 - 12:15 Black locust (*Robinia pseudoacacia* L), a key species for the forest-related rural economy in the west of Romania
Nicolescu VN, Hernea C

12:15 - 12:30 Mortality, re-sprouting vigor and physiology of coppice stumps after mechanized cutting
Magagnotti N, Pari L, Spinelli R, Aminti G, Giovannelli A

12:30 - 14:00 *-- Lunch break -- Poster Exhibition*

Wednesday 21st June, 2017: Conference & Panel Discussion

- afternoon -

14:00 - 15:00	**Session 3 – Environmental Aspects of Coppice Utilisation** *Moderator: Philippe Ruch, FCBA*
14:00 - 14:15	The effect of clear-cut on nitrogen fluxes and storages in a grey alder coppice stand in Estonia *Aosaar J, Varik M, Becker H, Morozov G, Uri V*
14:15 - 14:30	Environmental aspects of short-rotation coppice culture: greenhouse gas balance and environmental life cycle analysis *Ceulemans R, Vanbeveren S, Berhongaray G, Broeckx LS, De Groote T, El Kasmioui O, Njakou-Djomo S, Verlinden MS, Zenone T*
14:30 - 14:45	Mapping and assessment of ecosystem services of coppice forests in Bulgaria - methodological approach *Bratanova-Doncheva S, Zhiyanski M, Nedkov S*
14:45 - 15:00	Restoration of traditional coppice in Denmark: Types, products, ecological values, legislation and general guidelines *Suadicani K*
15:00 - 15:30	*-- Coffee break -- Poster Exhibition*

15:30 - 17:30 EuroCoppice Results & Panel Discussion

EuroCoppice in a Nutshell – Results and Recommendations

Alicia Unrau, Action Manager of FP1301 EuroCoppice

Panel Discussion with European Stakeholders

Moderator: Raffaele Spinelli, Vice-Chair of FP1301 EuroCoppice

- Stéphane Corée, "Comptoir des Bois de Brive" (CBB), (France)
  General Manager of CBB, an International Paper's wood supplying company
  www.internationalpaper.com
- Dr. Andrea Cutini, CREA-Research Centre for Forestry and Wood (Italy),
  Senior Scientist, LIFE FutureForCoppiceS Project Coordinator,
  ww.futureforcoppices.eu
- Xavier Martin, Centre National de la Propriété Forestière CNPF (France),
  Director of Forecasting and Economic Studies, www.cnpf.fr
- Dr. Federica Ortelli, COST Association (Belgium),
  Scientific Officer of COST Action FP1301, www.cost.eu
- Dr. Ignacio Seoane, EC DG Agriculture and Rural Development (EU),
  European Commission, DG Agriculture and Rural Development,
  Deputy Head of Unit D.4: Environment, climate change, forestry and bioeconomy
  www.ec.europa.eu

17:30 Wrap up and Farewell

List of Posters

A South African mechanised harvester cut-to-length Eucalyptus pulpwood productivity case study
Ackerman P, Norihiro J

Coppice with standards: Modeling understory light and stump sprout growth of redwood and tanoak in mixed multiaged stands in California
Berrill J-P, Schneider KA, Dagley CM, Webb LA

Evaluation of regeneration of Oriental Beech (*Fagus Orientalis* Lipsky) after mechanical cutting
Ertekin M

Dynamics of oak coppice in SW Slovakia: past, present and future
Feher A

Technology of firewood harvesting in Bulgarian coppices
Glushkov S, Markoff I, Nikolov M

The contribution of chestnut coppice forests in providing ecosystem services for carbon storage and climate change mitigation: A case study
Glushkova M, Zhiyanski M, Markoff I, Glushkov S

Impact of light regime in development of oak coppice forest
Kola H

Various strategy of management and clonal selection effect on short rotation coppice willow biomass and manual harvesting productivity
Lazdina D, Liepins J, Sarkanabols T, Polmanis K, Saule G, Daugavietis U, Bardulis A, Spalva G, Lazdins A

Coppicing potential of Eucalyptus species across a range of site productivities, South Africa
Little KM, Gardner R

Improving safety and productivity in firewood harvesting from coppices
Neri F, Laschi A, Fabiano F, Marchi E

The influence of design and management technology on hybrid aspen agro-forestry system productivity
Sarkanabols T, Lazdina D, Rancane S

Fine firewood collection after motor-manual pruning in *Quercus ilex* open forests in Salamanca (Western Spain)
Tolosana E, Laina R, Martínez-Ferrari R, Ambrosio Y, Martín M

Productivity of mechanized harvesting in coppice stands
Tsioras PA, Karaszewski Z, Mederski P, Bembenek M

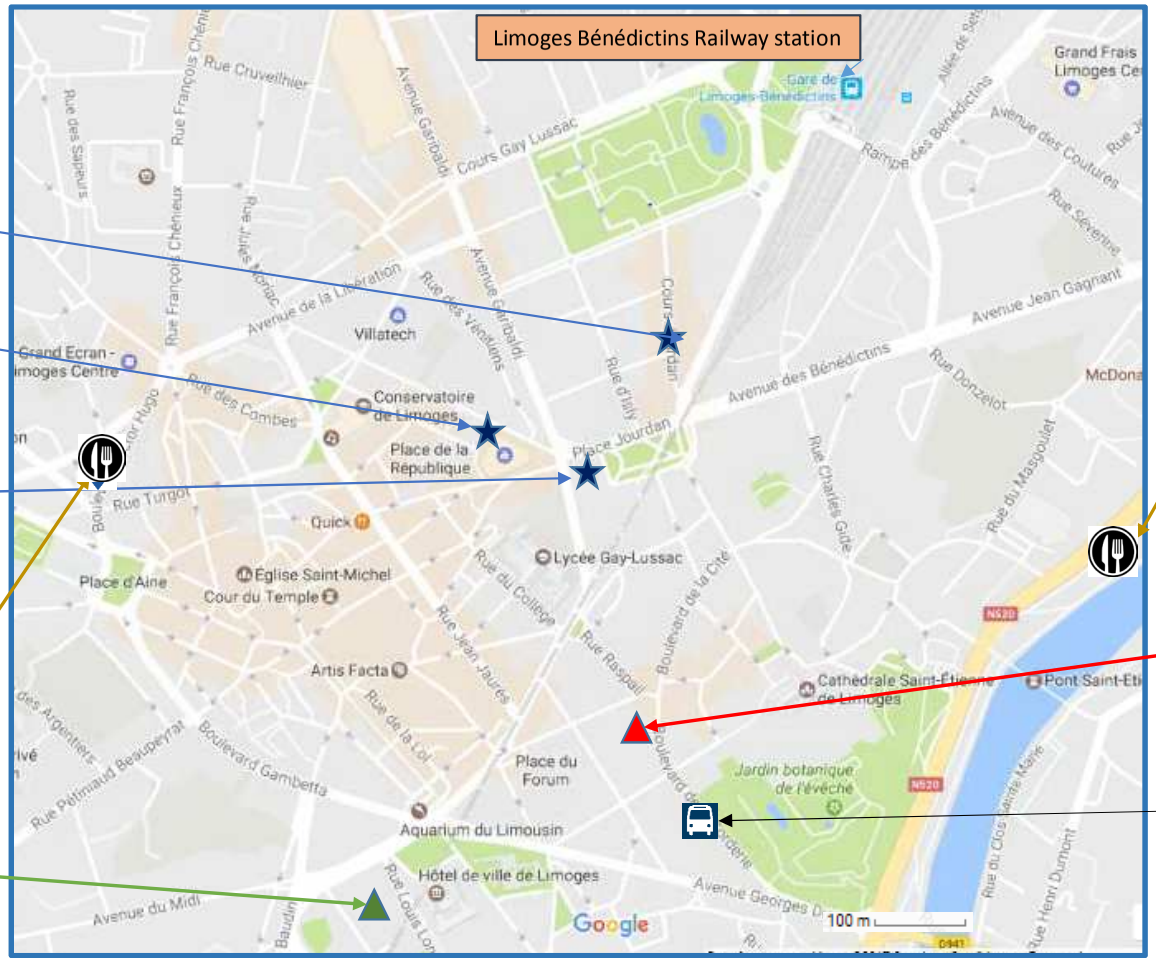
Carbon budgets in a chronosequence of downy birch stands growing on drained swamp
Varik M, Aosaar J, Becker H, Morozov G, Kukumägi M, Uri V

Identification of suitable areas for cultivation of short rotation coppices of poplar and eucalypt for bio-energy
Viana H, Gonçalves A, Godinho P, Cadima I, Rodrigues A

Environmental aspects and potential benefits of using wastewater sludge in SRC of fast-growing woody species – a case study with Salix spp.
Tsvetkov I, Hristova HR, Tzvetkova N, Petrova V, Marinova SV

MEETING EUROCOPPICE
19, 20 and 21JUNE 2017

Survival map in Limoges !



Hôtel Lion d'Or
9-11 cours Jourdan
+33 (0)5 55 77 49 71
GPS coordinates: 45.833102, 1.264297

Hôtel Mercure
Place de la République
+33 (0)5 55 34 65 30
GPS coordinates: 45.832301, 1.260806

Hôtel de la Paix
25 place Jourdan
+33 (0)5 55 42 86 25
GPS coordinates: 45.831447, 1.263336

Restaurant « BISTROT GOURMAND »
5 place Winston Churchill
+33 (0)5 55 10 29 29
Monday 19th evening (19h30)

Bibliothèque Francophone Multimédia
French Multimedia Library
2 place Aimé Césaire
+33 (0)5 55 45 96 00
Wednesday 21st of June: Conference

Restaurant « BISTROT DES QUAIS »
16 rue du Port du Naveix
+33 (0)55 79 01 01
Tuesday 20th evening (end of the excursion)

Conseil Régional Nouvelle Aquitaine
Regional Council of New Aquitaine
27 boulevard de la Corderie
+33 (0)5 55 45 19 00
Monday 19th June: Action-internal Meetings

Parking bus (Excursion)
Boulevard de la Corderie
Tuesday 20th morning (8:00)

Presentation Abstracts

Techniques and productivity of coppice harvesting operations in Europe: a meta-analysis of available data

Raffaele Spinelli[1@], Emmanuel Cacot[2], Matevz Mihelic[3], Ljupco Nestrovski[4], Piotr Mederski[5], Eduardo Tolosana[6]

Operating within the scope of COST Action FP1301 "Eurocoppice", the Authors conducted a survey of coppice harvesting studies produced in Europe from 1970 to present. The survey focused on traditional coppice stands and excluded industrial short-rotation coppice, established with willow, poplar, eucalyptus or other fast-growing species. The goals were to calculate productivity benchmarks for coppice harvesting operations, and to gauge the progress achieved over the past 40-plus years. Data from 102 studies were collected through a harmonized questionnaire and gathered into a single master database that contained. Of the 102 studies used to build the database, only 20% had been published in English. In fact, over 50% of the studies collected in this survey consisted of unpublished internal reports, which were not available to the larger scientific community. The remaining 30% of the studies had been published in national languages different from English, and were difficult to access for most researchers. Statistical analysis was used to estimate productivity models and determine possible differences between methods, work conditions and time periods. Six productivity models were estimated for the main harvesting steps and technologies. Productivity varied with a number of factors, and notably with removal (m3 ha-1). The analysis disclosed a clear trend towards increased mechanization and higher productivity. Coppice harvesting is being mechanized, but the mechanization deployed in coppice stands is adapted to the specific conditions offered by these stands. Light, cheap and versatile machines are generally preferred to heavy industrial equipment.

Keywords: felling, extraction, logging, hardwood mechanization, clearcut, selection

[1] CNR IVALSA, Via Madonna del Piano 10, Sesto Fiorentino (FI) - Italy, email: spinelli@ivalsa.cnr.it

[2] FCBA, Les Vaseix, Verneuil-sur-Vienne - France, email: Emmanuel.cacot@fcba.fr

University of Ljubljana, Dept. of Forestry and Renewable Resources, Vecna pot 83, Ljubljana –Slovenia, email: Matevz.Mihelic@bf.uni-lj.si

[3] Ss. Cyril and Methodius University of Skopje, Bul. Aleksandar Makedonski, Skopje – Republic of Macedonia, email: nestorovski@sf.ukim.edu.mk

[4] Poznan University of Life Sciences, Faculty of Forestry, Wojska Polskiego 71°, Poznan – Poland, email: piotr.mederski@up.poznan.pl

[5] Universidad Politécnica de Madrid, Ciudad Universitaria s/n., Madrid – Spain, email: eduardo.tolosana@upm.es

@ Corresponding author: spinelli@ivalsa.cnr.it

Mechanised harvesting of short-rotation coppice: a review

Stefan P. P. Vanbeveren[1@], Raffaele Spinelli[2], Janine Schweier[3], Natascia Magagnotti[2], Ioannis Dimitriou[4], Blas Mola-Yudego[5], Mauricio Acuna[6], Mark Eisenbies[7] & Reinhart Ceulemans[1]

Considering the vast amount of research done on short-rotation coppice (SRC), farmers are still reluctant in establishing SRC. In this review, the harvest – and more specifically the machinery used to conduct it – has been studied. We collected literature references to 166 field trials, in which the single pass cut-and-chip harvesting technique was most studied. Mean machine productivity was 30, 19 and 14 Mgfw h^{-1} for the cut-and-chip, cut-and-store and cut-and-bale technique, respectively. This is, however, a biased result because the most powerful harvesters (> 200 kW) are all cut-and-chip harvesters. When confining all harvesters to a maximum engine power of 200 kW, cut-and-chip harvesters were least productive (5 Mgfw h^{-1}). This is not surprising, as they perform more work tasks (cutting and chipping) than cut-and-store harvesters (only cutting) and the cut-and-bale harvester (cutting and baling). In any case, the trend is towards continually growing engine power for cut-and-chip and cut-and-store harvesters. No trends were detected for the productivity of the cut-and-bale harvesting technique, which is much more recent and has been produced in one version only. Field stocking (5-157 Mgfw ha^{-1} in the reviewed studies) proved to have a significant effect on harvester productivity: it caps the maximum material capacity of the machine, considering that harvesting speed can only be increased to a point, and it may not be pushed high enough to offset low field stocking. Source studies did not contain sufficient harvesting cost data for a thorough analysis, leading to excessively wide ranges and poor reliability.

Keywords: baling, chipping, costs, cut, machine productivity, performance

[1] Centre of Excellence on Plant and Vegetation Ecology (PLECO), Department of Biology, University of Antwerp. Universiteitsplein 1, B-2610 Wilrijk, Belgium.
[2] Tree and Timber Institute (IVALSA), National Council for Research (CNR). Via Madonna del Piano 10, I-50019 Sesto Fiorentino, Italy.
[3] Chair of Forest Operations, University of Freiburg. Werthmannstraße 6, D-79085 Freiburg, Germany.
[4] Department of Crop Production Ecology, Swedish University of Agricultural Sciences, PO Box 7043, SE-75651 Uppsala, Sweden
[5] School of Forest Siences, Univeristy of Eastern Finland. PO Box 111, FI-80101 Joensuu, Finland.
[6] Australian Forest Operations Research Alliance (AFORA), University of the Sunshine Coast, 90 Sippy Downs Drive, AU-4556 Queensland, Australia
[7] College of Environmental Sciences and Forestry, State University of New York, 1 Forestry Dr., Syracuse, NY 13210.
@ Corresponding author: stefan.vanbeveren@uantwerp.be; Tel. +32 3 265 2349, fax. +32 3 265 2271.

Bucking accuracy of alder and oak logs harvested in coppice stands during and after the growing season

Zbigniew Karaszewski[1@], Piotr S. Mederski[2], Mariusz Bembenek[2], Petros A. Tsioras[3], Martyna Rosinska[2]

Alder stands on forest sites difficult to access in Poland are usually managed as coppice forests. Thinning operations on such sites are usually motor-manual with light extraction methods, although it is possible in some cases to apply mechanised operations. However, thinning with harvesters in coppice stands may be difficult as a result of other factors, such as the number of trunks growing from one stump and morphological stem features. Thick branches and trunk sweep may affect the bucking accuracy of the logs, which may lead to economic losses when logs are delivered to the customer which may be too short for a particular product, e.g. pallets. For some species (e.g. birch) it is also important for better length accuracy if the logs are processed after the growing season. Therefore, the objective of this research was to discover if the harvester processing of other species, such as alder and oak, will also give better length accuracy after the growing season. The research was carried out in two compartments 92h and 6b in Northern Poland: in a 37-year old alder stand and in a 53-year-old oak stand. Two different harvesters, a TMB 85 and Valmet (jaki), were used in each stand, respectively. Both harvesters were calibrated prior to timber processing and in both cases 2.50 m logs were cut. After bucking, the logs, divided into bottom, middle and top logs, were measured using tape with an accuracy of 1 cm.

Keywords: harvester head, log length, round wood quality, forest operations, wood measurement

[1] Wood Science and Application Department, Wood Technology Institute, Poznan, Poland; z_karaszewski@itd.poznan.pl

[2] Department of Forest Utilisation, Poznan University of Life Sciences, Poznan, Poland; piotr.mederski@up.poznan.pl; mariusz.bembenek@up.poznan.pl; Martyna.rosinska@up.poznan.pl

[3] Lab of Forest Utilisation, Aristotle University of Thessaloniki, Greece; ptsioras@for.auth.gr

@ Corresponding author: z_karaszewski@itd.poznan.pl

Manual and Mechanized Forest Operations in Ukrainian coppicing: Products Diversity and Economic Assessment

Ivan Sopushynskyy[1@], Charles David Ray[2], Vasyl Zayachuk[1], Ruslan Ostashuk[3], Mykola Sopushynskyy[1]

Ukrainian coppicing has faced substantial changes in the institutional, legislative, and economic conditions during recent years. Coppice forests occupy a significant ecological niche that are of great social and economic value. The research work represents the economic issues of manual and mechanized forest operations in coppicing. These are to be used in planning, monitoring and controlling of harvesting operations in order to enhance operational efficiency and minimise environmental impacts. Improving operations performance, product quality and value, we studied the design of the coppice system emphasizing the profitability, long-term viability and competitiveness, etc.

The plots were set as actively manual and mechanized coppice stands of *Betula verrucosa* Ehrh., *Salix caprea* L., *Alnus glutinosa* (L.) Gaerth., *Sorbus aucuparia* L., *Malus sylvestris* Mill., *Populus tremula* L., *Corylus avellana* L.), *Quercus robur* L., and F*raxinus excelsior* L.). In our study, the following variables were involved costs, merchantable timber use for assortments, analysis of timber used against diameter at breast height, productivity, fixed and variable costs, operational time, volume of harvested timber. In the frame of the study, we have developed the practical recommendation for eco-efficient and cost-effective harvesting coppice systems. Five main categories of coppicing were proposed by the timber harvesting as the integration of all operations related to the cutting of trees and the extraction of merchantable wood for subsequent processing into industrial products.

Keywords: coppicing, timber, forest operation, operational efficiency, coppice system

[1] Department of Botany, Wood Science and Non-Wood Forest Products, Ukrainian National Forestry University, Ukraine

[2] Department of Ecosystem Science and Management, Penn State University, USA

[3] State Forest Enterprise “Navirna Forestry”, Ukraine

@ Corresponding author: sopushynskyy@nltu.edu.ua

The use of battery powered chain saw in coppice forest

Matevz Mihelic[1@], Anton Poje[1]

Increasing number of battery powered chain saws, coupled with their potential for use in harvesting operations was the main reason for setting up the trial. The coppice forest has lower dimensions of trees, making it ideal for testing such chain saws. In the study productivity and operator exposure to noise and hand-arm (HA) vibration at felling of deciduous trees (*Carpinus betulus, Sorbus aria*) with a battery powered chain saw was measured. The results indicated that productivity (PMH) of felling trees of DBH from 7 to 24 cm varied between 84.9 and 31.5 min/m^3. During productive time the operator was exposed to noise levels of 90.1 dB(A) and to HA vibration of 4.33 m/s^2. It was concluded that the use of battery powered chain saw is appropriate in stands with small diameters and that the main advantage of use is a significantly lowered exposure to noise. For a wider use of battery chain saw in forestry several improvements have to be implemented (i.e. battery capacity, engine power).

Keywords: chain saw, battery power, coppice, deciduous

[1] University of Ljubljana, Biotechnical Faculty, Department of Forestry and Renewable Resources, Vecna pot 83, 1000 Ljubljana

@ Corresponding author: matevz.mihelic@bf.uni-lj.si

Forest Operations Sustainability: an overview on traditional coppices

Andrea Laschi[1@], Francesco Neri[1], Rodolfo Picchio[2], Martina Cambi[1] and Enrico Marchi[1]

Nowadays the concept of Sustainability has become fundamental according to the modern needs of Society. Despite the easy meaning of the general definition, a sustainable approach implies a multitude of complex interactions between economic, environmental and social interests. Research activities must take into account these different interests, and modern studies aim to give answers regarding the achievement of all the functions of forests. Wood production must be guaranteed together with ecosystems functionality and workers' health and safety. In this context, it is important to evaluate how the traditional Italian management of coppice forests answers to these requirements. The aim of this contribution was to illustrate some results on different aspects of Forest Operations Sustainability of coppice with standards, and to show possible relations. Different topics were analysed in coppice stands: i) analysis of the environmental impacts related with common forest operations for firewood production through Life Cycle Assessment; ii) physical impacts on soil due to forest operations, considering the effects of both the silvicultural treatment on the entire surface and the effects of trafficking on compacted tracks; iii) forest workers exposure to wood dust and exhaust fumes in motor-manual felling and processing by chainsaw; iv) cost analysis of forest operations in Tuscany. This work, thanks to each contribution on different aspects of Forest Operations Sustainability, will give an overall view on the performance of traditional coppice under different perspectives, highlighting how this historical method of forest management is still valid in Europe.

Keywords: forest management, environmental impacts, emissions, soil compaction, costs, ergonomics

[1] GESAAF – Department of Agricultural, Food and Forestry Systems, University of Florence, Florence, Italy
[2] DAFNE – Department of Agriculture and Forestry Sciences, Tuscia University, Italy
@ Corresponding author: Address: Via San Bonaventura 13, 50145 Firenze, Italia; Tel.: +39 055 2755615; E-mail address: andrea.laschi@unifi.it

Economic evaluation of mechanized and motormanual options for selective felling of *Quercus pyrenaica* coppices in Leon (NW Spain)

E. Tolosana[1@], R. Laina[1], R. Martínez-Ferrari[1], Y. Ambrosio[1], M. Martín[1]

Four strata of dense young even-aged coppices of *Q. pirenaica* oak ranging from 2000+ to 9000 + trees/ha and 6 to 10 cm dbh on gentle terrain were felled applying strong thinnings (50 to 80% trees extracted), both motor-manually and using forest harvesters with conventional harvesting heads, and extracted using forest forwarders (CTL harvesting system). Productivity equations were fitted for forwarding, and were significantly different for motor-manual and mechanized felling. Using conventional hourly costs estimation methods, under the current Spanish socio-economic conditions, motor-manual option was economically preferable (motor-manual felling, processing and piling cost ranging from 11,2 to 19,5 €/m^3, in front of mechanized costs between 16,3 and 68,1 €/m^3), even when the mechanized option reduced forwarding costs 1,07 €/m^3 as an average, because of the better piling. Extrapolation of total cost equations showed that mechanized felling total cost would equal motor-manual total cost for this stand type and selective thinning only for dbh greater than 12 cm o.b.

Keywords: *Quercus pyrenaica*, coppice, thinning, mechanization, productivity, forest operations costing, Spain

[1] Technical University of Madrid (U.P.M.). Ciudad Universitaria, s/n. 28040 Madrid - Spain
@ Corresponding author: eduardo.tolosana@upm.es

Eucalypt coppice harvesting costs for stands of varying stump and stem densities, South Africa

Kylle Schwegman[1], Keith M Little[1@], Andrew McEwan[1] and Simon A Ackerman[2]

From the early 2000's there has been a general shift in harvesting in South Africa from manual and motor-manual to the use of semi- or fully-mechanised harvesting systems. Current coppice management recommendations advise that the coppice stems following harvesting are reduced so that the final stocking is the same as that which was originally planted. This means that two stem are left on those stumps adjacent to missing stumps, with a higher number of double stems occurring in those stands with higher stump mortality. The presence of these double stems has posed difficulties in terms of harvesting productivity due to poor stem form, high variability of stem size and the extended handling times associated with felling two stems in close proximity on one stump. Data from five eucalypt coppice management trials were used to determine the impact of stump survival (60 - 100%) and/or stem stocking (60 - 100%) on harvesting productivity. The stem stocking for each site included a range of treatments that had single, or double stems per stump. Establishment and maintenance costs over the rotation (7 - 10 years, dependent on site), were combined with harvesting, extraction and transport costs, so as to work out the income relative to the price received at the mill. From this the Internal Rates of Return (IRR) could be determined for each of the sites, as well as for the various coppice management regimes. There were large differences in terms of merchantable volume and hence harvesting costs between sites and treatments. This was mainly related to stem stocking, with the IRR indicating various options in terms of future coppice management that will favour mechanised harvesting without loss of income.

[1] Nelson Mandela Metropolitan University, Private Bag X6531, George, 6530, South Africa
[2] Institute for Commercial Forestry Research, PO Box 100281, Scottsville, 3209, South Africa
@ Corresponding author: keith.little@nmmu.ac.za

Small scale pellet production from poplar (*Populus sp.*) and aspen (*Populus tremula L*) timber: a case study

K. Makovskis[1], D. Lazdina[1], A. Arsanica[2], V. Solodovniks[2]

Small scale pellet production could be alternative timber use for farmers and coppice owners, if the timber could not be used as high quality timber. Low quality timber or small dimension timber could be used in pellet production. In many cases coppice land owners has different tree species at one time and by mixing them in pellets, they could use them more efficiency.

During the case study Poplar (*Populus sp.*) and Aspen (*Populus tremula* L) timber was tested in small scale pellet production. Different tree species (Pine (*Pinus sylvestris*), Lodgopole pine (*Pinus contorta*), European larch (*Larix decidua* Miil.) and Birch (*Betula sp.*)) were mixed with Poplar and Aspen to test different tree mixture mechanical durability and water absorption. Totally 25 tree mixture were tested where Poplar and Aspen timber was taken as base material. Pellets from these mixtures were compared with pellets, where other tree species were used as base material. In totally 49 different tree mixtures were tested and compared. Mechanical durability where Poplar and Aspen was taken as base material varied from 99% to 83.3% and water absorption from 0.7 to 0.8 ml/g. Best mechanical durability (99%) from all tested pellets showed mixture where Poplar (80%), Contorta Pine (10%) and European Larch (10%) were mixed together. Mechanical durability for pellets where only Poplar timber was used (100% poplar timber) was 98.8%, what according to ENpluss certification scheme is A1 (highest) class according to pellets mechanical durability.

Acknowledgements: Research was done by implementation of European Regional Development Fund projects No 2013/0049/2DP/2.1.1.1.0/13/APIA/VIAA/031.

Keywords: pellets, poplar pellets, aspen pellets, coppice products

[1] Latvian State Forest Research Institute “Silava“, Latvia
[2] LTD NewFuel , Latvia
@ Corresponding author: kristaps.makovskis@silava.lv

Coppicing of oak and beech as seen from Bulgaria – a case study

Ivailo Markoff[1@], Erik Findeisen[2], Grud Popov[1], Sotir Glushkov[1]

Bulgaria has 2,000,000 ha of coppices (50% of the forest area), most traditional coppices in process of conversion into high forest (74%). The rest are black-locust plantations and oriental hornbeam shrubs. Conversion forests are dominated by oak (80%), beech and hornbeam. In addition, oak is the natural alternative of pine plantations established below their natural range (700 m above sea in Bulgaria, 300,000 ha) which are increasingly instable.

Rising prices and stable demand of energy wood give cause to reconsider the policy of conversion. Examination of mean increment shows that the optimal rotation time for Bulgarian coppices is about 20 years. At that age they regenerate by re-sprouting only. Economical analysis shows that oak coppices are even more profitable than pine plantations. Examination of terrains shows that in most cases the use of modern machinery is possible. Cost analyses show that the use of harvesters and forwarders is already competitive in Bulgaria confirmed by first real steps. However, resuming the coppicing is a challenge because of the advanced age of the coppices (average age 45) and the resulting regeneration problems. The sustained management requires making use of the available natural seedlings to renew the root system. Most suitable is the femel-cut with a regeneration period from 15 to 20 years. Where the natural regeneration has failed, acorns have to be sown. Thus, coppicing is promising, but the immediate action field is limited. The barrier are the investments. A psychological trial is to start coppicing an extant young high forest.

Keywords: resuming of coppicing, oak and beach, energy use, regeneration

[1] Forest Research Institute – Bulgarian academy of sciences, Sofia
[2] University of Applied Sciences, Erfurt
@ Corresponding author: imarkoff@abv.bg

Black locust (*Robinia pseudoacacia* L.), a key species for the forest-related rural economy in the west of Romania

Valeriu-Norocel Nicolescu[1@], Cornelia Hernea[2]

Since its introduction in the north-west of Romania at the end of 19th century (1892) until its current use on thousands of hectares, black locust stands treated as low coppice have played a major and growing role in the forest-related rural economy of the western counties.

Among many wood products, *firewood* has always been and still is the most important product of black locust coppices from early ages (as low as 10 years), being used on both local and international markets.

The local vegetable and wine production in the north-west of Romania also depends on the black locust coppice stands as *poles and props* are the most used and demanded for their low prices combined with good/long resistance.

As the forest sites with sandy soils are mostly favorable for its culture, black locust trees grow quickly and can also produce thick (minimum 25 cm) and high quality logs (e.g., straight, knot-free, without rot or abnormal discolorations) at rotations as long as 30-35 years. Such valuable logs are used for *solid wood furniture* and *flooring/parquetry* in Romania and abroad.

Since short ago, even still on a quite small scale, the use of black locust coppice wood was diversified by an innovative wood product for bio-energy production in the south-west of the country: the trademark Rebina *pellets*.

Last but not least, black locust coppice forests of the north-west of Romania are a major source of *honey and bee products* of major importance for the rural employment, market and economy as such products are used domestically as well as internationally.

Keywords: black locust, firewood, solid wood, flooring/parquetry, honey, pellets

[1] "Transylvania" University of Brasov, Faculty of Silviculture and Forest Engineering, Brasov-Romania
[2] Banat's University of Agricultural Sciences and Veterinary Medicine, Timisoara-Romania
@ Corresponding author: nvnicolescu@unitbv.ro

Mortality, re-sprouting vigor and physiology of coppice stumps after mechanized cutting

Natascia Magagnotti[1@], Luigi Pari[2], Raffaele Spinelli[1], Giovanni Aminti[1] and Alessio Giovannelli[1]

The presence of multiple stems on the same stump offers a serious challenge to the introduction of mechanized felling in coppice harvesting operations. Coppice felling can be mechanized with the right technology and skilled operators.

The study investigated the effect of felling technology on coppice regeneration and was performed in a typical Mediterranean coppice stand located in central Italy. The oak-dominated coppice was cut using a chainsaw (control), a high-speed circular saw and a hydraulic shear. The experiment adopted a split-plot design, based on 5 plots divided into 15 subplots (one subplot per plot and technology). Overall, 344 stumps were selected, tagged and monitored over the first growing season after cutting. Stump size, cutting height and cutting damage were determined right after cutting. At the end of the first growing season the following parameters were also recorded: n° of shoots, height, diameter and type of the tallest 5 shoots. Samples were collected from randomly selected stumps during the main phonologic phases in order to determine the content of C, N, starch and soluble sugar, as well as the C:N ratio.

Mortality was limited and ranged from 4 to 8%. Re-sprouting was generally vigorous, and dominant shoots often exceeded the height of 1.5 m after one year. Cutting technology had a significant effect on cutting height and cutting damage, but it had no effect on mortality, re-sprouting vigor and nutrient balance within the stumps, at least in the first growing season. In contrast, regeneration vigour was found to depend mainly on species.

Oak stumps produced the largest shoots, for both diameter and height.

While previous studies indicate that effects recorded during the first growing seasons may be representative of longer-term trends, the experiment will be further continued to obtain additional confirmation.

Keywords: felling, growth, shoots, mortality, C/N ratio

[1] CNR IVALSA Via Madonna del Piano 10, I-50019 Sesto Fiorentino (FI), Italy
[2] CREA ING Via della Pascolare 16, Monterotondo Scalo (Roma), Italy
@ Corresponding author: magagnotti@ivalsa.cnr.it

The effect of clear-cut on nitrogen fluxes and storages in a grey alder coppice stand in Estonia

Jürgen Aosaar[1@], Mats Varik[1], Hardo Becker[1], Gunnar Morozov[1], Veiko Uri[1]

Grey alder (*Alnus incana* L.) is a widespread fast growing pioneer tree species which is a promising for short-rotation forestry in Baltic and Nordic countries with the optimal rotation length of 20-25 years. Due to its vigorous natural regeneration ability from stump sprouts and root suckers as well as high biomass production potential, grey alder is a typical coppice forestry species of our region. The symbiotic dinitrogen (N_2) fixation ability makes it an important species for the regulation of nitrogen (N) cycle in forested areas.

The main aim of the study was to estimate the effect of the clear-cut on the N storages and fluxes during three years after the felling. The soil of the area is classified as *Umbric Planosol* and the site type is the most fertile one in Estonian forests (*Aegopodium*). Based on earlier studies our working hypothesis was that there will be no drastic N cycling after the clear-cut compared to the control.

N storages and fluxes in above- and belowground biomass and production of trees and herbs, N flux via leaflitter and fine root litter, N leaching and net nitrogen mineralization were estimated in 22-year-old stand (control) and the adjacent area with the abundant emerging natural regeneration during three years after clear cut.

Keywords: *Alnus incana*, natural regeneration, nitrogen cycling, clear-cut, biomass

[1] Estonian University of Life Sciences, Institute of Forestry and Rural Engineering, Department of Silviculture
@ Corresponding author: jyrgen.aosaar@emu.ee

Environmental aspects of short-rotation coppice culture: greenhouse gas balance and environmental life cycle analysis

Reinhart Ceulemans[1@], S. Vanbeveren[1], G. Berhongaray[1], L.S. Broeckx[1], T. De Groote[1], O. El Kasmioui[1], S. Njakou-Djomo[1], M.S. Verlinden[1] and T. Zenone[1]

To assess the environmental benefits of short-rotation coppice (SRC) for energy production and for carbon mitigation we monitored an operational SRC from the establishment of the plantation to the production of bio-energy. The high-density poplar (*Populus*) plantation in East-Flanders (Belgium) is managed in two-year rotation cycles. Eddy covariance techniques monitor net fluxes of all greenhouse gases (GHG's) between the plantation and the atmosphere. For the global warming contribution and the energy efficiency assessment, we used life cycle analysis (LCA) from the cultivation of the plantation to the conversion of the harvested chips into electricity and/or heat. The collected information on the GHG's and the energy inputs of the two-year rotations was used toward predictions and simulations of the net reduction of fossil GHG emissions of SRC. During two rotations the SRC supplied woodchips – ca. 10 tons of dry mass ha^{-1} yr^{-1} – for decentralized bio-energy operators in Belgium. The SRC yielded nine times more energy than was put in. The SRC plantation was a net carbon sink, i.e. absorbed more carbon from the atmosphere than was produced. Although the plantation was a small net producer of GHG, the electricity and green heat from bio-energy reduced greenhouse gas emissions by 78% as compared to electricity from fossil fuel generators in the EU. The bio-energy culture was, however, economically not viable. The total cost of producing bio-energy was five times higher than the benefit of the renewable energy produced.

Funding support: ERC Advanced Grant agreement (# 233366) POPFULL under the EC 7th Framework Programme (FP7/2007-2013), as well as Flemish Hercules Foundation as Infrastructure contract # ZW09-06.

Keywords: POPFULL, environmental life cycle analysis, energy efficiency, greenhouse gas balance

[1] University of Antwerp, Department of Biology, Research Group of Plant and Vegetation Ecology, BE-2610 Wilrijk, Belgium.

@ Corresponding author: Reinhart.Ceulemans@uantwerpen.be

Mapping and assessment of ecosystem services of coppice forests in Bulgaria - methodological approach

Svetla Bratanova-Doncheva[1@], Miglena Zhiyanski[2], Stoyan Nedkov[3]

With an area of 1 750 000 ha the coppice forests in Bulgaria play an important role in conserving biological diversity and to supply a variety of specific ecosystem services. Actually in the context of Action 5 of the EU Biodiversity Strategy 2020 the mapping and assessment of the condition of coppice and their capacity to provide ecosystem services is a part of the national concerns. The overall aim of the forest managers is to protect the huge biodiversity and to assess the effects of climate changes and land use on coppice forests. The present paper deals with elaboration and application of an innovative and integrated methodological approach for mapping and assessment of ecosystem services in coppice forests at national scale. The specific indicators for selected relevant ecosystem services provided by coppice forests are presented. The maps presenting the condition of coppice forests and their capacity to provide ecosystem service are developed based on deep analyses in case-study area. This study is part of the project MetEcoSMap, funded by EEA, Programme BG03 “Biodiversity and ecosystem services”.

Keywords: coppice forests, Bulgaria, ecosystem condition, ecosystem services, methodology, assessment, mapping

1 IBER-BAS, Sofia, Bulgaria
2 FRI-BAS, Sofia, Bulgaria
3 NIGGG – BAS, Sofia, Bulgaria
@ Corresponding author: sbrat@abv.bg

Restoration of traditional coppice in Denmark: Types, products, ecological values, legislation and general guidelines

Kjell Suadicani[1@]

Since 1900 coppice forestry in Denmark gradually lost the economic importance as other products replaced the products from the coppice forests, and many coppice forests grew up to normal high forest. Still marks of the old coppice system can be seen as stumps and crooked growth in stands of old trees.

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

Coppice forestry is forest development type no. 91 in the Danish system of forest development types. The forest development type describes the long term goal of the desired forest development type. In this system four different coppice forest types are described.

Oak coppice forests. Oak, aspen, birch, rowan, hazel.
Hazel coppice forests. Hazel, ash, oak, alder, maple, thorn, elder.
Alder coppice forests. Swamp forests. Alder, ash, birch, willow.
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 1980's

In this presentation are presented methods for restoration used by the Danish Nature Agency.

Some of the guidelines are:

* Cut down only small areas at a time (0,1-0,5 ha).
* Plan the restoration so vegetation and and wildlife can circulate.
* Avoid driving.
* Use haymaking the first years after cutting.
* Use grassing on some areas
* Create permanent open areas in the coppice .
* Stop drainage.

Keywords: restoration, traditional coppice, guidelines, Northern Europe

[1] University of Copenhagen
@ Corresponding author: kjs@ign.ku.dk

Poster Abstracts

A South African mechanised harvester cut-to-length Eucalyptus pulpwood productivity case study

Pierre Ackerman[1@] and Jennifer Norihiro[1]

There has been a concerted shift from more motor-manual and semi-mechanised orientated timber harvesting systems to more mechanised CTL operations particularly in eucalyptus pulpwood timber felling and processing, which makes up 83% of the commercial wood resources for pulp and paper. This change has been necessitated through safety, product quality and productivity concerns. The objective of this study is to develop general productivity models for mechanise eucalyptus pulpwood cut-to length harvesting operations by combining the results of a number of individual studies done over a period of 24 months in the summer rainfall areas of South Africa. The study takes geographic location, species, machine type (purpose built vs excavator based), silvicultural (planted vs coppiced) and slope into account. The pooled data revealed productivity ranges from 5.16 m^3 PMH^{-1} to 27.49 m^3 PMH^{-1} (r^2 = 0.6411, p = 0.00, N = 4388). Taking the location of the individual studies the highest potential productivity was found in study area 1 with Y = 5.7995+102.7838x (r^2 = 0.4521, p < 0.00) and the lowest Y = 1.0382+83.3281x (r^2 = 0.7626, p< 0.00) for areas 4 and 5 and as tree volume decreased below 0.19 m^3 (x = tree volume). With regards species of Eucalypts which ranged from *E. smithii, E.dunii, E grandis x urophylla* and *E grandis x camaldulensis; E. smithii* and *E. dunii* were the most productive, while operations of *E. grandis x urophylla* were the least productive overall Yet, as tree volumes decrease, productivity for *E. smithii* and *E. dunii* eventually fall below both *E. grandis x camaldulensis* and *E. grandis x urophylla*. Where tree volume falls below 0.21m3, harvesting of *E. grandis x camaldulensis* is the most productive. In terms of silvicultural treatments (planted vs coppice); when tree volume increased to greater than 0.23 m^3, coppice stands proved more productive than planted; Y = 4.8824+62.468x (r^2 = 0.6448, p< 0.00) and Y= 2.4528+72.903x (r^2 = 0.6427, p < 0.00) respectively. Machine type showed significant differences with purpose-built machines being more productive for larger tree volumes (> 0.05 m^3), but as becomes less tree volume decreases so does the margin of significance.

[1] Department of Forest and Wood Science, Stellenbosch University, South Africa
@ Corresponding author: packer@sun.ac.za

Coppice with Standards: Modeling Understory Light and Stump Sprout Growth of Redwood and Tanoak in Mixed Multiaged Stands in California

John-Pascal Berrill[1], Kurt A. Schneider[1], Christa M. Dagley[1], and Lynn A. Webb[2]

We studied conifer and hardwood stump sprout response to coppice, and coppice with standards methods of reproduction. Our experimental harvest treatments were conducted approximately 100 years after the first coppice harvest (clearcut). We examined relationships between understory light, varying overstory tree retention, and growth of coast redwood (*Sequoia sempervirens*) and tanoak (*Notholithocarpus densiflorus*) stump sprouts arising after complete and partial harvest. First, we quantified understory light throughout this 30 ha experiment comparing four different retention treatments repeated at four sites. Then we related understory light to post-treatment stand density and treatment type (i.e., complete harvest or aggregated or dispersed retention of standards). Finally, we quantified growth of stump sprouts in response to understory light, retention treatment, and other variables influencing growth of stump sprout regeneration after partial harvesting. As expected, coppice with standards treatments with higher residual stand density had lower levels of understory light. When density was held constant, mean understory light did not change significantly when residual trees were retained in aggregated vs. dispersed spatial patterns. However, high density dispersed treatments had the lowest minimum light levels when compared to high density aggregated. The dominant sprout within clumps of redwood sprouts generally grew faster than dominant tanoak sprouts within tanoak clumps. Differences in sprout height growth between aggregated and dispersed treatments were minimal. In the low density dispersed treatment, redwood sprouts (commercial species) outperformed tanoak sprouts (non-commercial species) by the greatest margin. Regeneration of redwood and tanoak was most rapid following coppice harvest without retention of overstory standards.

Keywords: coppice, *Notholithocarpus densiflorus*, regeneration, *Sequoia sempervirens*, variable retention

[1] Department of Forestry and Wildland Resources, Humboldt State University, 1 Harpst Street, Arcata, CA 95521, USA

[2] Jackson Demonstration State Forest, California Department of Forestry and Fire Protection, 802 North Main Street, Fort Bragg, CA 95437, USA.

@ Corresponding author: +1-707-527-1767; pberrill@humboldt.edu

Evaluation of regeneration of oriental beech (Fagus orientalis Lipsky.) after mechanical cutting

Murat Ertekin[1@]

Turkey contains very different phytogeographic regions (the Euro-Siberian, Irano-Turanian and Mediterranean). Due to climate and geographic diversity, there are many species than other western Palaearctic country. Especially, oriental beech, that's origin is coppice, is dominate in northern parts (black sea region) of Turkey.

This study is about the determination of success rates of saplings and regeneration in designated regeneration areas and it was conducted in seven forest enterprises administered by Bartın Directorate of Forest Management (Ardıç Sökü,Kumluca, Kocağız, Günye, Hasankadı and Arıt). For this reason, twenty-four different study areas were chosen from twenty four lands and some measurements and studies were carried out in those areas.

The research in terms of the success rate of regeneration studies revealed the affecting factors. Those factors determined according to the analyses were physiographic conditions, land status, climate and social pressure. According to the measurements and detections carried out on regenerated beech saplings, the origins of samplings were ignored and cultivation and management of plants were not carried out properly. In addition, social pressure reduced the success rate of regeneration.

Keywords: Oriental beech, regeneration success, coppice forest, environmental factors

[1] Necmettin Erbakan University, Konya, Turkey
@ Corresponding author: muratertekin@hotmail.com

Dynamics of oak coppice in SW Slovakia: past, present and future

Alexander Feher[1@]

Coppicing increases diversity of tree species, but this is true only to a certain limit. If oak stands are not supported by artificial planting or influence by coppicing, we can expect a natural retreat of oak. One reason of decline is also that oaks are light-demanding. If no clearings are created, oak seedlings will die in the shade of the forest and without the traditional uses, which did not allow full canopy closure, thus preventing the dominance of shade-demanding species, it is not possible to maintain their competitiveness. Hornbeam, which is more shade-demanding, can over-proliferate and suppress the oak seedlings. The retreat of oaks in the Carpathian Basin was attributed also to selective logging. Some authors do not consider oak-hornbeam forests at lower altitudes as climax forests at all. Unsuitable climatic conditions weaken trees, which are subsequently attacked by fungal diseases and misletoe hemiparasites. Reduction of oak cover was/is supported by introduction of other, often invasive species. Coppice forests can be considered as an important part of the landscape suitable for protection, including the declaration of protected areas or NATURA 2000 sites within them. It remains a challenge also in other areas, whether to preserve forests with less intensive management and risk the decline of oak and or to manage the forests more intensively, even in protected areas, so that forests would be lighter and would maintain "their" rare species. Drier areas require simple management with thinning, wetter forests require more frequent management.

[1] Slovak University of Agriculture in Nitra
@ Corresponding author: alexander.feher@uniag.sk

Technology of firewood harvesting in Bulgarian coppices

Sotir Glushkov[1@], Ivailo Markoff[1], Miroslav Nikolov[2]

Firewood is by far the most important sort of biomass used for heating in Bulgaria. Over 50% of Bulgarian families use wood for heating. Most firewood (70%) is harvested in the oak coppices, the usual forest type of the inhabited area, which comprises essentially the altitudes up to 600-700 m above sea.

The investigation has been made in the forests of the town Kostenets – almost 9200 ha, incl. 2000 ha of oak coppices. The investigation involved several transportation means: agricultural tractor with a winch, horses (pulling trailers and carts or carrying firewood on packsaddle) and iron horse. The iron horse had a mini winch powered by the chain saw and used to haul the firewood to the logging trail. In all cases the distance between the logging trails was 40 m. The performance of the iron horse has been investigated. Cost analysis of the above listed technologies has been made. Quality and sizes of the fire wood have been assessed.

Keywords: coppice, firewood, logging trails, iron horse, horses, mini forestry winch

[1] Forest Research Institute – Bulgarian academy of sciences, Sofia
[2] Communal forest service, town Kostenets
@ Corresponding author: sotirgluschkov@abv.bg

The contribution of chestnut coppice forests in providing ecosystem services for carbon storage and climate change mitigation: A case study

M. Glushkova[1@], M. Zhiyanski[1], I. Markoff[1], S. Glushkov[1]

Coppice forests are particularly species-rich habitats that make a contribution to the preservation of cultural and historical diversity and provide important regulation services (e.g. local climate regulation, water cycle and CO_2 sequestration, mitigation of natural hazards etc.) and biodiversity supporting services. The aim of this work was to analyze carbon storage of various ecosystem compartments (above-ground biomass, forest floor and soil) of selected coppice forest stands of European chestnut (*Castanea sativa* Mill.) in Belasitsa Mountain, SW Bulgaria, as well as to identify the ecosystem services, provided by these forests. It was found that the mature mixed coppice chestnut stands of Belasitsa are characterized with relatively high carbon stock, large part of which was accumulated in the above-ground biomass. The pure chestnut stands have the highest potential for carbon storage, mostly in the forest floor and mineral soil (topsoil), indicating the existence of favorable conditions for the inclusion of organic substances in the soil system. An analysis of the results showed that coppice chestnut forests in Belasitsa Mountain have a high potential for carbon capture and sequestration and are of essential importance in maintaining and enhancing ecosystem services in the region, in climate change mitigation and for increasing of sustainability and productivity of forests in regional long-term planning.

Keywords: European chestnut, coppice forests, carbon stock, above-ground biomass, forest floor and soil, ecosystem services

[1] Forest Research Institute – Bulgarian academy of sciences, Sofia
@ Corresponding author: m_gluschkova@abv.bg

Impact of light regime in development of oak coppice forest

Haki Kola[1@]

Kosovo's forest cover 481,000 hectares while the coppice forest share is 84 % of total forest area. Oak coppice forest is the main source for production of firewood. There are different management practices in private and public forest resulting in forest stands with different indicators. The paper contributes to identify the reasons of coppice forest degradation, summarizing the results of surveys and experiments realized under the project "Strengthening the sustainable decentralized and private forest in Kosovo" financed by Sweden Government and CNVP. The methodology on establishment of experiments and permanent sample plots aims to compare the impact of management practices on coppice forest light regime, in development and increment and of next generation oak coppice stand. Based on the grid established in frame of National Forest Inventory, 20 circular permanent plots were established on selected from two main categories of coppice stands originate from (i) selective cuttings system resulting from illegal production of firewood, (ii) coppicing through clearcutting each year on small panels 0.1 up to 0,5 hectares, resulting in an irregular patchwork of panels at different stages of growth in each private coppice forest. Preliminary results indicate that young oak sprouts tolerate little shade, and shows that the difference in the light regime coming from harvesting practices can be an important factor for coppice forest new generation, the competition between sprouts and forests composition. Further surveys, experiments and analyses s are required as precondition to realize better use the potential of the land covered by coppice forest.

Keywords: coppice forest, light regime, silvicultural practices

[1] Connecting Natural Values and People Foundation, CNVP Office – Prishtine, Kosovo
@ Corresponding author: haki.kola@cnvp-eu.org

Various strategy of management and clonal selection effect on short rotation coppice willow biomass and manual harvesting productivity

D. Lazdina[1@], J. Liepins[1], T. Sarkanabols[1], K. Polmanis[1], G. Saule[1], U. Daugavietis[1], A. Bardulis[1], G. Spalva[1], A. Lazdins[1]

SRC willows becomes more important crop in Latvia year by year. Clones of willows Sven, Klara, Inger, Gudrun, Lisa, Tora, Stina, Torhild, as well the candidates of willow clones *Salix burjatica, Salix viminalis, Salix smithensis, Salix purpurea* (10 000 cuttings of willows ha^{-1}), were planted in Latvia, Vidzeme region in May, 2011. Before planting fields were fertilized with wood ash (6 tonnes$_{DM}$ ha^{-1}), waste water sludge (10 tonnes$_{DM}$ ha^{-1}) and fermentation residues from biogass plants (30 tonnes ha^{-1}). Soil type in the experimental fields is *Luvic Stagnic Phaeozem* (*Hypoalbic*) and *Mollic Stagnosol* (*Ruptic, Calcaric, Endosiltic*) according to FAO (2006); dominant soil texture is loam (at 0–20 cm depth) and sandy loam (at 20–80 cm depth). Five years after planting trees were harvested doing the time studies and estimating above ground biomass by weighing.

Above ground biomass of the commercial clones of willows at 3, 4, 5 years age stems in average was 20.9 T$_{DM}$ ha-1 (the value is close to the average yield in large scale commercial willow plantations in Nordic countries), while "candidates" produced only 12.6 T$_{DM}$ ha^{-1}. The treatment with wastewater sludge increased the yield by 18 % in plantations of the "candidate" clones. The productivity of the commercial clones was increased by 10% by treatment with wood ash. The most productive manual harvesting equipment were chain saw with frame (~70 productive h per ha).

Keywords: willows, fertilization, harvesting, productivity

[1] Latvian State Forest Research Institute "Silava"
@ Corresponding author: dagnija.lazdina@silava.lv

Coppicing potential of *Eucalyptus* species across a range of site productivities, South Africa

Keith M Little[1@] and Robin Gardner[2]

Due to the large variation in sites within South Africa, selected eucalypts and/or their hybrid combinations are matched to specific sites to ensure optimum potential productivity. These include *Eucalyptus nitens*, *E. macarthurii* and *E. smithii* 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. Recent increases in various eucalypt pests and disease, when in combination with climatic shifts, has resulted in the need to test alternative eucalypts in a range site x species matching trials. Although the determination of the best performers of the parent crop within these trials, the ability to coppice is also advantageous due to lower re-establishment costs. To determine this, the ability for these species to coppice was assessed in five trial sites with widely different growing conditions. This included a comparison of 20 eucalypts at two cool temperate sites, 23 eucalypts at two warm temperate sites, and 16 eucalypts at a sub-tropical site. Coppice potential differed between eucalypt, provenance, site and region, with site productivity and vigour of the parent crop also important. The information gained from these trials emphasises the importance of not only matching eucalypt to site, but also the ability of that eucalypt to coppice if this form of regeneration is to be used.

[1] Nelson Mandela Metropolitan University, Private Bag X6531, George, 6530, South Africa
[2] Institute for Commercial Forestry Research, PO Box 100281, Scottsville, 3209, South Africa
@ Corresponding author: keith.little@nmmu.ac.za

Improving safety and productivity in firewood harvesting from coppices

Francesco Neri[1@], Andrea Laschi[1], Fabio Fabiano[1] and Enrico Marchi[1]

Despite the introduction of safe mechanised methods in Italy, in forest utilization and especially in coppice harvesting the risk of injuries for the operators is still high.

In Italy coppice are mainly harvested to produce firewood and risks are mainly due to the use of chainsaws in felling and processing and also to the operations of wood extraction, loading and transport from forest to the further processing industries.

The traditional working method is based on the cut to length systems and the harvesting cycle begins with motor-manual felling and ends when firewood is loaded onto truck. The wood extraction may be carried out, depending on slope and accessibility by animals, chute, tractor and trailer and tractor with bins.

After extraction firewood is manually loaded onto trucks by two or three operators standing on the truck while a loader lifts the firewood to be stacked. This work phase is one of the most dangerous of the whole process and the risk to slip or to fall is very high.

This study analyses the use of a firewood baler at the landing and the advantages, in terms of safety, of using a loader to load bales onto trucks.

The firewood baler is mounted on three-point hitch of a tractor and the compaction is carried out by two couples of mobile arm pushed down by hydraulic cylinders. After compaction the bales are fastened with twine or iron wire. This method is also compared to the traditional use of tractor with bins in terms of productivity.

Keywords: firewood, safety, ergonomics, wood harvesting, bales

[1] GESAAF – Department of Agricultural, Food and Forestry Systems, University of Florence, Florence, Italy
@ Corresponding author: Address: Via San Bonaventura 13, 50145 Firenze, Italia; Tel.: +39 055 2755615; E-mail: francesco.neri@unifi.it

The influence of design and management technology on hybrid aspen agroforestry system productivity

T. Sarkanabols[1], D. Lazdina[1] and S. Rancane[2]

Since 2011 aspens are eligible agriculture energy crop with rotation period up to five years in Latvia. Research aim is to determine productivity of hybrid aspen (*Populus tremula* L. x *P. tremuloides* Michx.) planted in spring 2011 at the fifth year rotation period after managing it as agroforestry system together with perennial crops – reed canary grass (*Phalaris arundinacea* L.), festulolium (x *Festulolium pabulare*) and fodder galega (*Galega orientalis* Lam.) as intercrop and fertilized by fermentation residues, waste water sludge and wood ash. During the study were measured hybrid aspen clones No 4 and No 28 planted in the 2.5x5 m planting design with 2.5 m wide intercrop stripes between tree rows. Plantation is established in 4 replicates with each fertilizer, intercrop and control. It is recognized that best effect on tree growth for both clones gives fertilizing with digestate and waste water sludge, averagely 30–31% better tree height compared to control. The best effect on tree growth gives red canary grass and fodder galega intercrop, comparing to control the average tree height is 16% higher. It is recognized that hybrid aspen clone No 4 is significantly (+33%) more productive than clone No 28. The most important impact on plantation productivity gives the clone selection, although there is relevant impact on the tree growth from fertilizer and intercrop too. All kinds of fertilizers significantly increased seed yield of festulolium by 30%, but fodder galega showed positive response just to wood ash fertilization resulted to +15% of seeds yield.

Keywords: hybrid aspen, agroforestry, intercrop, fertilization, perennial crops

[1] Latvian State Forest Research Institute "Silava"
[2] Latvia University of Agriculture, Institute of Agriculture
@ Corresponding author: toms.sarkanabols@silava.lv

Fine firewood collection after motor-manual pruning in *Quercus ilex* open forests in Salamanca (Western Spain)

E. Tolosana[1@], R. Laina[1], R. Martínez-Ferrari[1], Y. Ambrosio[1] and M. Martín[1]

Holm oak (*Quercus ilex*) "dehesa" forests (meadows with scattered trees), have commonly an agroforest use in Spain, both for grazing – producing grass and nutritive acorns for Iberian pork - and firewood. Frequently, coarse firewood is extracted while fine firewood – less than 10 cm thick – is piled and left on the terrain. To evaluate the productivity and the possible profitability of collecting this fine firewood, forwarding and chipping for energetic use, these operations were time-studied in five gentle sloped strata, both for regular (fruition) pruning and for heavier shape pruning. Single tree equations for coarse and fine firewood yield in both pruning types were fitted. Different work systems were studied, being the least costly those in which the fine firewood was not cut and piled, but the whole branches were left on the terrain to be collected by a forest forwarder and chipped at landing afterwards. If this – reduced - pruning cost is assigned to coarse firewood production, the direct cost of fine firewood chips would reduce to 45,8 €/fresh chips tonne at landing.

Keywords: dehesa, holm oak, pruning, fine firewood collection, chipping, productivity, forest biomass

[1] Technical University of Madrid (U.P.M.). Ciudad Universitaria, s/n. 28040 Madrid - Spain
@ Corresponding autor: eduardo.tolosana@upm.es

Productivity of mechanized harvesting in coppice stands

Petros A. Tsioras[1], Zbigniew Karaszewski[2], Piotr Mederski[3] and Mariusz Bembenek[3]

Coppice is a traditional method of woodland management used all over the world. By providing a large variety of wood and non-wood products as well as other services, coppice forests are of special importance. In recent decades, in some parts of Europe, the management of coppice forests has been abandoned due to socioeconomic changes. This resulted in aged coppice stands, whose potential of providing wood products remains unutilized, in times where the demand for wood and wood-based products is constantly rising. A possible solution to this problem could be the introduction of small- and medium- sized harvesters in coppice stands. However, limited bibliography is available on the topic compared to SRC harvesting.

In this study, one oak and two alder coppice stands in NE Poland have been harvested with the TBM PREUSS 84V.II 6WD harvester and time consumption was investigated by means of time studies. The results show a wide range of productivity rates: 10.43m^3/PMH$_0$ (9.30m^3/PMH$_{15}$) for site 1 (oak), 4.99m^3/PMH0 (4.29m^3/PMH$_{15}$) for site 2 (alder) and 3.76m^3/PMH$_0$ (3.13m^3/PMH$_{15}$) for site 3 (alder). Tree dimensions and form affect the production rate as well as the driving skills of the harvester operator and the soil moisture at the harvesting site. Trafficability issues result in higher time consumption and when combined with limited working experience even more unnecessary maneuvers are observed. The introduction of mechanized harvesting in coppice stands should be the result of careful consideration on behalf of the forest enterprise otherwise low production rates and poor financial outcomes are to be expected.

Keywords: harvester, oak, alder, production rates, Poland

[1] Lab of Forest Utilisation, Aristotle University of Thessaloniki, Greece; ptsioras@for.auth.gr

[2] Wood Science and Application Department, Wood Technology Institute, Poznan, Poland; z_karaszewski@itd.poznan.pl

[3] Department of Forest Utilisation, Poznan University of Life Sciences, Poznan, Poland; piotr.mederski@up.poznan.pl; mariusz.bembenek@up.poznan.pl

@ Corresponding author: ptsioras@for.auth.gr

Carbon budgets in a chronosequence of downy birch stands growing on drained swamp

Mats Varik[1@], Jürgen Aosaar[1], Hardo Becker[1], Gunnar Morozov[1], Mai Kukumägi[2] and Veiko Uri[1]

Assessing carbon (C) storages and fluxes in forest ecosystems is crucial for explaining their C sequestration ability. The influence of stand age on net ecosystem production (NEP) and net primary production (NPP) in five downy birch stands, aged between 12 and 78 years, growing on well-drained *Histosols* were studied. Young and middle-aged downy birch stands acted as C sink ecosystems, accumulating 1.4-3 t C ha^{-1} yr^{-1}. In the 38-year-old stand NEP was roughly zero; annual C budget was almost in balance. Mature downy birch stand acted as a C source, emitting 0.95 t C ha^{-1} yr^{-1}. Annual woody biomass increment of stand was the main factor which affected the forest to act as a C accumulating system. Below-ground woody biomass production made up 16-20% of total woody biomass increment of the trees. Since production decreases in older stands then for more effective C accumulation, optimisation of rotation age for downy birch stands should be applied. Annual total soil respiration (R_s) and heterotrophic respiration (R_h) ranged from 7.4 to 8.8 t C ha^{-1} and 4.7 to 6.2 t C ha^{-1}, respectively. Both annual aboveground litter (1.5-1.9 t C ha^{-1} yr^{-1}) and fine root litter (0.9-1.5 t C ha^{-1} yr^{-1}) input fluxes were comparable for stands of different ages.

The main proportion of the C stock in the drained swamp downy birch stands was soil carbon; the storage of C accumulated in the woody biomass of the trees accounted for only 5-20% of the total C storage of the ecosystem.

Keywords: *Betula pubescens*, drained swamps, net ecosystem production, carbon fluxes

[1] Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Kreutzwaldi 5, 51014 Tartu, Estonia

[2] Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise 46, 51014 Tartu, Estonia

@ Corresponding author: mats.varik@emu.ee

Identification of suitable areas for cultivation of short rotation coppices of poplar and eucalypt for bio-energy

Helder Viana[1,2@] Ana Gonçalves[3], Paulo Godinho[4], Irene Cadima[4] and Abel Rodrigues[4,5]

In Portugal there are now about 1.5 M ha of shrublands. A fraction of that area can be successfully cultivated with short rotation coppices of poplar and eucalypt for bio-energy. Indeed, the plenty global solar radiation typical of Mediterranean areas is a necessary condition for the fast plant growing, typical of an intensive managed coppice such as SRC. In this context an estimation of suitable areas from a set of 8 counties in Southern Portugal for installation of poplar and eucalypt SRCs is performed. A GIS approach was carried out, based on environmental and productive variables, in order to obtain areas for the implementation of these cultivations and their potential biomass production. The variables considered to obtain biomass productive area classes of SRCs are rainfall, summer drought, soil use, soil texture and pH, topography, and frost. The results show the potential of SRCs as a complementary way for soil use, environmental protection and diminishing of desertification on extensive rural areas.

Keywords: coppice, biodiversity, shrubland, *Poplar*, *Eucalyptus*

[1] CI&DETS Research Centre, Instituto Politécnico de Viseu - 3504-510 Viseu, Portugal

[2] Centre for the Research and Technology of Agro-Environmental and Biological Sciences, CITAB, University of Trás-os-Montes and Alto Douro, UTAD, Quinta de Prados - 5000-801 Vila Real, Portugal

[3] Departamento de Geografia e Desenvolvimento Regional/Faculdade de Ciências Sociais e Humanas, CICS. NOVA- Centro Interdisciplinar de Ciências Sociais, Universidade Nova de Lisboa, Portugal

[4] INIAV - Lisbon, 2780-159 Portugal

[5] Maretec Research Center, IST, Av. Rovisco Pais, 1, 1049-001 Lisboa

@ Corresponding author: hviana@esav.ipv.pt

Environmental aspects and potential benefits of using wastewater sludge in SRC of fast-growing woody species – a case study with *Salix* spp.

I. Tsvetkov[1@], Hr. Hristova[1], N. Tzvetkova2, V. Petrova[2], Sv. Marinova[3]

Field trial and a pot experiment with two willow (*Salix* spp.) clones were established in 2013 with the purpose of estimating the effect of using sludge from wastewater treatment plants (WWTP) and general assessment of their potential for biomass production. A field trial (hardwood cuttings, classic randomized block design) for studying the effect of three doses of wastewater sludge (0.2, 0.4 and 0.6 t/ha) on the early stage growth and development of willow clones (*S. alba* L. and *S. viminalis rubra* Huds.) was established on Vertisols. Before tree planting, sludge and soil were analyzed for chemical, physical-mechanical and microbiological indicators. Standard biometric parameters (survival, number of shoots after coppicing, average shoot height, fresh and dry weighs) as well as some photosynthetic indices (photosynthetic activity, stomatal conductance, transpiration) were measured during the experiment. The gas-exchange measurements were carried out by portable infrared gas analyzer Li 6400 between 10 AM and 1 PM, with only green and healthy leaves being selected for that purpose. The performance of the clones and effect from the wastewater sludge treatments have been commented.

Keywords: biomass, coppice, *Salix* spp., short-rotation plantations, wastewater sludge

[1] Forest Research Institute, 132, Kliment Ohrdski Blvd., Sofia 1756, Bulgaria
[2] University of Forestry, 10, Kliment Ohridski Blvd., Sofia 1797, Bulgaria,
[3] Institute of Soil Science Agrotechnology and Plant Protection "N. Poushkarov", Sofia 1080, 7, Shosse Bankya Str., Bulgaria
@ Corresponding author: tsvet_i@yahoo.com

List of Participants

First Name	Last Name	Organisation	Country
Pierre	Ackerman	Dept of Forest and Wood Science, Stellenbosch University	South Africa
Neno	Aleksandrov	University of Forestry	Bulgaria
Jürgen	Aosaar	Estonian University of Life Sciences	Estonia
Debbie	Bartlett	University of Greenwich, Faculty of Engineering & Science	United Kingdom
Mariusz	Bembenek	Poznan University of Life Sciences	Poland
Pascal	Berrill	Humboldt State University, Department of Forestry	USA
Svetla	Bratanova-Doncheva	Institute of Biodiversity and Ecosystem research - BAS	Bulgaria
Peter	Buckley	Peter Buckley Associates	United Kingdom
Dominique	Cacot	Centres régionaux de la propriété forestière, CRPF	France
Emmanuel	Cacot	Institut technologique FCBA	France
Reinhart	Ceulemans	University of Antwerp, Department of Biology	Belgium
Hedwig	Ceulemans	University of Antwerp, Department of Biology	Belgium
Marin	Chaumet	Institut technologique FCBA	France
Stéphan	Corée	Comptoir des Bois de Brive / International Paper	France
Guy	Costa	Université de Limoges, Laboratoire LCSN-PEIRENE, SylvaLIM	France
Mario	Costa	Instituto Superior Técnico	Portugal
Andrea	Cutini	CREA-Research Centre for Forestry and Wood	Italy
Christa	Dagley	Humboldt State University, Department of Forestry	USA
Laure	Dangla	Parc Naturel Régional Périgord Limousin	France
Alexander	Feher	Slovak University of Agriculture	Slovakia
Cornelia	Hernea	Banat's Univ. of Agricultural Sciences & Veterinaty Medicine	Romania
Antoine	Hubert	Alliance Forêts Bois	France
Jyrki	Hytönen	LUKE – Natural Resources Institute Finland	Finland
Paula	Jylhä	LUKE – Natural Resources Institute Finland	Finland
Zbigniew	Karaszewski	Wood Technology Institute	Poland
Pieter D.	Kofman	Danish Forestry Extension A/S	Denmark
Georgi	Kostov	University of Forestry	Bulgaria

First Name	Last Name	Organisation	Country
Rubén	Laina	Technical University of Madrid - UPM	Spain
Andrea	Laschi	University of Florence, GESAAF	Italy
Dagnija	Lazdina	Latvians State Forest Research Institute - Silava	Latvia
Keith	Little	Nelson Mandela Metropolitan University, Faculty of Science	South Africa
Natascia	Magagnotti	CNR Ivalsa	Italy
Paola	Mairota	Università degli studi di Bari Aldo Moro	Italy
Kristaps	Makovskis	Latvian State Forest Research Institute - Silava	Latvia
Enrico	Marchi	GESAAF Universita degli Studi Firenze	Italy
Ivailo	Markoff	Forest Research Institute	Bulgaria
Xavier	Martin	Centres national de la propriété forestière, CNPF	France
Piotr	Mederski	Poznan University of Life Sciences	Poland
Matevž	Mihelic	University of Ljubljana, Biotechnical faculty	Slovenia
Jennifer	Mills	Peter Buckley Associates	United Kingdom
Vincent	Morillon	Institut technologique FCBA	France
Thierry	Néquier	Centres régionaux de la propriété forestière, CRPF	France
Francesco	Neri	GESAAF Universita degli Studi Firenze	Italy
Ljupco	Nestorovski	Cyril and Methodius University in Skopje - UKIM	R. of Macedonia
Valeriu-Norocel	Nicolescu	University "Transylvania" of Brasov	Romania
Federica	Ortelli	COST Association	Belgium
Pavol	Otepka	Slovak University of Agriculture	Slovakia
Eric	Paillot	Coopérative Forestière Bourgogne Limousin - MECAFOR	France
Thomas G.	Papachristou	Forest Research Institute, Hellenic Agricultural Organization	Greece
Nenad	Petrovic	University of Belgrade, Faculty of Forestry	Serbia
Anton	Poje	University of Ljubljana, Biotechnical Faculty	Slovenia
Abel	Rodrigues	INIAV	Portugal
David	Rossney	Esus Forestry - Training	United Kingdom
Philippe	Ruch	Institut technologique FCBA	France
Ignacio	Seoane	EC DG Agriculture and Rural Development	Belgium

First Name	Last Name	Organisation	Country
Ivan	Sopushynskyy	Ukrainian National Forestry University	Ukrainia
Raffaele	Spinelli	CNR Ivalsa	Italy
Martin	Šrámek	Mendel University in Brno	Czech Republic
Kjell	Suadicani	University of Copenhagen	Denmark
Eduardo	Tolosana	Technical University of Madrid - UPM	Spain
Toma	Tonchev	University of Forestry	Bulgaria
Pande	Trajkov	Cyril and Methodius University in Skopje - UKIM	R. of Macedonia
Petros A.	Tsioras	Aristotle University of Thessaloniki, Lab of Forest Utilization	Greece
Ivaylo N.	Tsvetkov	Forest Research Institute	Bulgaria
Alicia	Unrau	University of Freiburg	Germany
Stefan	Vanbeveren	University of Antwerp	Belgium
Mats	Varik	Estonian University of Life Sciences	Estonia
Helder	Viana	Instituto Politécnico de Viseu, Escola Superior Agrária	Portugal
Morgan	Vuillermoz	Institut technologique FCBA	France
Miljenko	Županic	Croatian Forest Research Institute	Croatia

Notes

Notes

Acknowledgements

This article is based upon work from COST Action EuroCoppice FP1301, supported by COST (European Cooperation in Science and Technology).

COST Action FP1301 EuroCoppice kindly received further support from the Eva Mayr-Stihl Stiftung.

COST is supported by the
EU Framework Programme
Horizon 2020

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

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Chair of FP1301 EuroCoppice
Gero Becker, gero.becker@fob.uni-freiburg.de

Vice-Chair of FP1301 EuroCoppice
Raffaele Spinelli, spinelli@ivalsa.cnr.it

Further Contacts: EuroCoppice initiated a long-term platform for coppice-related topics within IUFRO (www.iufro.org), the global organisation for forest research: Working Party 01.03.01 "Traditional coppice: ecology, silviculture and socio-economic aspects". Coordinator: Valeriu-Norocel Nicolescu, nvnicolescu@unitbv.ro