COST Action FP1301 EuroCoppice Innovative management and multi–functional utilization of traditional coppice forests – an answer to future ecological, economic and social challenges in the European forestry sector

Coppice forests in Europe: ecosystem services, protection and nature conservation

Conference information, Program & Book of abstracts
Edited by Stefan Vanbeveren & Reinhart Ceulemans

University of Antwerp, Belgium
16 – 17 June 2016

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

UNIVERSITEIT GENT

Universiteit Antwerpen

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Program

Wednesday 15 June 2016

20.00 – ...	ICEBREAKER

Thursday 16 June 2016

8.30 – 9.00	REGISTRATION
9.00 – 9.20	WELCOME INTRO

SESSION 1

Chairperson: Prof. Reinhart Ceulemans, University of Antwerp

9.20 – 9.50	Keynote Lecture: **Birds and forest structure** Hinsley SA & Fuller RJ
9.50 – 10.10	**Microhabitats in thinned aged oak coppiced forests in Luxembourg** Suchomel C, Pyttel P & Carneiro A
10.10 – 10.30	**The legacy of coppicing: the present reflects the past** Müllerová J, Altman J, Doležal J, Dörner P, Hédl R, Pejcha V & Szabó P
10.30 – 11.00	COFFEE BREAK

SESSION 2

Chairperson: Prof. Kris Verheyen, University of Ghent

11.00 – 11.20	**Ecosystem services provided by ground vegetation in three years old willow SRC** Lazdina D, Bebre I & Pučka I
11.20 – 11.40	**Coppice forest and invasive species: the case of Ailanthus altissima, a succesful survivor in Eastern and Central Europe** Feher A, Halmova D, Koncekova L & Borlea GF
11.40 – 12.00	**Ecosystem services from coppiced forests: the need to understand functional trait distributions in an era of environmental change and in light of land-use legacies** Perring MP, Depauw L, Maes S, Blondeel H, De Lombaerde E, Landuyt D, Verheyen K & the forestREplot-network
12.00 – 12.20	**Ecosystem services in coppice - importance and prospects as a strategic basis for effective forest management and human well-being** Tsvetkov I, Bratanova-Doncheva S, Dodev Y & Zhiyanski M
12.20 – 13.40	LUNCH BREAK & POSTER SESSION

SESSION 3

Chairperson: Prof. Valeriu-Norocel Nicolescu, University “Transylvania” of Brasov

13.40 – 14.10	**Keynote lecture: Root reinforcement dynamics in coppice woodlands and their effect on shallow landslides: a review**
	Vergani C, Schwarz M, Giadrossich F, Condera M, Buckley P, Piussi P, Salbitano F & Lovreglio R
14.10 – 14.30	**Coppicing for watershed protection: the case of Ulza Basin in Albania**
	Kola H, Diku A & Zeneli G
14.30 – 14.50	**A comparative review of coppice and high forest protective functions in a Romanian and European prospective**
	Pacurar VD
14.50 – 15.10	**Coppiced downy birch on cutaway peatlands: heterotrophic soil respiration and C sequestration in tree biomass**
	Hytönen J & Aro L
15.10 – 15.40	COFFEE BREAK

SESSION 4

Chairperson: Ir. Kris Vanderkerkhove, Research Institute for Nature and Forest (INBO)

15.40 – 16.00	**Conservation of coppice in relation in Natura 2000: hierarchies of rarity and protection**
	Buckley P & Mills J
16.00 – 16.20	**The significance of coppice woodlands in the protection of cultural heritage**
	Jarman R & Chambers FM
16.20 – 16.40	**Analysis of a scientific literature review on “coppice in Europe” for the period 1975-2015**
	Schneberger J & Dohrenbusch A
16.40 – 17.00	**Black locust-dominated coppice forests and continental sand dunes, a happy symbiosis in the Valea lui Mihai-Carei Plain (NW of Romania)**
	Nicolescu V-N & Hernea C
17.00 – 17.10	CLOSING REMARKS
19.00 – …	CONFERENCE DINNER

Friday 17 June 2016

The meeting point for the excursion is located in front of Antwerp's central train station main entrance (address: Koningin Astridplein). This is also in front of the main entrance to the Zoo of Antwerp.

8.00 – 9.00	Bus drive
9.00 – 10.30	STOP 1: MUIZENBOS (Ranst, Antwerp)
10.30 – 11.30	Bus drive
11.30 – 12.30	STOP 2A: SHORT-ROTATION COPPICE PLANTATION (Lochristi, East Flanders)
12.30 – 12.45	Bus drive
12.45 – 13.15	Lunch
13.15 – 14.15	STOP 2B: GROUP MOUTON (Lochristi, East Flanders)
14.15 – 15.00	Bus drive
15.00 – 16.30	STOP 3: BOS 'T ENAME (Oudenaarde, East Flanders)
16.30 – 18.00	Bus drive
17.00	Optional stop at Ghent Sint-Pieters train station
18.00	Arrival to Antwerp central train station

! Due to Belgium's reputation in traffic jams we cannot promise to arrive in Antwerp at 18h00. It is therefore advisable to schedule enough time for your departure from Antwerp. In case we expect too much delay, however, we can drop people at the train station in Ghent after the last stop.

Conference information

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For more information

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CONFERENCE DINNER @ Grand Café De Rooden Hoed

De Rooden Hoed (English: The Red Hat) has a rich history going back to the middle of the 18th century. Already then, this was a meeting point where travellers and traders stopped to eat, drink and rest. Even their horses were taken care of, traded or sold here. The main trade routes continued to Brussels, Leuven and Tienen.

Several stories depict the origin of this establishment's name: either it got its name from one of the cathedral's vicars, who would walk around the neighbourhood, dressed with a red hat. Another one refers to the fire red tile floor that is still there nowadays. The most likely explanation however, would be the red tiled roof, which acted as an easy reference in times when houses were not numbered yet. Rumour goes that Quinten Matsys would have lived at this address…

For more information

www.deroodenhoed.be/

Address

Oude Koornmarkt 25
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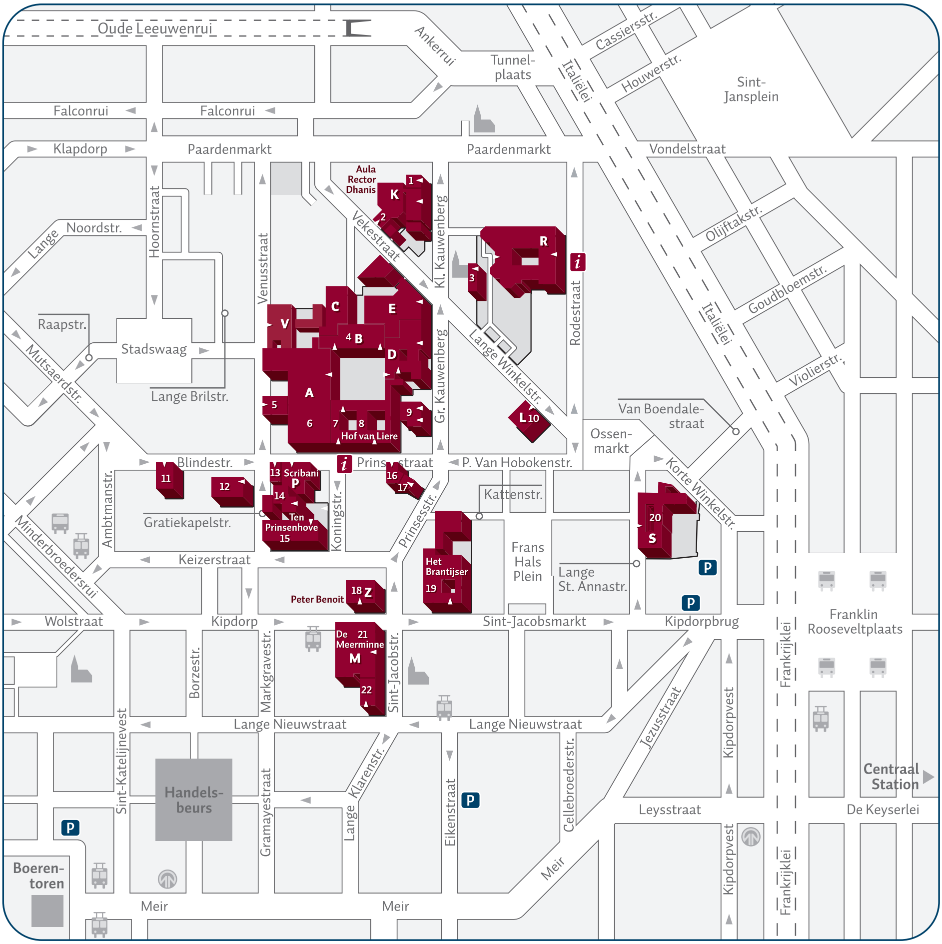
THE CONFERENCE VENUE Hof van Liere (nr. 7 on the map)



City Campus

i Reception

A Building A - Prinsstraat 13
B Building B - Prinsstraat 13
C Building C - Prinsstraat 13
D Building D - Grote Kauwenberg 18
E Agora / Sports centre - Grote Kauwenberg 2
K Aula Rector Dhanis - Kleine Kauwenberg 14
L Building L - Lange Winkelstraat 40
M De Meerminne - Sint-Jacobstraat 2
P Scribani - Prinsstraat 10
R Building R - Rodestraat 14
S Grauwzusters - Lange Sint-Annastraat 7
V Building V - Venusstraat 23
Z Peter Benoit - Kipdorp 61

1 **Linguapolis (secretary's office)** - Kleine Kauwenberg 12
2 **Central supply room** - Vekestraat 33
3 **Annexe** - Rodestraat 14
4 **Research centre Commodity Flows** - Prinsstraat 13
5 **Institute of Education and Information Sciences/Moral Consultant/Prevention Service** - Venusstraat 35
6 **Library** - Prinsstraat 13
7 **Hof van Liere** - Prinsstraat 13
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9 **Ruusbroec association** - Grote Kauwenberg 32-34
10 **Centre for Dutch Language and Speech** - Lange Winkelstraat 40
11 **Study centre Open University/Centrum WeST/ Centre for Law and Cosmopolitan Values** - Blindestraat 14
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13 **Linguapolis** - Prinsstraat 8
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21 **OASeS** - Sint-Jacobstraat 2
22 **Centre for Migration and Intercultural Studies/Research centre Equal Opportunities** - Lange Nieuwstraat 55

Universiteit Antwerpen

Lectures - Abstracts

Birds and forest structure

Shelley A. Hinsley[1, @] & Robert J. Fuller[2, 3]

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In Europe, forest structure, rather than floristics, is usually the major determinant of bird community composition and abundance. This is probably because most woodland contains a mix of tree and shrub species, and most birds use a range of species, making it difficult to detect definitive relationships. In contrast, for example, the bird fauna of woods with and without a well-developed shrub layer are clearly different.

Although structure changes enormously over the lifetime of a wood, much occurs within the first 20-30 years, while the following stages of maturity develop more slowly and may last for centuries. Thus, the habitat of bird species associated with early successional stages is relatively ephemeral compared to that of the birds of mature forest. Forest bird diversity therefore benefits from structural features (e.g. tree fall, wet or rocky ground, steep slopes) generating gaps and edges characterized by younger, lower and usually denser growth.

Coppice management creates an artificial patchwork of younger growth stages, offering habitat opportunities to early successional species, whilst the retention of standard trees maintains some resources associated with mature woodland. However, such structures do not suit some species; the relative proportions of coppice and mature woodland need to be considered. We will illustrate these aspects of birds and structure and discuss other modifying factors such as density of standards, coupe size, deer browsing and tree disease, especially, ash dieback. We will also demonstrate the application of airborne LiDAR, an optical remote sensing technique, facilitating measurement of woodland canopy height and structure.

Keywords

canopy height, coppice, LiDAR, shrub layer, woodland birds, woodland structure

Microhabitats in thinned aged oak coppiced forests in Luxembourg

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Coppice is an abandoned management system in Middle Europe. But there is still a large area of (aged) coppice stands. High potentials for nature conservation exist in many places. In Luxembourg still 10.250 hectares of coppice can be found. Most of them are not managed as coppice anymore. The remaining stands were managed by thinning for conversion or were abandoned since the last rotation.

The aim of this study was to quantify the distribution of microhabitats and to identify relationships between microhabitat frequency and conversion measures. Therefore micro-habitats were inventoried at 1175 trees growing in five 80 year old former coppice stands thinned in three different intensities: (i) no thinning, (ii) slight thinning, (iii) intense thinning.

We observed a considerable number of structures along the tree boles, of high ecological value like woodpecker cavities, mould cavities, branch holes, bore holes, bark loss, cracks and scars, bark pockets and many more. Furthermore, epiphytes were recorded as well as bird nests. Over all 1617 structures were recorded. The growth characteristic "single tree" or tree from a "stool with multiple stems" had no influence on quantity of microhabitats. Some microhabitats occur only at the typical coppice stool. These structures are mainly holes which could be potential habitats for small mammals. We found that microhabitats evolving along the tree boles (holes, cavities, pockets, cracks) are more frequently in non-thinned than in thinned stands.

Keywords

microhabitats, aged coppiced forests, structures, oak, thinning

The legacy of coppicing: the present reflects the past

Jana Müllerová[1, @], Jan Altman[2], Jiří Doležal[2], Petr Dörner[1], Radim Hédl[3], Vít Pejcha[2] & Péter Szabó[3]

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Periodical coppice harvests with short cycles in the past had a profound effect not only on the herbaceous layer but also on trees left in the forest to grow mature - so called standards. Even though coppice management lost its importance during the 19th and mainly 20th century and was abandoned in Central European forests, its footprints can still be traced in the forest ecosystem. In this presentation, we aim to reconstruct the historical development of coppicing combining several disciplines: history, dendroecology and vegetation ecology.

We analysed historical records on forest management (changes in coppice cycle and its gradual abandonment) at two former coppice-with-standards forest areas in the Czech Republic. We also examined the legacy of such practices in current forests, i.e. tree growth dynamics detected via dendroecology. Throughout history, coppicing showed significant changes in cycle length and standard density. The process of abandonement, similar at both sites, was gradual and apparently haphazard with no significant infuence by site conditions, such as slope or site productivity. Growth releases detected from the tree rings of mature oak standards were successfuly linked to the archival records to detect coppice events. Dendroecology proved to be a promising method to reconstruct the past management practices, although detection sucess depended on neighbouring competition, reflecting natural conditions at the site. Thorough knowledge of coppice history can serve as an input for current attempts of coppice reintroduction for conservation purposes.

Keywords

archival records, coppice-with-standards, dendrochronology, history, oak standards, tree ring analysis

Ecosystem services provided by ground vegetation in three years old willow SRC

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Short rotation plantations on agricultural lands are appropriate not only for biomass and bioenergy production and additionally gives other various ecosystem services. SRC contains high richness of plant species which is important for honey bees and other pollinators, as well, legumes are important for soil quality improvement as N fixing plant, seeds or plants is food for birds. Although the plant composition depends largely on the previous crop, land use and management practices. Higher ground vegetation cover and number of species are at the edges than in the inside of plantations. Investigation of ground vegetation and soil analyse were conducted for mix-stand of seven commercial willow SRC clones in Central Latvia, Skrīveri municipality. The objective of this study was to evaluate the influence of previous crop, light availability, plantation age, and soil properties on ground vegetation species composition in three years old short rotation willow coppice. Plantations consist of various willow clones, planted in rows. Weed control was carried out during the first year of plantation establishment. The qualitative and quantitative proportion of species, including species significant for bee-keeping and percentage cover as well the mean Ellenberg indicator values were calculated. In total, 64 vascular plant species and two tree species were found in the ground vegetation layer of willow coppice. Perennial plants (54 species) dominate in plantations and make up about 81 percent of the total of species in plantations, annuals – eight species, biennials – four species.

Keywords

ground vegetation, SRC plantations, agroforestry, willows

Coppice forest and invasive species: the case of *Ailanthus altissima*, a successful survivor in Eastern and Central Europe

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The *Ailanthus* Genus (Simaroubaceae Family, *Sapindales* Order) comprises several species distributed in India and in the Far East, its only temperate zone representative being the Tree of Heaven (*Ailanthus altissima*). In the Tertiary, it was a native species in Central Europe. It tolerates bad conditions of industrial zones, as well as drought, poor soils, acid and slightly salty soils. Its occurance was first recorded in Hungary in 1841-1843, in Romania in 1866 (Transylvania) and 1871 (Moldova) and in both Slovakia and the Czech Republic - in 1874. *A. altissima* is an excellent survivor, its seeds preserving their germination ability for a long time. It is allelopathic by roots, but also seeds and bark inhibit growth of other seedlings, accumulate nitrogen in the soil, its expected life span being up to 150 years. Due to its successful vegetative propagation by adventitious buds, it is a good competitor in coppice forests. By seeds, it quickly occupies new areas, the open areas of oak coppice forests (after logging etc.) being occupied by maximum dominance in one or two years. Our case study includes the analysis of changes in biodiversity (phytocoenological relevees recorded in two weeks periods) evaluated by multivariate methods (Canoco 4.5 and CanoDraw 4) and effects of physical removal of above-ground-biomass of *A. altissima*. Its distribution is difficult to limit (bark removal, spraying etc.) and besides the above mentioned, the species competitive natural regeneration potential and rapid growth could be important driving factors of its invasiveness.

Keywords

coppice forests, vegetative propagation, allelopathy, invasiveness

Ecosystem services from coppiced forests: the need to understand functional trait distributions in an era of environmental change and in light of land-use legacies

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Forests, including those that are coppiced, provide important ecosystem services, such as fire wood production, erosion protection, habitat for pollinators and recreational value. These services are partly underlain by biodiversity, especially that found in the understorey plant layer. Evidence suggests the relationships between biodiversity and ecosystem services depends, in part, upon the functional trait distributions that describe the plant community. However, the responses of fundamental traits, such as specific leaf area, height and seed mass, across multiple environmental gradients in space and time are poorly understood. Here, using resurvey data from forest understorey plant communities across land use, light availability, nitrogen deposition and climatic gradients, in conjunction with trait values from databases, we elucidate the effects of environmental changes on the aforementioned functional trait parameters including community weighted mean, range and dispersion. We highlight arguments, and present evidence, for why land-use legacies need considering in this endeavour, due especially to their influence on plant community processes of dispersal and selection. We discuss the importance of accounting for intraspecific trait variation. In so doing, we suggest that a more complete understanding of ecosystem service delivery in coppiced forests requires elucidation of functional trait responses to land-use legacies and contemporary environmental changes.

Keywords

climate change, forest management, land use history, nitrogen deposition, plant functional traits, resurveys, understorey communities

Ecosystem services in coppice – importance and prospects as a strategic basis for effective forest management and human well-being

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The forests cover 37.4% of the territory of Bulgaria thus making the supply of ecosystem services by these ecosystems very important in future perspectives. Some key challenges for efficient management of coppice forests to improve the provisioning, regulating and cultural ecosystem services are reviewed. The process of assessment and prioritization of forest ecosystem services at national level performed during the recent years was followed. Advantages in supply of ecosystems services by coppice forests were traced out and discussed. The optimal ratio supply/demand of ecosystem services was analyzed. The legislative initiatives ensuring basis and conditions for further practical implementation of the concept for sustainable and socially-oriented use of forest ecosystem services are mentioned.

Keywords

coppice ecosystems, ecosystem services, supply/demand, sustainable forest management, societal benefits

Root reinforcement dynamics in coppice woodlands and their effect on shallow landslides: a review

Chiara Vergani[1, @], Massimiliano Schwarz[1], Filippo Giadrossich[2], Marco Conedera[3], Peter Buckley[4], Pietro Piussi[5], Fabio Salbitano[5] & Raffaella Lovreglio[2]

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In mountain regions, forests play an important role in the mitigation of the risk due to natural hazards such as landslides, rockfall, floods and avalanches. In these areas the amount given over to protection forest cover can account for up to 50% of the total forest area. Conifer species usually provide a protective effect at higher altitude, while at lower altitude broadleaf species are dominant. Especially in the southern side of the Alps, these forest were often managed as coppice systems.

The high stem density of coppice stands, the rapid growth and the permanence of the root system in the soil can be considered as assets in terms of protective function. However, these considerations are poorly researched and there is generally a lack of studies investigating the suitability of coppice as protection forests. The issue is relevant considering that many coppice stands in mountain regions have become uneconomic and are abandoned and overaged. How to manage (or not manage) these forest stands is a key question for practitioners.

In this contribution we analyze the implications of coppice management for slope stability and in particular shallow landslides, focusing on root reinforcement, the main mechanism by which vegetation can reinforce slopes. We summarize available studies concerning root distribution and dynamics in coppice stands to formulate hypotheses about their contribution in terms of root reinforcement. Finally we highlight the lack of knowledge and the further steps needed to properly evaluate the effectiveness of the coppice system in protecting against shallow landslides.

Keywords

protection forests, landslides, root reinforcement, coppice

Coppicing for watershed protection: the case of Ulza Basin in Albania

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Historically, coppice forests covered a considerable area of Albania and provided fuel wood, timber, fodder, grazing, leaf litter as fertilizer supply for centuries. Yet, a high share of population depends on coppice forest resources for domestic supply and still makes extensive use of firewood for cooking and space heating. Human activities, associated with various other factors (climate, physical and chemical composition of rocks and tectonics) have led to a high degree of erosion. In this paper we report the role of coppice in erosion control and its influence on water management in the Ulza watershed in Albania, which is covered by oak coppice forest in more than 60% of the area. The Ulza watershed area feeds the Ulza Hydro Power Plant (HPP). The formed hydro lake serves as a head source for the Mat river flow. The results showed that land cover by coppice forests is important in reducing erosion. This is especially important to forests on high slopes >20%. The forest practices should stimulate a diversified forest structure with undergrowth. In cases of coppice forests and when clear cut is needed it can only be considered under good forest circumstances. In such cases, the coppice can be in belts along the contours, to always have a forest belt on the field that serves as retention of water and soil. The benefits of sustainable coppice management are assessed on downstream users and their willingness to contribute to securing such services. This should result in suggested potential systems for Payment for Environmental Services (PES).

Keywords

basin, carbon sequestration, clear cut, HPP, oak coppice

A comparative review of coppice and high forest protective functions in a Romanian and European prospective

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The protective services provided by forest vegetation are presently gaining an increasing recognition, being worldwide considered at least as important as the wood production function. The paper presents a comparative analysis of the protective functions provided by forest ecosystems, managed in the two alternative systems: coppice and high forest. The main focus is on the water regulation, erosion and landslides control, analysing the factors affecting the associated protective efficiency such as: canopy closure and leaf area (affecting interception), ground status and litter amount (influencing infiltration and runoff), root system structure (important for the water budget and landslide stability, by anchoring and physiological "drainage") etc. There are also considered the protective functions disturbances related to the specific management operations, outlining the coppice peculiarities with less "invasive" (the transport of small wood pieces requiring light machinery or only horse power) but more frequent interventions.

In addition to the literature review, the paper synthesises the author's opinions regarding the present opportunities and challenges for coppice woods in Romania, in relation to their potential ecological functions. These could provide land and water protection services, not as a substitute but in addition to the high forests (managed for their protective services as a priority, being included in the first functional group, according to the Romanian zoning system), especially on the small farm estates in steep terrain regions and on riparian areas.

Keywords

services, water, erosion, landslides, management, structure, efficiency

Coppiced downy birch on cutaway peatlands: heterotrophic soil respiration and C sequestration in tree biomass

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Fuel peat accounts for 5-7% of the total energy consumption in Finland. Total peat harvesting area is approx. 70,000 ha. About 2,500 ha of cutaway areas are released from production each year, currently totalling to 40,000 ha. Cutaway peatlands can be a significant source of atmospheric carbon. Therefore, their rapid reuse is recommended. The production of bioenergy can be continued by establishment of coppiced energy biomass plantations with woody species binding also atmospheric carbon.

We studied biomass production and carbon sequestration of dense coppiced downy birch stands growing on cutaway peatlands. The clearcut birch stand was regenerated by coppicing and sample plots were either left unfertilized or fertilized with PK or wood ash. Coppiced plots were grown for 21 years. Carbon sequestered in the biomass was compared with heterotrophic soil respiration measured in the same area by Mäkiranta et al. (2007).

The mean annual increment (leafless above-ground) of the 21-year-old fertilized stands was 4.1–4.6 Mg/ha. On average 493 kg of carbon was bound in one ton of leafless biomass. The annual soil CO_2 emission due to decomposition of the residual peat layer was 381 g CO_2-C m^{-2} a^{-1} on average while the coppiced and fertilized birch stands had bound 200–230 g C m^2 a^{-1} in their above-ground biomass. If also the root biomass (ca. 30% of above-ground biomass) and C bound in litter is also considered birch coppice would considerably compensate for the high CO_2 emission of cutaway peat.

Keywords

Betula pubescens, coppice, ecosystem services, C sequestration

Conservation of coppice in relation to Natura 2000: hierarchies of rarity and protection

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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 general habitat preferences of more than 1000 species listed in Annexes of the Directives. Forest habitats support many of these taxa, but relatively few are specific to those managed as coppice. In comparison, European red lists, both published and in preparation, contain many more species drawn from a wider range of different groups, whereas foresters tend to use much a narrower suite of species when setting practical conservation targets.

Achieving the objective of 'favourable' conservation status, as required by the Directives, applies equally to both 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 'indicator' species from a range of different plant and animal species could also be used in making assessments. Whereas representing coppice as a valid type of woodland with a long anthropogenic history is important, selecting a silviculture that mimics some aspects of the coppice rotation may achieve wider biodiversity benefits.

Keywords

natura 2000, annex species, forest habitat type, indicator species, coppice, silvicultural system

The significance of coppice woodlands in the protection of cultural heritage

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Coppicing as a form of woodland and tree management has been practised in Britain during and since the Bronze Age (c. 3500 BC). The British landscape has been formed by the clearance of woodland for farming and other land uses and by the retention, creation and management of woodland, creating notable regional landscapes. Coppice woodlands in some regions have their roots (literally) in the original 'wildwood': they retain some of the natural features of the primary woodland ecosystems, with human activities superimposed upon or embedded within or even congruent with them. Repetitive coppice management over millennia has sustained certain aspects of the wildwood, whilst creating specific types of physical, biological and cultural features. In cultural heritage terms, coppice woodlands are rich in 'ecofacts' (natural aspects modified or used by humans) and 'artefacts' (objects made by humans). Coppice woodlands are possibly the richest kind of land use when viewed in these terms: their protection and continued management is essential to perpetuate their rich diversity of 'ecofacts' and 'artefacts', in England and across Europe.

This paper presents some examples of coppiced woodland (including pollarded and shredded tree) landscapes found in England and makes the case for their conservation and continued productive management. Special attention is given to sweet chestnut (*Castanea sativa*) woods, following current research on the origins and antiquity of sweet chestnut in England compared with European sweet chestnut populations.

Keywords

cultural heritage, ecofact, artefact, sweet chestnut, *Castanea sativa*, coppice, pollard

Analysis of a scientific literature review on "coppice in Europe" for the period 1975-2015

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The production of woody biomass plays an increasing role in the energy sector in Europe. Thus, it is not alone useful to establish short rotation plantations with fast growing tree species on former agricultural land, for some European countries it seems also attractive to reactivate the historical forest management concept coppice for existing forests.

In a literature study on the base of more than 150 scientific and professional journals about 400 articles were selected with „coppice" and „short rotation coppice" related titles published in European countries within the period 1975 to 2015. The articles where grouped by five-year-periods and the main topics biology and ecology, silviculture and management, nature conservation, yield and growth potential, economic aspects and forest history. As an additional selection criteria the countries and regions have been identified, where these studies were performed. It is evident that the number of publications has increased significantly within the observed period. This development during the last 20 years is much stronger for the short rotation coppice than for the traditional coppice system. Specific country interests could also be observed. There are countries mainly dealing with yield and silviculture concepts while other countries are focussing their interest in aspects on nature conservation and other not economic functions.

Keywords

literature, review, coppice, Europe, journals

Black locust-dominated coppice forests and continental sand dunes, a happy symbiosis in the Valea lui Mihai-Carei Plain (NW of Romania)

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The Valea lui Mihai-Carei Plain is located in the NW of our country (along the Hungarian-Romanian border) and covers about 27,000 ha. The area has a temperate-continental climate (C.f.b.x. type according to Köppen), with a mean annual temperature of 10 °C, and a mean annual rainfall of 590 mm. The landforms are continental sand dunes (ca. 5,000 ha mobile and semi-mobile), of river and wind origin, with a SW-NE and NW-SE orientation. They are 10-15 m height and their elevation ranges between 140 and 160 m.

The soils evolving from such sand deposits are psamosoils, with a low fertility and nutrient content (N, P, and K). The soil texture is light (85-90% sand, mostly fine), its reaction is moderately acid to neutral (pH between 5 and 7) and the maximum fraction of humus reaches only 1%.

Under such harsh ecological conditions, characterizing the forest steppe zone of vegetation, black locust (*Robinia pseudoacacia* L.) is the dominant tree species. It was introduced in the area ca. 1890, replacing low-productive tree species such as pedunculate oak, small-leaved linden, field maple, and field elm, in order to prevent wind erosion and sand dune movement as well as produce firewood. The species has been subsequently treated as low coppice, with a rotation of 20-30 years depending on yield class, and covers nowadays ca. 90% of forest area (10-12% of overall plain area).

The best results in terms of both sand dune fixation and wood production have been achieved in the last 40-50 years, since using mixtures with black cherry (*Prunus serotina* Ehrh.), an invasive tree species able to compete with black locust above- and belowground and forming a dense understorey after regenerating from seed, stump sprouts and root suckers.

Keywords

continental sand dunes, NW of Romania, black locust, black cherry, coppice forests

Posters - Abstracts

Willow short rotation coppice – local natural populations versus selected commercial clones in various site conditions in Western Romania

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The present-day increasing demands for biomass, both in terms of quantity and quality require the existence of intensive plantations with high biomass production, resistance to pests and diseases and good adaptability to various local conditions. Energy willows (selected hybrids/clones of *Salix* sp. for biomass production) show high potential in this respect but local provenances of *Salix* sp. have not been tested so far in comparative experiments in Western Romania. Observations and measurements were performed in the studied experimental plots in specific soil potential conditions (typical plain region with moderately salty soil and hilly region with alluvial soil) to identify and address aspects related to specific pests and diseases in the energy willows plantations. The resistance to the parasites (defoliators and mites) attack was estimated at the age of one (2012) and three (2014) at individuals originating from cuttings with definite origin. Some of the existing commercial willow clones with outstanding results regarding the biomass production show adaptability difficulties and low resistance to the local pests and diseases attack, but the potential extension of the energy willow plantations could be increased in this respect, by including the interspecific diversity of *Salix* sp local provenances.

Keywords

biomass production, pest and diseases resistance, selected willow clones, local natural populations, interspecific diversity

Quantifying understorey responses to overstorey opening to better predict tree regeneration success

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Herbaceous understorey communities have the potential to exert a strong influence on the dynamics of forest tree regeneration, and thus forest overstorey composition. Following a disturbance, such as felling of overstorey trees, high light availability may favour the development of opportunistic, fast-growing herbaceous and woody species which compete for resources at the expense of tree seedlings. This leads to reduced growth and survival of the offspring, and in the worst case complete failure of tree regeneration. A better insight in the responses of understorey plant communities to altered resource fluxes is therefore crucial to better understand and predict forest tree regeneration.

Building on Verheyen et al. (2012) their 'nitrogen time bomb' hypothesis, we will: (1) analyse which species respond explosively to overstorey opening, especially in high N deposition regions, and their effect on tree seedlings, (2) investigate how these species persist under closed canopies and (3) predict understorey vegetation dynamics after canopy opening.

Hereto, we will use the forestREplot-database (http://www.forestreplot.ugent.be/), a vegetation resurvey database currently containing 56 datasets and more than 3000 plot-pairs. Many of these resurveys were performed in European temperate forests where traditional coppice or coppice-with-standards management has been abandoned over the past decades. Variation in the abundance of the studied species will be analysed along a gradient in observed overstorey openness and other varying environmental factors (e.g. N deposition, climate) (i.e. gradients across space). Furthermore, we will look at patterns of change between the old and recent surveys (i.e. changes across time).

Keywords

tree regeneration, competition, light, overstorey opening, understorey vegetation

Coppice forests as an alternative to shrubland areas in Portugal

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Portugal is a country with a high forest aptitude, inasmuch that about 35% of its territory is allocated to forest stands. Three dominant species covering 72% of forest area are: *Eucalyptus globulus* (812 thousand ha; 26%), *Quercus suber* (737 thousand ha; 23%) and *Pinus pinaster* (714 thousand ha; 23%). Eucalypt and pine high forests are growing mainly for the paper industry, plywood and roundwood and *Quercus suber* high forests are manly for cork production. These three species are distributed almost exclusively by distinct areas making the diversification of forest cover a huge priority for the whole country. In this context, high relevance should be given to coppicing of traditional hardwood, dominant in the past 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.) and willow (*Salix* spp.). This strategy would enhance biodiversity by strengthening the resilience of ecosystems against biotic and abiotic agents and also would contribute to diversify local forest economy by allowing or reinforcing small and medium industries related to firewood, poles, charcoal, raw material or basketry and cooperage. Moreover, considering that additional 1 500 157 ha are currently occupied by shrubland the partial conversion of this area into coppice forests would also contribute for the reduction of the risk of wildfires. In this study, we make an analysis to assess the areas with potential to introduce coppice forests as well the type of species ecologically adapted to those areas.

Keywords

coppice, biodiversity, landcover, shrubland, *Quercus* spp., *Castanea sativa*

Conversion of holm oak coppices (*Quercus ilex* L.) into high forest by application of shelterwood principles

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Forest ecosystems are becoming more vulnerable under unfavourable biotic and abiotic influences so the necessity of their preservation, enhancement of their resistance, ecological value and ecosystem services is more pronounced. Importance of the above especially refers to coppice forests. Even though coppice management is among the oldest silvicultural systems which has already been applied for centuries, up to recently it hasn't drawn too much attention. The main reason is its low productivity and profitability, which partially arises from poor state of coppices (e. g. overaged stumps, shift towards less valuable tree species, etc.) and lack of modern silvicultural concepts. Area of forests and forest land in the Republic of Croatia amounts to 2.688.687 ha, while share of coppices sums up to 533.828 ha (19,8%). Due to high share and potential of these forests in ecological, as well as in economic sense, it is desirable to convert them to higher/high silvicultural form by silvicultural activities.

Research provides concrete results of indirect conversion technique by application of shelterwood principles. During systematic long term research basic structure elements, soil condition, crown coverage together with emergence and number of young generation have been monitored. Due to strong shoot power of Holm oak and Laurel from stump and too dense shrub vegetation emergence and survival of young Holm oak generation from seeds demands efficient and regular tending with protection of regeneration area from game. Through ten year regeneration period, mast years monitoring and correct and adequate tending, quality young high stand of Holm oak has been obtained.

Keywords

forest ecosystems, conversion, coppices, young generation, natural regeneration, shelterwood

Drought effects on biodiversity of coppice forests in central Anatolia, Turkey

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Turkey contains very different phytogeographic regions (the Euro-Siberian, Irano-Turanian and Mediterranean). Due to climate and geographic diversity, there are many species of oak (*Quercus*) than other western Palaearctic country. Also, oaks dominate woodlands and shrublands in each of these, and in different altitudinal belts. *Q. pubescens* or *Q. cerris* is dominant trees in deciduous oak woodlands and shrublands with frequently both of them co-occurring on Central Anatolian in Turkey. As well as, much rarer are *Q. petraea* subsp. iberica, *Q. ithaburensis* subsp. macrolepis, *Q. trojana*, *Castanea sativa* and *Ostrya carpinifolia*. The shrubs represent wide spread Eurasian or East Sub-Mediterranean species such as *Juniperus oxycedrus*, *Rosa canina* and *Rubus canescens*.

In recent year's climatic change and silvicultural management affected coppice forests. Moreover, there has been a reduction in the water levels of the region. Thus, not only amount of coppice forests but also its species was changed. As well as new plants need to be introduced (from seed) to replace stumps those have lost their vigour after many coppicing cycles.

The goal of this study is to determine the drought and silvicultural effects on crown dieback, branch mortality and chancing biodiversity on the coppice forests of Central Anatolia in Turkey. A systematic sampling design will chose for this study. All type of woody vegetation will record for all sampling plots. All the statistical analyses will perform using the statistic program SPSS and PC-Ord V.6 Program, final choice of number of groups by means of the indicator species analysis.

Keywords

biodiversity, drought, coppice, landscape

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

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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.

Contribution to the dendrologic diversity in the forest of National Park "Fruska Gora" in Serbia

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The paper presents results of the dendrologic diversity study in the National Park "Fruska Gora" in Serbia, region of Vojvodina, which is, according to IUCN criteria classified in category V protection, and occupies an area of 22,518 ha. Dominantly are represented coppice forests with 80.3%: preserved forests with 70.5%, diluted has 8.3%, and devastated forests, only 1.5%.

In the forests of the National Park is expressed the diversity of forest vegetation since it is allocated 35 types of forests, which belong to the 65 eco-vegetation units (Jović N. et al., (1985-1988). There is pronounced the diversity of trees and shurbs, because there are registred 54 species of trees, from which 41 are autochthonous species. Silver lime (*Tilia tomentosa* Moench.), which is coppice origin, is dominant with 37,6% by volume, and after that the oaks are most represented: sessile oak (*Quercus petraea* Liebl /Matt./.) with 18.8% and Turkey oak (*Quercus cerris* L.) with 11.1%. Other native tree species such as beech (*Fagus sylvatica* ssp. *moesiaca* / Mally / Szafer), hornbeam (*Carpinus betulus* L.), common oak (*Quercus robur* L.), pubescent oak (*Quercus pubescens* Willd.) and black ash (*Fraxinus ornus* L.) are represented less than 10%, and all others species less than 1%. Diversity is characterized by the presence of noble deciduous trees and numerous shrub species. During the development these forests were under different anthropogenic influence so there is a large number of allochthonous species of trees, among which is the most common black locust (*Robinia pseudoacacia* L.).

Keywords

diversity of trees and shrubs, coppice forests, Fruska Gora, Serbia

Ecosystem services and tree growth on Hybrid aspen (*Populus tremula* x *tremuloides*) plantings under different fertilization and planting schemes

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During the study height and diameter of aspen clone No 4 and 28 (*Populus tremula* x *tremuloides*) after fourth year rotation cycle was measured. Both clones were planted in three different planting schemes - 5 by 2.5 m as agroforestry system with reed canary grass, *Festulolium* and *Galega*; 3 by 3 m as agroforestry system with grasses and 2 by 2 m as short rotation coppice (SRC). Sampling plots were fertilized with ash (6 Tdmha), sludge (10 Tdmha) and biogas fermentation residues (30 Tdmha).

Best diameter of root collar and height results at the end of fourth growth season shoved hybrid aspen clone number 4, in planting scheme 2 by 2 m, where fertilization was done with fermentation residues. In all planting schemes both tested hybrid aspen clones (No 4 and 28) better height and diameter results shoved in sampling plots where fertilization with fermentation residues was done.

Mushroom *Leccino aurantiaca* appeared in Hybrid aspen 2 by 2 m sampling plots during second growing season. Higher yields of mushrooms were in plots fertilized with waste water sludge and biogas fermentation residues. The content of copper (Cu), lead (Pb), chromium (Cr), cadmium (Cd) arsenic (As) and zink (Zn) in *Leccino aurantiaca* were determined. Results showed that application of different types of fertilization - sludge, ash and biogas fermentation residues increases content of the tested heavy metals in mushrooms compared with the control samples but does no overreach threshold values in national legislations and EU directive No. 2001/22/EC.

Keywords

SRC fertilization, mushrooms in SRC, SRC plantations, agroforestry, hybrid aspen

Ecological dynamics, vegetation and soil in a mesophilic European Hophornbeam stand during coppice rotation in central-northern Apennines (Italy)

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This study analyzes ecological dynamics of six forest management units located on Mt. Nerone (Central-Northern Apennines) that have been managed as coppices for more than three centuries to investigate, by means of a synchronic approach, the effects of coppicing practice on the forest ecosystem recovery process and the evolution of its various components during the rotation. In particular, the study analyses dendrometric, pedologic and floristic-vegetational data that characterize the increasing ages of the forest management units, delineating trends and dynamics. Our results show that, although from the phytosociological point of view all the stands belong to the same association (*Scutellario columnae-Ostryetum carpinifoliae*), the highest floristic richness and ecological diversification are realized in the early stages after the cut, because of sudden uncovering creates excellent conditions for the germination of the species found in the soil seed bank. Moreover, the conditions of edge are amplified, while maintaining suitable conditions for the nemoral flora in the vicinities of the stumps. Afterwards, with the closure of the canopy, decreased number of species and ecological homogenization were observed and they reached maximum 20th years after the cut.

Further the situation tends to change due to the decrease in coverage mainly due to the increasing number of gaps. With the overrun of the rotation, the number of species rises again, but not the quality of vegetation. We conclude that the analyzed stands appear very important for their ecologic characteristics, they aren't particularly affected by the coppicing practice, but rather dependent on it for their maintenance.

Keywords

European hophornbeam, coppice, stand rotation, flora, vegetation, soil, biodiversity

Estimating spatially explicit atmospheric emissions from wildfires in a coppice ecosystem of Greece

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Emissions from biomass burning include a wide range of gaseous compounds and particles that contribute significantly to the atmospheric budgets at local, regional, and even global scale. The aim of this study was to spatially explicit estimate the fire impact on air quality downwind of a potentially burning coppice ecosystem in Northern Greece. The approach was built on classical methodologies of high resolution fuel-map based emission estimation coupled with landscape fire behavior simulation modeling. Site-specific fuel models and fuel loads were created and estimated by measuring in the field several fuel parameters in representative natural fuel complexes, while the spatial extent of the fuel types was determined using a high-resolution imagery. Expected fire size and burnt area were predicted by using The Minimum Travel Time (MTT) algorithm, as it is embedded in FlamMap software. Wildfire emissions of carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), nitrogen oxide, (NOx), volatile organic compounds (VOC), sulphur dioxide (SO2) and particulate matter (PM2.5 and PM10) were considered in this study. The results showed that fires in coppice ecosystems have been found to increase the ambient level of CO, NOx, and particulate matter. Emissions from biomass burning are needed to account for the importance of fire in coppice ecosystems in the carbon cycle and wildfire and carbon feedbacks at regional level.

Keywords

wildfire emissions, landscape fire behavior modeling, coppice ecosystems, Greece

Sustainability and durability of tabor oak park-forest in the presence of wildfires and grazing: to resprout or not?

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Tabor Oak (Quercus ithaburensis) Park-Forest is a multifunctional ecosystem, benefiting cattle-grazing, silvi-agriculture, conservation and tourism needs. It is a fire-prone ecosystem with high frequencies of fire eruptions that cause severe damage to its multi-functionality. We have focused on re-sprouting as the main mechanism that allow forest recovery and sustainability in the presence of fire and grazing. We hypothesize that the main factors affecting forest recovery from fire are fire severity, tree developmental stage prior to fire eruption, and their interaction. Furthermore, the developmental stage of the tree might determine its ability to escape fire or to re-sprout after fire; however the degree of fire severity can change the response of the tree. Thus, we further hypothesize that the age structure of the forest is an important factor determining the system resilience to fire. Grazing, on one hand, reduce fire risk, but on other hand, may inhibit resprouting similarly to fire. Results demonstrate that resprouting increases with tree developmental stage; however, in the high diameter class (> 40 cm), there is a decrease in resprouting. Although it is common that the ability to resprout increases with fire severity, it was found that fire severity can only partially explain the ability to resprout (~ 40%). The ability to resprout increases with the increase in the number of trunks per individual tree. It is thus recommended to design the tree with multiple trunks to ensure forest regeneration following wildfires. Grazing removal after fire may have some benefits for recovery; however, fire severity and the developmental stage of trees are the main factors that determine forest recovery from fire.

Keywords

Quercus ithaburensis, resprouting, forest sustainability, fire, cattle grazing

Silvicultural assessment of natural coppice forests: a case study relating to coppice management by rural communities in the Ukrainian Subcarpathians

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Natural coppice forests in the Ukrainian Subcarpathians occupies a significant ecological niche that are of great social and economic value. They are mostly divided into two types regarding the site conditions: (1) along small rivers with temporary wet soils and (2) poor forest soil with low fertilization and moisture content. In both coppice forest types there are no regular forest management. The silvicultural treatments are mostly linked with demands of rural community on wood as raw materials (to harvest some elements for wooden construction, firewood, piles etc.), non-wood forest products (to harvest herbs, berries, mushrooms and eco-fishes), woodland pasture, games and recreational area for kids.

The research works on ecosystem-based management in the natural coppice forests are addressed on the development of "smart – coppice – districts" that foresee the coppice management plan regulating anthropogenic impact on biodiversity in coppice forests. The negative impact on natural forests coppice are connected to harvesting of almost all mature trees or to burn of huge area of coppice forests that caused crucial changes in site conditions and biodiversity of species. The main objectives are concentrated on development of silvicultural indicators and criteria to assess coppice forests in quantitative and qualitative approaches that follows to take the right decisions by the forest management planning. The ensuing case study relating to coppice management by rural communities in the Ukrainian Subcarpathians has tremendous implications for biodiversity conservation strategies.

Keywords

rural community, social and ecological values, coppice, biodiversity, Subcarpathians

Initial stage advantage of sessile oak coppice sprouts over seedlings under drought conditions

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Due to the increased frequency and intensity of drought events, high forests are facing a decline in growth and natural regeneration which suggests us to look for new adaptive strategies that could even be inherited from historic management practice. We hypothesize that young sprouts in coppice have different strategies comparing to seedlings for a drought survival as there are contrasts in spatial distribution of roots, different amount in belowground biomass and different photosynthetic utilization. In our study we compared two contrasting management systems, coppice and high sessile oak forests, both in regeneration and mature stage. Observed maximum assimilation rate and photosynthetic efficiency (i.e. maximal quantum yield) of young oaks in both forest forms, showed better performance of sprouts during three consecutive years (2012, 2013 and 2014, respectively), especially during drought period. Transpiration of the same young oaks was monitored using the sap flow systems during the whole growing season of 2014. Coppice sprouts transpired significantly higher than seedlings during drought conditions, while in non-limiting water availability conditions, no differences were found.

Additionally, dendroecological study was conducted on mature trees in the both forest forms and indicated that stands experienced different long-term growth trends and exhibit contrasting growth responses to climate and drought occurrence. Presented results attribute young coppice as one of promising adaptable forest forms for future with a presumed drought. We also observed for the presented stands, according to dendroecological study, that this pronounced advantage will persists during the first thirty years and then gradually wears out. This work was supported by the Ministry of Education, Youth and Sports of CR within the National Sustainability Program I (NPU I), grant number LO1415.

Keywords

coppice, high forest, sprouts, seedlings, sessile oak, comparison, drought

Patterns of change in the extent of coppicing at the landscape scale

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It is generally accepted that most woods in densely settled European lowlands were coppiced from approximately the Late Middle Ages until the 19th-20th centuries. Nonetheless, the distribution of coppicing at the landscape scale was not static and went through important changes probably in connection with fluctuations in population density. Little is known about the details of this process because gathering and processing the necessary data is technically complicated and time-consuming. Based on archival data (medieval charters and two cadastral surveys from the early modern and modern periods), we examine changes in the distribution and extent of coppicing in Moravia (eastern Czech Republic, ca. 27,000 km2) from the 14th to the 19th century. Data on coppice woods are connected to coeval information on population density and current environmental variables (elevation, climate, soil) in a GIS database. We analyse the interactions of these factors to derive conclusions about the driving forces of the observed changes.

Keywords

historical ecology, archival sources, geodatabase, lowlands

Introduction of *Entomophaga maimaiga* in the gypsy moth populations in some coppice beech forests in central Serbia

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Entomophaga maimaiga Hamber, Shimauzu & Soper is not the native entomopathogenic fungus in Europe. In 1999, it was introduced for the first time in Bulgaria. Recent data suggest that *E. maimaiga* is getting spread in Europe. Since 2011 the fungus has been found in several other European countries. First time this fungus was reported from the European part of Turkey in 2011 and in the same year it was also found in Serbia. During the latest outbreak of the gypsy moth (*Lymantria dispar* L.) in Serbia (2009-2014), some areas were particularly endangered, and one of them is located in the area of coppice beech forests in the Management Unit Žunjačko-Batotske planine (Public Enterprise Srbijašume, Forest Administration Brus). Since the number of the laid egg masses in the autumn 2013 guaranteed the defoliation of beech trees, and the presence of *E. maimaiga*, in Central Serbia had already been determined, at 19 selected plots the assisted spread of it was performed, through the introduction of the infectious inoculum in the beech forests. Since it was dealt with the living organism - fungus, which is particularly susceptible to the weather conditions, and under the conditions of the global warming, the special recipe for the preparation of inoculum was made. The introduction was conducted in December at selected plots with snow cover. In the following year the mass epizootic of the gypsy moth caterpillars occurred, which implies that *E. maimaiga* caused the crash of the outbreak of this most harmful species of the defoliating insects.

Keywords

Entomophaga maimaiga, *Lymantria dispar*, beech forests, introduction

Dynamics of biomass production in poplar clones grown under short rotation coppice management in the Czech Republic

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The cultivation of fast-growing trees, such as a poplar in short rotation coppice (SRC) systems has been intensified recently in the Czech Republic. With the aim to study the long-term biomass production and dynamics of SRC systems, a high density plantation with a considerable number of poplar (*Populus*) clones at five different sites in the Czech Republic were established. Research sites are located at altitudes from 219 to 551 m a. s. l. with the mean annual air temperatures varying from 5.7 to 8.8 °C and annual amount of precipitation from 500 to 600 mm. Plantations were established in different years (1998-2009) with different stand densities varying from 2000 to 10000 trees ha-1. Minimum length of rotation period was two and maximum eight years. The total number of rotation cycles varied from two to five. In the end of each growing season, stools survival, sprouts diameter, and the number of sprouts per stool were measured. Biomass production was assessed indirectly via power allometric equations or directly by harvesting the plantations in the each rotation. The number of sprouts per stool varied among the rotations due to parentages and locations. Stool survival rates varied among the locations, parentages and from year to year too. Therefore, the biomass productions of poplar SRC varied from 1.1 to 13.2 t ha^{-1} $year^{-1}$ among the locations, parentages, stand densities, and rotation cycles. Biomass production increased from year to year up to the third rotation, after which it decreased.

Keywords

biomass, *Populus* spp., SRC

Field tour

Field tour

Introduction

The Field trip will attend three locations in Flanders where a coppice or short rotation management is presently implemented (Ranst, Lochristi and Oudenaarde; see figure 1). These three forests or plantations have a specific management history and the coppice management is applied for different purposes, being either restoration of socio-historical forest management, biomass production and/or biodiversity conservation and restoration. At these three stops we can discuss to what extent these three aims can be combined with each other.

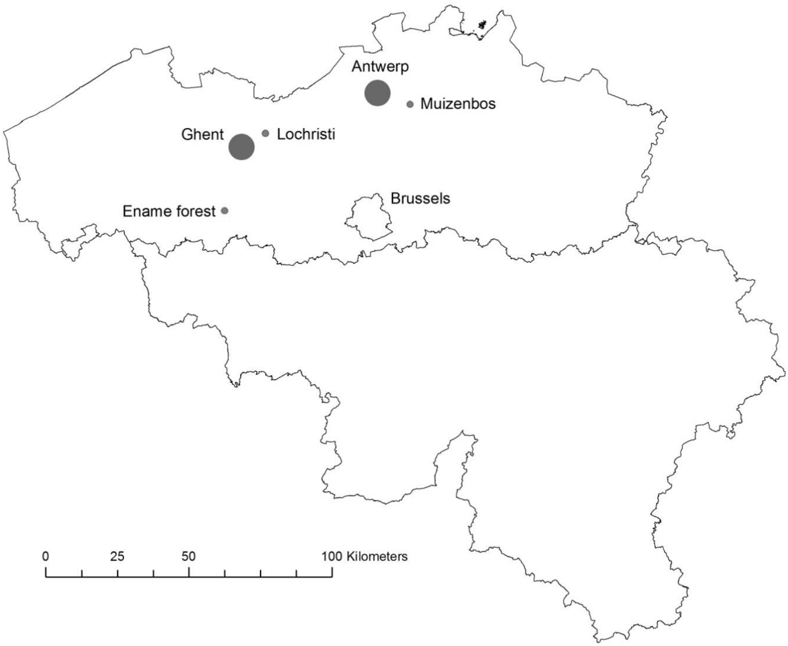

Figure 1 - Map of Belgium with an overview of the excursion stops.

At the first stop in Ranst, we will visit the forest reserve of Muizenbos. We will focus on the potentials of a coppice management to restore forest vegetation on reforested but eutrophicated farmland soil. As such this management could simultaneously meet economic and ecologic aims. This forest also illustrates the spatial arrangement of coppicing along a management gradient, in order to preserve light-demanding species.

At the second stop in Lochristi we visit a short rotation coppice (SRC) plantation. The 18 ha plantation was established for research purposes by Prof. R. Ceulemans from the University of Antwerp. The main aims of the project were to construct: i) a full greenhouse gas balance; ii) a full energetic balance; and iii) a full economic balance. Apart from these balances research focused on different aspects of the soil, plantecology and –physiology, and coppicing efficiency. In Lochristi, we will also visit Groep Mouton, a forest managing and wood processing company.

The third stop at the forest of Ename, near the city of Oudenaarde, is an ancient woodland that was property of the nearby abbey of Ename. The management history of this forest in the past 1000 years is very well documented and thoroughly studied. The historical coppice with standards management, with or without grazing, is restored in parts of the forest for socio-historical and ecological reasons.

STOP 1: Muizenbos (Ranst)

Site description

Muizenbos is a 34 ha forest reserve, in a flat region at approximately 10 m above sea level, situated 15 km east of Antwerp in northern Belgium (Figure 1). The topsoil varies from silty sand (periphery) to sandy silt (center). An impermeable sandy clay layer of tertiary marine origin, at 0.5 to 1 m depth, impairs water percolation and creates a Gleysol. The local presence of fossils in the sandy clay layer results in these Gleysols having a highly variable soil acidity, with pH-KCl values that range between +/- 3 and +/- 7. Well-developed forest vegetation is classified to the Violo-Quercetum roboris on acid soils (Habitat 9120) and tot the Primulo-Fraxinetum excelsioris (habitat types 91E0 and 9160) on moderately acid to calcareous soils).

The Muizenbos consists of a mosaic of small parcels (surface area between 0.5 and 1.5 ha) with a specific land-use history (Figure 2). Approximately 3.5 ha have always been forest since 1775 when the earliest maps were drawn. Many parcels were covered by forest in 1775 but converted into arable land between 1775 and 1834. These parcels were abandoned and reforested in the 19th and 20th centuries. The last afforestations date from 1991 on farmland that was never covered by forest before since 1775. There is a relationship between the phosphorous (P) content of the topsoil and the time of conversion to forest. Parcels that were converted from farmland to forest after 1945, are clearly eutrophicated with P and are often characterized by a herbaceous vegetation dominated by stinging nettle (*Urtica dioica*).

Up to the 19th century forest stands were managed as a coppice. After 1918, poplar cultivars were planted in between the coppice on 8 x 8 m or 10 x 10 m spacing but the coppice management was maintained. By doing so, the management resembled a coppice with standards management, albeit with even-aged poplar cultivars as standards. In the last decades before the installation as a forest reserve, poplar plantations were cut. Some clear-cuts were reforested with various tree species (mainly *Fraxinus excelsior*, *Tilia cordata* and *Quercus robur*), sometimes mixed with spontaneously regenerating woody species, and other clear-cut areas were left unmanaged.

In many poplar plantations on eutrophicated farmland, shrubs and tree species (in particular *Acer pseudoplatanus* and *Alnus glutinosa*) were planted in between the poplars. This resulted in varying levels of shadow on the forest floor of the poplar plantations.

Since 1997, most of the forest is left unmanaged as a strict forest reserve for scientific and biodiversity reasons. A central area is managed for light-demanding grassland and forest edge species. Since a few years there is a dieback of ash is caused by *Chalara fraxinea*.

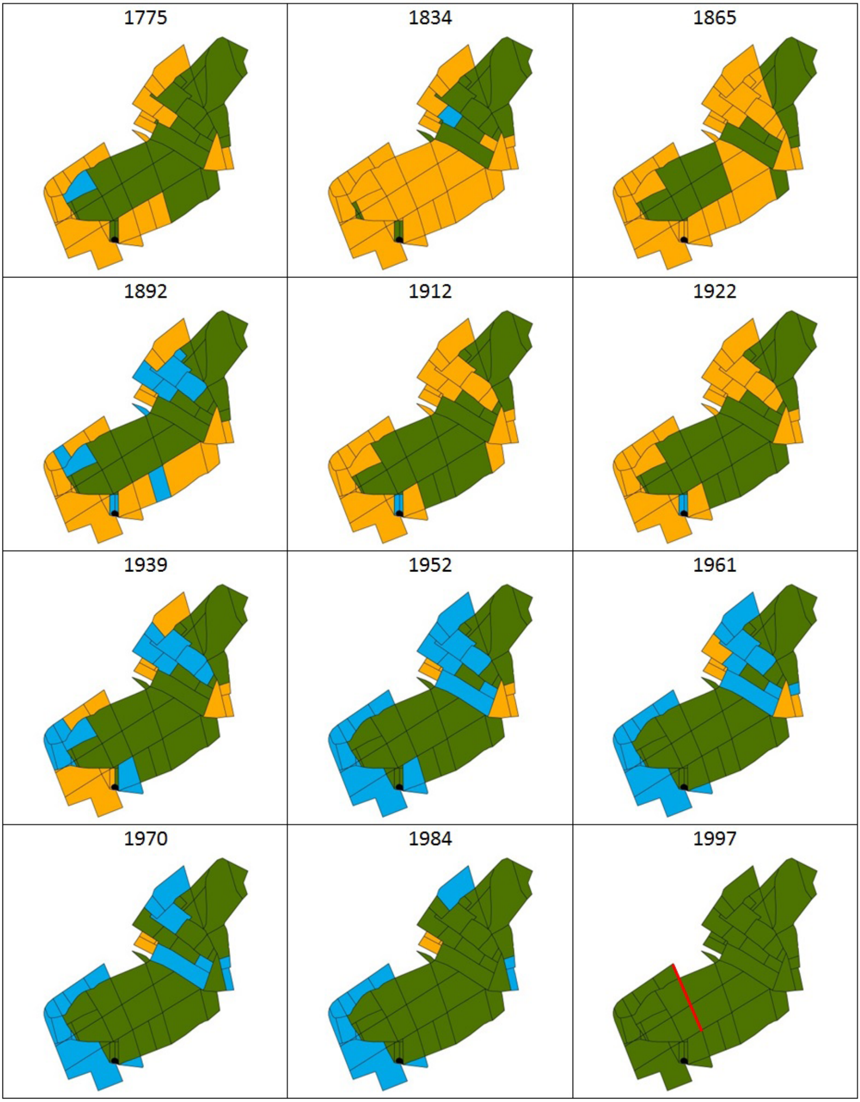

Figure 2 - Land-use history of Muizenbos between 1775 and 1997; green: forest; yellow: arable field; blue: grassland; black: pond; red line: path followed at the field trip.

Can coppice management promote the restoration of forest vegetation on eutrophicated farmland?

We enter the forest in a poplar stand, planted in 1991 on highly eutrophicated farmland soil, and observe the ecotone with an ash (*Fraxinus excelsior*) high forest where a species-rich vegetation is present. The level of total P in the topsoil is four times as high in the poplar stand as in the adjacent ash high forest.

Urtica dioica is dominant in well-illuminated areas of the poplar plantation, but its cover is reduced under shade-casting woody species, e.g. *Acer pseudoplatanus*, that were planted under the poplars. Observational and experimental studies in Muizenbos indicated that a reduction of competitive species by increased shading can promote shade-tolerant forest plants. At this ecotone, we can observe the colonization of *Ranunculus ficaria*, *Arum maculatum*, *Primula elatior*, and *Anemone nemorosa* (in order of decreasing colonization rate) into the poplar plantation (Figure 3).

Figure 3 - Ecotone between the Ash high forest with a species-rich vegetation, and the eutrophicated farmland planted in 1991 with poplar cultivars and ***Acer pseudoplatanus.***

At the turning point we observe a young forest that emerged after the felling of a 45 yr old first generation poplar stand, planted on farmland. The soil is moderately eutrophicated with P (twice the level of ancient forest parcels). *Acer* and *Alnus* were planted at the same time in between the poplars and managed as a coppice. Just before the felling in 1997 the canopy was dense and light-demanding tall herbs (*Urtica dioica* and *Aegopodium podagraria*) were only present along the stand borders (Figure 4).

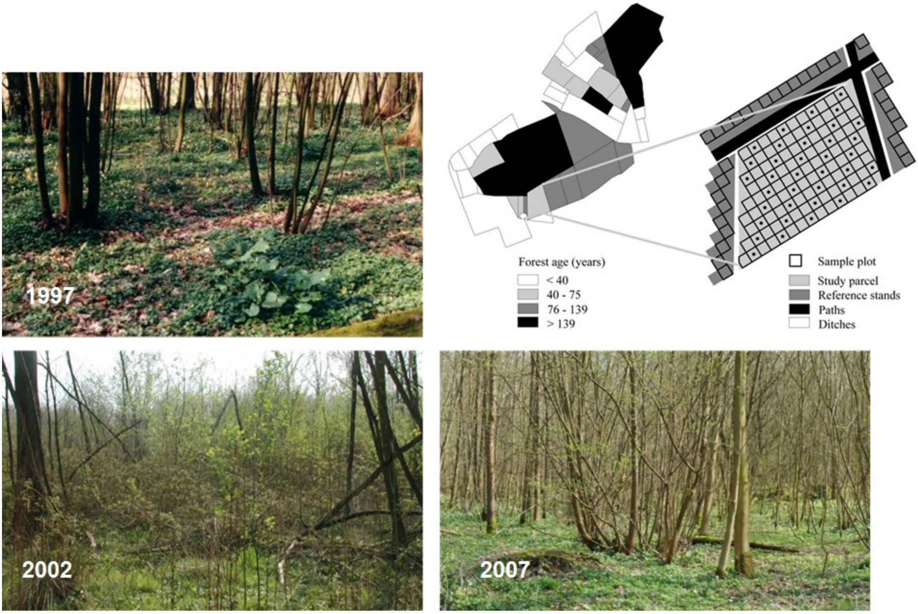

*Figure 4 - Location and views of the parcel planted in 1952 with poplars and an understory (**Acer** and **Alnus**) managed as a coppice, just before (1997), and five (2002) and ten (2007) years after the felling.*

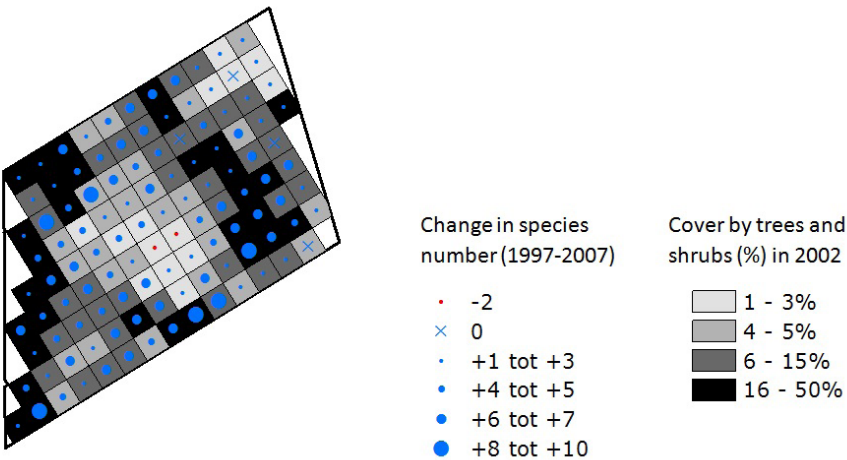

Figure 5 - Change in species number per plot (25 m2) within a decade after felling, in relation to the cover by regenerating trees and shrubs in 2002

The detailed inventory of this stand, just before (1997), five (2002) and ten (2007) years after the felling, revealed that colonization of most forest plant species was promoted by cutting (Table 1). However the rate of canopy recovery was crucial (Figure 5). We observed that colonization by shade-tolerant forest herbs lagged behind in plots with a sparse canopy cover, where light-loving herbs (mostly *Rubus* spp.) were still dominant one decade after felling.

*Table 1 - Frequency of forest plant species in the studied 25 m2 sample plots before (1997) and after (2002, 2007) felling, compared to the adjacent forest stand. * are ancient forest plant species*

Species	**1997**	**2002**	**2007**	**Adjacent**
Adoxa moschatellina	74	73	93	97
*Anemone nemorosa**	73	63	69	94
*Arum maculatum**	88	85	96	97
*Athyrium filix-femina**	0	1	51	21
Brachypodium sylvaticum	0	0	2	6
Carex remota	0	1	12	18
*Carex sylvatica**	0	7	23	21
Circaea lutetiana	29	69	86	76
Dryopteris dilatata	0	19	30	24
Dryopteris filix-mas	0	0	23	6
Festuca gigantea	1	0	0	12
Geum urbanum	2	2	21	39
Hedera helix	1	0	50	9
*Lamium galeobdolon**	4	3	11	48
Moehringia trinervia	0	4	16	18
*Paris quadrifolia**	0	0	0	15
Poa nemoralis	0	0	0	6
*Polygonatum multiflorum**	4	3	13	52
Primula elatior	29	49	63	82
Ranunculus ficaria	100	100	100	100
Ribes nigrum	0	1	4	0
Ribes rubrum	1	4	7	39
Scrophularia nodosa	1	1	0	0
Stachys sylvatica	0	8	7	42
Stellaria holostea*	3	1	4	18
Total species number	**14**	**19**	**21**	**23**

These findings indicate that short phases of increased illumination are favorable for most forest plant species. As the root system of a coppice is unaffected by felling, shoots already emerge in the first growing season after felling and canopy cover increases fast. A coppice management could thus reduce competitive exclusion by nutrient-demanding tall herbs (*Rubus*, *Urtica*, Poaceae) during the dark phase and also promote generative reproduction of forest plant species during a light phase, short in time, after cutting.

Spatial arrangement of coppice management for conservation of light-demanding biodiversity

Muizenbos is mostly a strict forest reserve since 1997, meaning that except for safety reasons at the edges of the forest, there is no more (forest) management. Such a zero intervention reserve is established to study natural forest dynamics and to protect and restore specific biodiversity (e.g. species associated with dead wood). In the case of Muizenbos near-natural forest (e.g. the ash high forest) as well as plantations recently established on farmland (e.g the stand where we entered the forest) are monitored.

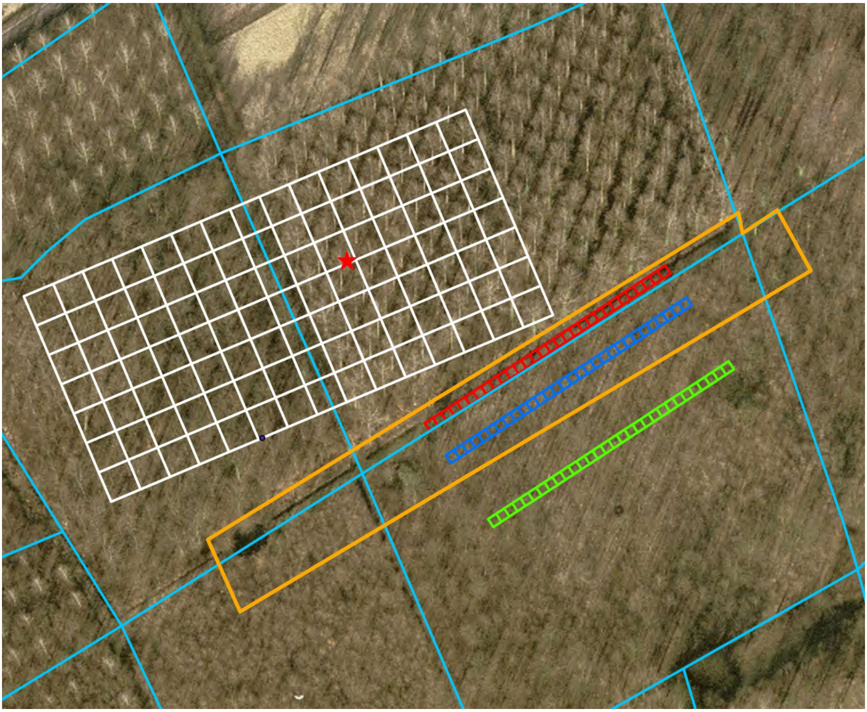

Figure 6 - The orange perimeter indicates the managed area in Muizenbos. Red plots are located on the forest path, blue plots in the coppice with standards, and green plots in the unmanaged forest. The white plots are the core area of the unmanaged forest, where spontaneous forest dynamics are studied.

Table 2 - L and R indicator values (Ellenberg) of species selected for monitoring, and the number of 3 m x 3 m plots they were observed on a total of 30 per management unit (mown path, coppice with standards, unmanaged forest)

Species	**L**	**R**	**Path**	**Cop + Stan**	**Unma-naged**	**Total**
Aegopodium podagraria	5	7	27	30	24	81
Ajuga reptans	6	6	29	0	6	35
Allium vineale	5	X	0	0	2	2
Anemone nemorosa	X	X	30	17	15	62
Angelica sylvestris	7	X	26	19	15	60
Cardamine pratensis	4	X	12	0	0	12
Carex flacca	7	8	8	1	0	9
Cirsium oleraceum	6	7	29	12	0	41
Colchicum autumnale	6	7	27	2	0	29
Dactylorhiza fuchsiï	7	7	9	4	0	13
Filipendula ulmaria	7	X	30	12	5	47
Listera ovata	6	7	27	13	13	53
Ornithogalum umbellatum	6	7	0	18	16	34
Paris quadrifolia	3	7	23	30	29	82
Primula elatior	6	7	29	29	29	87
Rubus caesius	6	8	20	30	29	79
Sanicula europaea	4	8	0	3	0	3
Valeriana dioica	7	5	8	1	0	9
Viola riv./Viola reich.	4	4/7	6	21	17	44

In Muizenbos, rare light-demanding species are present on the unimproved forest paths and in the adjacent forest edges, in particular on the most calcareous soils where plant-available P levels are very low (≤ 10 mg kg^{-1}). Among the target species for conservation are: *Colchicum autumnale*, *Valeriana dioca*, *Dactylorhiza fuchsia*. In the unmanaged forest where trees are immature, light-demanding species can decline as shade-casting trees and shrubs (*Acer*, *Corylus*, *Tilia*) increase and natural gaps are still scarce.

In order not to lose this light-demanding biodiversity, the most species-rich path and the adjacent forest edge in the center of the forest are still managed (Figure 6). A coppice with standards management is implemented to the edge of a forest stand that was a poplar plantation with coppice of ash until the felling in 1975. After that time, it was converted to a mixed forest with *Fraxinus* and *Acer* as dominant tree species, consisting of both planted and spontaneously regenerating trees. The first cut was in the winter 2007-2008 and standards that were spared are mostly *Fraxinus* trees as *Acer* has a denser canopy.

The coppice with standards management causes a permanent increase of insolation on the neighboring forest path, which is important for typical grassland species (e.g. *Valeriana dioica*). On the other hand, the forest edge becomes more suitable for establishment of light-demanding forest and forest edge species, e.g. *Colchicum autumnale* and *Dactylorhiza fuchsia* (Figure 7).

In spring 2009 we inventoried 30 plots with 3 x 3 m dimensions for the first time. These plots are permanently marked to follow-up the effect of the three management forms on a selection of species with a variable shade tolerance / light demand (Table 2). There were clear species preferences, probably already present before the coppice with standards management was implemented (e.g *Sanicula* and *Colchicum* were only found in the forest edge).

Figure 7 - View on the spatial arrangement of three management forms in Muizenbos: the unmanaged forest (left on the background and right), where Anemone nemorosa is dominant, surrounding the coppice with standards management (foreground to the left) and the forest path that is annually mown in August (foreground to the right) and where Primula elatior is abundant.

STOP 2A: Short rotation coppice plantation of fast-growing poplar (*Populus* spp.) (Lochristi)

The site is an operational scale plantation of short-rotation coppiced (SRC) poplar (Figure 8A) for the production of bioenergy (Table 3), operated and managed by the University of Antwerp (Research Centre of Excellence PLECO) and Group Mouton (private SME company). From 2010 till 2015 the plantation was the experimental research site POPFULL funded by the European Research Council and other funding agencies. The plantation is now in its third rotation and will be harvested again in February 2017. The woody chips are – via combustion or gasification – converted into renewable electricity and/or green heat. Since 2016 the plantation is a long-term (20 years) ecosystem observation station of the ICOS research infrastructure (ICOS = Integrated Carbon Observation System) (Figure 8C).

Table 3 – Description, management and main results after four years of the short-rotation coppice plantation in Lochristi

Site description	
Location	Lochristi, province East of Flanders
Coordinates	51° 06’ 44” N, 3° 51’ 02” E
Altitude	6.25 m above sea level
Average annual temperature	9.5 °C
Average annual precipitation	726 mm
Soil	Sandy texture with clay-enriched deeper layer
Soil type	Anthrosol
Water drainage	Poor natural drainage
Total area	14 ha
Planted area	11 ha
Previous land use	Grassland and cropland
Planting and plant materials	
Plant density	8000 trees ha^{-1}
Planting design	Double rows with 0.75 m and 1.50 m between rows; 1.10 m within rows
Plant materials	Species and hybrids of *Populus trichocarpa*, *P. deltoides*, *P. nigra* and *P. maximowiczii*
Number of genotypes	12
Age of below-ground stump	7 years
Age of above-ground shoot	2.5 years

Plantation management	
Weeding	Limited manual, mechanical or chemical during first two years, and after coppice
Fertilization	None
Irrigation	None
First harvest	2-3 February 2012
Second harvest	18-20 February 2014 (Figure 8B)
Third harvest	Early February 2017
Rotation scheme	2 + 2 + 3 (years)
Growth and productivity	
Average height growth	2.7 m yr^{-1}
Yield, first rotation	235 ton fresh weight (2 years)
Yield, second rotation	785 ton fresh weight (2 years)
Annual biomass yield, first rotation	6 t ha^{-1} yr^{-1} (dry mass)
Annual biomass yield, second rotation	13 t ha^{-1} yr^{-1} (dry mass)
Average annual yield	10 t ha^{-1} yr^{-1} (dry mass)
Meteorological and flux towers	
First telescopic mast (yellow Clark mast)	Eddy covariance flux setup (gas analysis and 3D wind speed), air temperature, gas concentrations, humidity sensors
Second mast	Radiometers, PAR sensors, pyranometer
Third, Truss mast	Phenocam (camera)
Continuous flux measurements	CO_2, H_2O, CH_4, N_2O, O_3, latent and sensible heat; BVOC's (biogenic volatile organic compounds)
Energy, economic and environmental balances	
Energy balance at farm gate	29 (= output / input)
Electricity / energy input	8.6
Cumulative carbon balance, two rotations	-144 g C m^{-2} = -1.44 Mg C ha^{-1} uptake
Annual greenhouse gas balance	1.8 Mg CO2 eq ha^{-1} yr^{-1} emission
Greenhouse gas emissions	75 g CO_2 eq kWh^{-1}
Greenhouse gas emissions	10 x less than non-renewable (EU) energy sources
Biomass price	20-30 € Mg^{-1} (wet biomass, 50% moisture)
Economic return	229 € ha^{-1}; break-even only after 7 rotations

Current research projects and funding at the site include the following.
ESFRI – ICOS: Integrated Carbon Observation System

- ICOS is one of the flagships of the European Strategy Forum on Research Infrastructures (ESFRI). The overall goal is a better understanding of the greenhouse gas balance of Europe in relation to climatic changes. ICOS is a decentralized infrastructure consisting of distributed, standardized observation stations and central facilities. These observation stations are located on land (ecosystem towers and atmospheric towers) or in the ocean (ships, observation buoys). In a standardized way all observation stations monitor concentrations and fluxes of greenhouse gases, i.e. CO_2 (carbon dioxide), but also CH_4 (methane) and N_2O (nitrous oxide). The SRC site is the only bioenergy observation station in the ICOS infrastructure.
- The ICOS infrastructure has a legal structure via a European Research Infrastructure Consortium (ERIC) signed on 15/10/2015 by nine countries. Duration: foreseen for 20 years.
- Websites: www.icos-ri.eu; www.icos-belgium.be

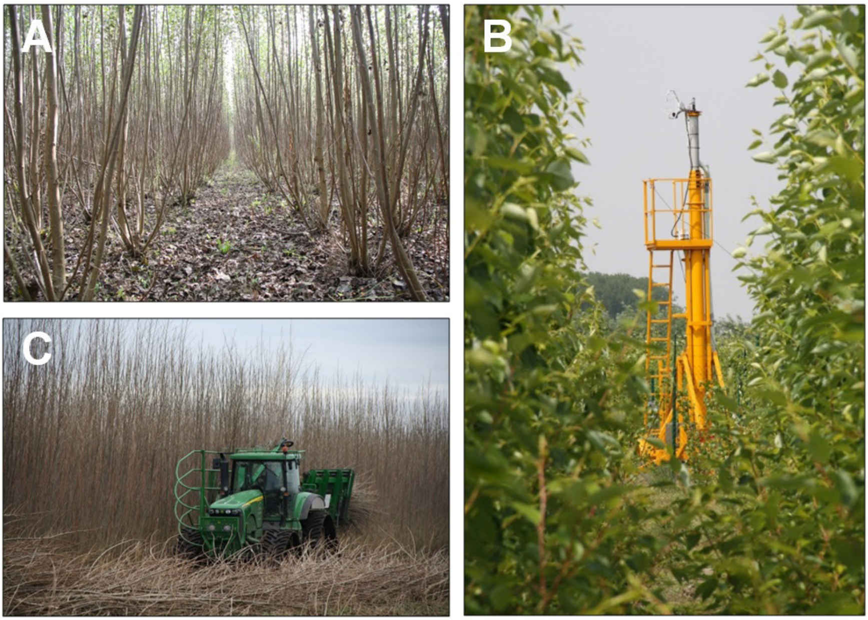

Figure 8 - A) genotype Oudenberg in September 2013, i.e. the second year of the second rotation; B) the eddy-covariance tower at the SRC plantation; C) the Stemster MKIII harvesting the plantation in February 2014, i.e. the second harvest

SRF-OZO: Ozone and VOC measurements of a poplar bioenergy plantation

- The aim of SRF-OZO is to assess the impact of poplar bioenergy cultivation on ozone and biogenic volatile organic compound (BVOC) emissions. Campaigns of BVOC measurements are performed with two PTR-MS instruments (time-of-flight- and quadrupole-based) to measure ecosystem fluxes of VOCs with eddy covariance as well as leaf level volatile emissions. Fluxes of ozone are measured via eddy covariance.
- Project in collaboration with the Netherlands Organisation for Applied Scientific Research (TNO).
- SRF-OZO is funded by the European Commission within the frame of the Marie Sklodowska Curie Actions (People Programme) as an Individual Fellowship. Duration 01/10/2014 - 31/10/2016.

PHYSIO-POP: Physiological and environmental controls of water and ozone fluxes in a short rotation poplar plantation

- The goal of PHYSIO-POP is to study transpirational water loss and ozone fluxes of different poplar genotypes at different biological levels (leaf, tree, ecosystem) and time scales (daily, seasonal).
- PHYSIO-POP is funded by the European Commission within the frame of the Marie Sklodowska Curie Actions (Horizon 2020) as an Individual Fellowship. Duration 1/9/2015 – 31/8/2017.

HYPI: Assessment of isoprene emissions by hyperspectral data

- The goals of HYPI are (i) to identify the most useful vegetation index and the optimal strategy to determine isoprene emissions at leaf and ecosystem levels, and (ii) to explore how to incorporate newly developed vegetation indices into the MEGAN model (Model of Emissions of Gases and Aerosols from Nature).
- Project in collaboration with the Belgian Institute for Space Aeronomy (BIRA-IASB); the Flemish Institute for Technological Research (VITO) and the Centre for Ecological Research and Forestry Applications (CREAF-CSIC), Barcelona, Spain.
- HYPI is funded by the Belgian Science Policy Office (BELSPO) in the frame of the STEREO III programme. Duration 1/12/2015 – 31/07/2017.
- Website: tinyurl.com/ua-hypi

More information?

- Visit the website http://uahost.uantwerpen.be/popfull and download the POPFULL leaflet
- Watch the documentary of National Geographic on the plantation:
  - http://behindthescience.uantwerpen.be/eng/renewable_energy/episode
  - http://natgeotv.com/nl/behind-the-science
  - http://behindthescience.uantwerpen.be/ and then choose English
- Read one of the 45 publications (all Open Access) available from http://uahost.uantwerpen.be/popfull

STOP 2B: Groep Mouton (Lochristi)

Groep Mouton is a timber company consisting of two divisions. Groep Mouton forestry does forestry while Groep Mouton woodenergy gives all the wood the appropriate destinations: construction timber, firewood, chips, biomass, pellets, briquettes,...

Groep Mouton – forestry

Trees grow naturally but to get a forest that has nature, wood or recreation value, there is a lot of work to be done. Therefore, it is important to think carefully about planning all kinds of forest management choices. There has always to be thought about long-term effects.

And just that is the task of Groep Mouton. As an individual, a company or a government agency, you can always contact Groep Mouton for advice and the execution of commercial and ecological forest clearing, thinning or pruning work. There is always a team ready for the most specific tree work.

Our company is VCA * certified and our people are also in possession of a recognized forestry card.

With all these advantages you are at Groep Mouton at the right place for all forestry and harvesting work in Belgium, the Netherlands and France.

Groep Mouton - wood energy

In addition, the harvested wood should be given the appropriate destination. The woodenergy department was created by the fusion of Cole bvba and Groep Mouton. Cole bvba worked in forestry, the purchase and sale of trees, the production of firewood and sales of wood pellets and wood briquettes. This company was already founded in 1983 and became an important supplier of all its products offered.

Until today Groep Mouton still aims to ensure that the harvested timber gets the best destination. If you are in the possession of a forest or harvested wood, you can rely on us selling it. Moreover, at Groep Mouton you will find wood for energy in all forms (firewood, wood chips, briquettes). Groep Mouton offers as such forestry products in the same honest way in various sectors, both wholesale, retail, and private.

STOP 3: Bos 't Ename (Oudenaarde)

Adapted from: Verheyen K, Bossuyt B, Hermy M & Tack G (1999) The land use history (1278-1990) of a mixed hardwood forest in western Belgium and its relationship with chemical soil characteristics. Journal of Biogeography 26: 1115-1128.

Physical setting

The present-day Ename Wood, which consists of two disjunct parts, occupies 62 ha in the province of Eastern Flanders, about 25 km south of Ghent. It is the remainder of the 145-ha historical Ename Wood (Figure 9).

The annual precipitation is 775 mm and the mean annual temperature 9.5 °C. On average, the vegetation growing period lasts about 170 days. The forest itself is located on the eastern side of the River Scheldt and the altitude ranges from 14 to 62 masl. The northern part (25%) lies on humic alluvial and colluvial sediments. The remainder of the forest is situated on the relatively steep slopes of the river valley on sandy–loam soils of Quarternary niveo-eolian origin with a clayey or stony sandy layer of Tertiary marine origin at variable depth. Some soils are derived from this Tertiary material.

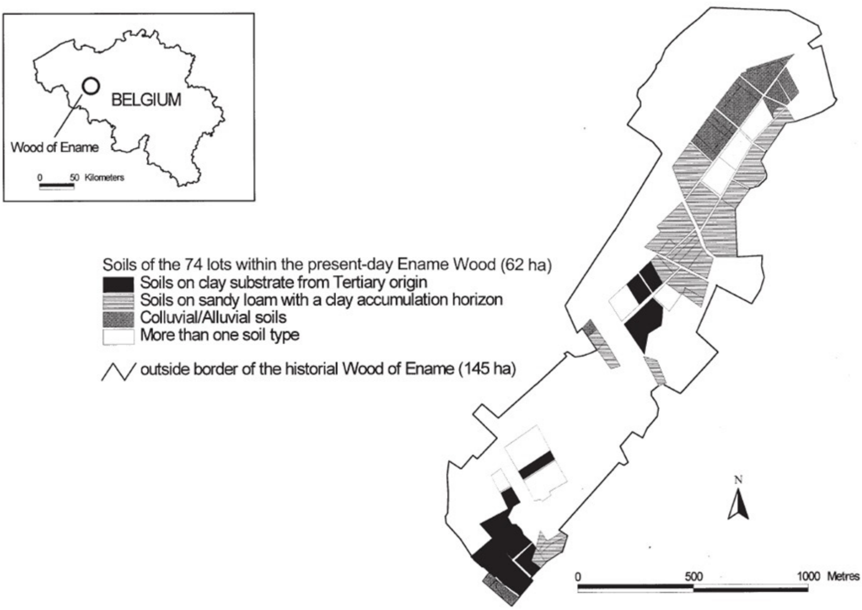

Figure 9 - Map of the historical and the present-day Ename Wood and the location of the seventy-four lots used for the soil sampling.

Biological setting

Ename Wood used to be managed as a coppice with standards for hundreds of years. However, during the last century the forest was gradually transformed into a highwood: 32% of the area was planted with homogeneous *Populus x Canadensis* (Moench) (nomenclature follows De Langhe et al., 1988); 39% of the area has a mixture of broadleaved trees of which *Populus x canadensis* (Moench) is the dominant tree species and 29% of the area has a mixture of *Fraxinus excelsior* (L.) and *Quercus robur* (L.). Underneath the tree canopy a neglected coppice layer is still found, consisting mainly of *Alnus glutinosa* (Gaertn.), *Fraxinus excelsior* (L)., *Acer pseudoplatanus* (L) and *Corylus avellana* (L.) (Verheyen & Vackier, 1997). The 75% of the forest which is situated on sandy–loam soils belongs to the *Endymio-Carpinetum* forest plant community (Noirfalize, 1984). This plant community is characterized by *Hyacinthoides non-scripta* (Chouard ex Rothm.). On the alluvial and colluvial sediments (25%), the forest belongs to the *Pruno-Fraxinetum* forest plant community (Oberdorfer, 1953) with *Filipendula ulmaria* (Maxim.), *Primula elatior* (Hill), *Cardamine pratensis* ssp. picra (De Langhe et D'Hose) as differential species.

Historical setting

The forests of the former county of Flanders have undergone four major periods of forest progression and regression (Tack et al., 1993):

- Prehistory (4000–50 BC): spontaneous afforestation following forest regression in the New Stone, Bronze and Iron Age. Settlements in that period were often concentrated in present-day forests.
- During Roman times (50 BC–300 AC), the extreme human interference in both forest and agricultural land involving considerable forest fragmentation was characteristic for the whole county of Flanders and neighbouring parts of the county of Hainaut and the Duchy of Brabant. After the Gallo-Roman period, in the so-called 'Dark Ages' (300–600 AC), forest recovered more or less naturally.
- Fourteenth to nineteenth century: increasing forest area following the deforestation movement in the eleventh to twelfth century. By 1300, forest covered only 9% of the total area. However, some large forest areas remained and they were connected by smaller forest patches and many hedges. All forests were used intensively for pasturing, resulting in a variety of transitional forms between forest and pasture. The abbeys, which developed from the eleventh century onwards, had a large influence on the land use history of the region. The increasing demand for fuel wood led to an extensive new reforestation, raising the area of forest to about 15% in the eighteenth century.
- 1880–1990: increasing forest area, mainly by planting, after deforestation in the nineteenth century. The forests were transformed from coppice-dominated systems into highwood.

Ename Wood is situated in the centre of the former county of Flanders (Fig. 1). The earliest traces of occupation near Ename Wood date from prehistory (Middle and New Stone Ages): three sites on the upper parts and two sites in the valley. Since one of these sites is situated within the forest, it is very likely that a part of the forest was already transformed into arable land, and that other parts were pastured and degraded. No systematic archaeological research has been carried out for the

Bronze and early Iron Ages. However, toponymic research indicates that the area was inhabited at that time. More data are available for the Roman period. Traces of habitation were found in sixteen sites, of which five settlements are situated in a radius of 1 km around Ename Wood (Tack & Hermy, 1998).

This high population density suggests that the forest was extensively pastured and wood was cut, probably resulting in a kind of open forest. Hardly any information exists about the Dark Ages. In 1063 the Abbey of Ename was founded and between its foundation and 1278 the abbey gradually acquired the historical Ename Wood (145 ha; Figure 9). The abbey possessed the forest until 1795 when the abbey was dismantled by the French occupier and the forest became state property. From 1845 onwards the forest has been private property. In the middle of the nineteenth century, due to an economic crisis, the forest was totally cleared and used as arable land. By the end of the nineteenth century most fields were abandoned and reforested, which gave birth to the smaller present-day Ename Wood (62 ha; Figure 9).

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