BOOK OF ABSTRACTS

NUORO
16th — 20th
MAY 2022

EURAF2022

6th EUROPEAN AGROFORESTRY CONFERENCE

Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry.

EURAF European Agroforestry Federation
UniNuoro Consorzio Universitario Nuoro
AIAF Associazione Italiana Agroforestazione

EURAF2022

WELCOME ADDRESS

As I write these words, a revanchist superpower has invaded a seemingly defenceless neighbour in a war of conquest the like we Europeans hoped never to see again. Sadly, this was not wholly unexpected: from Russia's invasion of Georgia in 2008 onwards (an event I witnessed from my job at the National Security Council in Tbilisi - yes, my career has been varied), those in the know - from the Baltic States to Romania - wasted no time trying to warn Western Europeans of the danger emanating from the Kremlin.

Surprise or not, our old friends in the petrochemical agriculture industry wasted no time making theirs the old proverb, "let no crisis go to waste". Almost as soon as as the bombs started falling, the cry went up: "we can't afford the Green Deal! We must plough up set-aside land! we must double down on industrial agriculture to make up for the loss of Russian and Ukrainian oils and cereals!".

The utter absurdity of calling for more spending on diesel and inputs at a time when the cost of diesel and inputs is going through the roof was only matched by the shamelessness of the immediate requests for - you guessed it - yet more subsidies to pay these inflated costs.

That is not very surprising to those who know the Brussels machine: every interest group uses every opportunity to try to get its hands on more European cash. For me, the surprise lay elsewhere: neither the EU Agriculture Commissioner, Janusz Wojciechowski, nor the Agriculture Council seemed to understand how serious the situation is - and how radical the measures needed to deal with it have to be.

Europeans, being rich, are unlikely to suffer overmuch from the rapid rise in food prices the war is bringing. But the FAO and WFP are warning us that across Latin America, Africa and Asia, hundreds of millions are going to tip into hunger. Some countries, like Lebanon or Egypt, depend on imports, mostly from Ukraine, for over half their calorie needs.

This suggests that the policies that feed a large fraction of Europe's agricultural output into cars and livestock must be urgently revised. But so far, not a peep from the Commission in that regard. Are the interests of our biofuel and livestock industries really more important than the bellies of tens of millions of men, women and children?

It also suggests that it is becoming imperative to rapidly wean Europe's farmers from their overreliance on expensive fossil fuel-derived inputs, and to help them adopt practices like agroforestry and adaptive mob grazing that help them do so. But again, not a peep from the Commission. On the contrary, it seems to be listening to those who are dismissing these agroecological practices with the nonsensical argument that "we cannot afford them in wartime".

The most charitable interpretation of this lack of political leadership is that everybody is simply hoping the war will stop very quickly and that business can return to its usual patterns.

Sadly, that is extremely unlikely to be the case. Back in 2008, we were telling anyone who cared to listen that unless we acted strongly against Russia's invasion of Georgia, Ukraine would be next. A year later, Secretary of State Hillary Clinton gave a big red "reset" button to Russian foreign minister Sergei Lavrov. The message was clear: "invade who you like, we won't care". Five years later, Russia invaded Ukraine, again without much pushback. Is it any wonder Mr Putin thought no one would mind if he completed the job of building his mythical "Russian World"?

Ukraine is not going to be conquered quickly or easily, and Putin won't give up. This means sanctions are likely to stay in place and the Black Sea ports to remain off-limits for a long time. Energy, food and fertilizer prices will stay high for the foreseeable future. Hunger will spread. Livestock and biofuel feedstocks will be diverted to feed people. The cost of agricultural inputs will put more and more farmers under rising pressure. This situation is unlikely to become normalised until Russia switches from revanchist totalitarianism to a functioning democracy - something it has no experience of.

The old normal of cheap gas, cheap oil and cheap agricultural inputs is gone. It won't come back.

Agroforestry and agroecology can relieve farmers from their reliance on these expensive inputs. Agroforestry produces more biomass per unit area than monocultures - with fewer inputs. It reduces the need for fertilizers, pesticidess and irrigation. And the bonus? It protects fields from the increasingly strong storms and droughts that climate change brings.

The best time to plant an agroforestry system is always 20 years ago. But the second best time is today.

Patrick Worms
EURAF President

WELCOME ADDRESS

I am honoured to present this volume of abstracts collected within the 6° European Agroforestry Conference under the umbrella of the European Agroforestry Federation, EURAF. This volume contains a rich and variegate assortment of research, studies, and best practices to testify to the potential of Agroforestry in contributing to the transition towards a bioeconomy and a more resilient and equal society.

For this reason, I want to first thank the authors for their deep interest in this Conference and the high level of contributions presented. More than 250 scientists and stakeholders will participate in the Conference. I am sure that the results will effectively help the change to a different view and management of forest and agriculture systems.

Indeed, this book results from rigorous work performed by the members of the Scientific Committee who evaluated about 200 abstracts sent from 4 continents and 33 countries. All the members of the Scientific Committee showed an outstanding commitment to using a rigorous approach in carrying out their tasks.

I also want to acknowledge the members of the Organizing Committee; only their determination made this Conference possible. They have successfully faced difficulties and obstacles related to such a difficult time.

All of us were joyful and proud of the idea of meeting in presence, thanks to the efforts of our local and national organizers. However, another tragedy suddenly appeared to make the situation difficult, devastating, and tragic: the aggression of Ukraine, causing a war in the heart of Europe. With all my strength, I would like this Conference to be a peacemaker; we can do so by achieving unifying scientific messages and the recognition of agroforestry and forest systems as perennial symbols of peace and life.

The Conference will take place in Sardinia, some land rich in diversity for environmental, social, and cultural characteristics and history. Sardinia is ideal for thinking together on scientific and technical issues relating to promoting agroforestry systems and models, saving and preventing our biodiversity, experiencing the landscape, good examples, and best practices. And together, try to correct and improve government and management options to make territories increasingly resilient and sustainable.

Agroforestry offers a holistic approach to obtaining biophysical, socio-cultural, and economic benefits from land management systems. This vision fits with the emerging paradigm known as One Health, where people's health is strongly connected to the potential nexus between land use change, food systems, and the health of animals and the environment. We are aware of the multiple benefits of this approach in mitigating risks associated with anthropized environments through the strategic actions related to intersectoral collaboration, collective education, and public awareness.

Furthermore, it is crucial to consider climate change impacts, entailing more complex feedback with ecosystems and trade-offs and synergies among the different sectors involved. This aspect is also emphasized in the last IPCC report encouraging testing of different integrated agricultural systems to assess synergies between mitigation, adaptation, and sustainability to reach low-carbon and climate-resilient pathways for sustainable food security and ecosystem health.

The Conference and this volume are organized on four main topics, including (1) agroforestry and the environment, (2) quality, safety, and sustainability of agroforestry productions, (3) economy and policy of agroforestry, and (4) agroforestry in society and culture. This structure strongly confirms the multidisciplinary and complex approach of agroforestry research and application.

I am confident you can find this volume and the entire conference program remarkable and inspirational for valuable opportunities and new connections between the scientific community, institutions, enterprises, and practitioners worldwide.

Donatella Spano
Chair of the Scientific Committee

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Overall Programme

SUNDAY

15th MAY

Eliseo Theatre, via Roma 73 - Nuoro

ROOM _A

15:00 - 17:45
Registration opening

MONDAY
16th MAY

Eliseo Theatre, via Roma 73 - Nuoro
ROOM _A

08:30 Registration

10:00 **Conference opening**
Welcome address

Donatella Spano, University of Sassari, Department of Agricultural Sciences, and CMCC Foundation Euro-Mediterranean

Francesca Camilli, EURAF Deputy President and CNR-IBE, Institute of the Bio Economy

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Gabriella Murgia, Minister of Agriculture, Autonomous Region of Sardinia (tbc)

Christian Solinas, President of the Sardegna Region (tbc)

11:00 *Coffee break*

MONDAY

16th MAY

Eliseo Theatre, via Roma 73 - Nuoro

ROOM_A

PLENARY SESSION 1

Chair - Donatella Spano, University of Sassari, Department of Agricultural Sciences, and CMCC Foundation Euro-Mediterranean Center on Climate Change

11:30 **National policy commitments to support agroforestry in Italy**
Pietro Oieni, Italian Ministry of Agriculture, Food and Forestry Policies

Chair - Giovanna Seddaiu, University of Sassari, Department of Agricultural Sciences

12:00 **A social-ecological agenda for agroforestry in the Mediterranean region**
Tobias Plieninger, University of Gottingen and the University of Kassel (Online presentation)

12:30 *Lunch*

TOPIC 1
Agroforestry and the Environment

T1.1 - Climate change (adaptation & mitigation)

Chair - Paul Burgess, Cranfield University, Bedfordshire, United Kingdom

14:30 **O_1.1_4 Carbon certification in agroforestry?! Assessment and recommendations**
Rico Hübner, Christoph A. Meixner, Christopher Morhart, Ernst Kürsten, Georg Eysel-Zahl, Norbert Lamersdorf, Penka Tsonkova, Tobias Peschel, Martin Wiesmeier, Christian Böhm

14:45 **O_1.1_12 Greenhouse and open field studies on water stress responses of new poplar clones with "high environmental sustainability" under testing for silvoarable systems in Italy**
Pierluigi Paris, Achille Giorcelli, Valentina Bosco, Simone Cantamessa, Maria Cristina Monteverdi, Gianpiero Vigani, Marco Grendele, Marco Lauteri, Pier Mario Chiarabaglio

15:00 **O_1.1_14 The use of biochar and wood chips to improve the productivity of mountain meadows in an organic system**
Paweł Radzikowski, Robert Borek, Marcin Wójcik, Krzysztof Jończyk

15:15 **O_1.1_6 Horizontal and vertical variations of root distribution and traits, soil physical, chemical and microbial properties associated with CNP cycles in a young alley-cropping system under Mediterranean climate**
Lorène Siegwart, Christophe Jourdan, Gabin Piton, Karel Van den Meersche, Soh Sugihara, Isabelle Bertrand

15:30 **O_1.1_8 Meriagos can contribute to achieve Net Zero Sardinian beef cow-calf system farms**
Mondina F. Lunesu, Maria F. Caratzu, Fabio Correddu, Anna Nudda, Gianni Battacone, Giuseppe Pulina

15:45 **O_1.1_9 Building a global carbon database to characterize agroforestry as a natural climate solution**
Susan Cook-Patton, Michael Jacobson, Tanushree Biswas, Remi Cardinael, Katherine Culbertson, Andrea DeStefano, Edenise Garcia, Kripa Neupane, Todd Rosenstock, Starry Sprenkle-Hyppolite, Marta Suber, Alison Surdoval, Drew Terasaki Hart, Bhuwan Thapa,YeseniaValverde, Stephen Wood, Sam Yeo, Alina Zarate

16:00 *Coffee break*

TOPIC 2

Quality, safety and sustainability of agroforestry productions

T2.1 - Crop and grassland productions

Chair - Anastasia Pantera, Agricultural University of Athens, Department of Forestry and Natural Environment Management

16:30 **O_2.1_50 Effect of shade on persistence of sown legumes under silvopastoral conditions**
Antonello Franca, Daniele Dettori, Daniele Nieddu, Federico Sanna

16:45 **O_2.1_51 Optimising productivity of silvoarable agroforestry systems in the temperate zone: screening crop species and varieties in an artificial shade experiment**
Bert Reubens, Paul Pardon, Rutger Tallieu, Tom De Swaef, Willem Coudron, Jolien Bracke, Willem Van Colen

17:00 **O_2.1_53 Light reduction affected agronomic performance and nutritive value of temporary grassland swards in a Mediterranean rainfed plot trial**
Lorenzo Gabriele Tramacere, Alberto Mantino, Massimo Sbrana, Marco Mazzoncini, Marcello Mele, Giorgio Ragaglini, Daniele Antichi

17:15 **O_2.1_54 Grazing sheep in commercial orchards after bud break: technical lockups and challenges regarding damage to trees and risk of copper poisoning**
Clémence Rivoire, Michel Bouy, Mathilde Facy, Guillaume Fichepoil, Amélie Lèbre, Raphaëlle Leinardi, Magali Montet, Pierre Pellissier, Martin Trouillard

17:30 **O_2.1_55 Yield and quality of arable crops in temperate alley cropping systems during the first decade after tree establishment**
Paul Pardon, Paul Quataert, Jolien Bracke, Dirk Reheul, Kris Verheyen, Bert Reubens

17:45 **O_2.1_52 Effect of trees on the phenology of dehesa grassland in the western Iberian Peninsule**
Gerardo Moreno, Isabel Arenas-Corralizas, Victor Rolo, Manuel Bertomeu

TOPIC 3
Economy and policy of agroforestry

T3.3 - Agroforestry Business Environment Models

Chair - Antonio Brunori, Programme for the Endorsement of Forest Certification (PEFC) - Italy, Perugia, Italy

18:00 **O_3.3_90 Assessing agroforestry options for sustainable land use in Germany**
Cory Whitney, Fred Kuhl, Eike Luedeling

18:15 **O_3.3_91 Assessing the potential of different economic incentives for stimulating temperate agroforestry. A case-study in Flanders, Belgium**
Helena Tavernier, Lieve Borremans, Jolien Bracke, Bert Reubens, Erwin Wauters

18:30 **O_3.3_92 Agroforestry systems in Portugal: studying traditional and innovation systems and its economical approach**
Henrique Santos, Joana Grácio, Leonardo Collier, Rita Bernardo, Rossano Filippini, Sara Rodrigues

18:45 **O_3.3_60 Effects of Agroforestry System Use on Wine Production in the Mosel Valley**
Nicklas Riekötter

TOPIC 4
Agroforestry in society and culture

T4.3 - Agroforestry and historical landscapes: heritage identity and a driver for sustainable tourism

Chairs - Claire Lemarié, Chambre d'agriculture des Pays-de-la-Loire, Direction Territoire, service Arbres et Biodiversité, ANGERS, France

19:00 **O_4.3_110 Green Infrastructure governance approaches in the Alpine Space – Synthesis of collaborative mapping approaches for selected case studies**
Rico Hübner, Werner Rolf, Linda Schrapp, Maren Buschhaus, Sara Salgado, Katalin Czippán, Anika Sebastian, Peter Blum

19:15 **O_4.3_111 Olive agroforestry in Sicily. Insights from the Roman past and the present**
Vincenza Ferrara, Giovanna Sala, Dominic Ingemark, Tommaso La Mantia

19:30 *End*

MONDAY

16th MAY

Chamber of Commerce, via Papandrea - Nuoro
ROOM_B

TOPIC 1
Agroforestry and the environment

T1.3 - Landscape planning and management

Chair - Felix Herzog, Agroscope, Switzerland

14:30 **O_1.3_32 Drivers of soil erosion in a Mediterranean agrosilvopastoral system: A comparative assessment of RUSLE model predicted value and perceived soil erosion risk in southern Tuscany (Italy)**
Stefano De Leo, Francesco Annecchini , Heitor Mancini Teixeira, Martina Occelli, Martina Re, Alberto Mantino

14:45 **O_1.3_33 Recent land cover changes affecting agroforestry systems in Extremadura (SW Spain): An intensity analysis at regional and farm scales**
Joaquin Francisco Lavado Contador, Estela Herguido Sevillano, Susanne Schnabel, Anthony Gabourel Landaverde, Jesus Barrena González

15:00 **O_1.3_34 UAV-Based Remote sensing technique to detect and analyze Ink disease in a chestnut orchard using high resolution multispectral imagery**
Lorenzo Arcidiaco, Angela Frascella, Giovanni Emiliani, Roberto Danti, Sara Barberini, Antonietta Mello, Francesco Venice, Gianni Della Rocca

15:15 **O_1.3_35 Recovery of cork forests and enhancement of by-products**
Giovanna Sala, Rafael da Silveira Bueno, Emilio Badalamenti, Andrea Laschi,Tommaso La Mantia

15:30 **O_1.3_37 Agroforestry systems in Portugal: is it possible to bring more biodiversity to traditional cropping systems towards sustainability?**
Henrique Santos, Joana Grácio, Leonardo Collier, Rita Bernardo, Rossano Filippini, Sara Rodrigues

15:45 **O_1.3_150 Common walnut (Juglans regia L.) - a promising tree species for agroforestry systems**
Christopher Morhart, Zoe Schindler, Jonathan Sheppard, Rafael Bohn Reckziegel, Hans-Peter Kahle, Thomas Seifert

16:00 *Coffee break*

TOPIC 3
Economy And Policy Of Agroforestry

T3.1 - Neutrality certifications and carbon farming

Chair - Anna Maria Mitrova, endel University in Brno, Faculty of Forestry and Wood Technology, Czechia

16:30 **O_3.1_81 Agroforestry systems to support carbon neutrality of dairy cow production: preliminary assessment of a carbon insetting scenario in northern Tuscany (Italy)**
Alberto Mantino, Margherita Tranchina, Marcello Mele, Josep Crous-Duran, Ricardo Villani

16:45 **O_3.1_82 Sustainable management of Agroforestry systems: state of the art of PEFC certification in Italy**
Antonio Brunori, Francesco Marini, Eleonora Mariano, Francesca Camilli, Silvia Baronti

17:00 **O_3.1_83 Increased tree root growths due to soil management in agroforestry systems**
Sonja Kay

TOPIC 2
Quality, safety and sustainability of agroforestry productions

T2.3 - Livestock productions

Chair - Robert Borek, Institute of Soil Science and Plant Cultivation - State Research Institute, Puławy, Poland

17:15 **O_2.3_72 Herbage intake, nutritive value and cattle productivity within silvopasture and open pasture systems: a case- study in a Mediterranean livestock farm**
Alice Ripamonti, Giovanni Pecchioni, Francesco Annecchini, Laura Casarosa, Alessio del Tongo, Jacopo Goracci, Marcello Mele, Alberto Mantino

17:30 **O_2.3_73 Carbon footprint labelling in the agri-food sector: a preliminary study on consumer behaviour for beef in Spain**
Andrés Horrillo, Celia Balas, Carlos Díaz-Caro, Paula Gaspar, Francisco Mesías, Miguel Escribano

17:45 **O_2.3_75 Dynamic of 16 fodder trees' nutritive values from June to October**
Geoffrey Mesbahi, Philippe Barre, Rémy Delagarde, Fabien Bourgoin, Romain Perceau, Sandra Novak

TOPIC 4
Agroforestry in society and culture

T4.1 - Education, training, dissemination and promotion

Chair - Judit Csikvari, Zsörk Alapítvány (Zsörk Foundation), Zsörk farm

18:00	**O_4.1_99 Agroforestry education in the transition for the new decade: the example of Greece** *Andreas Papadopoulos, Anastasia Pantera,George Fotiadis, Konstantinos Mantzanas, Vasileios Papanastasis, Charles Burriel, Ghislaine Nouallet, Maria-Rosa Mosquera-Losada*
18:15	**O_4.1_100 «Club des agroforestiers Sarthois» When farmers become agroforesters** *Claire Lemarié*
18:30	**O_4.1_101 Bringing research, extension and training partners together for agroforestry upscaling: A look at of the French network "RMT AgroforesterieS"** *Delphine Mézière, François Warlop, Patrick Cochard, Brendan Godoc, Sandrine Emeriau, Frédrick Lévêque, Clélia Saubion, Graziella Tostain, Juliette Grimaldi, François Birmant*
18:45	**O_4.1_102 Participatory serious games: developing a tool to design mixed farming and agroforestry systems** *Rosemary Venn, Elsbeth Smit, Isabella Selin-Norén, Andrew Dawson, Jeroen Watté, Sara Burbi,*
19:00	**O_4.1_103 Regenerative landscapes and communities: assessing socioecological functions of an agroforestry peri-urban system** *Stefano Bocchi, Valentina Capocefalo, Gemma Chiaffarelli, Alice Giulia Dal Borgo, Andrea Schievano, Ilda Vagge*
19:15	*End*

TUESDAY

17th MAY

Eliseo Theatre, via Roma 73 - Nuoro
ROOM_A

TOPIC 1
Agroforestry and the environment

T1.1 - Climate change (adaptation & mitigation)

Chair - Christian Dupraz, INRAE, UMR Absys, University of Montpellier, Montpellier, France

09:00 **O_1.1_10 Soil carbon after prescribed burnings combined with silvopasture in Galicia (NW Spain)**
Nuria Ferreiro-Dominguez, Antonio Rigueiro-Rodríguez, María Rosa Mosquera-Losada

09:15 **O_1.1_11 Preliminary results from the use of soil covers to decrease soil moisture evaporation, decrease flammable biomass buildup, and enhance regeneration in a silvopastoral system**
Anastasia Pantera, Pinelopi Papadopoulou, Panagiotis Kalaitzis, Lisa Radinovsky, Konstantinos Blazakis, Maria Sampathianaki

09:30 **O_1.1_5 Agroforestry system with cereal crops and wood plantations: an economic case study in the Po Valley**
Laura Rosso, Simone Cantamessa, Domenico Coaloa, Pier Mario Chiarabaglio

09:45 **O_1.1_2 Tree root pruning in maize alley-cropping: would it have saved the maize? The Hi- sAFe model answers. Will you believe it?**
Lory Boutchakdjian, Christian Dupraz, Isabelle Lecomte, Marie Gosme, Francesco Reyes

10:00 **O_1.1_13 Impact of cattle grazing on soil and stand structure in a Mediterranean silvopastoral system in Tuscany**
Maria Chiara Manetti, Francesco Marini, Francesco Pelleri, Alessandra Pacini, Pier Mario Chiarabaglio, Sara Bergante, Francesca Camilli, Silvia Baronti, Anita Maienza, Fabrizio Ungaro, Francesca Ugolini, Jacopo Goracci

10:15 **O_1.1_15 Increasing tree survival to facilitate the conversion of conventional systems to agroforestry systems using plant growing aids and plant-plant facilitation under climate change**
Rafael da Silveira Bueno, Emilio Badalamenti, Giovanna Sala, Michele Russo, Tommaso La Mantia

10:30 **O_1.1_16 Agroforestry for climate smart agriculture: farmer perception of ecosystem services and the contribution to on farm resilience**
Rosemary Venn, Katharina Dehnen-Schmutz, Michelle Allen, Sara Burbi

10:45 **O_1.1_17 Agroforestry innovation with walnut: the Woodnat experience**
Simone Cantamessa, Achille Giorcelli, Maria Chiara Manetti, Francesco Pelleri, Sara Bergante, Pier Mario Chiarabaglio

11:00 *Coffee break*

TOPIC 1
Agroforestry and the environment

T1.3 - Landscape planning and management

Chair - Manuel Bertomeu, University of Extremadura

11:30 **O_1.3_47 Agroforestry component of ecological optimization of agro-landscapes within Gully Steppe of Ukraine**
Vasyl Yukhnovskyi, Yulia Bila, Olha Tupchii, Nataliia Solomakha, Yurii Urliuk

11:45 **O_1.3_40 Conversion of a Conventional Arable Land to a Multifunctional Landscape through Research by Design**
Miroslav Čibik, Attila Tóth

12:00 **O_1.3_41 Forest cover changes under agroforestry program in dryland of Sudan**
Mohamed Hemida, Andrea Vityi

12:15 **O_1.3_36 Decision support for farmers – a systems approach illustrated by an analysis on the impact of integrating chicken into German apple orchards**
Katja Schiffers, Zoe Heuschkel, Lars Caspersen, Linda Lurz, Cory Whitney, Eike Luedeling

13:00 *Lunch*

TOPIC 3
Economy and policy of agroforestry

T3.2 - Agroforestry european policy

Chair - Patrick Worms, EURAF President and CIFOR-ICRAF

15:00 **O_3.2_84 A scoping review of the economic competitiveness of temperate agroforestry systems in Europe and North America**
Alma Thiesmeier, Peter Zander

15:15 **O_3.2_85 Upscaling agroforestry practices from the field to the regional scale: a case study in the Walloon region, Belgium**
Géraud de Streel, Olivier Baudry

15:30 **O_3.2_86 Agroforestry in the agricultural plans of 14 EU Member States plus the UK and Switzerland.**
Gerry Lawson, Manuel Bertomeu, Paul Burgess, Jakub Houska, Rico Huebner, Sonja Kay, Dagnija Lazdina, Fabien Liagre, Anders Linden, Grega Milcinski, Joao Palma, Vasilios Papanastasis, Julie Rohde Birk, Greet Ruysschaert, Zita Szalai, Patrick Worms, Michael den Herder

15:45 **O_3.2_87 European state of agroforestry: an overview of the current policy contexts**
Jesse Donham, Rosemary Venn, Paola Migliorini, Ulrich Schmutz

16:00 **O_3.2_88 An agroecological future: which frameworks should we apply when developing agroforestry policy in England?**
Rosemary Venn, Sara Burbi

16:15 **O_3.2_89 The benefits of Agroforestry for the environment, climate change mitigation and agricultural production – a global synthesis**
Andrea Schievano, Marta Pérez-Soba, Mathilde Chen, Simona Bosco, Ana Montero-Castaño, Giovanni Tamburini, Giuseppe Bertolina, Stefano Bocchi, Jean Michel Terres, David Makowski

16:30 *Coffee break*

17:00 **AGROMIX #AskAScientist campaign:**
Agroforestry Q&A session

Moderator:
Dimitri Tsitos, The Regenerative Agroforestry Podcast

Panel of experts:
Patrick Worms, EURAF President and ICRAF

Dagnija Lazdiņa, Latvian State Forest Research Institute "Silava", Latvia

Anastasia Pantera, Agricultural University of Athens, Department of Forestry and Natural Environment Management

Bohdan Lojka, Czech University of Life Sciences in Prague, Faculty of Tropical AgriSciences, Department of Crop Science and Agroforestry, Czech Republic

18:00 *End*

TUESDAY

17th MAY

Chamber of Commerce, via Papandrea - Nuoro

ROOM_B

TOPIC 2

Quality, safety and sustainability of agroforestry productions

T2.1 - Crop and grassland productions

Chair - Rico Hübner, Technical University of Munich, TUM School of Life Sciences, Chair of Strategy and Management of Landscape Development, Freising-Weihenstephan

09:00 **O_2.1_56 Grafting: a sustainable agricultural tool to face climatic stressful conditions in hazelnut (Corylus avellana L.)**
Silvia Portarena, O. Gavrichkova, E. Brugnoli, A. Battistelli, S. Proietti, S. Moscatello, F. Famiani, C. Zadra, D. Farinelli

09:15 **O_2.1_58 A remote sensing approach to assess the stability of forage production from legume-rich mixtures oversown in Mediterranean wooded grasslands**
Antonio Pulina, Ana Hernández-Esteban, Victor Rolo, Giovanna Seddaiu, Pier Paolo Roggero, Gerardo Moreno

09:30 **O_2.1_59 Effect of reclaimed water on corn plants' height intercropped with trees in a silvoarable alley plot**
Pinelopi Papadopoulou, Evangelos Statiris, Simos Malamis, Constantinos Noutsopoulos, María Rosa Mosquera-Losada

TOPIC 1
Agroforestry and the environment

T1.2 - Biodiversity

Chair - Bert Reubens, Flanders research institute for agriculture, fisheries and food (ILVO), Belgium

09:45 **O_1.2_22 Ecological relations of soil fauna under long term Agroforestry system in temperate climate: results from central Italy**
Anita Maienza, Erica Lumini, Gherardo Biancofiore, Silvia Baronti, Francesca Ugolini, Fabrizio Ungaro, Francesca Camilli

10:00 **O_1.2_23 Hedgerow biodiversity – a proxy for the biodiversity potential of alley cropping**
Beate Strandberg, Jørgen Aagaard Axelsen

10:15 **O_1.2_26 Apiculture and biodiversity of honey plants of Montenegro - Potential for agroforestry practice**
Jelena Beloica, Boris Radak, Predrag MIljković, Boro Vujošević, Goran Anačkov, Milan Medarević, Nikola Kovačević, Predrag Radišić, Jelena Lazarević

10:30 **O_1.2_25 Potential of agroforestry systems in preserving Europe's soil biodiversity in lowland and highland**
Rafal Wawer, Piotr Koza, Jacek Niedźwiecki, Robert Borek, Adrian-Eugen Gliga, Bhim Bahadur Ghaley, Ying Xu, Jo Smith, Laurence Smith, Mignon Șandor, Andrea Pisanelli, Angela Augusti, Giuseppe Russo, Marco Lauteri, Marco Ciolfi, Lisa Mølgaard Lehmann, Eugeniusz Nowocien, Damian Badora

11:00 *Coffee break*

TOPIC 2
Quality, safety and sustainability of agroforestry productions

T2.3 - Livestock Productions

Chair - Marcello Mele, University of Pisa, Department of Agriculture, Food and Environment, Pisa, Italy

11:30 **O_2.3_76 Feeding preferences of Highland cattle reveal their attitude to exploit woody vegetation in mountain environments**
Ginevra Nota, Marco Pittarello, Simone Ravetto Enri, Davide Barberis, Rebecca Pagani, Michele Lonati, David Frund, Mia Svensk, Massimiliano Probo, Giampiero Lombardi

11:45 **O_2.3_77 In France, silvipastoral arrangements in grasslands can mitigate moderate heat stress in sheep**
Mickaël Bernard, Robin Russias, Cécile Ginane, André Marquier, Urbain Kokah, Léa Ottmann, Sophie Tournier, Pascal Walser, Emma Chanet, Bruno Moulia, Marc Saudreau

12:00 **O_2.3_78 Performance of Iberian x Duroc cross breed pigs according to age at the beginning of free-range finishing phase in Montanera**
Alberto Ortiz, David Tejerina, Susana García-Torres, Paula Gaspar, Elena González

12:15 **O_2.3_79 Willingness to pay for certification in the case of Iberian ham. Sustainability labels vs. agroforestry attributes**
Paula Gaspar, Carlos Díaz-Caro, Inés del Puerto, Alberto Ortiz, Miguel Escribano, David Tejerina

12:30 **O_2.3_74 Impact of technical-economic management on the greenhouse gas emissions and carbon sequestration in organic livestock farms**
Andrés Horrillo, Francisco Mesías, Paula Gaspar, Miguel Escribano

12:45 **O_2.3_80 Water quality for livestock in semi- arid rangelands of the southwestern Iberian Peninsula**
Ubaldo Marín-Comitre, Susanne Schnabel, Jesús Barrrena-González, Manuel Pulido-Fernández

13:00 *Lunch*

TOPIC 2
Quality, safety and sustainability of agroforestry productions

T2.2 - Timber, energy and non-wood forest productions

Chair - Jakub Houška, The Silva Tarouca Research Institute for Landscape and Ornamental Gardening (VUKOZ)

15:00 **O_2.2_61 Agroforestry vs. agrivoltaics: advantages and disadvantages of two approaches to combining food and energy production on the same land**
Adolfo Rosati, Maggie Graham, Serkan Ates, Chad Higgins

15:15 **O_2.2_62 Lessons from physiological monitoring of truffle productive vs. non-productive plants**
Alessia Sartori, Enrico Vidale, Davide Pettenella, Giai Petit

15:30 **O_2.2_63 Reconstruction of the tree growth dynamics in an historical agroforestry plot with dendrochronology to validate the Hi-sAFe biophysical agroforestry model**
Christian Dupraz, Alain Sellier, Jean-François Bourdoncle, Marie Gosme

15:45 **O_2.2_64 Light saturation point, radial growth and leaf phenology show the suitability of different species of the genus Corylus to live under a dominated tree layer**
Gaia Pasqualotto, Vinicio Carraro, Daniela Frarinelli, Tommaso Anfodillo

16:00 **O_2.2_65 The production of Edible Wood in a coppice system**
Pip Gilmore

16:30 *Coffee break*

LIVINGAGRO Side event

18:10 *End*

WEDNESDAY
18th MAY

All day (Study Visits)

Study Visit "Montiferru"
Elighes Uttiosos Farm - LIFE Regenerate project

Study Visit "Monte Sant'Antonio"
Experimental Farm of Agris Sardegna

Study Visit "Arborea"
Eucalyptus windbreaks and research projects on groundwater pollution and Infiltration Forested Areas - University of Sassari

Study Visit "Monti"
Farm Mu - ENI CBC LIVINGAGRO Project

THURSDAY

19th MAY

Eliseo Theatre, via Roma 73 - Nuoro

ROOM_A

TOPIC 1
Agroforestry and the environment

T1.1 - Climate change (adaptation & mitigation)
Parallel session co-hosted by the project SALAM-MED

Chair - Pier Paolo Roggero, University of Sassari, Department of Agricultural Sciences

09:00 **O_1.1_21 Sustainable approaches to land and water management in Mediterranean drylands: the SALAM-MED project**
Chiara Ceseracciu, Elena Bresci, Mauro Centritto, Nicola Lamaddalena, Ehab Zaghloul, Mongi Ben Zaied, Stavros Solomos, Zein Kallas, Said Wahbi, Antonio Del Campo, Houssemedin Henchir, Alessio Merella, Andrea Galante, Jean Marc Fures, Youssef Brahimi, Taysir Arbasi, Pier Paolo Roggero

09:15 **O_1.1_7 DIGITAF, a European project to help agroforestry meet climate, biodiversity and farming sustainability goals: linking field and cloud**
Marie Gosme, Bert Reubens, Gerry Lawson, Paul J. Burgess, Sonja Kay, Marco DeBoer, Patrick Worms

09:30 **O_1.1_19 Harvest index and nitrogen uptake of barley in intercropped walnut orchard**
Helena Žalac, Ante Bubalo, Vladimir Ivezić, Jurica Jović, Miro Stošić, Vladimir Zebec

09:45 **O_1.1_20 Framework for building climate change resilience into landscape restoration through agroforestry: an England case study**
Will Simonson, Colin Tosh, David Wolfe, Daan Verstand, Saskia Houben, Isabella Selin Norén, Michelle Allen

TOPIC 1
Agroforestry And The Environment

T1.4 - Wildfires

Chair - Christopher Morhart, University of Freiburg, Chair of Forest Growth and Dendroecology, Germany

10:15 **O_1.4_48 Using satellite images and GEE to monitor post-wildfire forest vegetation response in Monte Serra (Tuscany, Italy)**
Lorenzo Arcidiaco, Chiara Torresan, Giorgio Matteucci

10:30 **O_1.4_49 Managing wildfire risk in mosaic landscapes: A case study of the upper Gata river catchment in Sierra de Gata, Spain**
Manuel Bertomeu, Javier Pineda

11:00 *Coffee break*

TOPIC 4
Agroforestry in society and culture

T4.1 - Education, training, dissemination and promotion
Parallel session co-hosted by the project LIVINGAGRO

Chair - Sara Maltoni, Fo.Re.S.T.A.S. (Regional Forest Agency of Sardinia)

11:30 **O_4.1_109 Living Labs for promoting innovations in Mediterranean agroforestry. The LIVINGAGRO experience**
Sara Maltoni, Maurizio Malloci, Mauro Forteschi, Marina Bufacchi, Andrea Pisanelli, Claudio Porqueddu, Antonello Franca, Luciana Baldoni, Daniele Chiappini, Roberto Cippitani, Salam Ajoub, Milad El Riachy, Peter Moubarak, Joseph Kahwaj, Lamis Chalak, Panagiotis Kalaitzis, Eleni Stamataki, Kostas Blazakis, Dina Porazzini, Alessandro Mancosu, Rita Melis, Pasquale Arca

11:45 **O_4.1_104 Revealing the multiple shades of trees in the agroforestry discourse in Quebec, Canada**
Geneviève Laroche, Jean Mercier, Alain Olivier

12:00 **O_4.1_105 The opportunity, capability and motivation of farmers to expand agroforestry and orchards in England**
Paul Burgess, Anil Graves, Lucy Dablin, Hannah Martin, Twinkle Panchal, Jeremy Bregaint, and Haoshen Li

12:15 **O_4.1_106 Increasing tree cover on Irish dairy and drystock farms: the main barriers and perceptions that impede agroforestry uptake**
Rachel Irwin, Áine Ní Dhubháin, Ian Short, Mohammad Mohammadrezai

12:30 **O_4.1_107 Agroforestry dissemination under Organic Farming scope: The I Portuguese Encounter of Successional Agroforestry Systems**
Ricardo Leitão, Rosa Guilherme, Isabel Dinis, Daniela Santos, Pedro Mendes-Moreira

13:00 *Lunch*

TOPIC 2
Quality, safety and sustainability of agroforestry productions

T2.2 - Timber, Energy And Non-Wood Forest Productions

Chair - Michal Pástor, National Forest Centre, Forest Research Institute, Slovakia

15:00 **O_2.2_66 Agroforestry produced hybrid poplar to implement green building with engineered wood products as foundation for the bio-based economy**
Joris Van Acker

15:15 **O_2.2_67 Peeling of agroforestry walnut: comparison of the deformation of agroforestry vs. forestry walnut veneers**
Lucie Heim, Louis Denaud, Rémy Marchal, Joffrey Viguier, Jean-Claude Butaud, Kevin Candelier, Eric Badel

15:30 **O_2.2_69 Black walnut (Juglans nigra L.) as a multifunctional and suitable tree species for agroforestry systems in Slovakia**
Michal Pástor, Jaroslav Jankovič

15:45 **O_2.2_70 Mechanized pollarding of poplar trees in an alley cropping system**
Natascia Magagnotti, Raffaele Spinelli, Loris Agostinetto, Federico Correale, Giustino Mezzalira

16:00 **O_2.2_71 Mediterranean species Myrtus communis L. and Castanea sativa Mill., as natural source of bioactive compounds**
Paola Cetera, Silvia Medda, Angela Fadda, Raffaella Lovreglio and Maurizio Mulas

16:30 *Coffee break*

17:00 **EURAF General Assembly**

19:00 *End*

THURSDAY

19th MAY

Chamber of Commerce, via Papandrea - Nuoro

ROOM_B

TOPIC 1
Agroforestry and the environment

T1.2 - Biodiversity

Parallel session co-hosted by the project AGROMIX

Chair - Rosemary Venn, Centre for Agroecology, Water and Resilience (CAWR), Coventry University, UK

09:00	**O_1.2_24 Will biodiversity and ecosystem service benefits of alley cropping be similar to from traditional agroforestry systems?** *Felix Herzog, Jana Collatz, Martin Entling*
09:15	**O_1.2_27 Vitiforestry: Farmers' intent to include almond trees into viticultural systems in Switzerland and Germany** *Lara Basile, Lukas Flinzberger, Sonja Kay*
09:30	**O_1.2_28 Breeding birds in European Agroforestry systems** *Manon Edo, Verena Rösch, Martin Entling*
09:45	**O_1.2_29 Nature-based Solutions in Tree Covered Systems: possibilities for biodiversity conservation in forests across gradients of wildness and land-use intensity** *Michael Straarup, Tommy Dalgaard, Signe Normand, Jens-Christian Svenning*
10:00	**O_1.2_31 Establishing a Tree Crop Improvement Program within Savanna Institute Assembling germplasm repositories to support the breeding of Midwest-adapted agroforestry crops** *Scott Brainard, Eliza Greenman, Fred Iutzi, Keefe Keeley*
11:00	*Coffee break*

TOPIC 1
Agroforestry and the environment

T1.3 - Landscape planning and management
Parallel session co-hosted by the project BOSCOLAMENTO

Chair - Camilla Dibari, University of Florence, Department of Agriculture, food, environment, and forestry (DAGRI)

11:30 **O_1.3_43 Agroforestry systems in the European Union – extent and spatial distribution**
Susanne Schnabel, Judit Rubio-Delgado, Anthony Gabourel Landaverde, Joaquin Francisco Lavado-Contador

11:45 **O_1.3_44 A grazing experience of Aberdeen- Angus under poplar stand in Italy**
Simone Cantamessa, Giuseppe Nervo, Domenico Coaloa, Pier Mario Chiarabaglio

12:00 **O_1.3_42 Dehesas as high nature value farming systems: A social- ecological synthesis of drivers, pressures, state, impacts, and responses**
Tobias Plieninger, Lukas Flinzberger, Maria Hetman, Imke Horstmannshoff, Marilena Reinhard-Kolempas, Emmeline Topp, Lynn Huntsinger, Gerardo Moreno

12:15 **O_1.3_45 Use of remote sensing data and GEE (Google Earth Engine) for detection and monitoring of cork oak decline caused by Phytophthora cinnamomi**
Andrea Brandano, Lorenzo Arcidiaco, Bruno Scanu, Giorgio Matteucci, Simone Mereu

12:30 **O_1.3_39 Agroforestry systems an important tool for environmental restoration and connection of Atlantic Forest remnants in the State of São Paulo-Brazil**
Maria Teresa Vilela Nogueira Abdo, Isabel Fonseca Barcellos, Antonio Pries Devide, Joaquim Adelino de Azevedo Filho, Elaine Cristine Piffer Gonsalves, Teresa Cirstina Tarlé Pissarra, Gislaine Costa de Mendonça, Renata Egydio Carvalho Costa Manço, Marli Dias Mascarenhas, Monica Helena Martins, Marccella Lopes Berte, Thiago Ribeiro Coutinho

13:00 *Lunch*

TOPIC 3
Economy and policy of agroforestry

T3.4 - Governance for traditional sustainable agrosilvopastoral systems

Parallel session co-hosted by the project MIXED

Chair - Julie Rohde Birk, Innovation Center for Organic Farming, Denmark

15:00 **O_3.4_94 Co-creation of sustainable ecosystems and resilient livelihoods in agroforestry value chains: organized shade-grown coffee producers in Mexico**
Antoine Libert Amico, Fernando Paz Pellat, Gontrán Villalobos Sánchez, Martín Bolaños González

15:15 **O_3.4_95 Trees on agriculture land**
Dagnija Lazdiņa

15:30 **O_3.4_96 Re-thinking the national supply chain of summer truffle: towards investments structural small-scale on agroforestry**
Enrico Vidale, Nicola Andrighetto, Giai Petit, Alessia Sartori, Jacopo Giacomoni, Davide Pettenella

15:45 **O_3.4_97 Land Consolidation Associations for the conservation and the restoration of agricultural landscapes**
Giampiero Lombardi, Ginevra Nota, Pier Paolo Roggero, Giovanna Seddaiu

16:30 *Coffee break*

FRIDAY
20th MAY

Eliseo Theatre, via Roma 73 - Nuoro
ROOM_A

PLENARY SESSION 2

09:00 **Chair - Antonello Franca,** CNR-ISPAAM
Research and Innovation towards the sustainable development of silvopastoral systems
Teresa Pinto Correia, University of Évora (Online presentation)

09:30 **Chair - Adolfo Rosati,** Council for Agricultural Research and Economics (CREA),
Digital agriculture: threat or opportunity for agroforestry?
Marie Gosme, INRAE Montpellier (Online presentation)

10:00 **Chairs - Alberto Mantino, Antonello Franca, AIAF,** Associazione Italiana di Agroforestazione
Farmers experiences on agroforestry
Jacopo Goracci, Tenuta di Paganico, Grosseto, Italy
Pietro Todde, Fatima Todde Caseificio Todde Desulo, Nuoro, Italy

10:40 **Sisef Poster Awards**
Pierluigi Paris, Sisef, Società Italiana di Selvicoltura ed Ecologia Forestale

11:00 *Coffee break*

11:30 **Conference summary and statement**

12:00 **EURAF2024 launch**
Bohdan Lojka, Czech University of Life Sciences Prague
Jakub Houška, The Silva Tarouca Research Institute for Landscape and Ornamental Gardening (VUKOZ)

12:15 **5th World Agroforestry Conference announcement**
Alain Olivier, Université Laval, Quebec

12:30 **Conference closing**
Patrick Worms

13:00 *Lunch*

POSTER SESSION

Virtual poster session during the whole conference

TOPIC 1 - AGROFORESTRY AND THE ENVIRONMEN

T1.1 - CLIMATE CHANGE (ADAPTATION & MITIGATION)

P_1.1_112 **A review of carbon sequestration and storage potential of agroforestry trees in Denmark**
Anne Mette Lykke and Jørgen Axelsen

P_1.1_113 **Interactions between trees, crops and pedosphere: experiences in irrigated bioenergy-agroforestry system in Hungary**
Beatrix Bakti, Csaba Bozán, Zsolt Keserű, Mihály Jancsó, Ildikó Kolozsvári, Csaba Gyuricza, Agnes Kun

P_1.1_114 **The valuation of forest ecosystem services in Kenya: a comparative case study of Karura forest reserve and Kakamega national forest reserve**
Erick O. Osewe and Ioan Vasile Abrudan

P_1.1_115 **Effect of the planting system on the carbon balance components of a black locust-based agroforestry site under Mediterranean climate**
Jérôme Ngao, Lorène Siegwart, Christophe Jourdan, Didier Arnal, Rémi Dugué, Maxime Duthoit, Alain Rocheteau, Carlos Trives-Segura, Isabelle Bertrand

P_1.1_116 **ROBUST: Agroforestry - a sustainable agricultural system for plant and milk production in northern temperate climate**
Julie Rohde Birk

P_1.1_118 **Simulating the effect of climatic variations on the long-term performance of different agroforestry systems within field trials using virtual experiments**
Klaus A. Jarosch, Michelle Allen, Daniele Antichi, Mickaël Bernard, Lory Boutchakdjian, Paul Burgess, Lydie Dufour, Christian Dupraz, Jonathan Eden, Anil Graves, Marcello Mele, Gerardo Moreno, Alice Ripamonti, Rodrigo Olave, João Palma, Victor Rolo, Will Simonson, Colin Tosh, Lorenzo Gabriele Tramacere, Felix Herzog

P_1.1_119 **GHG gas measurements in agroforestry system with different tree species and fertilization regimes**
Kristaps Makovskis, Dagnija Lazdina, Arta Bardule

P_1.1_120 **Investigation of the effect of plant and soil conditioners on irrigated agroforestry system (industrial poplar plantation; alfalfa)**
Ágnes Kun, Ádám Palást, Zsolt Keserű, Mihály Jancsó, Csilla Török, Emese Sóvágó, Ildikó Kolozsvári, Csaba Gyuricza, Beatrix Bakti

P_1.1_121 **The environmental impacts of agroforestry in agri-food systems: a life cycle assessment approach**
Mónica Quevedo Cascante, Lisbeth Mogensen, Anne Grete Kongsted, and Marie Trydeman Knudsen

P_1.1_122 **The AgroForageTree project: Agroforestry for forage production in permanent grasslands using fodder tree hedgerows**
Pierre Mariotte, Charlotte Grossiord, Sonja Kay, Frigga Dohme-Meyer, Silvia Ampuero Kragten, Sébastien Dubois, Paolo Silacci, Massimiliano Probo

P_1.1_124 **Agroforestry systems to support sustainable agriculture in Serbia**
Saša Kostić, Saša Orlović, Dejan B. Stojanović

P_1.1_125 **Development of genomic tools for improving efficiency of selection in Corylus americana and C. americana x C. avellana hybrids Mitigating climate change through carbon sequestration by supporting the transition from annual to perennial agriculture**
Scott Brainard, Julie Dawson, Lois Braun, Jason Fischbach, Fred Iutzi

P_1.1_127 **Comparing production systems - including agroforestry - in organic vegetable production on the basis of microclimate data**
Zita Szalai, Barbara Ferschl, Krisztina Boziné Pullai, László Csambalik

P_1.1_126 **Synergies in integrated systems: Improving resource use efficiency while mitigating GHG emissions through well- informed decisions about circulari**
Sophie Stein, Julia Schneider, Sabine Zikeli

P_1.1_128 **CARAT: an online tool for quantifying carbon sequestration in agroforestry systems**
Thomas Vanneste, Fien Vandekerchove, Tom Coussement, Kris Verheyen, Paul Pardon, Bert Reubens

P_1.1_129 **Contribution of mountainous silvopastoral systems on soil organic matter in Evritania, Central Greece**
Vasiliki Lappa and Anastasia Pantera

P_1.1_130 **Climatic parameters in/of selected agroforestry systems**
Jan Weger, Jakub Houška, Jan Šinko, Jiří Kučera, Jakub Červenka

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TOPIC 1 - AGROFORESTRY AND THE ENVIRONMEN
T1.2 – BIODIVERSITY

P_1.2_133 **A transect survey of the functional characteristics and biodiversity of weeds in modern silvoarable agroforestry systems**
Anna-Lea Ortmann, Teelke Meyenburg, Lutz Kosack, Julia Binder, Thomas Middelanis, Thomas Döring

P_1.2_134 **Evaluation of tree species in agroforestry enrichment of monoculture of Calophyllum brasiliense Cambess in area of temporary water saturation**
Antonio Carlos Pries Devide, Cristina Maria de Castro, Antônio Carlos de Souza Abboud, Raul de Lucena , Duarte Ribeiro, Marcos Gervasio Pereira, Maria Teresa Vilela Nogueira Abdo

P_1.2_135 **A draft of a parasitoid dispersal model applied in agroforestry**
Enrico Gabrielli

P_1.2_136 **Relationship between carnivore mesomammal and agro-forest ecosystems in Vico Protected area**
Giulia Luzi, Giuseppe Puddu, Marzio Zapparoli

P_1.2_137 **Monitoring of biodiversity of two selected insect groups in Agroforestry Systems in the Czech Republic**
Jakub Houška, Jan Weger, Jaroslav Bubeník, Bohdan Lojka, Dan Preininger

P_1.2_138 **Natural recovery of vegetation in a highly anthropized classified forest in Côte d'Ivoire**
Kouame Jean Marc Kouman, Yao Sadaiou Sabas Barima

P_1.2_139 **Intercropping of buckwheat (Fagopyrum esculentum Moench) with oxytree (Paulownia elongata x P. fortunei) in Polish conditions**
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P_1.2_141 **Long-term taxonomic changes in the species composition of Dokuchaev shelterbelts in the southern steppe of Ukraine**
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Svitlana Sydorenko, Serhii Sydorenko, Nataliia Solomakha

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P_1.3_144 **A systematic approach to agroforestry system planning, case studies from Slovakia**
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P_1.3_145 **Agro Fluvial Park of Calore Salernitano Restoration and valorization of historic and landscaped heritage of fluvial area in the territory of Aquara**
Sofia Cerruti, Patrizia Giannattasio, Domenico Scorziello, Marzio Marino, Pasquale Maiale, Fabio De Feo, Nadia Chianese

P_1.3_146 **Traditional and Innovative: A Review of Diverse Agroforestry Systems across European Landscapes and Cultures**
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P_1.3_148 **Effects of Unplanned Space Utilisation on Water Resources of Serbia**
Boško Josimović, Božidar Manić, Ljubiša Bezbradica

P_1.3_149 **Satellite imagery for land classification and detection of agroforestry systems: a study case of Olive trees classification in Tuscany**
Celeste Righi Ricco, Lorenzo Brilli, Piero Toscano, Federico Carotenuto, Ilaria Tabarrani, Beniamino Gioli

P_1.3_151 **Developing row planting structures in agroforestry practices taking into account their potential for air phytoremediation**
Ewa Podhajska, Anetta Drzeniecka-Osiadacz, Bronisław Podhajski, Tymoteusz Sawiński, Magdaena Zienowicz

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P_1.3_154 **Exploiting the Google Earth Engine platform for mapping agroforestry in Italian rural landscape**
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P_1.3_156 **Approach for prioritizing areas for watershed restoration through agroforestry systems**
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P_1.3_158 **Quantification of shade cast by windbreaks of different sizes in South Africa**
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P_1.3_159 **Detecting stemflow-induced preferential flow pathways through time-lapse ground-penetrating radar surveys**
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P_1.3_160 **Thirty-year Trend of Forest Seedling Production in Croatia in Respect to Agroforestry Needs and Opportunities**
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P_1.3_166 **Do distance-dependent competition indices contribute to improve diameter and total height growth estimates in undebarked cork oak trees?**
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P_2.1_180 **Effect of mixed sheep and goat grazing on the structural dynamics of Ulex gallii plants**
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P_2.1_188 **Quantification of agroforestry effects in Denmark**
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P_2.1_190 **Exploring the potential of late budding walnut (Juglans regia) varieties in temperate agroforestry systems: a long-term monitoring study in Flanders and the Netherlands**
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Jacek Walczak, Wojciech Krawczyk

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P_2.3_197 **Livestock Residence Index to monitor Sarda cattle grazing in a Mediterranean silvopastoral system**
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P_3.4_201 **Associativism and cooperativism in the rubber trees culture in Brazil**
Elaine Cristine Piffer Gonçalves, Antonio Lucio Mello Martins, Maria Teresa Vilela Nogueira Abdo

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Sara Bergante, Pier Mario Chiarabaglio, Simone Cantamessa, Josep Crous-Duran, Patricia Carbonell, Sara Burbi

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Theresia Markut, Peter Meindl, Ruth Bartel-Kratochvil

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O_1.2_27	Vitiforestry: Farmers' intent to include almond trees into viticultural systems in Switzerland and Germany
O_1.2_28	Breeding birds in European Agroforestry systems
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O_4.1_101	Bringing research, extension and training partners together for agroforestry upscaling: A look at of the French network "RMT AgroforesterieS"
O_4.1_102	Participatory serious games: developing a tool to design mixed farming and agroforestry systems
O_4.1_103	Regenerative landscapes and communities: assessing socioecological functions of an agroforestry peri-urban system
O_4.1_104	Revealing the multiple shades of trees in the agroforestry discourse in Quebec, Canada
O_4.1_105	The opportunity, capability and motivation of farmers to expand agroforestry and orchards in England
O_4.1_106	Increasing tree cover on Irish dairy and drystock farms: the main barriers and perceptions that impede agroforestry uptake
O_4.1_107	Agroforestry dissemination under Organic Farming scope: The I Portuguese Encounter of Successional Agroforestry Systems
O_4.1_109	Living Labs for promoting innovations in Mediterranean agroforestry. The LIVINGAGRO experience

POSTER

P_4.1_202	FOODLEVERS project: Leverage points for organic and sustainable food systems
P_4.1_203	The Roots of Tree Crops: J. Russell Smith and the Origins of Agroforestry

P_4.1_205	Implementation of AGFOSY project – experience from the Czech Republic
P_4.1_207	Ecosystem services provision and adoption of agroforestry in England
P_4.1_208	Successional Agroforestry's central role in a project of rural development and climate change adaptation in Alentejo, Portugal
P_4.1_209	The Knowledge Exchange Hub of the AGROMIX project
P_4.1_210	Agroforestry in Austria - an EIP-AGRI project: know-how transfer and implementation of silvoarable AFS

T 4.3 AGROFORESTRY AND HISTORICAL LANDSCAPES: HERITAGE IDENTITY AND A DRIVER FOR SUSTAINABLE TOURISM

ORAL

O_4.3_110	Green Infrastructure governance approaches in the Alpine Space – Synthesis of collaborative mapping approaches for selected case studies
O_4.3_111	Olive agroforestry in Sicily. Insights from the Roman past and the present

POSTER

P_4.3_212	Chamugrö: An ancestral agroforestry system from the indigenous Bribrí- Cabécar culture in Talamanca, Costa Rica
P_4.3_213	Vinehills of the Carpathian Basin: the benefits of isolation. Environment, traditions, landscapes and opportunities in tourism
P_4.3_214	Abandonment of traditional agroforestry systems in Northern Greece
P_4.3_215	Adoption constraints to agroforestry systems in the Algarve, Portugal

Abstracts

Invited speakers

DIGITAL AGRICULTURE: THREAT OR OPPORTUNITY FOR AGROFORESTRY?

Marie Gosme
INRAE Montpellier, France

Agroforestry is often presented as a good example of an agroecological system, because it allows an increase in biodiversity, in terms of species diversity (both planted and spontaneous) as well as functional diversity (e.g. trees and herbaceous plants). Furthermore, it produces a number of ecosystem services (Torralba et al. 2016; van Noordwijk 2021). Agroforestry systems are more complex than monocrops, due to the higher number of species, to the complex interactions between these species, to their spatial heterogeneity and long temporal scales, to the diversity of objectives that are assigned to them on top of food production, and to the higher number of management operations. Therefore, it is more difficult to understand the functioning of these systems, to design such systems, and to assess their performances.

Digital tools could offer solutions to overcome these difficulties. These tools are varied, relying on different aspects of digitalization: data collection, analysis, exchange, storage, use to control automata, etc. (Bellon Maurel and Huyghe 2017). All these tasks could be useful for agroforestry, from cheap sensors to better characterize the spatial heterogeneity within agroforestry systems to satellite data analysis to evaluate the extent of agroforestry systems at global scale, and from advanced data analysis techniques (deep learning, machine learning) to be able to generate knowledge about the functioning of complex systems to software to help farmers make decisions when designing or managing agroforestry systems. The exchange of data (via web technologies, IoT (Internet of things) networks) and information (via social networks, for example) can promote the development of knowledge-intensive agroforestry systems, while bringing citizens closer to agriculture via open sciences. The complexity of agroecology can be addressed through new pedagogical devices enabled by digital technology, such as MOOCs or serious games (Jouan et al. 2020). For the design of agroforestry systems, modeling allows to explore a multitude of scenarios that could not be tested experimentally thus allowing system optimization and/or ex-ante evaluation.

However, voices have been raised against the digitalization of agriculture, particularly among some promoters of agroecology. Indeed, one of the objectives of agroecology is to reduce the dependency on inputs and increase the autonomy of farmers. Being dependent on buying new equipment and software licences, and relying on external businesses to make decisions would defeat the purpose of agroecology. In this talk, I will try to present the different opportunities offered by digital tools for agroforestry, and highlight their limits and the precautions to take to avoid the threats that they could create.

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NATIONAL POLICY COMMITMENTS TO SUPPORT AGROFORESTRY IN ITALY

Pietro Oieni
Ministry of Agriculture, Food and Forestry Policies, Italy

Agroforestry cannot be easily classified at institutional and administrative level. However, such a modern but, at the same time, ancient land use system can provide so strong environmental, productive and landscape performances that it can rightly be considered an almost infinite source of models for good agricultural and forestry practices to be promoted far beyond the current standards. Among the many types of agroforestry supported by the General Forestry Directorate of the Italian Ministry of Agriculture, Food and Forestry Policies (MIPAAF), there are specific commitments in favor of poplar cultivation for timber production, the cork oak cultivation and the exploitation of the rich world of forestry non-wood products. Furthermore, agroforestry provides opportunities for land use planning that, under certain conditions, can guarantee a significant prevention and containment of the increasing wildfires risk in connection to the current Climate Crisis. Such actions have been possible through recent important regulatory national interventions coordinated by MIPAAF, in strong collaboration with local administrations (Regional and Autonomous Provinces offices), for guidance, planning and implementation. Interventions of this kind go far beyond the institutional activities and were developed to make agroforestry emerge out of the niche of exclusively forestry interests. Agroforestry systems and practices have been penalized by legislative and administrative definitions and classifications making agroforestry marginal for the rural development of Italy. An effective synthesis to counteract such limits was set up by developing important objectives and actions to support agroforestry, together with many stakeholders, through a participatory approach. This was possible also by means of the TUFF, the National Forestry Strategy Consolidated text of forestry supply chains (Legislative Decree 34/2018) and involving AIAF, the Italian Agroforestry Association, concerning the agroforestry actions.

The participation at EURAF2022 will be able, on one side, to foster a confrontation with the experiences of the ministries of other countries in order to strengthen agroforestry policy at EU level and, on the other, to encourage interdisciplinary collaborations to make agroforestry a resource for rural developments, within the goals of the ecological transition, according to the recent European New Green Deal and Farm to Fork Strategy.

A SOCIAL-ECOLOGICAL AGENDA FOR AGROFORESTRY IN THE MEDITERRANEAN REGION

Tobias Plieninger
University of Gottingen and the University of Kassel, Germany

Agroforestry is at the nexus between agriculture, forestry, nature conservation, and other sectors. It is increasingly recognised as a key strategy for implementing the UN-Sustainable Development Goals across the world's production landscapes and attracts substantial interest from a diversity of scientific disciplines and practice and policy fields. However, a major challenge – whether in science, policy, or practice – is to merge this large number of disciplines and fields into an integrated systems perspective that is crucial for enabling agroforestry to contribute to multiple Sustainable Development Goals. Over the past 20 years, social-ecological systems has developed as a vibrant research area, advancing the understanding of the interlinked dynamics of environmental and societal change. Using case examples from the Mediterranean region, this keynote will highlight the usefulness of social-ecological research approaches to better understanding agroforestry as a system. Firstly, the presentation will highlight how a historical perspective on the origin and development of agroforestry systems over time can improve understanding of their future trajectories. Secondly, research on social-ecological values can elicit how agroforestry provides ecosystem services that are meaningful to the well-being of a diverse range of beneficiaries, and which trade-offs may arise between different values and beneficiaries. Thirdly, the presentation will explore the role of products, value chains, and social-ecological innovations in supporting the sustainability of agroforestry systems.

The paper concludes by proposing six key steps to strengthen social-ecological agroforestry research and to capitalize on agroforestry for sustainable landscape management: (i) moving towards an "agroforestry sustainability science"; (ii) understanding local land-use trajectories, histories, and traditions; (iii) upscaling agroforestry for landscape-scale benefits; (iv) promoting the multiple economic, environmental, social, and cultural values of agroforestry; (v) fostering inclusive forms of landscape governance; and (vi) supporting the innovation process of agroforestry system analysis and design.

RESEARCH AND INNOVATION TOWARDS THE SUSTAINABLE DEVELOPMENT OF SILVOPASTORAL SYSTEMS

Teresa Pinto-Correia
University of Évora, Portugal

Silvo-pastoral systems of Iberia, Montado and Dehesa, and around the Mediterranean basin, are paradigmatic examples of European and world silvopastoral systems. They occupy in total 4 M hectares of generally considered marginal land and unlike many other of Europe's silvopastoral systems, they persist. They include a large variability in soils and morphology, as well as in structure and composition, e.g. tree density, vertical vegetation structure and state of conservation. In the long term, these systems have shown to be highly resilient to the impact of extreme natural or socio-economic phenomena and long term changes in the agricultural and forestry sectors. They can be a source of knowledge to be applicable to current (and future) silvopastoral territories in other regions across the world.

However, the preservation of silvopastoral systems is increasingly threatened by the effects of global economic forces and socio-cultural changes. Agricultural intensification and specialization are increasingly driven by external financial interests and global market forces, and consequently the patterns of farm ownership, employment and production are changing at an unprecedented scale. These changes affect also the territorial capital. In face of these pressures, finding new pathways for the farming strategies and practices is highly challenging. In the case of silvopastoral systems, besides their inherent qualities and the trends they are subject to, there are now also new societal demands as they can provide multiple ecosystem services and public goods. This demand increases the complexity of their management, as new actors and expectations need to be integrated. Surprisingly, the social and institutional drivers of the changes taking place and also the possible solutions for launching a sustainability transition, remain almost unseen, by science and by decision makers at different governance scales. The existing scientific literature on Dehesa/Montado pays little attention to its social dimension. While there is already a tradition of scientific research on the ecology and productive capacity of silvopastoral systems, texts on the social fabric of these systems are very limited.

There is an issue of governance, as learning how to live with uncertainty and finding new governance mechanisms and institutional arrangements to deal with the present and future challenges can be a pathway to improved resilience. Innovation requires the integration of the multiple actors which have a stake and an impact on the Montado and Dehesas. Governance mechanisms can foster innovation and facilitate the processes of transition towards sustainability that need to occur.

TOPIC 1

AGROFORESTRY AND THE ENVIRONMENT

1

T 1.1

CLIMATE CHANGE (ADAPTATION & MITIGATION)

Tree root pruning in maize alley-cropping: would it have saved the maize? The Hi-sAFe model answers. Will you believe it?

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Theme: Climate Change (adaptation & mitigation)

Keywords: alley cropping; walnut; modelling; tree-crop competition,

Abstract

In 2021, a maize crop was a total failure in our alley-cropping agroforestry site of Restinclières. The walnut trees are now mature, and capture up to 70% of the incoming radiation during summer months. Maize yield dropped drastically in alley cropping to values below 25% of the monocrop control, for well irrigated, poorly irrigated and non-irrigated maize as well. This relative yield was even less than the relative incident radiation, suggesting that no compensation mechanisms for light limitation were at work. The 2021 summer was however rainy and no heat wave was recorded. In such conditions the climate protection of the maize crop by the trees could not be efficient, and the light competition was probably the dominant mechanism. However, some observations suggested that water competition by the trees was still active, as testified by maize wilting close to the tree rows, even in deep shade.

To explore this issue, we used the Hi-sAFe agroforestry simulation model. After calibrating the maize variety parameters on the monocrop control, we obtained sensible simulations of the alley-cropping system. Then we made a virtual experiment by root-pruning the walnut trees to cancel below ground competition for water and nitrogen between trees and maize. This allowed us to predict what would have happened if we had root-pruned the trees. Other simulations with a dryer and hotter summer helped to understand what would have happened if the weather had been more extreme. This work illustrates the subtle interactions between erratic weather conditions and tree and crop management in silvoarable alley cropping, and the limits of climate change adaptation that can be expected in agroforestry systems.

Figure 1: A maize crop in the deep shade of a mature walnut plantation at Restinclières, France.

Carbon certification in agroforestry?! Assessment and recommendations

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Theme: Climate Change (adaptation & mitigation)

Keywords: carbon farming, carbon certification, agricultural policy, climate change

Abstract

Agroforestry has long been seen as having great potential for increasing and, above all, permanently storing carbon in biomass and soil (Nair, 2012). The IPCC (2019) and the WBGU (2020) also see agroforestry as a suitable option in the fight against the climate crisis and in adaptation to its impacts. The European Commission sees carbon farming as a suitable measure in its ambitious climate target plan, a 55 percent greenhouse gas reduction by 2030 compared to 1990 (COWI et al., 2021). In this context, there is intensive discussion about the part that agroforestry can play in this (EUROPEAN COMMISSION - DG CLIMA, 2020).

The carbon reduction potential in agroforestry can be realised in principle in four areas - comparable to other land use-based strategies (Figure 1). With regard to the quantifiability of the carbon storage potential in the biomass and especially in the soil, however, there is the problem that, depending on the soil type, climate zone or design of the AFS, the ranges of variation are enormous. Very different values

can also be applied with regard to the carbon reduction potentials in the upstream and downstream areas.

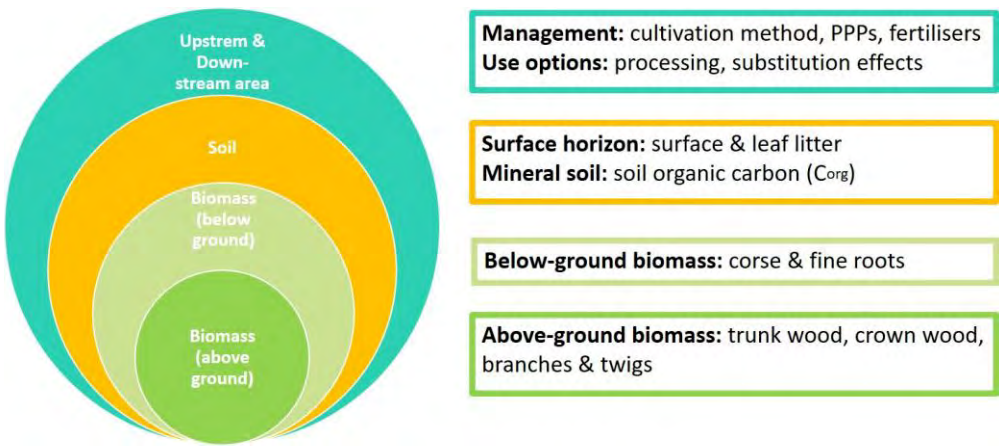

Figure 1. Components of agroforestry systems for achieving carbon mitigation effects

Climate protecting and adapting services of agroforestry in the form of carbon reduction potential can and should be rewarded by so-called climate certificates, so that more and more companies are interested in the topic of certificates in the field of agroforestry. On the one hand, this could be seen as a new and promising way of financing future agroforestry systems; on the other hand, it must be ensured that the measures meet minimum scientific and social requirements.

The "Assessment and Recommendations" developed by the German Association for Agroforestry (DeFAF) e.V.. are addressed to the various actors involved in targeted carbon sequestration through agroforestry methods or involved in the development of planning, measurement and reward approaches. An interdisciplinary approach is taken to assess the opportunities and challenges of certificates for the establishment and maintenance of agroforestry systems. The expert assessment was prepared according to the currently available knowledge and represents the view of the DeFAF.

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Agroforestry system with cereal crops and wood plantations: an economic case study in the Po Valley

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Subtopic: Climate Change (adaptation & mitigation)

Keywords: Agroforestry, Poplar, Cereal Crop, Shading Effect

Abstract
Agroforestry aims to achieve productivity according to environmentally sustainable rural development and improve agriculture's sustainable development level (Smith et al. 2012). For many years "modern agriculture" was the synonym of large areas covered by high-yield crop monocultures and massive demand for resources (e.g., fertilizers and pesticides) (Brooker et al. 2015). Researches conducted on trees outside forest (TOF) showed that the presence of such trees is valuable for ecosystem services, such as biodiversity and landscape conservation, carbon sequestration in biomass and soil, pest and pathogen reduction, moderate yield, reduction of soil erosion, and nutrient leaching (Palma et al. 2007, Brooker et al. 2015). Moreover, TOF can also minimize deforestation, forest degradation, reduce wild-fire risk, act as a windbreak, decrease wind damage and limit soil evapotranspiration. Indeed, agroforestry can be used in association with livestock farming, especially in arid environments, since conventional crop cultivation would not guarantee revenue in these fragile ecosystems (Singh et al. 1998).
Surveys conducted by Michele Prevosto (1971) (ex researcher of ISP, now CREA - Research Centre for Forestry and Wood) have been revisited to evaluate the actual feasibility of poplar in agroforestry combined with cash crops (wheat and rice). An update of agricultural practices and prices has been taken into account to assess whether an agroforestry system can positively influence farm incomes. Four scenarios have been simulated with poplar clone 'I-214', assuming four different positions of the poplar row (along the field borders, towards the cardinal points) and the relative shadows.
Table 1 shows that the agroforestry system is economically advantageous, especially for wheat with poplar. The achievable benefits could be more significant with political and financial support that promotes these practices, considering the ecosystem services they provide.

Table 1. crops and agroforestry incomes (in EUR). * poplar wood value of 80€ t-1.

Exposure	Area	Wheat	Wheat + Poplar in row*	Rice	Rice + Poplar in row*
North	1 ha	587.20	613.49	660.78	660.54
South	1 ha		638.31		723.91
East	1 ha		622.09		691.43
West	1 ha		619.16		675.51

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Horizontal and vertical variations of root distribution and traits, soil physical, chemical and microbial properties associated with CNP cycles in a young alley-cropping system under Mediterranean climate

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Theme: Climate Change (adaptation & mitigation)

Keywords: soil carbon sequestration, root distribution, root traits, soil depth

Abstract

Agroforestry is suggested by the 4p1000 initiative for climate change mitigation through soil C sequestration. By contrast to the aerial plant biomass, the role of belowground parts is not sufficiently investigated. A better understanding of the root distribution is needed to investigate the benefits that deep rooting varieties in agroforestry systems could bring for soil C storage. This study aims to assess the heterogeneity of root distribution and characteristics in two main component of an alley cropping agroforestry system, i.e. the crop and the understory vegetation strip (UVS) located under the tree rows; and to relate root biomass, architecture and traits to soil characteristics and functions.

In the "DIAMS" experimental agroforestry site planted (294 trees ha^{-1}) with *Robinia pseudoacacia* in 2017 (Mauguio, France), 3 soil layers (0-20, 20-50 and 50-100cm) and 3 locations (the UVS under the tree rows, the wheat (Crop-1m) at 1 to 2m perpendicular to the tree line (under tree shade) and the crop (Crop-4m) at 3.4 to 4.5m from the tree (no tree shade) were sampled through trenches (1.5m wide*2m depth) in 3 independent replicated plots. The root biomass was assessed comparing two methods (based on different sampled soil volume), root distributions and traits were determined with root density maps, images and chemical analyses. The soil was characterized following the same sampling strategy than the roots for physical, chemical and biological properties.

The plants under the UVS and the Crop-4m locations had more than 50.0% of their root biomass between 0 and 20cm of depth. UVS roots tended to have higher lignin content than the Crop-4m. In the Crop-1m, no UVS roots were found, demonstrating the absence of competition at the UVS-Crop interface. However, compared to Crop-4m, Crop-1m had a root biomass reduced by 3-fold, higher specific root length and twice higher root lignin content, especially at 0-20cm ($p<0.05$). No differences regarding the global root growth orientation. The root biomass density increased with soil nutrients contents, and it was even stronger in the UVS, where the mineral N content was lower ($p=1.18\times10^{-2}$). The

soil C stocks increased with the root lignin-cellulosic index at all depths and with root C stocks at 0-20 and 20-50cm. This relation was inversed at 50-100cm. For all locations, the root C stocks represented less than 1% of the soil C stocks (Fig. 1), which was very low, but repeated every year at harvest (crop) and through root turnover (UVS). Only slight relationships were noteworthy between the soil C microbial activity and the root properties (C stocks and C:N). By contrast, the N-enzymatic activity increased in response to low root N content at depth, while it decreased with increasing root lignin:N ratio in the ploughed layer.
After 3 years of agroforestry, the root biomass and quality were modified in and near the UVS, inducing a spatial heterogeneity of C inputs. Roots contributed to soil C stocks up to 50cm of depth. In the deeper layers, the microbial response and the soil C stocks responded differently to the root characteristics than the topsoils.

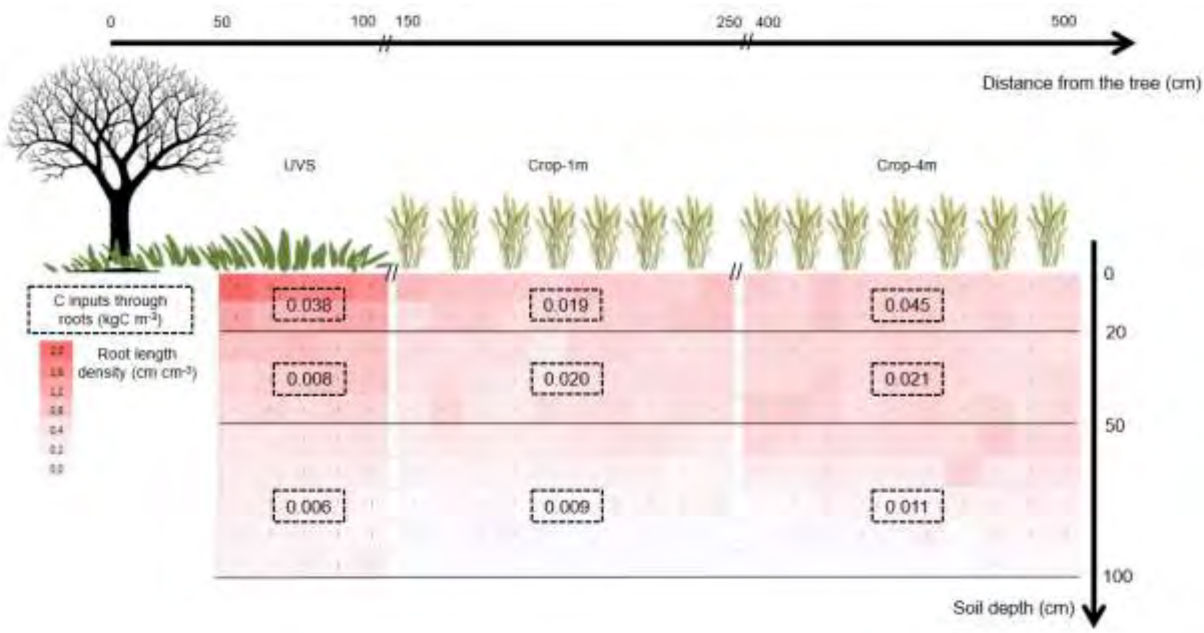

Figure 1. Root length density and carbon inputs through root biomass from 0 to 100 cm of depth and from 50 to 500 cm far from the tree line in the studied agroforestry system (n = 3).

DIGITAF, a European project to help agroforestry meet climate, biodiversity and farming sustainability goals: linking field and cloud

EURAF 2022
Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Climate Change (adaptation & mitigation)

Keywords: European project, Horizon Europe, Living lab

Abstract
Research and practice have demonstrated that agroforestry can improve farm sustainability and adaptation to climate change, enhance biodiversity, mitigate climate change, and conserve soil, but the specific performance of each system is context-dependent. One of the barriers that hinders agroforestry adoption is the lack of tools to guide decisions, assess economic, environmental, and social benefits and costs, and monitor the impact of policies on agroforestry.
In this presentation, we will summarize a recently accepted Horizon Europe project called "DigitAF: DIGItal Tools to help AgroForestry meet climate, biodiversity and farming sustainability goals: linking field and cloud". The overall aim of the four-year project is to scale up and boost agroforestry in the EU by defining the right conditions for its high-quality implementation. The project will enable this by developing digital tools tailored to the needs of key stakeholder groups whose decisions impact agroforestry implementation. Thus, DigitAF will:
(1) Help policy actors design policies better suited to encourage the adoption of agroforestry and carbon farming;
(2) Provide tools that help practitioners manage the complexity of agroforestry systems by letting them optimize the design and management of agroforestry systems, at field and farm scale;
(3) boost the capacities of key actors along the value chain to assess, quantify and market the economic, environmental and social performance and benefits of agroforestry.
DigitiAF will follow a multi-actor approach centred on end-users (Fig 1), made possible by implementing six living labs in Italy, Germany, the Netherlands, the United Kingdom, Finland, and the Czech Republic. Open-source tools, based on existing and novel practical knowledge, scientific evidence and models, will be developed and submitted for feedback to living lab actors. The widest possible dissemination to a

broad range of stakeholders will be ensured by those DigitAF partners such as EURAF which have members and networks across Europe.
The DigitAF consortium brings together 25 partners from 21 countries from the EU, associated countries and beyond. It is comprised nine research and technology organisations, five universities, six small and medium sized enterprises, four European and international organisations, and one NGO/cooperative. Between them, the consortium members and the living labs cover the key value chain actors needed to support a broader implementation of agroforestry across Europe.
The project is about to start, and we invite fellow researchers, agroforestry practitioners, policy-makers, modellers, food processors, marketers, and others to join us in this adventure. Together, let's co-develop tools that will address the key economic, environmental, and social needs of our time.

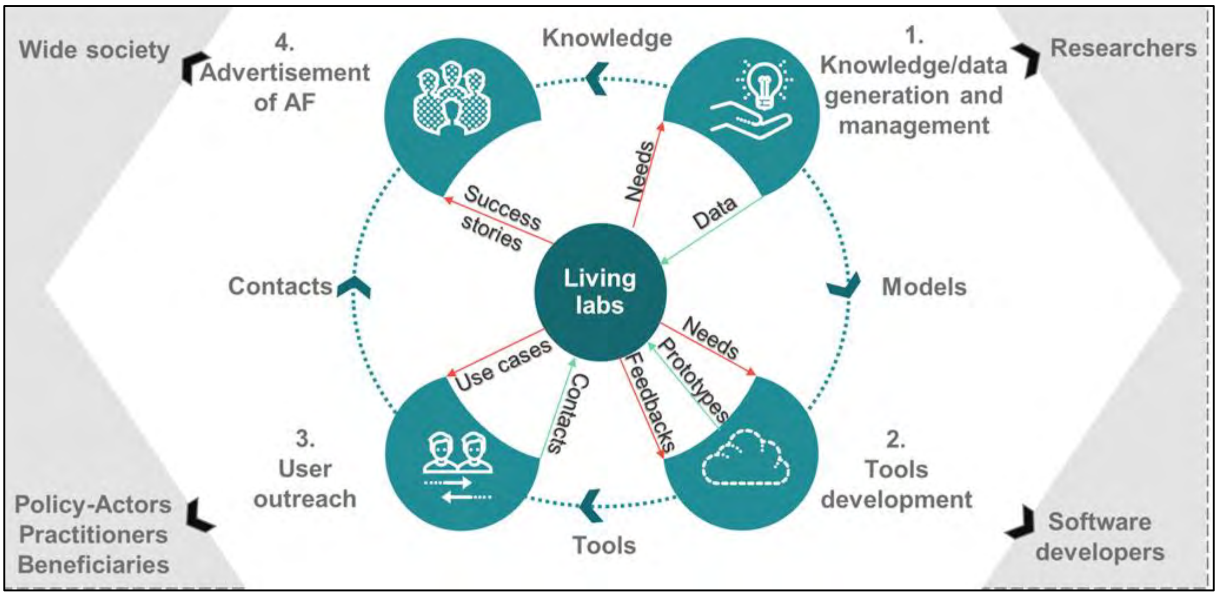

Figure 1. DigitAF uses an end-user centred multi-actor approach

Meriagos can contribute to achieve Net Zero Sardinian beef cow-calf system farms

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Agroforestry for the Green Deal transition.
Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Climate Change (adaptation & mitigation)

Keywords: Meriagos, beef, carbon sequestration, carbon neutral, GHG emissions

Abstract
The Meriagos are Sardinian typical agroforestry-pasture systems where herbaceous and arboreal species are simultaneously present, similar to Spanish and Portuguese Dehesas and Montados. In Sardinia region they cover an area of about 170,000 ha where the beef cow-calf farms are widespread. The aim of this work was to estimate the minimum area of Meriagos that allows compensating greenhouse gases (GHG) emissions of Sardinian beef cow-calf system farms.
Six beef farms, representative of the Sardinian cow-calf system, were surveyed in a complete annual life cycle inventory (LCI) of cradle-to-gate farm production processes. The LCI included information of the last 5 years, from 2016 to 2021. System boundaries included: enteric CH_4, CH_4 and N_2O from manure, CO_2 from energy audit, CO_2 from purchased and on-farm feeds emissions, in accordance with the IPCC 2019 Refined Method. Total GHG emissions were aggregated into CO_2eq using the 100-yr global warming potential of 1 for CO_2, 25 for CH_4 and 298 for N_2O. The functional unit (FU) was defined as "1 kg of meat" (i.e 1 kg of meat carcass). A range of estimates of carbon sequestration potential were considered: a) the minimum of 1.28 t CO2eq ha^{-1} year^{-1} from tree and soil carbon sequestration measured in Dehesas by Eldesouky et al. (2018) and b) the maximum of 19.89 t CO2eq ha^{-1} year^{-1} from soil carbon sequestration of Sardinian agroforestry measured by Sanna et al. (2021).
The 6 farms have on average 47 ± 37.7 ha of Meriagos on 116 ± 50 ha of total area, 72 ± 44.9 heads in total and sold 27± 19.8 calves at live weight of 346 ± 77.7 kg with a slaughter yield of 55%. The Carbon footprint of Sardinian beef cow-calf system farms was estimated at 19.3 kg CO_2 eq/kg of carcass meat. When a and b carbon sequestration potential were taken into account, carbon footprint was 7.7 and -160.5 kg CO_2 eq/kg of carcass meat, respectively. The minimum area of Meriagos per calf sold, needed to achieve carbon neutral condition was 2.85 and 0.19 ha for a and b carbon sequestration estimates, respectively.
In conclusion, 47 ha of Merigos can ensure carbon neutrality of calf production if soil carbon sequestration of Sardinian agroforestry is considered. In contrast, when tree and soil carbon sequestration measured in Dehesas are considered, the minimum area of Meriagos required per the average farm to achieve net zero balance could be equal to 78 ha.

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Building a global carbon database to characterize agroforestry as a natural climate solution

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Theme: Climate Change (adaptation & mitigation)

Keywords: climate mitigation, carbon sequestration, systematic review

Abstract

There is growing interest in agroforestry as a climate solution, given its potential to store additional carbon in agricultural landscapes, while also enhancing livelihoods and biodiversity. However, substantial uncertainty remains around how much carbon can be captured, and how that varies by location and by practice. One of the central challenges is the sheer diversity of agroforestry practices employed across the globe. Species identity, planting density, and management practices, as well as many other factors, will influence the overall climate mitigation potential of an individual agroforestry system. Although recent reviews have begun to compile carbon sequestration rates and stocks within agroforestry systems, the current evidence base is not fully comprehensive. Individual reviews have examined only a subset of the existing literature and typically partition agroforestry systems into coarse categories that do not reflect the diversity of actual on-the-ground practices.

As individuals, corporations, and governments decide whether and how to deploy agroforestry as a climate solution during this climate critical decade, there is a strong need for a readily available and comprehensive dataset to better predict climate outcomes across diverse agroforestry systems. We have therefore conducted a systematic review of published studies to find empirical estimates of carbon sequestration rates and stocks in agroforestry systems. After reviewing over 18,000 papers, we have identified 800 or more papers that appear to have the necessary information. We are compiling this information into a consistent data structure to create a publicly available dataset that can help to accelerate our scientific understanding of the climate mitigation potential of agroforestry and facilitate the incorporation of agroforestry into climate goals. Although agroforestry offers high potential as a climate solution, delivering on that promise requires a more precise understanding of how much carbon can actually be captured, based on the best available data.

Soil carbon after prescribed burnings combined with silvopasture in Galicia (NW Spain)

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Theme: Climate Change (adaptation & mitigation)

Keywords: grazing, fire, soil aggregates, climate change

Abstract

In the last years, the abandonment of rural areas in Galicia (NW SPAIN) has increased the risk of forest fires in territories linked to Nature 2000. The combination of prescribed burnings and silvopasture is a cheap alternative to reduce the fire risk at the same time young farmers are attracted to the rural areas. However, prescribed burnings and silvopasture can modify the soil carbon sequestration which is a key factor to combat climate change. In this context, soil carbon can be linked to macroaggregates (250-2000 µm) in the short-term and microaggregates (53-250 µm) and smaller aggregate sizes (<53 µm) in the long-term. This study aimed to evaluate the effect of a prescribed burning combined with silvopasture on soil carbon in each soil aggregate fraction (250–2000 µm; 53–250 µm and < 53 µm). In February 2019, the prescribed burning was carried out in a mountain area of Galicia. After the prescribed burning, the area was divided into two plots of one hectare each, being one plot grazed with horses (two mares in the gestation phase and a mare with a foal) and the other plot maintained without grazing. Moreover, a control plot was established without burning and grazing. Soil samples were collected before and after the prescribed burning and after grazing. In the laboratory, carbon in the different soil fractions was estimated. Data were analysed using ANOVA and differences between averages were shown by the LSD test, if ANOVA was significant. The results of this study showed that the carbon linked to the smallest soil fractions increased after grazing, being this carbon very stable and maintained in the soil in the long-term. Therefore, in forest areas with edaphoclimatic conditions similar to those of Galicia the combination of prescribed burnings and silvopasture could be used as a climate change mitigation strategy.

Acknowledgements

This study has been supported by the Open2preserve project (SOE2/P5/E0804) from the Interreg Sudoe Programme and the Pilot Program of the University of Santiago de Compostela (USC) for the hiring of distinguished research staff - call 2021, funded under the collaboration agreement between USC and Banco Santander, for the years 2021-2024.

Preliminary results from the use of soil covers to decrease soil moisture evaporation, decrease flammable biomass buildup, and enhance regeneration in a silvopastoral system.

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Theme: Climate Change (adaptation & mitigation)

Keywords: oak, livestock, grazing, soil properties

Abstract
Agroforestry and specifically silvopastoralism is a traditional land use system in Xeromero, Aetoloakarnania, Western Greece, where livestock breeders have used the valonia oak forest for grazing while collecting acorn cups from the oaks. In this way they have ensured a steady and enhanced economic return every year, irrespective of weather conditions or other types of hazards. The forest has been dominated by old-growth valonia oak trees for centuries. However, there has been a gradual abandonment of this kind of combined land use lately and a tendency to convert the system to a monoculture of olive groves. Another problem the system faces is low natural regeneration. An experiment commenced in May 2021 to test the effect of soil covers on tree establishment as well as soil moisture and properties. The experiment involved a split-plot design. The factors considered included cloth soil covers, bare soil and natural vegetation. The plot was divided into 6 sub-plots representing the treatments: 3 subplots lie underneath the tree crown, and 3 are exposed to the open. One of the three subplots is covered by a soil cover, one is cleared of competing natural vegetation and one is left with natural vegetation (Figure 1).

)

Figure 1: The experimental plot and the different treatments applied, in May and October 2021(left and right respectively

Oak seedlings were measured in each type of treatment per plot. Soil moisture detectors were established to provide continuous soil moisture readings.
On October 2021 oak survival, seedlings' height and regeneration were evaluated for the different treatments. Soil covers protected the already established seedlings during the warm summer of 2021. Soil moisture was similar in the covered plots (with cloth and natural vegetation) throughout the experiment. Seedlings in the bare soil did not survive the summer. The experiment continues in order to evaluate the hypothesis in the long term.

Acknowledgements
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Greenhouse and open field studies on water stress responses of new poplar clones with "high environmental sustainability" under testing for silvoarable systems in Italy

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Theme: Climate Change (adaptation & mitigation)

Keywords: drought adaptation; gas exchanges; Populus, stable isotopes;

Abstract
Italian poplar (*Populus* spp.) tree cultivation, based on specialized hybrid clones, has recently been able to make use of clones characterized by high resistance to the main biotic stress: the so-called 'High Environmental Sustainability' (HES) clones. The use of these cultivars allows for sustainable management thanks to the lower energy inputs required, in particular for the chemical inputs for controlling leaf pathogens. These clones are suitable for agroforestry plantations, not requiring canopy spraying. However, to date, information on their tolerance to water stresses is limited.
This work aims to report the results of 3 experiments, 2 in the greenhouse and 1 in the field, to determine the degree of tolerance/sensitivity to drought of some of the HES clones compared to the reference clone 'I-214', the clone most used in cultivation, in Italy and in other countries. The experiments were conducted in summer 2020 at CREA - Forest and Wood Research Center in C. Monferrato (Italy).
A first experiment was conducted to identify the level of water stress (WS) for inducing significant morphometric and physiological responses, using 3 clones of *Populus x canadensis* ('I-214', 'Neva' and 'San Martino'), grown in pots in a controlled environment, subjected to a cycle of water stress and rehydration. The test established that the threshold value is a 50% reduction in water supply, statistically decreasing the morphometric and physiological parameters compared. Furthermore, this trial showed that 'Neva' was the more tolerant clone to WS.
A second experiment, again on potted cuttings sprouts, was carried out with 7 clones and subjecting them to two water regimes (100% and 50%), and using the analytical techniques of leaf gas exchange measurement and stable structural carbon isotopes ($\delta^{13}C$). Main results confirmed a greater degree of tolerance to WS in the 'Neva' clone, together with 'Tucano'. On the contrary, the 'Lena' and 'San

Martino' were found to be more susceptible to WS. In particular, WS significantly reduced the performance of photosystem II, the stomatal conductance and transpiration of these 2 clones. The analysis of leaf $\delta^{13}C$ has provided long-term evidence on water use efficiency (WUE).

Figure 1. Greenhouse experiment of poplar clones with 2 watering regimes (CREA, C. Moferrato, Italy)

A third experiment was conducted in the field, on 4-year-old trees, to determine the depth of water extraction by the roots of the MSA clones, by analyzing leaf $\delta^{13}C$ and water oxygen ($\delta^{18}O$) from woody twigs for the extraction of xylem water, soil moisture and groundwater. 'San Martino' was found to be the clones with deeper soil moisture extraction, along with lower WUE.

In conclusion, it appears that 'Neva' and 'Tucano', with conservative behavior to WS, are suitable for sites with limited water resources. 'San Martino, with avoidance mechanism, is suitable for combining high productivity and use of deep soil moisture resources, thus being suitable for agroforestry systems not entering in competition with herbaceous crops with shallow root systems.

This contribution is included among the communication initiatives by 'CARTER: Biochar and new forest areas: a winning combination for the conservation and C soil sequestration'. The project is funded by the 2014-20 Rural Development Program, Veneto Region, Measure 16 - Cooperation, with Confagricoltura Rovigo as the leader.

Impact of cattle grazing on soil and stand structure in a Mediterranean silvopastoral system in Tuscany

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Theme: Landscape planning and management

Keywords: silviculture in agroforestry, soil characteristics, stand structure, silvopastoral grazing impact

Abstract

This study was conducted by the EIP-AGRI Operational Group (RDP of the Region of Tuscany 2014-2022) "NETWork for agro-forestry in TOscaNa - NEWTON", which promotes agroforestry and enhances environmental sustainability of agroforestry systems.
The activities were conducted in the agrosilvopastoral farm Tenuta di Paganico (Grosseto) in Tuscany (about 1500 ha), where Maremmana cattle are raised in a semi-wild state in over-80-year-old turkey oak (*Quercus cerris* L.) stands. Four grazing theses have been identified: 1. intensive-grazing area with calves (PV); 2. high-intensity-grazing area with adult cattles (PVA); 3. low-intensity-grazing area with adult cattles (PVB); 4. ungrazed area (ANP).
The aim of the study was to evaluate the impact of the different grazing regimes on the main agroecosystem components, soil and vegetation.
The soil component was analyzed through chemical (soil organic carbon; total nitrogen), physical (bulk density and soil hydraulic conductivity) and biological (QBS - biological quality of the soil) parameters. The vegetation was investigated through the monitoring of tree structure, shrub component, natural

regeneration and growth of the dominant storey.

QBS values, bulk density and soil hydraulic conductivity (Ksat) showed that grazing type and intensity affect soil physical and biological characteristics. The QBS index showed a high biological quality value in the non-grazed area, (above 200), typical of natural and undisturbed soils and a trend relative to cows trampling. Ksat values showed a pronounced trend as a function of animals treading, even in the absence of statistically significant differences. In the PVA1 plot, which is more prone to animal treading, the values were lower (8.24 mm hr-1) both compared to the other two plots of the same thesis, and in the high ungrazed forest (13.05 mm hr-1). As a result, the water penetrates in the soil faster. In the calves grazing area, the infiltration capacity was even more meaningful according to the distance from the barn, from a Ksat value of 0,091 mm hr-1 in the area of greatest treading to a maximum of 21.99 mm hr-1 in those less traded, further away from the barn.

The stand vegetation analysis showed differences between theses only in the dominated and shrub layers and in natural regeneration, where density, height and coverage values were significantly different among the four theses, inversely related to grazing intensity. Differently, in the dominant tree layer the dendrometric and structural parameters showed a homogeneous distribution in the four theses.

In conclusion, the present grazing management does not seem to affect the soil and tree structure, whilst it influences the consistence and the development of regeneration, shrub and dominated layers. This could be a management problem to be considered in the silvicultural treatment for the stand regeneration in the next future.

Figure 1. The four grazing theses identified in the agrosilvopastoral farm Tenuta di Paganico (Grosseto, Italy)

The use of biochar and wood chips to improve the productivity of mountain meadows in an organic system

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Them: Climate Change (adaptation & mitigation)

Keywords: biochar, agroforestry, biodiversity

Abstract

Mountain meadows in the Low Beskids region in southern Poland are characterized by a large variety of flora, but their productivity of hay is relatively low in compare with lowland and conventional grasslands. In the case of meadows managed in an organic production system, the possibility of increasing the biomass productivity is significantly limited. The source of soil-improving ingredients can also be agroforestry, by providing a large amount of wood from trees pruning and dead trees. Such wood can be considered as a by-product of this system. The wood can be cut into wood chips or pyrolyzed to produce biochar. Both components can then be used as a carbon source to stabilize nitrogen-rich fertilizers such as manure. It is expected that the use of wood chips and biochar will significantly improve a positive effect of manure in the organic meadow. For this purpose, in 2018 an experiment was set up in a traditional silvopastoral farm, based on the use of waste from agroforestry production in the form of wood chips and biochar. The experiment consists of 30 2x2 m plots, on which plant diversity is assessed and from which biomass has been collected since 2019. Wood chips in the amount of 2 $Mg \cdot ha^{-1}$ were applied on surface of 10 randomly selected plots. On the next 10 random plots, biochar was applied at a dose of 1 $Mg \cdot ha^{-1}$. The remaining 10 randomized plots were kept as control. Manure in the dose of 10 $Mg \cdot ha^{-1}$ was applied shortly after the experiment was set up on all plots. In three consecutive years of research, no significant decrease in plant biodiversity was found in any of the tested variants. Average number of species was about 29 in all variants. Shannon diversity index was also very equal for all variants, respectively, H'=2,81 for control plots, H'=2,75 for wood chips treated plots and H'=2,77 for biochar (Figure 1). Mostly, the same species of plants were found in all 30 plots, however, in the treated plots, the share of legumes and grasses clearly increased. More importantly, changes in the meadow productivity were observed (figure 2). The average yield of green biomass was 6.6 $Mg \cdot ha^{-1}$ in the control objects, while it was higher by 10% in the objects with wood chips and by 26% in the objects with biochar. The hay yield was 1.68 $Mg \cdot ha^{-1}$ in the control, and it was higher by 5% for wood chips variant and by 22% for biochar variant. Increase in productivity was significant, while decrease of biodiversity was not. The experiment showed that with the use of agroforestry production waste materials, it is possible to increase the productivity of organic grasslands without the need for radical agrotechnical measures and without drastic loss of biodiversity. Also, there is better to convert wood chips into biochar for better soil amendment. Positive effect of biochar on fresh biomass yield was changing in following years (+15% in 2019, +38% in 2020 and + 33% in 2021) so experiment will be continued.

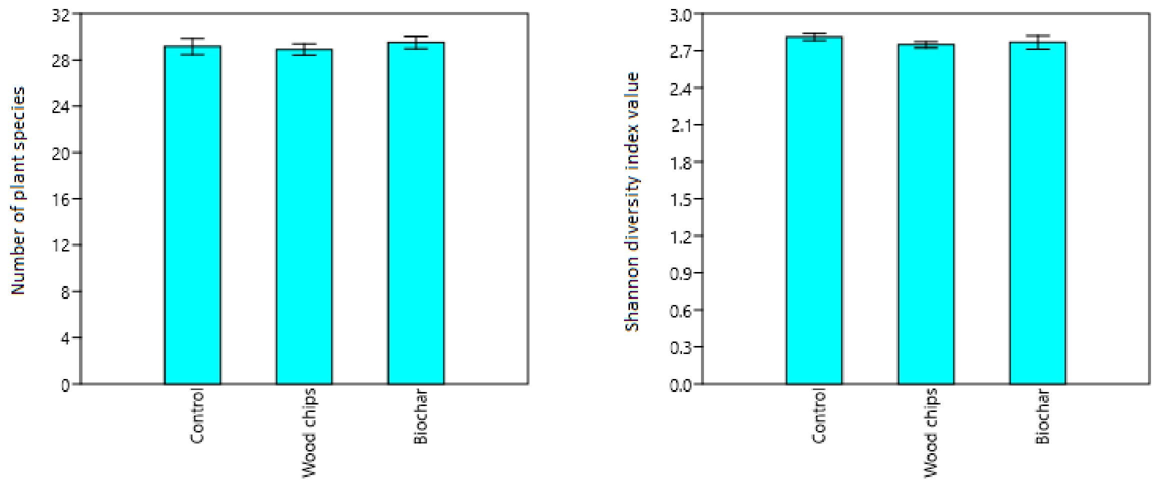

Figure 1. Average number of species identified and average value of Shannon diversity index of vegetation in 2x2 m plots in three variants: control, wood chips [2 Mg·ha-1] and biochar [1 Mg·ha-1].

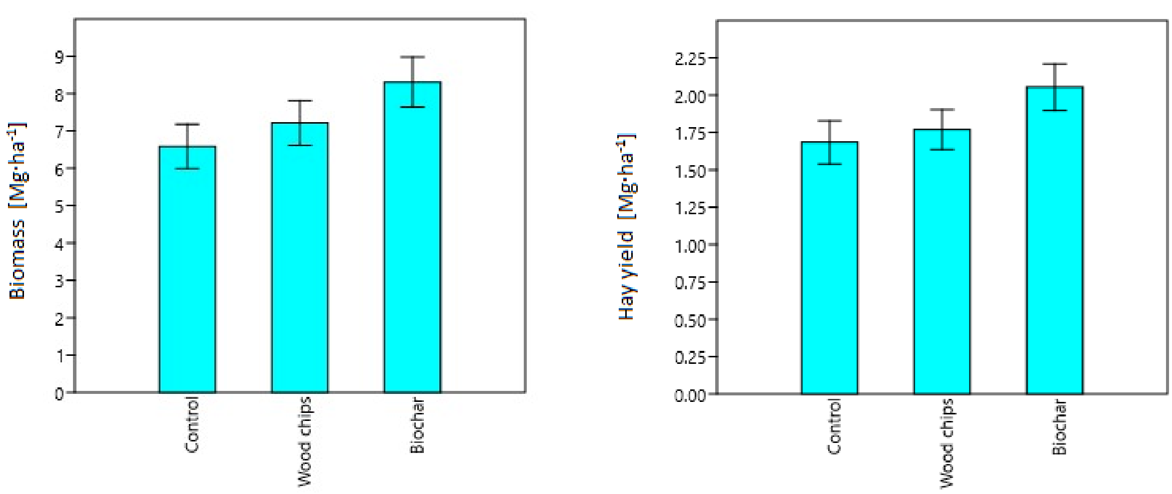

Figure 2. Average yields of green biomass and of hay from mountain meadow in mid Jun from plots in three variants: control, wood chips [2 Mg·ha-1] and biochar 1 [Mg·ha-1].

Increasing tree survival to facilitate the conversion of conventional systems to agroforestry systems using plant growing aids and plant-plant facilitation under climate change

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Theme: Climate Change (adaptation & mitigation)

Keywords: agroforestry, ecological restoration, facilitation, growing aids, seedling recruitment

Abstract
Several global commitments have established a compromise to greatly increase the presence of trees in agricultural lands, fostering therefore the adoption of agroforestry systems and the destination of some areas for reforestation. Such tasks are challenging, particularly under the current climate change scenarios, and several studies have demonstrated a high risk of seedling mortality under harsh and extremely variable environmental conditions, calling for solutions that must increase the success and reduce the costs of growing a tree. In this study, inside the project LIFE Desert Adapt, we tested the effects of different types of growing aids such as shelters, mulching and innovative methods such as biodegradable paper devices (Cocoon™) as well as plant-plant facilitation using nurse species to try to enhance survival and growth of planted seedlings in agricultural and forest areas at high desertification risk in Sicily, Italy. The growing aids were used on three species, two native (wild olive *Olea europaea var. sylvestris* and broom *Spartium junceum*) and one crop (almond *Prunus dulcis*) in three different sites, while plant-plant facilitation was evaluated assessing the effects of prickly pear (*Opuntia ficus-indica*) and wild olives on richness and density of recruitment at community level in four sites. Growing aids greatly enhanced seedling growth and survival in all cases, with a high mortality found on the control seedlings, mostly due to drought. Both prickly pear and wild olives facilitated the recruitment of 8 native species, in some cases boosting tree growth very quickly. We found relevant species-specific responses, a crucial data to define whether invest on more costly methods, such as the cocoon. However, in all cases emergency irrigations during summer were needed. Our results indicate that with current variations in climate, the use of growing aids to promote tree growth is highly recommended, or in some cases obligatory. Additionally, our results indicate a very good potential in the use of prickly pear and wild olives as facilitators to promote natural regeneration and to speed up the formation of agroforestry systems.

Figure 1. Example of a cork oak (*Quercus suber*) growing within a prickly pear (left) and a hawthorn (*Crataegus monogyna*) inside a biodegradable shelter (right)

Agroforestry for climate smart agriculture: farmer perception of ecosystem services and the contribution to on farm resilience

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Theme: Climate Change (adaptation & mitigation)

Keywords: Climate smart agriculture, payments for ecosystem services, agroforestry, farmer perception, resilience

Abstract
Ecosystem services (ES) as a framework and as way of assessing agroecosystems is not new. There are many studies looking at the services (provisioning, regulating and cultural) that ecosystems provide and in particular, agroecosystems. Some argue that by giving a monetary value to these natural processes, or services, we can incorporate them into our economies and find ways to financially incentivise sustainable forms of agriculture and the sectors negative externalities. Progression within the ES framework in recent years has given rise to 'payments for ecosystem services' (PES). With the scramble to reach 'net zero' and protect biodiversity, PES are beginning to be rolled out by governments and corporates, in particular for carbon sequestration. Farmers and land managers are of course wise to this, and some are beginning to 'farm carbon' However there is very little regulation, legislation or accountability around these payments and markets. AGROMIX, a participatory research project which aims to facilitate the transition to mixed farming (MF) and agroforestry (AF) systems as sustainable land use and value chain options across Europe, evaluated farmers' perceptions of ES and ecosystem disservices (ED) on their farms and whether they contributed to 'climate smart agriculture'. Farm practices were deemed either more or less important relative to the ES and ED they generated. Based on the criteria for CSA, the following practices were deemed the most climate-smart: enhanced soil fertility; carbon sequestration; cultivated crops for nutrition; carbon cycling, and reduced erosion. There was a clear understanding and appreciation from farmers of the importance of these services on food production, resilience and biodiversity. Carbon sequestration was cited the most times as a desirable ES to improve upon and the link with AF and MF systems was recognised. Despite having identified which farming practices are most 'climate-smart' in the context of this work, it is important to continue taking a systems approach when making management and policy decisions around land use given the dynamic relationship and interconnectedness of multiple ES. Shackleton *et al,* (2009) warn that, "an overly narrow focus on maximising a limited set of ES could lead to unexpected trade-offs or to undesirable and sudden declines in other ES". For this reason, whilst applying an ES assessment to farming systems is helpful, it is in no way the final way we should be assessing the suitability, sustainability, resilience and productivity of these systems. Maintaining a systems approach and incorporating principles for food systems transformation will be vital if we are to find an internationally agreed upon, contextually variable method of analysis that will facilitate and de-politicise decisions about land use and farming systems.

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Agroforestry innovation with walnut: the Woodnat experience

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Theme: Climate Change (adaptation & mitigation)

Keywords: tree farming, mixed plantation, walnut, poplar

Abstract
Walnut species (*Juglans spp*.) are among the most popular and widely used tree species in tree farming activities, characterized by marketable nuts and high timber quality. Among all the European Countries, Italy, Spain, and France are currently the most active in cultivating walnut trees. In 2016-2019, in the frame of the H2020 Woodnat project (www.woodnat.eu), an investigation on walnut plantations were carried out in Italy and Spain, sampling 96 plantations. For each sampled plantation, a site characterization and description of the planting layout with management type were surveyed. Significant differences were found between the two countries. In Spain prevail pure wide plantations with Hybrid walnut (*Juglans x intermedia* Mj 209) managed intensively while, in Italy the plantations are smaller, different types are present (pure, mixed, and polycyclic), and Common walnut (*Juglans regia*) is the dominant species. Based on the experience of Woodnat partners and considering the results of the project, three different silvicultural systems have been identified as the most promising ones: Pure plantations, Polycyclic plantations, and Agroforestry systems. At the beginning of 2019, two paired planting trials were established in Italy, where Hybrid walnut and Common walnut have been tested under two selected silvicultural systems.
<u>Pure plantation</u> with a square layout with a 6 x 6 m between the trees was established. Intensive management is applied with irrigation, fertilization, pruning and thinning. Mechanical weed control will be applied only in the first period then obtain weed control by sheep grazing. One or two thinning will be applied after 12-15 years and stumps degradation of the felled trees will be realized by edible mushrooms (De la Parra et al 2020).
<u>Mixed plantation</u> (Polycyclic) with different broadleaved species (Common walnut, Hybrid walnut, Ash, Lime and Oak) were used intercropped with hybrid poplar clones ('Tucano' and 'Diva') and with nurse trees (Italian alder and Hazel). All these trees and shrubs were planted in the same area according to the specific distance and layout set up by CREA in the last 20 years (Photo 1). The presence of trees with different rotations and the wide spacing permits a new cultivation cycle after the harvesting partially maintaining the carbon storage in the soil. The layout allowed the plantation of pumpkins in 2019 and in 2021CREA tested the production of saffron in an agroforestry context (Photo 2). Preliminary results indicated the absence of allelopathy by mixed plantation (in particular walnut).

Figure 1. Polycyclic plantation at CREA field research station with pumpkins, Casale Monferrato, Italy (left); Saffron production at CREA field research station, Casale Monferrato, Italy (right)

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Harvest index and nitrogen uptake of barley in intercropped walnut orchard

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Theme: Climate Change (adaptation & mitigation)

Keywords: barley, intercropping, harvest index, nitrogen use efficiency

Abstract

Introduction. Intercropping of annual crops with woody species has shown to be a great ecologically sustainable alternative to conventional agricultural systems. Besides ecological benefits, intercropped systems may be more efficient in terms of productivity and resource capture. Trees can help intercrops acquire nutrients by different mechanisms; absorption of nutrients from deeper soil layers outside the root zone of agricultural crops or absorption of nutrients in chemical forms that are not available for crops, and fixation of atmospheric nitrogen (Cannell et al. 1996). Aim of our research is to investigate barley productivity and nitrogen use efficiency in an intercropped system with common walnut (*Juglans regia*). Materials and methods. The trial was set up in Eastern Croatia near city of Đakovo. It consisted of a barley monoculture plot and an intercropped walnut orchard. The orchard was 12 years old with a distance between tree rows of 8 m and barley was sown in strips of 6 m width from October 2019 until June 2020. At harvest, plant samples were collected form 0,5 m^2 subplots where the plants were cut at the soil level and grain and straw were weighted separately for determination of yield and harvest index. Harvest index was calculated as ratio of barley grain yield and total aboveground biomass. From dried samples, nitrogen concentration was determined by Kjeldahl digestion method. Nitrogen uptake (whole plant) and nitrogen use efficiency (NUE) were calculated as follows:

$$\text{N-uptake (kg ha}^{-1}\text{)} = \text{N\%} * \text{DM}/100 \qquad \text{eq. 1}$$

$$\text{NUE (kg kg}^{-1}\text{)} = \text{Grain Yield/Nuptake} \qquad \text{eq. 2}$$

Results. Barley yield in monoculture plot was 7383.86 kg ha-1 and in intercropped orchard 7094.59 kg ha-1 (per cropped area). Since intercropped orchard had generally better soil properties than monoculture plot, this yield reduction is probably due to shading effect by walnut trees. However, harvest index (HI) was significantly greater in intercropped orchard and accordingly had significantly lower total aboveground biomass. This observation suggests that barley in intercropped orchard allocated more assimilates to grains in expense of biomass production. Since HI strongly depends on water availability, this improved reproductive/yield efficiency could be a result of improved microclimatic conditions in intercropped orchards (Gosme et al., 2016). Furthermore, strong correlation was found between HI and NUE ($r=0.81$, $p<0.01$). Although barley in monoculture plot has taken up more N in kg ha-1, intercropped barley had better NUE in terms of producing more grain yield per N taken up. Also, intercropped barley had higher grain N content than monoculture barley, which is a result of better N remobilization. This high N content, however, is negatively correlated with the final grain yield due to the dilution effect. This observation could be connected with shading by walnut trees and it is in accordance with results obtained by Artru et al. (2016) and Dufour et al. (2012) who found the highest grain protein content in wheat grown in continuous/uniform shade. In conclusion, our results show that intercropping may improve

harvest index and nitrogen use efficiency of crops as well as possibly produce more nutritious food without high inputs.

Table 1.

System	Grain Yield kg ha^{-1}	Total biomass kg ha^{-1} *	Harvest index (HI) *	N % in grain *	N uptake kg ha^{-1}	NUE kg kg^{-1}
Monoculture	7383.86	17400	0.44	0.74	177.27	43.60
Intercropped	7094.59	12107	0.59	1.09	159.74	46.61

*stiatistically significant difference obtained from ANOVA, $p < 0.001$

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Framework for building climate change resilience into landscape restoration through agroforestry: an England case study

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Theme: Climate Change (adaptation & mitigation)

Keywords: landscape, restoration, adaptation, resilience

Abstract
Landscape restoration is a European and global priority, with the UN Decade on Ecosystem Restoration 2021-2030 aiming to scale-up ambition and delivery on restoration targets. In England, Landscape recovery is a component of the Environmental Land Management Scheme (ELMS), the new agricultural payments regime post-Brexit. This component will support large-scale habitat restoration and land use changes that achieve biodiversity, water quality and net zero gains. The value of agroforestry in delivering such objectives at landscape-level is well recognised, and its part in ELMS is being actively investigated through a co-design process.
For agroforestry, and its part in a landscape restoration strategy, to successfully contribute to climate change mitigation, adaptation and other environmental targets, the practice of agroforestry itself needs to be resilient to anticipated climate changes and impacts. Taking the example of a pioneering agroforestry farm in Eastern England (Wakelyns Agroforestry, a 22 ha silvo-arable system in Suffolk) and more recently established agroforestry farms in the region, we demonstrate two methodological frameworks for (1) characterising resilience across biophysical and socio-economic dimensions at the farm level; and (2) building resilience into the scaling up of agroforestry in this region as a landscape restoration strategy:
(1): The first framework (Verstand et al. 2021), being applied under the AGROMIX Horizon 2020 project (i in experimental sites across Europe, including Wakelyns, is a set of 17 farm-scale indicators of resilience to climate change stressors, each based on qualitative classification 1-5 and translated into an AMOEBA diagram-model. For silvo-arable systems the indicators encompass ecological aspects (e.g. crop diversity, stability of production, soil organic matter and plant available water), economic aspects (e.g. number of income sources, dependencies on external inputs) and social aspects (e.g. memberships of farmer

networks, cooperatives and projects, and shortness of supply chains). In this paper the set of resilience indicators is illustratively applied to Wakelyns.
(2): The second framework (Simonson et al. 2021) is based on a comprehensive overview of climate change risks and considerations across the whole life cycle of a restoration initiative. It identifies seven areas of restoration design and implementation in which climate change is important to address: setting restoration objectives, selecting sites and managing connectivity, choosing target species and ecosystems, managing key ecosystem interactions and micro-climates, identifying and mitigating site-level climate change risks, aligning the project with long-term policies, and designing a monitoring framework that enables adaptive management. We show how each of these steps can be built into a restoration strategy using Wakelyns and other agroforestry sites as catalysts for scaling up, and building the climate change resilience, of this land use in the target region.
We argue that the adoption of these two approaches can help to define and build the resilience of agroforestry systems as part of landscape restoration and thus improve its long-term effectiveness in delivering climate change, biodiversity and other environmental targets.

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Sustainable approaches to land and water management in Mediterranean drylands: the SALAM-MED project

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Theme: Climate Change (adaptation & mitigation)

Keywords: Land degradation, desertification, Mediterranean socio-ecological systems, silvopastoral systems, living labs, nature-based solutions, sustainable soil & water management, business opportunities

Abstract
Land degradation and desertification in Mediterranean (MED) dryland socio-ecological systems emerge from the structural coupling of ecological and socio-economic processes, where climatic pressures are combined with weak adaptive capacity. The sustainability of rural livelihoods in endangered drylands depends on the capacity of local stakeholders to adopt systemic innovations, supported by innovative tools and services leading to minimum-input and tailored solutions for soil fertility and water conservation as a basis for long term investments and new business opportunities.
The SALAM-MED project, in the context of the "PRIMA S1 2021 water management" call, is designed to identify, test and validate "nature-based" practical solutions to enhance the resilience of endangered MED drylands or to restore degraded ecosystems in arid and hyper-arid land. The concept is framed in a systemic innovation process for sustainable development (Colvin et al. 2014) empowered by six Living Labs (LL) located in hotspots for soil and water degradation in Egypt, Greece, Italy, Morocco, Spain and Tunisia. The hotspots encapsulate a wide range of societal, agricultural, forestry and environmental conditions. The LL approach (Hossain et al 2019) (Fig. 1) relies on social learning and knowledge-sharing

processes for the generation of new scientific+local hybrid knowledge (Nguyen et al. 2014). New integrated tools and processes, co-developed, tested and validated with stakeholders, facilitate the efficient usage of 'every last drop' of water for civic, agricultural and ecosystem services and enhance the potential of scaling-up at the policy-making level and scaling out to other socio-ecological systems.

The SALAM-MED hotspots represent MED agricultural and forestry ecosystems across a gradient of aridity indices (AI). In Valencia (ES, AI=0.45), the effectiveness of the C.A.F.E. approach is being tested to address sustainable forest management in contrast to abandoned forests affecting the hydrological cycle of watersheds providing freshwater to rural and urban societies over 50% of Southern Europe's land. The improvement of watersheds' hydrology and soil fertility is being addressed by combining system dynamics approaches with new bio-based and digital agriculture technologies. The Messinia LL (GR, AI = 0.5), will represent the over 8 Mha of olive orchards in the MED; the Sardinian LL (IT, AI=0.5) is representative of silvopastoral systems in dehesa-type habitats covering some 15Mha in the MED. Water harvesting, microbial consortia and smartAg technologies will be tested and validated in the hyperarid desert agriculture of the wadis in Matrouh (EG, AI<0.05). The out-scalability of Managed Aquifers Recharge (Standen et al. 2020) and their role in the restoration of sustainable agriculture are studied in Medenine (TU, AI=0.05-0.2), where drought and abandonment are the main drivers of land degradation. Smart grazing management, Subsurface Water Retention and Water Harvesting technologies are combined to reverse land degradation in the Argan forests at Essaouira (MO, AI=0.15).

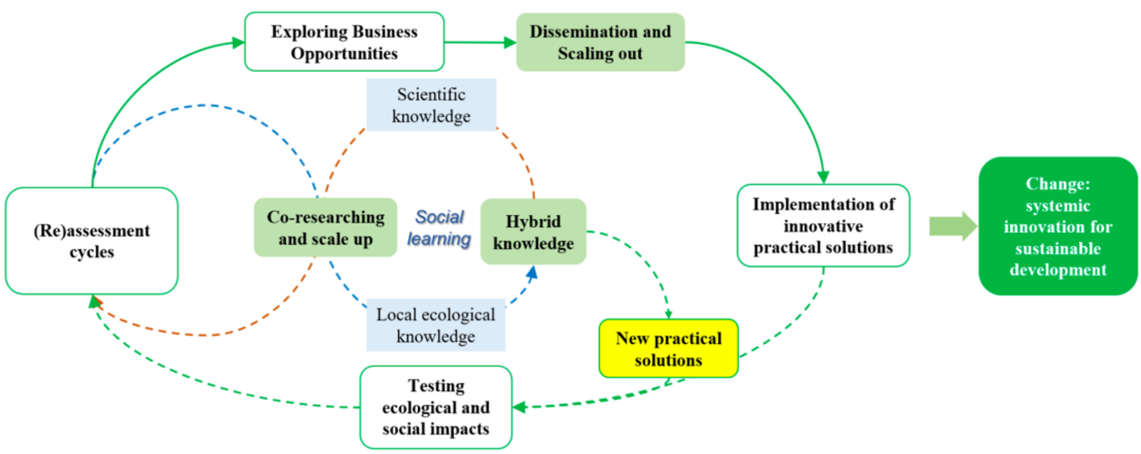

Figure 1. SALAM-MED Living Lab systemic innovation system

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A review of carbon sequestration and storage potential of agroforestry trees in Denmark

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Theme : Climate Change (adaptation & mitigation)

Keywords: Literature review, Carbon storage, Carbon sequestration, Temperate climate

Abstract

Carbon sequestration by trees is an obvious, simple and efficient tool for climate change mitigation. Carbon is mainly stored in wood above ground, in roots below ground and in the soil. Sequestration rate and storage are highly variable depending on tree species and varieties, spacing among trees, climate and soil properties. Despite the obvious need for carbon sequestration by trees, relatively little quantitative information is available for the estimation of mitigation potentials. This presentation aims to give an overview of tree- and plot level carbon sequestration and storage potentials of trees under a temperate climate in Denmark. It is based on a review of available literature, including allometric models of tree dimensions and technical forestry growth tables and software. Uncertainty in carbon calculations related to species, varieties, spacing, climate and soils will be discussed. Coniferous trees often have higher carbon sequestration potential than deciduous trees, but lower value regarding biodiversity. When establishing agroforestry, a compromise between climate change mitigation and biodiversity potential needs attention. A long-term perspective is important in order to evaluate the full carbon storage potential of long-living trees in agroforestry compared to trees in conventional forestry (Fig. 1).

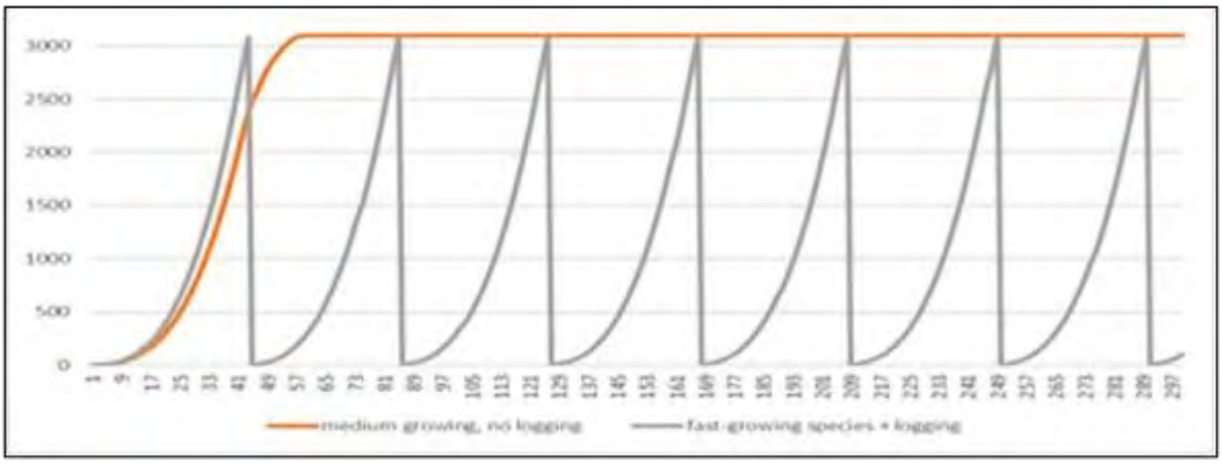

Figure 1. Schematic illustration of carbon storage potential of medium growing trees with no logging versus fast growing trees with logging.

Interactions between trees, crops and pedosphere: experiences in irrigated bioenergy-agroforestry system in Hungary

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Theme: Climate Change (adaptation & mitigation)

Keywords: Pedosphere, irrigation; aerobic rice; organic mulching; earthworm; willow; poplar; energyplant; agroforestry system, climate change

Abstract

The aim of our study was to evaluate a complex agroforestry system with the intercropping of aerobic rice and the utilization of reclaimed water for sustainability and climate change adaptation. The foreseeable positive outcomes of the intercropping system could be higher yields for the arable crops, additional woody product and indirectly favourable microclimate, water conservation, increased biodiversity and wind damage reduction.

In our small scale (0.3 ha) experiment aerobic rice production took place between poplar and willow rows in 2019. Hungarian rice, cultivar 'M488' was irrigated with river water and effluent water from an intensive catfish farm (micro sprinkler irrigation). The effect of different irrigation doses on the tree species via measurement of phenology parameters and root growth was analysed. Beside the rice and woody plant biomass production, the changes of soil parameters and mineral composition of rice were evaluated as well due to the properties of the effluent water (high nitrogen, sodium (313 mg/dm^3) and bicarbonate (951 mg/dm^3) content of the water). According to our hypothesis, the inorganic nitrogen content of the effluent water contributed to meeting plant nutrient requirements; however, soil salinization should be avoided. In addition, the effects of soil improvements (limestone grit: 2.5 t calcium-carbonate per ha) and mulch (winter wheat straw: 2.5 t/ha) on soil processes were also explored. The effect of irrigation and organic mulching on earthworm abundance, biomass and species composition was also investigated. Soil mulching significantly increased earthworm abundance and biomass in summer, while irrigation quality and doses significantly decreased it.

The valuation of forest ecosystem services in Kenya: a comparative case study of Karura forest reserve and Kakamega national forest reserve

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Theme: Climate Change (adaptation & mitigation)

Keywords: climate change, ecosystem valuation ,green economy, forest ecosystem

Abstract :
Forests play an important role in climate mitigation and are relevant drivers towards achieving green economy as the world is showing more commitment towards carbon neutral economies (Stavins et al., 2014; UNEP, 2008). The global collective efforts to mitigate the effects of climate change emphasize the need to value natural capital in enhancing and sustaining societies and economies (D'Amato et al., 2020). These include: Kyoto Protocol of 1997, Cancún Agreement (2010), Montreal Protocol in 2014 (MP14), Paris Agreement in 2015 and Glasgow-COP26 (UNFCCC, 2019; Metz & Metz, 2012; Moosmann et al., 2019). Forest ecosystems contribute to climate mitigation because of their capacity to sequester carbon with estimates of about 3 billion tons of atmospheric carbon sequestered per year through net growth (Locatelli, 2016). The valuation of forest ecosystem services supports the decisions regarding the sustainable management of natural capital, leading to more adaptive approaches towards climate change and reduction of anthropogenic pressures on forests (Pache et al., 2021).
In Kenya, the overall forest cover is estimated to be 5.5% to 7.2% of the total land cover (Rodríguez-Veiga et al., 2020). In a case study of East Mau forest ecosystem, Langat et al. (2018) cites the discrepancy of limited data on ecosystem valuation of forest in Kenya and their economic potential. This is a similarly stated by Christie et al. (2012), in a study assessing techniques for ecosystem valuation in developing countries, attributing this mainly to the lack of technical capacity to undertake the studies. This comparative study on the valuation of ecosystem services of Karura Forest Reserve and Kakamega National Forest Reserve allows us to quantitatively link socio-economic development with the forest ecosystem services. The aim is to provide a comparative forest ecosystem evaluation for impact chain analysis on climate change using quantitative data on ecosystem services. The three major objectives of this project include: (i) to link socio-economic development with the forest ecosystem services, (ii) to establish the total economic value of natural resources explored by referencing major differences between Karura forest reserve and Kakamega National forest reserve, (iii) to identify the effects of disturbance (both human-induced and natural), spatial differences and management systems on forest ecosystem services .
Through this valuation of ecosystem services, an appreciation of the total economic value of natural resources is explored by referencing the major differences in ecosystem services provided by the two forest reserves. The methods for valuation include: travel cost methods, replacement and avoidance cost methods

and market value approach. Economic valuation of forest ecosystems offers a way to understand the complexities of nature, in a simple economic language of trade-offs and costs (Sannigrahi et al., 2019; Victor, 2019; Xepapadeas, 2011). Valuation of forestry ecosystem services is thus essential as it quantifies the role of forests in the overall economy and establishes the social implications of forest degradation and deforestation (Rodríguez-Veiga et al., 2020).

Effect of the planting system on the carbon balance components of a black locust-based agroforestry site under Mediterranean climate

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Theme: Climate Change (adaptation & mitigation)

Keywords: Agroforestry, Black Locust, Carbon Balance, Soil Organic Matter

Abstract
Agroforestry systems (AFS) can provide many services, among which sequestering atmospheric carbon (C) dioxide (CO2) into both tree biomass and soil organic matter for mitigating climate warming. Such high performances were documented in several studies, but data are still scarce for covering the broad range of agrosystems – climate combinations. More particularly, data of the different C stocks and fluxes among the different components of the AFS needs to be documented for robust estimates of C sink strength. This study aims at providing values of C stocks and fluxes of a black locust (*Robinia pseudoacacia* L.)-based agroforestry site in Mauguio, Southern France. The different compartments of the AFS were investigated: the black locust rows, the herbaceous strip planted of various grassland species along the trees and the intercropping, constituted by a rotation cereals/legumes. The crop rotations comprised durum wheat, barley, chickpea and pea, but we presented the data for the barley planting year in 2021. A forest plantation and a pure crop planting systems were also studied as control modalities. The three planting systems were repeated in three independent blocks. Aboveground tree biomass growth was estimated for the agroforestry and the forestry plots from allometric models. Black locust litter fall was quantified also in the agroforestry and forestry plots. For each planting systems, root biomasses, root C contents and root growth were estimated . Aboveground herbaceous biomasses and C contents were also measured in 1m2 squared plots at different seasons. Soil microbial biomass and soil CO2 efflux were measured in all components and planting systems. All data currently under processing will be normalized per area unit. The effect of the planting system was assessed in order to determine the added value of the agroforestry system with respect to the pure planting systems.

ROBUST: Agroforestry – a sustainable agricultural system for plant and milk production in northern temperate climate

EURAF 2022
ROBUST: Agroforestry – a sustainable agricultural system for plant and milk production in northern temperate climate

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Theme: Climate Change (adaptation & mitigation)

Keywords: Temperate, climate, biodiversity, Denmark, milk, plant.

Abstract

Background: Agroforestry was practically non-existent in Denmark until 2017. From 2018-2020 three small pilot projects tried to map agroforestry effects on agricultural challenges in Denmark. It became clear that results from other countries could not be translated directly onto a Danish context and that we need research into these effects. Thus, the ROBUST project was launched in 2020. The choice of focusing on plant breeding and milk production is based on areas where there is the greatest potential for the spread of agroforestry in Denmark.

Objectives: The aim is to research, develop and spread agroforestry in DK. The objectives are (i) to document the effect of agroforestry on important green parameters such as: carbon storage in soil and wood mass, nitrogen leaching, nature value, competition with crops, feed value of deciduous biomass and animal welfare, (ii) to model the effects of spreading agroforestry on a larger national scale and (iii) to examine the production economic effects.

Methods: Four new organic agroforestry farms have been developed and established, and the farmers will have their systems continuously monitored regarding the following parameters.

- **Animal welfare**: The project will investigate the impact of trees on cattle animal welfare during grazing in relation to shade, shelter, shelter, and skin care.
- **Biodiversity**: The project will provide data that will form the basis for important knowledge about the biodiversity effects of forestry in northern temperate climates in regard to insects on the soil surface and in the air.
- **Carbon and nitrogen cycles**: The purpose is to determine C storage and N uptake in agroforestry systems woody plants (above and below ground biomass), including the annual C accumulation and N balance.

- To quantify and document **competition** between trees and agricultural crops there will be:

1. Repeated yield measurements in crops at two experimental sites at four different distances from the planting
2. Measurements of light and nutrient competition between trees and crops at two experimental sites
3. Evaluation of business potential

- To explore the **business potential** of agroforestry in company brands by:

1. Development of agroforestry product portfolio
2. Analysis of needs and value creation among customers
3. Development of marketing material for agroforestry products
4. Development of digital cultivation tools

Results: The project began in mid-2020 and the first trees were planted at the end of 2021. Results will be available on an ongoing basis from 2021.

Discussion: Interest in agroforestry has increased greatly since the start of this research project. In just a few years, a large part of the farmers has learned about agroforestry - a hitherto almost unknown phenomenon in Denmark. The potential for spreading agroforestry to many of these farmers is based to some extent on the verification and quantification of effects that this project will provide.

Figure 1. Planting a new agroforestry test-system near Esbjerg in 2021

Simulating the effect of climatic variations on the long-term performance of different agroforestry systems within field trials using virtual experiments

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Agroforestry for the Green Deal transition.
Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Climate Change (adaptation & mitigation)

Keywords: AGROMIX, silvopastoral, silvoarable, numerical modelling

Type of presentation (oral or poster): poster

Abstract

Agroforestry systems can reduce some of the adverse effects of climate change in agriculture by e.g. serving as a windbreak or shade provider to protect crops or grazing livestock and supporting beneficial species for pest control. The prediction of the long-term performance of different agroforestry options is however difficult to obtain through field quantify experiments due to the length of time trees grow for experiments. Numerical modelling can contribute to a better understanding of a system's performance, since the effect of different climatic alterations can be tested using virtual experiments for different periods of time.
Within the Horizon 2020 AGROMIX project, we are analysing the long-term performance of eight different agroforestry trials (Figure 1), using different modelling approaches. The trials are spread over three biogeographic regions (Mediterranean, Continental, and Atlantic) and are of varying age (4 to 33 years). In total, six silvoarable and five silvopastoral farming systems are maintained at the eight field trials. Through the use of different numerical models the effect of changes in temperature and precipitation patterns or the occurrence of extreme events such as droughts or late spring frost on the different agroforestry systems will be predicted. Additionally, experimental data on crop performance

as well as animal behaviour and welfare, in particular under heat stress, are being obtained and will potentially be included in the model predictions.
This poster aims to give an overview on the field trials and the numerical modelling approaches that are being applied to predict long-term system performance.

#	Field experiment	Silvoarable	Silvopastoral	Start monitoring
1	Dehesa of Majadas		✓	2014
2	Tenuta di Paganico	✓	✓	2014
3	Arnino	✓		2018
4	Restinclières	✓		1995
5	Lamartine		✓	2015
6	Elm Farm	✓	✓	2011
7	Wakelyns	✓		1994
8	Loughgall	✓	✓	1989

Figure 1. Field trial location, name, type of tested farming systems(s) and year of initiation

GHG gas measurements in agroforestry system with different tree species and fertilization regimes

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Theme: Climate Change (adaptation & mitigation)

Keywords: agroforestry, GHG measurements, agroforestry systems

Abstract

In 2011, an agroforestry field in Skriveri (56.691, 25.136) was established on abandoned agriculture land, to test biomass increase of different tree species, different planting schemes and different fertilizers – wood ash and wastewater sludge. The impacts of different fertilizers on growth rate, height and diameter of different tree species were measured. To compare tree species not only by biomass growth rates, but also to GHG emission rates, in 2020 GHG gas measurement trials were installed, to see how soil GHG emissions change under different tree species and fertilizers. Measurements were done monthly for one year, to cover all climatic conditions. In total 30 GHG sampling plots were established and in every plot 3 simultaneous repetitions were done. GHG emission measurements were done under birch, hybrid aspen, black alder, hybrid alder and willow canopies, as well on meadow, where wastewater sludge, wood ash and no fertilizers (control) were applied. Aim of the study was to compare GHG emissions under different tree species canopies and on meadow with different fertilizers. Results showed that there is difference in GHG emissions between different tree species and meadow, but there is no significant difference between fertilizers. Results can be used in decision-making processes, before fast growing woody crop plantation establishment, when choice between different tree species and fertilization should be done, therefore aspects included in the selection are not only biomass growth rates, but also GHG emission results.

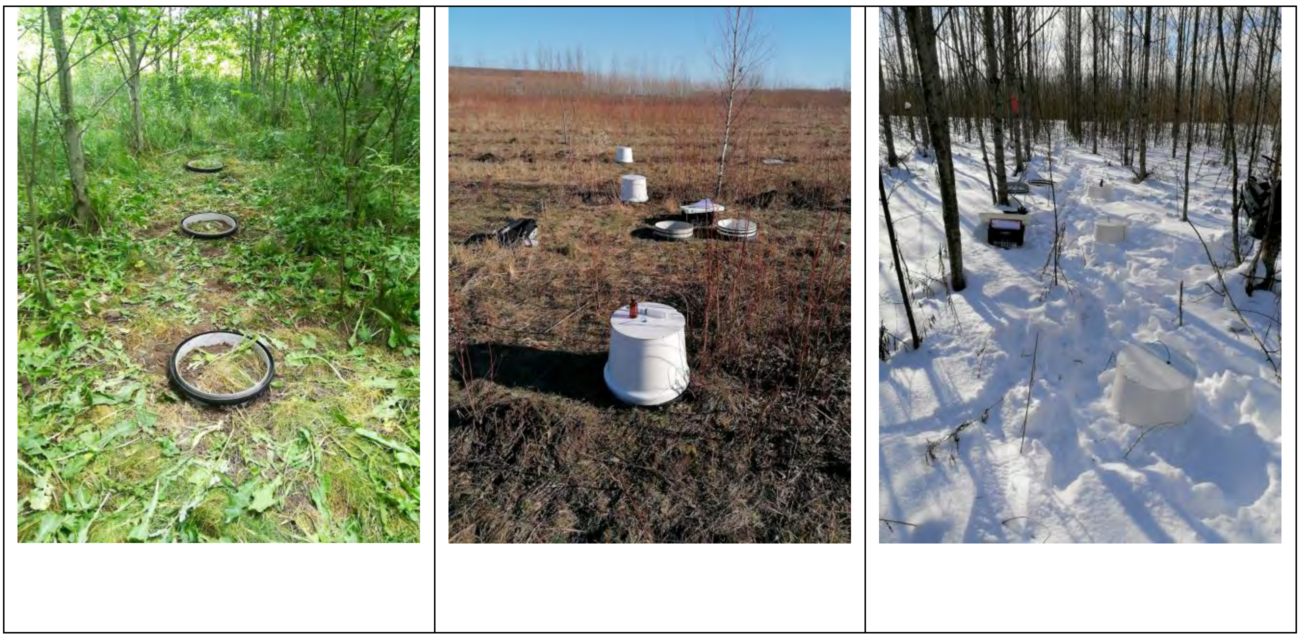

Figure 1. GHG emission measurements plot design

Investigation of the effect of plant and soil conditioners on irrigated agroforestry system (industrial poplar plantation; alfalfa)

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Theme: Climate Change (adaptation & mitigation)

Keywords: agroforestry, irrigation, alfalfa, soil improvement, industrial poplar, biomass

Abstract

Agricultural crop production is facing new challenges due to the negative effects of climate change in recent years. One possible means of adapting to this change is the practical application of agroforestry systems. In contrast with traditional farming practices, agroforestry systems can have a number of benefits (ecological or economic) through interactions between system members. Agroforestry is a land use in which woody plants are used in different chronological or spatial order together with arable crops, pasture farming and animal husbandry. Fast-growing industrial tree plantations can be planted in agroforestry systems.

Our research area was established in Szarvas, within an area of 1.6 hectares, with a poplar system in a 10x4 spacing, including the I214 (*Populus x euromericana* cv. I-214) and Kopecky (*Populus x euromericana* cv. Kopecky) varieties, and alfalfa (*Medicago sativa* var. 'Olimpia') as an intermediate

plant. We chose this Hungarian-bred alfalfa variety because of its excellent drought tolerance and winter hardiness. The rows of trees were installed on April 15, 2020. At the time of planting, poplar seedlings were two years old. At the time of planting, poplar seedlings were two years old. We performed 5 different treatments in the area, both irrigated and non-irrigated. In the treatments we used agents that perform the functions of nutrient replenishment, moisture and nutrient retention, and organic mineral fertilizer. The water of the irrigated area was obtained from the Bikazugi backwater of Kőrös. We used a sprinkler irrigation method, thus giving the plants the most natural and one of the most environmentally friendly irrigation methods.

The aim of the study is to find out the effect of the microclimate of the system on the heat and water balance of the soil, the shading effect of the tree rows, the wind-catching property, the crown size in the given system, the impact of shading and the needs and technology requirements of all this from the point of view of tree management in long term. In the course of our research, we expect that agroforestry systems in Hungary will result in a more balanced microclimate compared to traditional arable crops and will mitigate the negative effects of weather extremes. Reduced radiation, lower daily maximum temperatures, and higher relative humidity reduce the extremes of heat waves and atmospheric drought. Our goal is to quantify the hydrological, microclimatic and soil effects of agroforestry systems in Hungary, to provide basic information according to these aspects as a basis for a complex ecological and economic assessment.

The environmental impacts of agroforestry in agri-food systems: a life cycle assessment approach

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Agroforestry for the Green Deal transition.
Research and innovation towards the sustainable development of agriculture and forestry

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Subtopic: Climate Change (adaptation & mitigation)

Keywords: Life Cycle Assessment; agroforestry; systematic review; food

Abstract

Agricultural activities contribute to several environmental problems that lead to environmental degradation (FAO, 2013). These problems include biodiversity loss and climate change (Knudsen et al., 2019). In order to address some of these issues, a variety of alternative farming systems have been proposed (Garibaldi et al., 2017). Agroforestry Systems (AFS) are one such alternative where trees, crops or livestock can be combined (FAO, 2013; Garibaldi et al., 2017).

The question of whether AFS are favorable for the environment can be investigated through a Life Cycle Assessment (LCA) (Baumann & Tillman, 2004). However, the arbitrary selection of functional units, allocation methods and impact categories can largely determine the LCA results (van der Werf et al., 2020). Unlike monocultures or specialized livestock systems, the assessment of the effects and interactions of AFS on the environment are far more complex. It is therefore important to explore how the existing methodological choices in current LCA studies of AFS capture fundamental elements grounded in the general literature of agroforestry. Thus, the objective of this paper is twofold. First, to identify, select and review a collection of LCA studies of AFS that focus on the provision of food. Second, to critically analyze gaps in knowledge in narrative and descriptive forms.

To achieve this paper's objective, a preliminary systematic review was conducted. The review was based on pre-defined inclusion criteria following established guidelines and protocols (Bilotta et al., 2014; Zumsteg et al., 2012). A total of 165 studies were identified, 117 of which were screened at the abstract level. From the identified studies, only 13% were relevant for this paper. The excluded studies did not meet the inclusion criteria in terms of **P**roduct or process category, **I**mpact of interest, **F**lows or economic sectors contributing to the impact, and **T**ype of LCA (PIFT) (Zumsteg et al., 2012).

Preliminary results suggest that in the past decade, the most prevalent studied AFS were agrosilvicultural. This was followed by silvopastoral and agrosilvopastoral to a lesser extent. Shade trees, cattle and cereals were the main agroforestry components addressed by the literature. Geographically, studies were concentrated in tropical zones, mainly in South America. Only a handful of studies were in temperate regions, such as Southern Europe. Most functional units were based on mass or area, followed by monetary, energy or composite units. Systems boundaries were primarily defined from cradle to gate.

The reviewed studies focused on three major impact categories: climate change, eutrophication potential and acidification potential. Environmental hotspots were mainly linked to upstream emissions (e.g. fertilizers, animal feed and agrochemicals) followed by downstream emissions (e.g. diesel, soil management and enteric fermentation).
The preliminary results suggest a great deal of variation among the reviewed studies and their methodological choices across the four phases of an LCA. In addition to challenging the interpretation, this variation may hinder the understanding of the possible impacts of AFS on agri-food systems. Thus, the development of AFS indicators may require further exploration and incorporation into LCA since they have not been specifically outlined in the existing LCA literature.

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The AgroForageTree project: Agroforestry for forage production in permanent grasslands using fodder tree hedgerows

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Theme: Climate Change (adaptation & mitigation)

Keywords: biodiversity, drought, fodder trees, forage production and quality, hedgerows.

Abstract

Considering the economic importance and acreage of European permanent grasslands, it is important to maximize the yield and quality of the forage they produce through optimized management. An important driver of losses in forage yield and quality is climate change, especially due to increasing drought periods during the vegetative season. Agroforestry for forage production could be a promising solution to provide additional tree-based forage, especially during summer, when risks of drought-induced decrease in forage production are the highest. Indeed, many tree species can be more resistant to drought than herbaceous species, because they can access water in deeper soil layers due to their deeper root system. Leaves of specific fodder tree species, such as *Fraxinus* spp., *Morus* spp. and *Salix* spp. can have excellent digestibility and nutritional value for livestock. Moreover, many fodder tree species achieve their maximum leaf production over summer and they can maintain high leaf forage quality until late summer/early autumn, when forage yield, quality and digestibility of herbaceous species generally decrease, above all during drought periods. The abundance of condensed tannins in fodder tree leaves can also provide additional benefits for ruminant by increasing intestinal protein availability,

protecting against bloat and decreasing gastrointestinal parasites. Furthermore, condensed tannins have also been shown to help decrease ammonia production and reduce methane emission during rumination. Beside direct positive impacts on animal nutrition, health and gas emissions, agroforestry systems for forage production also provide multiple ecosystem services, such as increase in biodiversity (e.g., plant, insect and bird diversity) and carbon storage, as well as decrease in nutrient leaching. Nevertheless, a more holistic and interdisciplinary study on agroforestry systems is warranted, since the complex interactions among specific management techniques, productivity, sustainability, and various ecosystem services associated with agroforestry for forage production have been poorly investigated. The AgroForageTree project aims at evaluating the potential of five fodder tree species (Table 1) to provide supplementary tree-based forage (in addition to grass-based forage) in late summer-beginning of autumn along a climatic (900 to 1600 mm) and altitudinal gradient (450 to 800 m) composed of seven sites with different livestock categories (horses, cows, goats). The project is organized according to four main objectives, which will be presented in the poster together with the adapted methodology:

1) Monitoring the survival, annual growth, carbon uptake, water-use efficiency and photosynthetic activity of five selected fodder tree species in different permanent grassland sites across an altitudinal and climatic gradient.

2) Determining leaf production, leaf nutrients content and digestibility of the five fodder tree species and their variation along the growing season across the altitudinal and climatic gradient.

3) Investigating the impacts of fodder tree hedgerows on ecosystem biodiversity and services along the years after the establishment of the agroforestry system.

4) Assessing the palatability and selection for the five fodder tree species by different livestock categories, as well as methane emissions, nutrient absorption and digestibility resulting from the tree-grass diet.

Fodder tree species	**Digestibility**	**Crude protein**	**P**	**K**	**Ca**	**Mg**	**Condensed tannins**
Morus alba	87	153	2.4	23.7	31.3	3.0	2
Tilia platyphyllos	87	161	3.1	14.0	31.6	4.3	26
Fraxinus ornus	75	140	1.0	13.5	35.0	6.0	2
Alnus cordata	61	171	1.4	11.9	15.6	1.8	13
Salix caprea	77	160	3.5	17.6	15.4	1.5	39

Table 1. Late summer average values for digestibility (%DM), crude protein content, phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) content (g.kg^{-1} dry matter) and condensed tannins content (g.kg^{-1} dry matter) of the five fodder tree species selected for the experiment.

Agroforestry systems to support sustainable agriculture in Serbia

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Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Climate Change (adaptation & mitigation)

Keywords: Agroforestry, adaptation, drought, climate change

Abstract

The forest area in Serbia is 2.2 million hectares. Their Northern part - Vojvodina Province is region which is characterized by a very small share of forests (6.5 %). The arable land is shaped by hedges, and covered by randomly spread groups of trees. An increasing area covered by trees are necessary and can be achieved by establishment of agroforestry systems in agricultural landscapes. The aims are reduction of wind erosion, increasing biodiversity level and carbon storage capacity, providing better environment to both agricultural crops as well as forestry trees and ensuring the sustainability of agricultural production.
As the region is exposed to strong winds, the dominant type of agroforestry systems are windbreaks as a part of long-term strategy aimed at soil protection and enhancement of crop production. Windbreaks were established by planting pedunculate oak (*Quercus robur*), poplar species (Populus sp.), birch (Betula pendula), Siberian elm (*Ulmus pumila*), and black locust (*Robinia pseudoacacia*).
In the near future, special attention must be paid to the establishment of silvo-pastoral systems, because large areas under pastures are primarily on different saline soils. Silvo-pastoral systems will be established primarily from tree species that are salt-tolerant, and have fruits which can be used as a livestock feed. The most suitable tree species is pedunculate oak (*Quercus robur*), which is a native tree species. Research has shown that the allochthone American species honey locust (*Gleditscia triachantos*) is also appropriate, primarily due to its sugar content in fruits and high tolerance to the saline soils, as well as the European wild pear (*Pyrus pyraster*). Planting above-mentioned tree species will provide more favourable conditions for grazing and feeding livestock and wildlife, neutralize high salinization, provide shade to animals as well as they are a valuable bee forage, which will enable diversification of local habitats income.

Acknowledgements

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Development of genomic tools for improving efficiency of selection in Corylus americana and C. americana x C. avellana hybrids

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Theme: Climate Change (adaptation & mitigation)

Keywords: Corylus species, carbon sequestration, tree breeding, marker-assisted breeding

Abstract

Alternative specialty crops can provide small-to-medium scale Midwestern farmers in the United States an important avenue to financial diversification, and crops that facilitate the transition from the maize-soybean rotation toward agroforestry systems can play a critical role in this respect. The understory shrub American hazelnut (Corylus americana), native to Wisconsin, could provide such an opportunity, if commercially viable varieties were available. Importantly, estimates suggest that if planted across large acreage, replacing the 84 million acres of soybeans currently grown in the Midwestern United States annually, 1500 Mt of carbon (roughly 1/3 of annual US CO2 emissions) could be sequestered in woody biomass alone (Wolz et al., 2018).

As a step toward the development of such varieties, this research aims to deploy the modern breeding tools that have historically been under-utilized in secondary crops such as hazelnut. Breeding improved varieties of hazelnuts is complicated by the fact that they are a woody perennial, often not flowering until they are three years old, and not reaching their mature growth form for a decade. This challenge makes the issue of resource allocation central to effective hazelnut crop improvement, insofar as it is critical to select breeding targets for which gains from selection can realistically be made in a given population, as well as develop genetic markers that can facilitate marker assisted selection.

This study represents an initial attempt at developing molecular markers that might aide in selection for kernel quality traits. A recently-developed, high-throughput, digital image-based phenotyping method has allowed us to precisely quantify size and shape characteristics of in-shell and kernel features of hazelnuts (Fig. 1). This phenotypic data is being collected from two types of experimental populations, which are being used to identify quantitative trait loci (QTL) for various kernel quality traits. First, linkage mapping within a large F1 family, replicated at three different locations across Wisconsin, will be used to estimate the genetic variance of putative QTL in terms of additive and dominance effects within a

relevant breeding background. This family was derived from a bi-parental cross between phenotypically divergent hybrid lines made in 2010, and large populations (>300 individual plants) are now reaching maturity in three different environments evenly distributed across Wisconsin.

In addition to these linkage mapping approaches, a diversity panel of wild C. americana germplasm will be used to carry out a genome-wide association study. Instead of a known mating design being employed to generate phenotypic and genotypic diversity, the presence of a relatively greater amount of historical genetic recombination will in this case allow for much higher precision in locating specific QTLs, as well as help characterize phenotypic diversity in natural populations. This research will hopefully allow for substantial improvements in the efficiency of breeding efforts, both through the development of specific molecular markers that are associated with kernel traits in breeding populations of interest, as well as the development of genomic selection models to allow for the screening of larger number of progeny in wide crosses.

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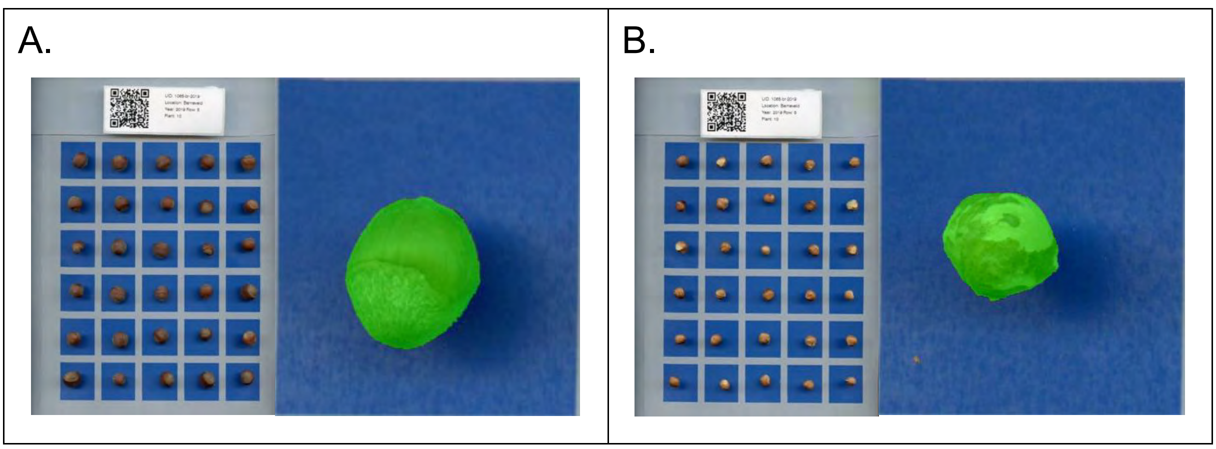

Figure 1. The phenotyping methodology being employed to estimate in-shell and kernel characteristics. Scan of 30 in-shell nuts (**A**) and kernels (**B**), as well as overlays showing computer-vision based identification of the nut and kernel. QR codes aides in automated file-management. Together, average kernel size and the percent of the nut which is represented by the kernel can be estimated. Combined with a calliper measurement of the 3rd dimension not captured in these scans, in-shell and kernel volume and sphericity can also be calculated.

Synergies in integrated systems: Improving resource use efficiency while mitigating GHG emissions through well-informed decisions about circularity

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Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Climate Change (adaptation & mitigation)

Keywords: crop-livestock-forestry systems, nutrient flows, sustainability assessment tools, circularity scenarios

Abstract

Specialization and the often resulting spatial separation of crop, livestock, and forestry production systems lead to loss of biodiversity and contribute to climate change. Integrating or combining crop, livestock, and forestry offer numerous opportunities to reduce the environmental impacts of agricultural production systems. Circular systems have been proposed to increase the efficiency of resource use, especially for scarce nutrients, and to use them more sustainably than conventional systems.

Therefore, the project SENSE aims to contribute to the study of integrated systems to gain a solid knowledge on the environmental impact of circular agroforestry systems (livestock-agroforestry, crop-agroforestry, and livestock-crop-agroforestry). In addition to the European partners of this project (Germany, Netherlands, United Kingdom and Italy), the expertise of more than 20 years of intensive research on these kinds of systems from the partners from South America (Argentina, Brazil and Uruguay) will be provided. Objectives in this project are to further develop indicators for effective quantification of the status of circularity, near real time measurements of greenhouse gas (GHG) emissions and prediction of emissions and nutrient fluxes through modelling. In order to assess the impacts of climate compatible management measures in a system-oriented way, multidimensional sustainability assessments with different tools (SMART, RISE, TAPE) will be carried out (Hani et al. 2003; Schader et al. 2016; Mottet et al. 2020).

The project activities will be based on case studies of farms and experimental sites of the different participating project countries. The core is formed by benchmark farms where the objectives (indicators for circularity, GHG emission, modelling, sustainability assessment tools) will be applied. The nutrient fluxes and GHG emissions of these farms, as well as trade-offs of further societal demands and ecosystem services, will be recorded and optimized. In a second group of farms (participatory), a scenario-based approach will be used to compare them according to their potential of reducing GHG emissions and investigate farmer acceptance of management practices to increase circularity. Leveraging information from individual farms and involving farmers at multiple levels and times during the whole activities will be crucial to the outcome of our project.

Our project will therefore address, among others, the questions which circular activities in integrated (crop, livestock, and forestry) systems lead to potential GHG reductions at the farm level, what are the externalities that determine the extent of circularity at the farm level, and what are the impacts of circularity measures in crop, livestock, and forestry systems on the SDG target 13 " Climate Action" and on other major challenges, such as biodiversity and appropriate incomes for farmers. The SENSE project will contribute to the European Union's net zero emissions target, the European Farm to Fork strategy and to the cross-cutting actions of the European Circular Economy Action Plan(Montanarella and Panagos 2021). Circularity is considered a prerequisite for climate neutrality, but has potentially negative impacts on other major societal challenges. We will provide guidance for informed decisions on circularity at the farm level, considering trade-offs with other sustainability goals.

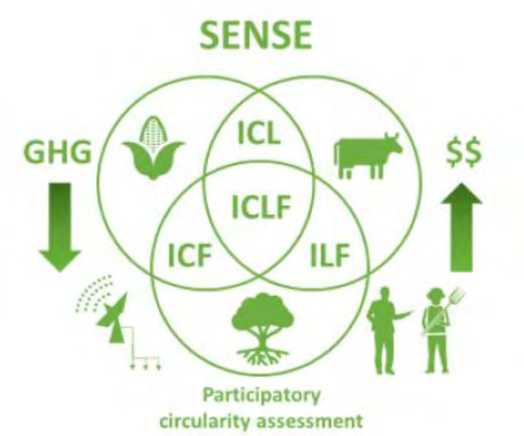

Figure 1. Integrated production systems may be conducted in different ways: (1) integration of crop–livestock (ICL), (2) crop–forestry (ICF), (3) livestock–forestry (ILF) and (4) crop–livestock–forestry (ICLF)

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Comparing production systems - including agroforestry - in organic vegetable production on the basis of microclimate data

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Theme: Climate Change (adaptation & mitigation

Keywords: agroforestry, air temperature, production systems, organic tomato production

Abstract

Introduction Agroforestry systems have great importance in organic farming, especially in areas where climate (shortage of rainfall) and soil properties (sandy soil with H 1,5%) do not meet the optimal production requirements. We have focused our recent experiments on investigating the role of trees in field vegetable production in organic system. To reach our aim we have compared different tomato production systems, based on different indicator traits, specially on air and soil termperature under field conditions. Our results in three years were promising according to data measured by air and soil sensors from tomato plant population level; comparing three type of production systems, including two traditional field production and one agroforestry, where willow trees were used in the rows of tomato plants.(Szalai et al 2020) Our goal was to compare traditional field production systems with a new one in order to mitigate the harmful effects of temperature, and precipitation extremes during the vegetation season. Ont he other hand to show through measured data of temperature the microclimatic differences in the studied production systems during.

Material and method: The experiment was set up in 2019-20-21 in order to compare the different production systems of organic tomato production on the basis of soil and climatic properties. The characteristics of different production methods are summarized in Table 1.

Table 1. Overview of the investigated tomato production systems.

System code	Soil coverage	Supporting system	Nutrient supply	Irrigation
AG	agrotextile	wooden frames	organic manure	no
ST	straw	bamboo sticks	organic manure	drip irrigation
TREE	grass/straw	willow trees	sheep manure	no

To monitor the temperature air and soil sensors (type:Voltcrat and Tinytag) were applied in the studied production systems.

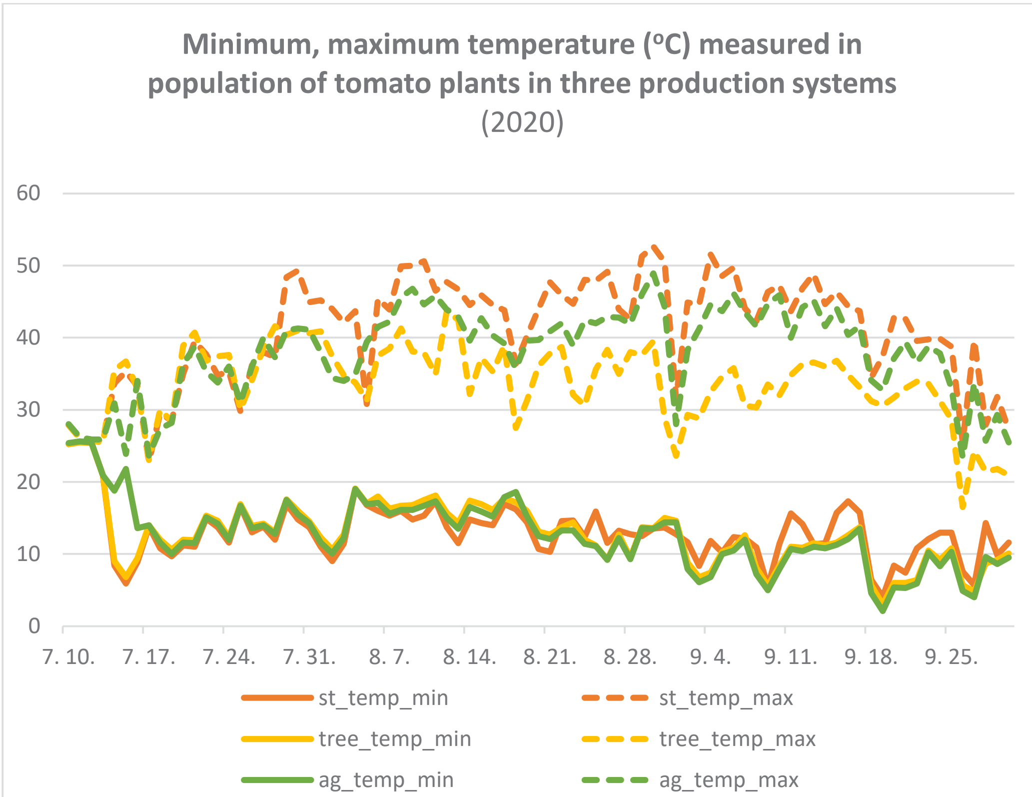

Figure 1. Minimum and maximum temperature (°C) measured in the three different production systems by air sensor 2020 at experiment field of Organic Farming Unit of MATE Experiment Station

Results: Figure 1. shows that the highest temperatures were measured in production type ST (soil covered by straw) and the lowest temperatures were recorded in type TREE, where trees were used as supporting system of the tomato plants in 2020. The average temperature reached 32.7 °C on the plots covered by straw. Plots where trees were present the highest daily average temperature was 27,8 °C.
Considering Min and Max air tempearture even higher differences were measured. As Figure 1. shows the highest maximum temperature reached the 53,8 °C on ST plots while the lowest maximum temperature was 39,6 °C on plots TREE on the same day. Difference is 14,2°C. Data of soil water capacity, and soil water content were also different in the measured production systems.
In 2021 we have got different data, of temparature values specially for the TREE system. The crown size of willow trees decreased due to dehydration, some of the trees withered and dried up during the vegetation period.
The average temperature reached 34.76 °C on the plots covered by agrotextil. Plots where trees were present the highest daily average temperature reached 33,29 °C, the lowest daily average temperature was 32,9 °C on the plots covered by straw (with drip irrigation) in 2021.
Conclusion: Data of air temperature had changed in plots TREE in the three consequent years. Measured temperature differences of compared systems began to decrease because the number of living trees had started to decrease too on the experiment plots TREE. It will explaine the slowly but continuosly increasing level of temperature data measured in the production system 3. (TREE).
Our results point to the importance of the presence of trees (agroforestry system) in vegetable production systems in terms of mitigating extreme climatic conditions in the studied tomato production systems under field conditions.

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CARAT: an online tool for quantifying carbon sequestration in agroforestry systems

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Theme: Climate Change (adaptation & mitigation)

Keywords: carbon sequestration, carbon pricing, online tool, RothC model, soil organic carbon

Abstract

Agroforestry systems may play an important role in mitigating climate change by their ability to sequester carbon dioxide (CO_2) in the soil and trees. Quantifying this carbon sequestration permits carbon pricing in agroforestry systems and may give an economic incentive for land managers to start with agroforestry. Ex-ante simulations of carbon sequestration might also be supportive for (comparison of alternative scenarios in) designing climate effective agroforestry systems. The online tool CARAT (CARbon sequestration Agroforestry Tool) makes it possible to estimate the carbon sequestration in agroforestry systems.

CARAT was developed for 19 tree species typically used in temperate agroforestry systems, and is widely applicable to any type of tree configuration (e.g. alley cropping, silvopastoral systems, etc.). Carbon storage in plant biomass is quantified using species-specific allometric relations and growth data from literature. Annual leaffall is quantified using a state-of-the-art leaffall distribution model developed by Ferrari and Sugita (1996). The model is spatially explicit and predicts the annual leaf litter fall around trees assuming an exponential decline of foliage biomass with distance and using species-specific allometric equations.

The leaffall model is subsequently coupled to the RothC model (Coleman and Jenkinson, 1996), a model for the turnover of soil organic carbon in the topsoil of non-waterlogged agricultural fields. Combining these two models allows the user to estimate the effect of leaffall on the soil organic carbon content. The combined model was tested and the model outputs were validated with soil organic carbon measurements on existing alley cropping systems. CARAT is an interactive tool, the user can change input parameters such as the design of the agroforestry system, the initial soil organic carbon content, crop rotation, tree species, etc.

We see this tool as a living product that can be improved through in-situ measurements. Using this tool, scientists, policy makers and land managers will be able to accurately estimate above- and below-ground carbon stocks in agroforestry systems and how these stocks evolve through time. In turn, CARAT can be a powerful tool for carbon pricing, making agroforestry a more attractive and valid option for farmers.

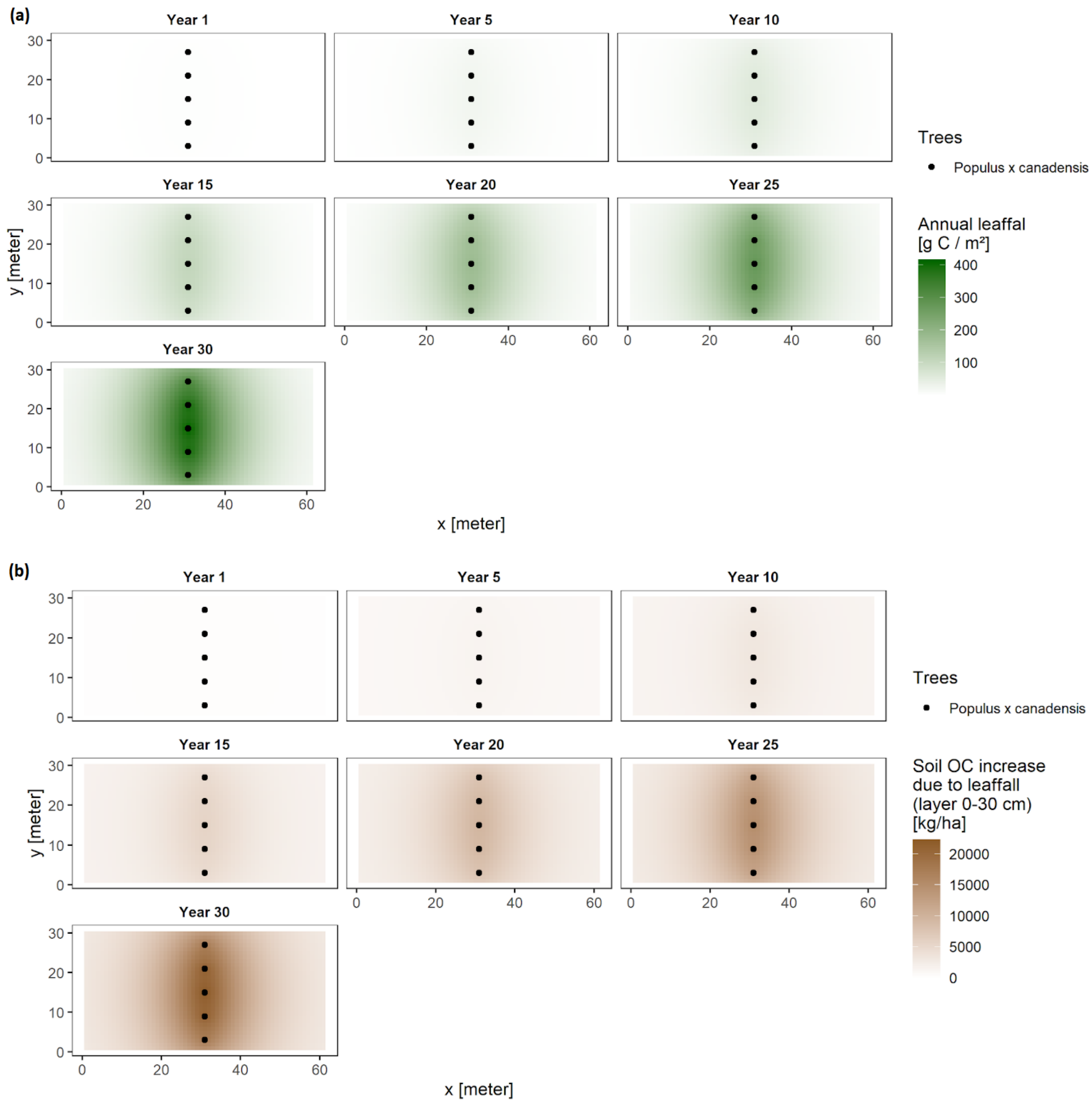

Figure 1. (a) Annual carbon input by leaffall of a tree row of Populus x canadensis on a field with dimensions 30 by 61 meter, for trees of 1, 5, 10, 15, 20, 25 and 30 years old. (b) Soil organic carbon increases in the soil layer 0-30 cm due to leaffall of a tree row of Populus x canadensis on a field with dimensions 30 by 61 meter, 1, 5, 10, 15, 20, 25 and 30 years after the planting of the tree row (preliminary results).

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Contribution of mountainous silvopastoral systems on soil organic matter in Evritania, Central Greece

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Theme: Climate Change (adaptation & mitigation)

Keywords: ecosystem services, climate smart landscapes, organic matter, carbon storage

Abstract
Mountainous silvopastoral systems areas of the Mediterranean basin are recognized as multifunctional systems for the use of the land. Their value is both ecologically and culturally high (HNCV) since they are recognized as climate smart landscapes. They support a variety of agroforestry landscapes and a large biodiversity of wildlife, supporting, by their long-term productivity the income of mountain inhabitants, such as by animal husbandry and traditional agroforestry practices. The 21st century finds these ecosystems under suffocating from the pressure and threats due to the fact that traditional agroforestry systems are gradually abandoned while climate change affects them by the rising temperatures and eventual drought. The management practices that aim to the rehabilitation of the abandoned silvopastoral systems and to the improvement of local pastures, set the priorities to preserving these unique ecosystems. Preserving those ecosystems will contribute to the global effort to mitigate the effects of climate change since they act as carbon dioxide pools. Based on the above, to investigate the contribution of mountainous silvopastoral systems on soil organic matter, an experiment was established in Evritania, Central Greece. The experiment compared soil organic matter content of two silvopastoral systems, one grazed and one abandoned. In this article, the results are presented to highlight the importance of grazing on the preservation of these systems as well as their contribution to carbon sequestration. The aim of the experiments is to highlight the appropriate management practices that will contribute significantly to the effort of natural ecosystem conservation and human societies' food security globally.

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Agroforestry systems influence and buffer important (micro)climatic parameters

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Theme: Climate Change (adaptation & mitigation)

Keywords: buffering climatic extremes, microclimatic parameters, soil water content, agroforestry

Abstract
Monitoring of microclimatic and soil-hydrological parameters has been carried out in three sites resp. stands: (i) an alley-cropping agroforestry system (AFS), (ii) a short rotation coppice (SRC) and (iii) a conventional crop field (CF: wheat in 2020, pea in 2021) in the Michovky research station of VUKOZ Průhonice since January 2020 by a complex monitoring system. All stands are situated on a plain terrain with similar soil conditions (Cambisol; haplic Luvisol). Air temperature and relative humidity is measured both 1 m and 4 m above ground. Photosynthetically Active Radiation (PAR) and wind speed is recorded 4 m above ground. Soil water content is measured both 30 and 60 cm below soil surface.
The main conclusions about microclimatic parameters after 2 years (resp. vegetative seasons) are:

- The occurrence of trees lead to decrease of air temperature - average air temperature in ALS and SRC was lower by 0,3 and 0,9 °C compared to field;
- In AFS and SRC in the second year after harvest (4m tree height), wind speed and PAR decreased by about 50 % in comparison with the conventional crop field.
- The higher the trees (or the faster the growth), the greater the decrease of temperature and increase of relative humidity, especially in dense growth (average relative humidity in SRC was higher by 4 %),
- The course of soil water content (soil humidity) was generally less fluctuating in 60 cm than 30 cm. The greatest soil water content decrease was observed at SRC during growing seasons. However, during winter, soil water content was supplemented from rainfalls.

We also used UAV-derived data in order to estimate temperature regime on the AF plot in respect to tree shadow dynamics during the day. Three times during the vegetation season the UAV flights were operated (23.6., 8:52-9:13; 25.8., 11:20-11:38; and 9.9.2020, 11:34-11:45) over the AF study plot. Whereas the intercrop was growing in June, the flight in August detected the situation already after the wheat

harvest with some remaining organic residues. We used the multispectral Micasense sensor with bands: R, G, B, red edge, near IR, and thermal. Further NDVI index and surface temperatures were calculated. Basic statistics of temperatures and NDVI were computed for divided polygons corresponding to trees, shadowed and sunned intercrop. Average temperatures in time of first flight were 16.81±0.96, 16.65±0.66 and 15.02±0,54 °C for trees, sunny intercrop and shadowed intercrop, resp. Thus, even in very early morning, there is a difference in temperature between shadow and sunny places more than 1.5°C in average. Notable is, that areas with lower temperatures (shadowed intercrop) have in general moderately higher NDVI values (0.87±0.09; 0.87±0.05 and 0,90±0.06 in average). Similar comparisons for August and September show much more important differences in temperatures (app. more than 10°C). However, we are treating the surface temperatures of nearly naked soil, in these periods.
We will continue to monitor all climatic and hydrological parameters based on both ground and aerial data in following season with the aim to find interactions between climatic conditions and production and quality parameters of agricultural crops.

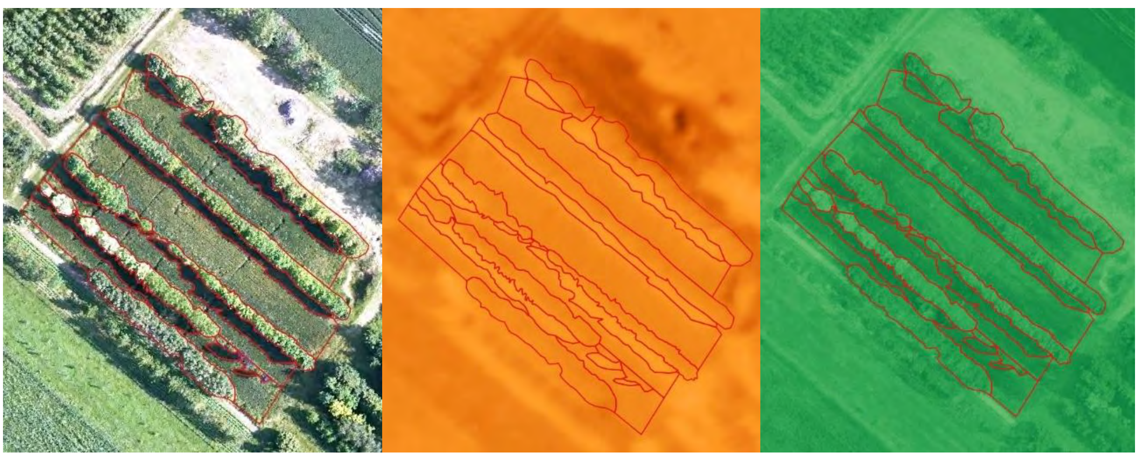

Figure 1. The Michovky AF study plot: RGB image (left), surface temperatures (middle) and NDVI (right) with delineated areas of trees, shadowed and sunned intercrop. UAV image dated of 23.6.2020 at 8:52 to 9:13 a.m.

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Ecological relations of soil fauna under long term Agroforestry system in temperate climate: results from central Italy

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Theme: Biodiversity

Keywords: soil fauna; microarthropods; fungi; carbon stabilization

Abstract
Agroforestry systems positively enhance the agroecosystem resources (Rosales at al., 2018) providing several benefits (Polanía-Hincapié et al., 2021). Despite several studies on positive effect on soil, the way soil fauna and their functions are affected by a diversity of agroforestry systems around the world is always an open question (Mardsen at al., 2020). Accordingly, long-term agroforestry (LTA) study in temperate climate are extremely interesting to analyze the soil biota communities and relative roles of the ecological drivers of organic carbon dynamics.
Within the EIP-AGRI Operational Groups (RDP of the Region of Tuscany 2014-2022) "NETWork for agro-forestry in TOscaNa - NEWTON" promoting agroforestry practices and the implementation of economic and environmental sustainability of agricultural systems, we verified LTA management effect on soil ecology. Tests were performed at Tenuta di Paganico, an extensive farm devoted to organic agro-zootechnical productions at Civitella Paganico in Tuscany, central Italy. Since 2000, one of the farm's main activities is breeding, based on silvopasture practices, of the local beef cattle breed, Maremmana, for meat production. The grazed land includes a forest area (about 800 ha) made up of a mixed woodland with a prevalence of Turkey oak (Quercus cerris L.) in the form of stands, and grasslands for forage production and pasture. Stables are not used, while feeding stations located in open areas are used to facilitate an integrated animal diet.
This study aimed to provide monitoring tools and to highlight specific "biological traits" and/or ecological relations for soil quality assessment. Moreover, since ecological equilibrium matches organic carbon dynamics (Caruso et al., 2018) biological data were taken in consideration to evaluate the persistence of organic carbon.
During spring and autumn 2021, we analyzed the meso- and the micro- soil fauna community. Special attention was given to collembola and the relations with fungi, as these can significantly influence soil carbon cycle. Soil Biological Quality index (QBS-ar) was applied to assess soils quality and Mites and Collembola ratio to define the ecological equilibrium. Four theses were identified based on the silvopasture vs. grassland and the intensity of grazing high stand with four levels of grazing intensity (non-grazed-ANP, high-PVA1, medium-PVA2, low-PVA3), depending upon the maximum distance that animals usually reach from the main feeding stations (high density pasture at shorter distance from the feeding station and low-density pasture at farther distance), and grassland (PTP).
The results showed a substantial tendency to lower soil respiration in PVA1 as compared to areas with lower grazing intensities, likely connected to different soil porosity and especially to reduced biology quality. PVA2 and PVA3 showed high level of soil biodiversity by mesofauna detection and fungal metabarcoding analyses, as well soil biological quality and ecological stability. The results suggest that LTA, based on the regulation of animal load in the forest, support biodiversity and soil ecological equilibrium. Moreover, QBS-ar index is confirmed as a very efficient and responsive method to evaluate soil quality to take in consideration in monitoring agroforestry systems.

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Hedgerow biodiversity – a proxy for the biodiversity potential of alley cropping

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Theme: Biodiversity

Keywords: alley cropping, plant species richness, flowering, pollination

Abstract

Hedgerow biodiversity – a proxy for the biodiversity potential of alley cropping

Agroforestry has been documented as a sustainable agricultural system over conventional European agriculture, conserving biodiversity, and enhancing ecosystem services (e.g., Torralba et al. 2016). This conclusion, however, is mainly based on studies from Central and Southern Europe. Here studies have demonstrated that alley cropping systems with short rotation coppices may among others enhance biodiversity compared to conventional agriculture. Very few studies have been carried out in temperate Northern Europe. Studies of hedgerow biodiversity may, however, serve as a proxy for the biodiversity potential of alley cropping systems. We present results from several studies of hedgerow biodiversity in Denmark, clearly demonstrating that biodiversity improvements take time. Enhancing species richness of hedgerow ground vegetation is a slow process. The studies included different farming practices (conventional versus organic), landscapes of varying composition, and different soils (Figure 1). The studies showed hedgerows at organic farms contained more plant species that flowered for a longer period and at higher intensities compared to conventional, thereby contributing more resources to pollinators. Moreover, landscape heterogeneity played an important role shaping the size of the local species pool with higher species richness in landscapes with a large proportion of semi-natural habitats.es.

Will biodiversity and ecosystem service benefits of alley cropping be similar to from traditional agroforestry systems?

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Theme: Biodiversity

Keywords: farmland bird, landscape scenery, natural pest control, pollinator

Abstract

Traditional agroforestry systems such as Dehesas/Montados, high-stem fruit orchards, hedgerow landscapes (bocage, Knick) or woody pastures are renowned for biodiversity and ecosystem services. Can we expect similar benefits from modern temperate agroforestry systems such as alley cropping? Here we summarize results of research conducted over the last ten years that can help answering this question.

- Biodiversity conservation: Woody elements in farmland increase the numbers of birds (Klein et al. subm.). Their connectedness seems to be more important than their actual amount. Species richness of birds, spiders and beetles, and the abundance of some bird species was higher in well-connected fruit orchards than in isolated ones (Bailey et al. 2010). Yet, some ground nesting bird species (e.g. skylark) avoid vertical structures and require open farmland (Hagist & Schürmann 2021). Thus, the planning of agroforestry should be spatially differentiated to account for the specific biodiversity potential of landscapes.
- Functional biodiversity: Seasonal pollen records revealed that in early spring, bees and natural enemies (ladybeetles, lacewings) rely particularly on pollen collected from trees and shrubs (Bertrand et al. 2019). *Salix*, *Prunus* and *Juglans* species, which are often also used in alley cropping, were among the most frequently collected pollen types. The early availability of pollen (and nectar) is the pre-requisite for building up insect populations, so that later in the season pollinators and natural enemies can provide their services in agricultural crops. Isolation was particularly detrimental for those groups. It affected the pollination services and interactions with herbivorous insects, fruit set and tree growth (Schüepp et al. 2013, 2014). Conversely, well connected fruit orchards were more affected by the invasive fruit fly *Drosophila suzukii*, which can lead to severe damage in stone fruit, despite the presence of many natural enemies in hedgerows (Henning & Mazzi 2018, Siffert et al. 2021).
- Cultural ecosystem services: Woody landscape elements and traditional agroforestry systems are rated higher than agricultural crops and grasslands regarding visual quality (Schüpbach et al. 2020) and other cultural ecosystem services such as recreation, social interaction, spiritual values (Rolo et al. 2021, Kay et al. subm.).

We expect that alley cropping agroforestry will have similar biodiversity effects to the ones observed for woody farmland elements in general. The lines of trees will contribute to habitat connectivity, which is particularly important for many species. However, management intensity and the type of tree or crop are likely to be important and require further study. Potential negative effects on certain species and for the spreading of particular pests, however, should also be taken into account when planning for agroforestry. It is less clear if cultural ecosystem services will also be promoted in a similar way because the visual aspect of alley cropping differs significantly from traditional agroforestry landscapes.

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Potential of agroforestry systems in preserving Europe's soil biodiversity in lowland and highland

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Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Biodiversity

Keywords: innovative food & non-food systems, ecological zones, soil biodiversity, SustainFarms

Abstract
SustainFARM was a FACCE EraNet Surplus project aimed to enhance agronomic, environmental and economic performance of integrated food and non-food production systems (IFNS) by optimizing productivity and valorizing woody components, residual wastes and co-products. A spatial modelling approach has been used to assess the geographical, environmental and ecological conditions of the existing IFNS systems. A network of representative integrated food and non-food systems (IFNS) was identified in different socio-economic and environmental settings in Northern, Eastern and Southern Europe across countries and bio-geographical zones (Figure 1). The network comprised of both traditional and innovative systems in which trees, crops and livestock are integrated in different ways and at different spatial scales (table 1). Six of these farms were chosen to be included in the spatial analyses – those are highlighted in table 1.
SystainFArm case studies of IFNS are located across longitudal and latitudal geographical gradients. The variety of climate, soil cover and agricultural practices presents a challenge in comparing those systems. Another challenge remains the diversity of spatial data sources, coming from various providers. Although the INSPIRE Directive sat out a framework for Spatial Data Infrastructure in Europe, still data sources, even those provided by the European Commission, lack proper metadata and are difficult to harmonize. To assure semantic interoperability of data among the countries and regions of case studies, EU-wide datasets were chosen as the foundation of environmental indicators. Those datasets are usually coarse, with the reference scale varying form 1:250.000 to 1:1000.000, not suitable for farm or even village level analyses but usable at NUT3 level and higher.
Because of the increasing pressures exerted on soil, below-ground life is under threat. Knowledge-based rankings of potential threats to different components of soil biodiversity were developed in order to assess the spatial distribution of threats on a European scale. A list of 13 potential threats to soil biodiversity was proposed to experts with different backgrounds in order to assess the potential for three major components of soil biodiversity: soil microorganisms, fauna, and biological functions. This approach allowed us to obtain knowledge-based rankings of threats. The spatial analyses of delineated IFNS fields' borders overlaid with soil biodiversity threat raster datasets downloaded from the ESDAC website revealed high variability of threats both between IFNS systems as well as between threat categories within each of IFNS. Dealing with threats to soil biodiversity is a complex issue, requiring long term strategies, that provide i. e. incentives for farmer to exercise alternative, less environmentally-

unfriendly farming systems. An extra factor of climate change, that carries with it more extreme events and microclimate shifts, adds to the urgency to change farming practices on threatened soils. Agroforestry seems to be an attractive alternative for intensive farming in both plant production and animal production domains. Most of all, however, the agroforestry farming systems promote biodiversity in soil and above, which increases the content of soil organic matter in soils and through it also resilience of agricultural ecosystem against pests and changing climate.

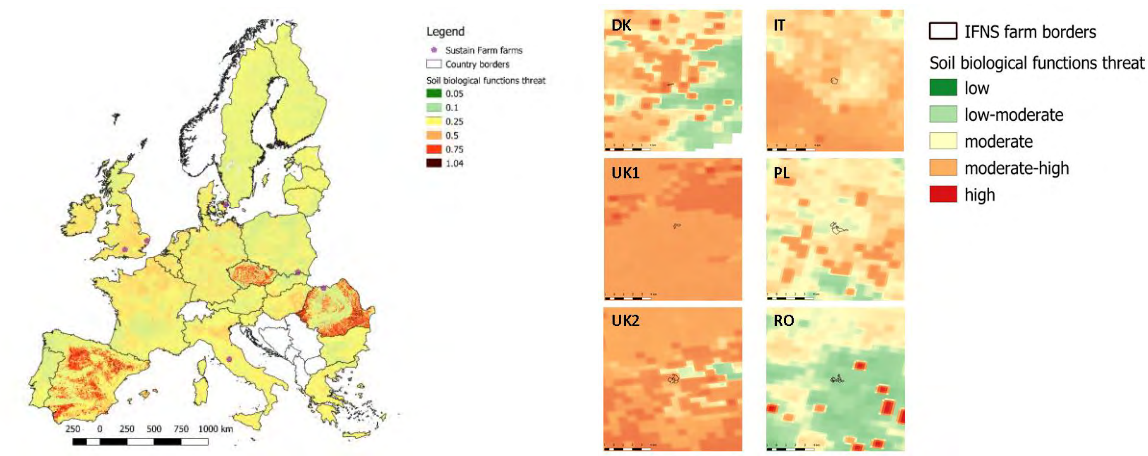

Figure 1. Soil biological functions threat (source: ESDAC)

Table 1. Network of IFNS sites in partner countries

IFNS category	Site location	Farm size	Country code	DMEEREEA Zone code*
Combined food and energy production systems	**Experimental farm Taastrup, Denmark**	**11 ha**	**DK**	**13**
	Marek Popis Farm, Tomaszkowo village, Stawiguda municipality, Poland	233 ha	PL	20
Multipurpose olive tree production systems	**Muzzi Farm, Bagni village, Orvieto municipality, Italy**	**7 ha**	**IT**	**161**
	Eugenio Ranchino Farm, Porano municipality, Italy	260 ha	IT	161
	Gianluigi Maravella Farm, Ficulle municipality, Italy	80 ha	IT	161
Silvopastoral systems	**Elm Farm, Berkshire, United Kingdom**	**85 ha**	**UK**	**31**
	Mihalca Farm, Petrova Municipality, Romania	**26 ha**	**RO**	**59**
	Oikos farm, Sękowa, Poland	**111 ha**	**PL**	**59**
Silvoarable systems	**Wakelyns Farm, Suffolk, United Kingdom**	**22.5 ha**	**UK**	**31**
	Tadeusz Januszewski Farm, Przygorzele village, Poland	44.6 ha	PL	20
Cereal-based integrated food and bio-energy production system	La Campiña, Spain	-	ES	159

*DMEEREEA codes:

13 – Baltic mixed forests

20 – Central European mixed forests

31 – English Lowlands beech forests

59 – Carpathian montane coniferous forests

161 – sclerophyllous and semi-deciduous forests

161 – Italian sclerophyllous and semi-deciduous forests

Apiculture and biodiversity of honey plants of Montenegro - Potential for agroforestry practice

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Theme: Biodiversity

Keywords: honey plants, beekeeping, plant diversity, agroforestry, Montenegro

Abstract

Availability and diversity of floral resources at the landscape scale have been recognized in traditional Agroforestry systems by apiculturists a long time ago, as a critical determinant of honeybee colony success. Foraging honeybees (*Apis mellifera* L.) can routinely travel as far as several kilometers from their hive in the process of collecting nectar and pollen. In Montenegro, as one of the most floristically diverse Balkan areas, about 3,600 vascular plant species and subspecies have been recorded, and nearly 500 of them have been recognized as melliferous species. The number of endemics is also high - there are as many as 392 Balkan (regional) endemic species, which accounts for over 7% of the Montenegrin flora. Diverse habitats that exist in five biogeographical zones, present in small geographic areas, have influenced high richness that needs to be studied and compiled as the unique melliferous species database of Montenegro. About 30 species were recognized as very important and dominant honey plants, which represents the strengths and benefits for Montenegrin honey production and market position. Seventy five percent (75%) of dominant honey plant species are trees and shrub species that are typical representatives of forest communities, and 25% are perennials and herbaceous species.

This paper presents the methodology and results of the ongoing Project Development of the Atlas of Honey Plant with the Apiary Cadastre of Montenegro financed by the World Bank. One of the main Project goals is collecting and processing data on the spatial distribution of the melliferous species of Montenegro, as well as information regarding temporal honey flow. This database with the following web platform are prerequisites for the sustainable economic development of beekeeping based on the optimal use of beekeeping pasturage resources and planned utilization of natural resources. One of the outputs of the Project is to promote the significance of the biodiversity of natural honey species and to define key species for the honey plantations to fill the flowering gaps in the bee pasturage.

The outputs of the project will provide useful data for the development of organic beekeeping as an agroforestry practice since it will enable determining the suitability of locations for the formation of organic apiaries.

In order to develop the most reliable information regarding the list of melliferous plant species in Montenegro, dominant melliferous species for bee forage, spatial distribution, and flowering duration, data from four sources of information were processed through (Figure 1):

1) Digitizing the existing literature data (as a background data and basis for planning of fieldwork);
2) Fieldwork, collecting data using Q-Field application project specially designed for this purpose;
3) Melissopalynological analysis of honey samples (pollen analysis), determining the presence of a botanical species in honey;
4) Crowdsourcing.

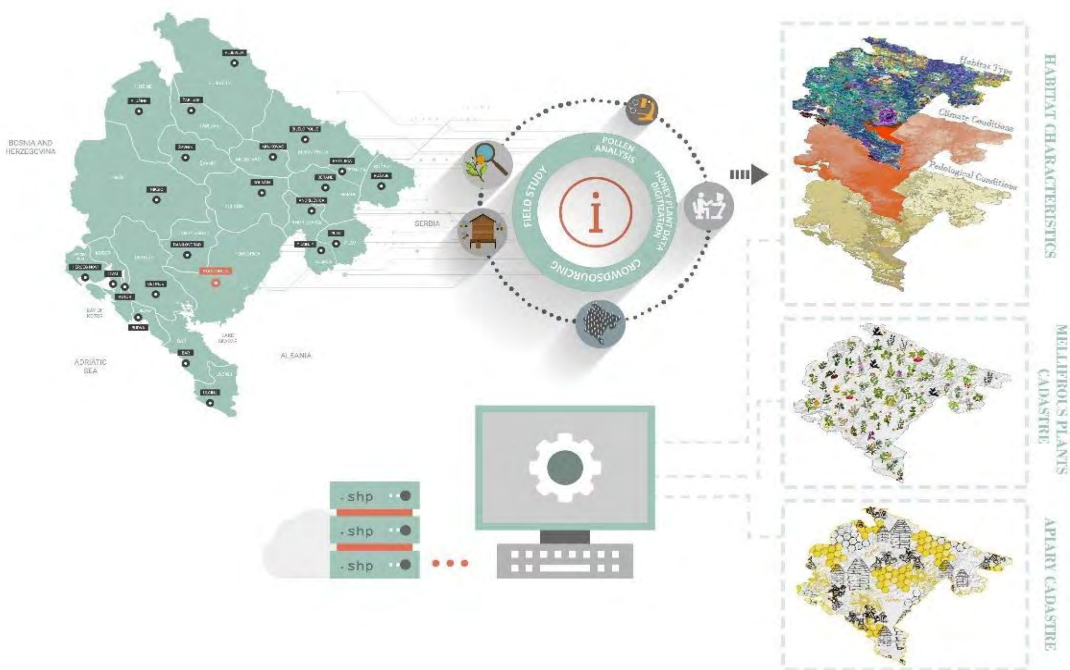

Figure 1. Graphical abstract of the proposed methodology

Vitiforestry: Farmers' intent to include almond trees into viticultural systems in Switzerland and Germany

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Theme: Biodiversity

Keywords: almond, vitiforestry, biodiversity, farmers' motivation

Abstract

So far, vine grapes are predominantly cultivated in monocultures with high intensity and low diversity. Hence they offer great potential for increasing biodiversity (Paiola et al., 2020). Through ground vegetation management, cover cropping, hedge strips, and fallow land between the grape plants many winemakers already diversified their vineyards. Some winegrowers are going further by introducing different tree species. Vitiforestry – the combination of trees and vine – is an old cultivation system and was practiced in ancient times until the mechanization of agriculture (Bourgade et al., 2018). Due to land consolidation and the machine-friendly restructuring of vineyards, there are hardly any trees between vines in Germany and Switzerland. However, field names in wine-growing regions and historical documents show that almond trees, in particular, were planted in between vines (Eisenbarth, 2020). In Germany, they were cultivated commercially until the 1940s (Eisenbarth, 2020). Wine-growing regions in the North of the Alps are particularly suitable for almonds as they have comparable climatic requirements to their areas of origin. Today a few winegrowers restarted to integrate almond trees into their vineyards. Therefore, the project aims to explore the motivations of winegrowers in Germany and Switzerland that re-introduced almond trees (*Prunus dulcis*) into their cultivation systems and what benefits the trees provide. Qualitative interviews with winemakers were conducted, complemented by expert interviews with scientists and viticulture consultants.

The first results show that there are very different motives for the cultivation of almond trees in viticulture North of the Alps. While climatic and aesthetic reasons as well as biodiversity play an important role, economic considerations are of secondary importance. In Palatinate in Germany, new almond plantings are carried out mainly for aesthetic reasons and consequently for tourist attraction. For this reason, mostly ornamental almond varieties are planted. Other winemakers plant the almonds explicitly to promote biodiversity. According to the interviewees, almonds are particularly suitable for viticultural systems because of their low foliage providing optimal shading. In addition, almonds require little space due to their slender growth and have low maintenance requirements. Further, drought resistance has been cited as a very important characteristic regarding climate change. Some winegrowers are using the space under the almond tree for piling up stones which further increases structural diversity and creates valuable habitats. Others are planting almond trees in so-called pinch areas where mechanical processing is impossible. Additionally, almonds in viticulture could be a possibility for economic diversification. Examples from Germany and research in Switzerland were able to confirm the economic profitability of almond cultivation (Reutimann et al., 2020). The motives for the cultivation of almond trees by winemakers are complex, but the promotion of biodiversity and its ecological benefit by planting almond trees in viticulture are dominant reasons. To better understand the ecological effects of almond trees on biodiversity quantitative data must be collected and analyzed. Due to the small number of trees in

vineyards, information campaigns, knowledge transfer, and incentives are needed to support farmers' decisions to incorporate almonds into their vineyards and profit from their economic and ecological benefits.

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Breeding birds in European Agroforestry systems

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Subtopic: Biodiversity

Keywords: Birds, Audio recordings, Europe, silvo-arable, silvo-pastoral

Abstract

Declining numbers of farmland birds across Europe can be attributed to agricultural intensification and landscape simplification. This calls for drastic changes in agricultural systems. Agroforestry (AF) could be an option in which open farmland elements are mixed with trees.

In the EU project AGROMIX, we study bird biodiversity in mature AF systems. These systems combine either trees and crops (silvoarable systems) or trees and livestock grazing (silvopastoral systems). Here, we present first results regarding breeding birds in AF systems in temperate Europe, with sampling sites in England, Switzerland, France and Germany.

Sampling was performed in spring 2021 in two silvopastoral systems in Germany and France and two silvoarable sites in England and Switzerland. Two to three AF fields in each site were sampled using autonomous sound recorders (AudioMoth). We compared the biodiversity of each of the AF fields with crop monocultures for silvoarable systems and grassland for silvopastoral systems as well as orchards (only for AF systems including fruit trees). We also sampled a forest patch as an additional control field.

Our analyses suggest that species richness in mature AF sites is comparable to forests, but higher than in orchards, grasslands and arable control fields. In addition, the species composition in AF sites differed from the other habitat types and included species that depend on semi-open habitats. This leads to the conclusion that a more widespread inclusion of agroforestry in today's intensively used agricultural landscapes through the combination of trees with crops or livestock can offer the possibility to create habitats with both a high conservation value and pest control potential

Nature-based Solutions in Tree Covered Systems: possibilities for biodiversity conservation in forests across gradients of wildness and land-use intensity

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Theme: Biodiversity

Keywords: agroforestry, biodiversity, herbivores

Abstract
Biodiversity is under ever increasing pressure from numerous stressors and human land-use is by far the most important driver contributing to the decline in species richness and abundance across taxonomic groups (Newbold et al., 2015; Sanchez-Bayo & Wyckhuys, 2019).
In some European countries, combining different land-use types and sustainable practices is gaining popularity. Specifically, in agroforestry, combining tree production with herbivore grazing can serve both agricultural and conservational purposes while reaping the benefits of multiple ecosystem services (Buttenschøn & Gottleib, 2019; Jensen et al., 2019). Documenting the impacts of these trends in nature management and agroforestry will be paramount in optimizing these practices, both with respect to agroforestry and natural ecosystems, for various sustainable development goals.
The overarching theme of the project will focus on Nature-based solutions in both agricultural systems, specifically agroforestry, and in rewilded woodlands where large herbivores has been introduced as part of a production regime or as a central part of restoring key ecosystem processes. The prime interest will be, how biodiversity across taxonomic levels as well as ecosystem structure and heterogeneity develop in systems with grazing animals as a production unit and a keystone species.
In Northern Europe, most of these methods have been small in scale and has been limited to the conservation of mostly high value nature and are still mainly focused on open landscapes. Thus, to conserve biodiversity at large, there is a need for a large-scale approach, which includes tree covered landscapes including both natural forests for rewilding and arable land for sustainable agroforestry.
The project will mainly focus on forest ecosystems in oceanic and continental temperate regions of Northwestern Europe. It will comprise a straightforward plot-based ecological study of agroforestry systems of various character. Ideally the sites will be picked on a gradient of different degrees of wildness, structural heterogeneity and continuity. Plot-sampling will include a variety of biological indicators such as insect diversity, plant diversity, lichen diversity, Shannon biodiversity index, structural variation, dead wood mass, insect biomass, etc. The plots will be compared to a group of controls using space-for-time substitution.
Depending on the availability of different sites, we expect to see significant differences in biodiversity between stands of different ages, different types of management and of different grazing intensities (Figure 1). Especially, tree diversity and the structural heterogeneity of the stands will be expected to have a pronounced effect on the diversity of tree living species. Soil conditions and floristics will be critical to biodiversity in more wild systems, but we expect tree-based species assemblages to be the deciding factor for biodiversity in more intensively driven agroforestry systems.
Among interesting findings will be the response of different taxonomic groups and the occurrence of rare vs common and specialist vs generalist species. Additionally, it will be interesting to see if the species assemblages will mainly be of ones normally associated with agricultural, nutrient-heavy landscapes or if the tree cover will have an ameliorating effect on the influence of nutrients.

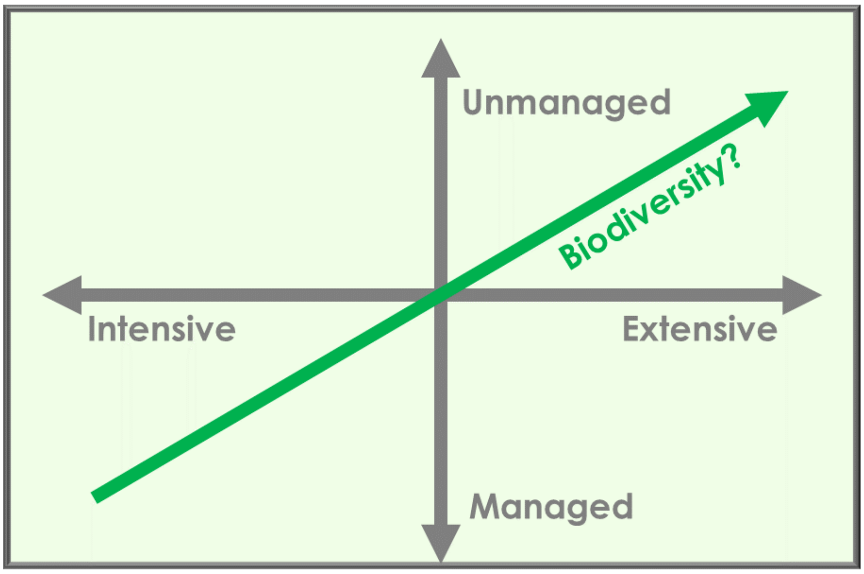

Figure 1. Illustration of the main concept for the PhD-project. It will aim to explore biodiversity of multiple taxonomic and functional groups across gradients of forest management (from "managed" to "unmanaged") and grazing pressures and stocking rates (from "intensive" to "extensive").

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Establishing a Tree Crop Improvement Program within Savanna Institute Assembling germplasm repositories to support the breeding of Midwest-adapted agroforestry crops

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Theme: Biodiversity

Keywords: Genetic resources, tree breeding, ecological restoration, historical horticulture

Abstract

A prerequisite for any efficient use of modern breeding technologies and methods requires first establishing useful breeding pools of relevant germplasm for target crops, as well as the collection of multi-year, quantitative phenotypes, and high-density molecular markers. Savanna Institute's recent acquisition of land in the Upper Midwest of the U.S. (in Spring Green, WI and Urbana, IL), uniquely position our organization to begin establishing germplasm repositories to support such breeding. For some of our target crops, such as native black locust and elderberry, these repositories would be the first of their kind in the U.S., while for others, such as hazelnut and currants, these would represent the first such collections established in the Midwest. This groundwork will constitute the basis for the next stage of coordinated breeding, which will integrate genotypic and phenotypic data in informing rounds of controlled crosses and progeny evaluation. Furthermore, much of the existing improved germplasm that exists for the tree crops that are central to Upper Midwest agroforestry systems is at high risk of being lost from the landscape, due to a lack of coordinated efforts in preserving the seminal tree crop breeding efforts of the early 20th century. While this program takes as its long-term goal the continual improvement of tree crop varieties, a very concrete immediate consequence of the initial stages of this effort will include preserving these historical selections.

Initial crops that would be amenable within this program include hazelnut, persimmon, mulberry, elderberry, black locust, and currants. These crops represent a diverse sampling of potential components of agroforestry systems both in terms of general characteristics such as climatic and edaphic adaptation and market niches, as well as breeding-specific aspects, such as time to maturity, ease of propagation, and traits most in need of improvement. Our initial focus will be on developing diverse breeding populations through a combination of wild collections, and evaluation of historically-relevant material. Until now, most tree crop improvement in the Midwest has fallen to a limited set of a few highly motivated, but relatively isolated pioneers who have carried out nearly all of the wild selections and limited breeding that has occurred in these crops. Their work is a valuable historical legacy that cannot be ignored.

Key deliverables will be the establishment of breeding pools for each crop at Savanna Institute Home Farm locations, composed of populations that are sufficiently phenotypically and genotypically diverse that we will be able to make crosses and selections in the future. Simultaneously, phenotyping protocols and genotyping pipelines will be developed for each of these crops, yielding multi-year, quantitative phenotypic datasets and dense molecular marker sets for each plant that is included in these germplasm repositories. Together, these resources will well-position SI to utilize modern breeding methods to make rapid genetic gains across a range of key agroforestry species.

A transect survey of the functional characteristics and biodiversity of weeds in modern silvoarable agroforestry systems

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Theme: Biodiversity

Keywords: vegetation science, arable weeds, biodiversity, agroforestry monitoring

Abstract

The practice of agroforestry is taking root in Germany as its potential becomes more widely understood and the legal situation changes in its favour (DeFAF 2021). However the contribution of modern silvoarable agroforestry to agroecological biodiversity, and challenges regarding agroforestry management in central Europe – especially Germany – remain poorly explored (Sharaf 2018). Farmers are confronted with many unknowns, for example, from the macro-level, e.g. subsidies, laws, and the micro-level, e.g. potential invasive weeds spreading from agroforestry tree rows into field strips.

This research is embedded in an agroforestry-monitoring project (https://agroforst-monitoring.de/) that looks at several dimensions of complex agroforestry systems (e.g. crops, socioeconomics, soil, fauna). A transect method was designed for the long-term investigation of several such dimensions and their interactions with one another. The transect design was furthermore developed such that it is applicable in different agroforestry systems e.g. with different field widths (see Figure 1a).

This study investigates the small-scale distribution of weed communities in two modern silvoarable agroforestry systems in Germany. In total 19 vegetation transects were placed across the tree rows of the young silvoarable agroforestry systems (both planted in 2020) and neighbouring reference systems (Figure 1b). Each transect consisted of 7 sample sites, each of 25 m² (Figure 1a) as suggested as the minimum area for arable weed communities by Mueller-Dombois and Ellenberg (1974). The survey of a total of 133 sample sites was carried out in June 2021.

Alpha- and beta-diversity were compared for the agroforestry and reference systems and the functional diversity of weeds was analysed. Ellenberg-indicator values were calculated comparing the site

conditions along the transects from the middle of the fields to the tree rows. The presence and coverage of invasive weeds such as *Cirsium arvense* were compared.

Results indicate that the tree rows of agroforestry systems add new ecological niches to fields – creating habitats for weeds with differing habitat requirements than those present in the middle of the fields or in the reference systems. Through tree rows - especially wildflower strip sowing within those trees - species richness was more than tripled compared to reference systems. While planned biodiversity in agroforestry systems obviously gets increased by planted tree species and e.g. sown wildflowers strips also associated biodiversity of arable weeds was higher in tree strips than within field strips or reference system. This indicates tree rows are presenting a refugium for weeds. The migration of weeds from tree rows into the field was not observed. This vegetation assessment presents an important baseline for coming years' assessments and analyses of weed developments within the still very young agroforestry systems.

Ageing agroforestry systems are dynamic agroecosystems, thus tree row effects change over time. The long-term monitoring of modern agroforestry systems is required to prove their ecological and socio-economical potential and benefits, as well as to better understand the challenges and problems relating to agroforestry system management.

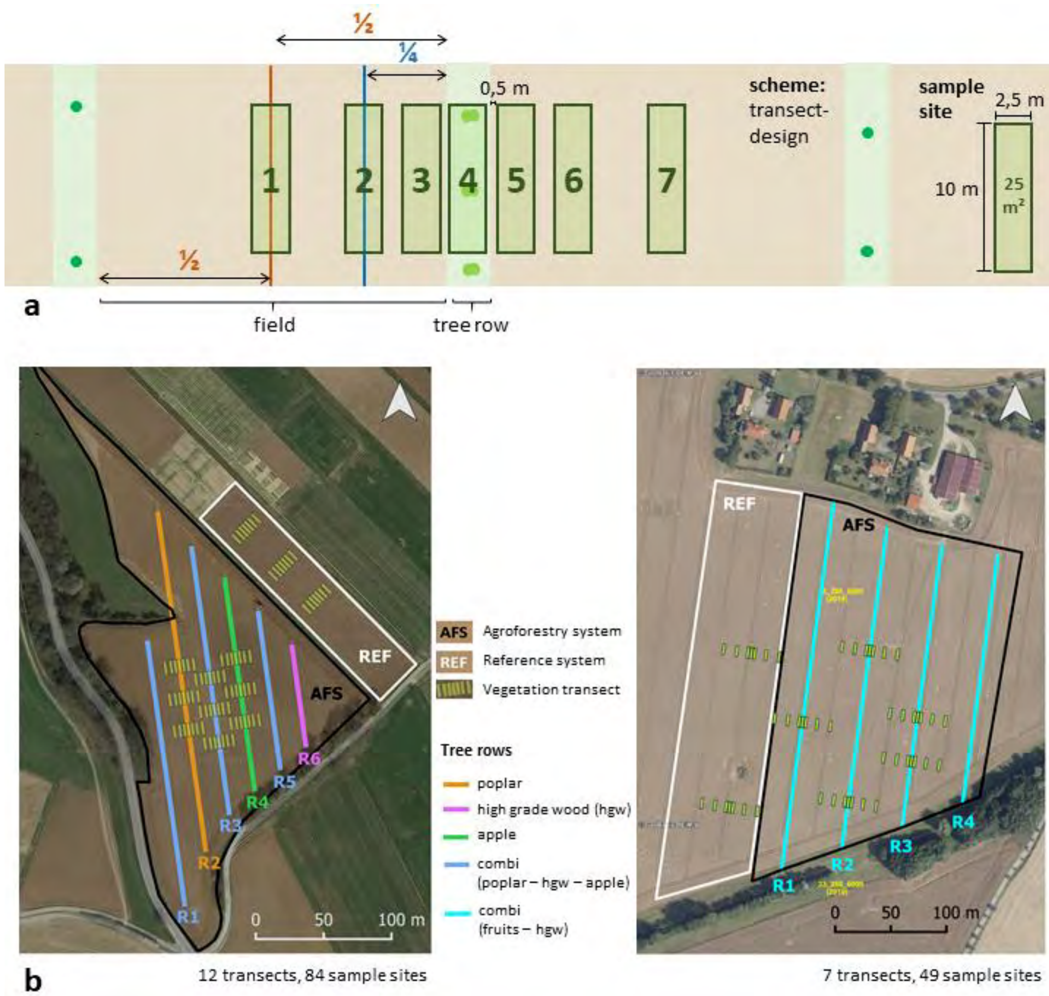

Figure 1. Transect design as placed across tree rows into field strips (**a**: scheme, **b**: AFS Gladbacher Hof, Aumenau and Hof Garvsmühlen, Rerik)

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Evaluation of tree species in agroforestry enrichment of monoculture of Calophyllum brasiliense Cambess. in area of temporary water saturation)

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Theme: Biodiversity

Keywords: Atlantic Forest, ecological restoration, enrichment planting

Abstract
Restoration of flood plains with enrichment of forest monocultures is limited by little knowledge about suitable species. The aim of this study was to evaluate the survival (%), growth, and biomass input in the pruning of native tree species planted and managed in a biodiverse agroforestry system (SAF) between rows of Calophyllum brasiliense Cambess monoculture in an area of temporary water saturation. Eleven pioneer and five non-pioneer species were evaluated. The survival of species in these groups was similar. Growth was not limited by light, but pioneers grew faster than non-pioneers. The height was what most differentiated the species; the most successful were Sesbania virgata (Cav.) Pers., Schinus terebinthifolius Raddi, Handroanthus impetiginosus (Mart. ex DC.) Mattos, Inga vera Willd. and Citharexylum myrianthum Cham. The largest canopy rays were found in Schinus terebinthifolius Raddi, Inga vera Willd. and Citharexylum myrianthum Cham. The largest supply of phytomass was Sesbania virgata (Cav.) Pers. and Schinus terebinthifolius Raddi. Intercropping of Euterpe edulis Mart. and Sesbania virgata (Cav.) Pers attenuated the temperature allowing the fruits of this palm to be used between the lines of Calophyllum brasiliense Cambess. Agroforestry systems can reconcile agricultural and forest production demands for ecological restoration.

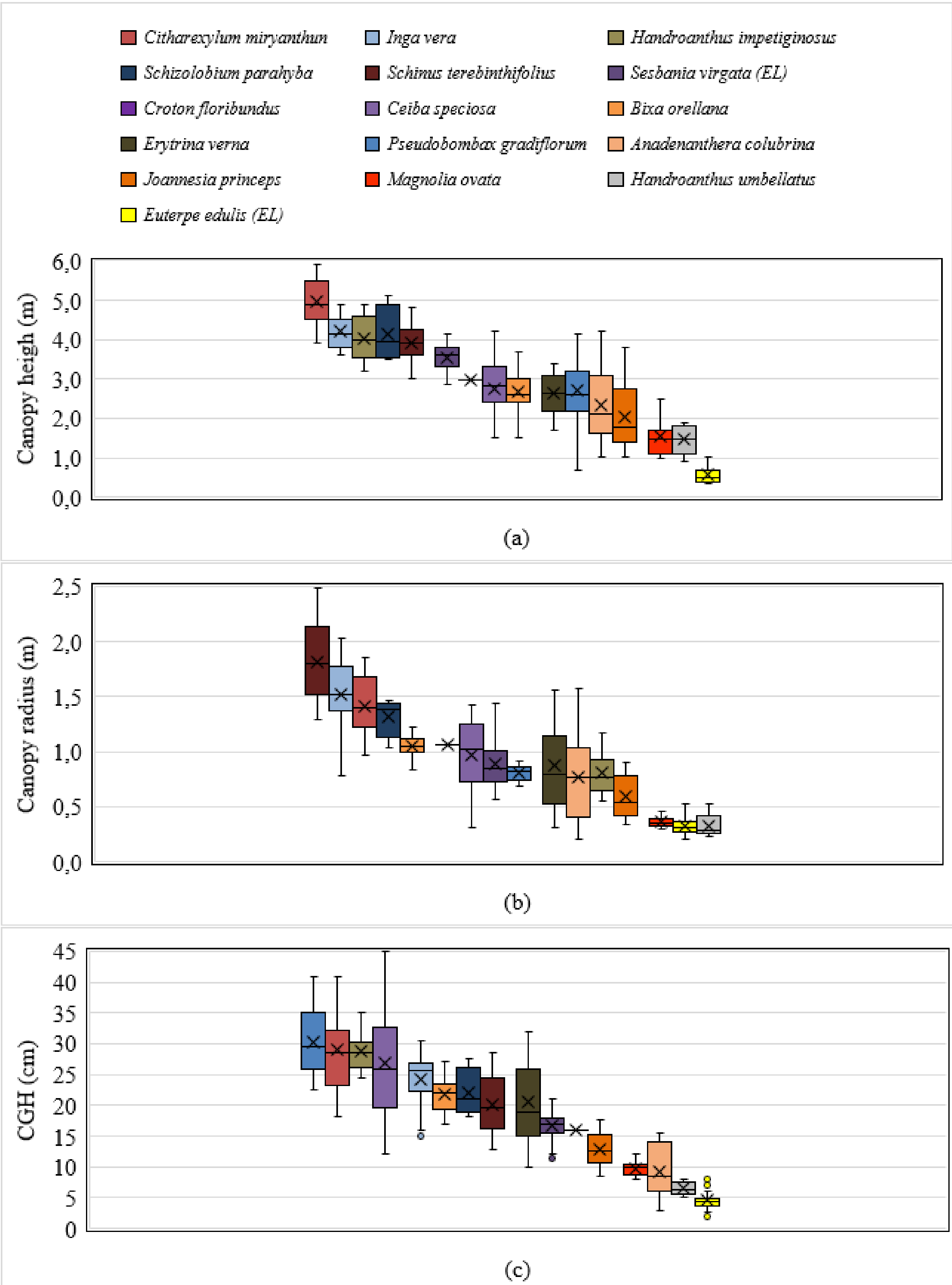

Figure 1. Box-plot of canopy height (a), canopy radius (b) and circumference at ground height – CGH (c) of forest species in agroforestry system in alluvial plain, Pindamonhangaba – SP (2014)

A draft of a parasitoid dispersal model applied in groforestry

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Theme: Biodiversity

Keywords: Trissolcus japonicus, Halyomorpha halys, dispersal, movement ecology

Abstract

The invasive Halyomorpha halys (Heteroptera: Pentatomidae) is an allochtonous invasive stink-bug, key pest of fruits in the Emilia-Romagna region of Italy. On the other side, Trissolcus japonicus (Hymenoptera : Scelionidae) is an allochtonous egg parasitoid, most promising agent for the classical biological control of H. halys.

In 2020, releases of Trissolcus japonicus were carried out in woodland habitat, in all fruit growing areas of the region. The dispersal capacity of parasitoid hymenoptera is highly dependent on the agroecosystem. To try to simulate the dispersion capacity of Trissolcus japonicus from release points in some farms, we took as a reference new connectivity models using random walk theory, based on the concept of spatial absorbing Markov chains.

First, we estimate species' intrinsic requirements and movement preferences in environmental space, considering T. japonicus may prefer edge habitat, near herbaceous floral resource, and it is assumed that bark of woody trees is an overwintering habitat. So, we made a cartography of the suitable habitats based on these assumptions.

Second, we have built a calculation algorithm for a weighted habitat diversity index, in order to produce continuous assessment of suitable landscape gradient.

Third, we have empirically parameterized two maps derived from the suitable landscape gradient: one of the resistances of movement, and one of the absorbance, i.e. of the non-possibility of movement.

Fourth, the resistance and absorbance map were used as the basis for run the same R package that quantifies landscape connectivity using absorbing Markov chain theory, for the theoretical calculations of dispersion capacity of Trissolcus japonicus.

Finally, we compared the theoretical dispersion in current spatial situation of agroecosystems with a farm agroforestry scenario.

The theoretical dispersion does not take into account, for simplicity, the demographic process of the species, and the spread of the host. It also does not consider the action of wind, which is a powerful diffusion factor for small insects, but difficult to evaluate. The objective of the work is currently only technical support for landscape planning decisions.

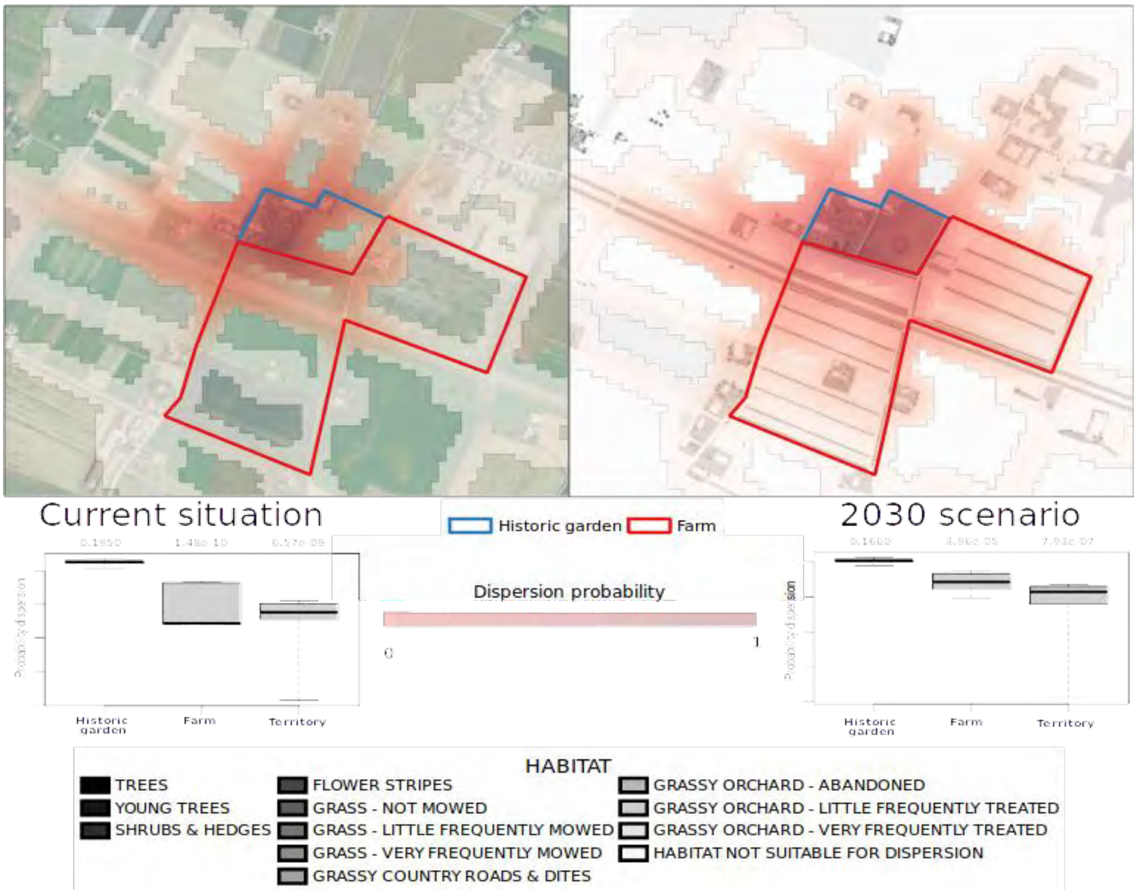

Figure 1. example of map and boxplot diagram of dispersion capacity

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Relationship between carnivore mesomammal and agro-forest ecosystems in Vico Protected area.

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Theme: Biodiversity

Keywords: Landscape biodiversity, monitoring fauna, biodiversity conservation

Abstract
Aim of this work is the study of the relationship between three mesomammal with forest areas using camera-trapping techniques around “Lago di Vico” Natural Reserve (Lazio, Italy). The targeted species was European badger (Meles meles Linnaeus, 1758); European pine marten (Martes martes Linnaeus, 1758); Red fox (Vulpes vulpes Linnaeus, 1758). Through a systematic and stratified sampling design constituted by 1 km2 square grid, 57 monitoring points were identified, located in the respective centroids. All the points fall in the wooded areas of the municipalities of Canepina, Caprarola, Ronciglione, Vallerano, Vetralla and Viterbo, all located in Viterbo province. The grid covers the whole forest compositions of the Vico district, with greater attention to forest entities of European beech (Fagus sylvatica), Chestnut (Castanea sativa) and Turkey oak (Quercus cerris). The monitoring was conducted starting on 07/31/2018 for a total period of 249 sampling days, divided into three different surveys with around 20 sites each, and an average of 66 sampling days (min = 57; max = 81). The data collected from the camera trapping monitoring, were elaborated using an occupancy model (MacKenzie et al., 2006) for each species investigated. Vico's woods were analysed to collect descriptive dendroauxometric measurements, used as covariates in the statistical models. Were also investigated the possible correlation between presence/absence of the species and the ecological and management features of forest ecosystems.
These three species were taken as top predators in various food chains. The results show that the European pine marten is linked to forest environments *sensu stricto*, while the European badger and the Red fox benefit from environments with greater structural diversity, where the various landscape tiles intersect each other. Their ecological niches are only partially overlapping.
The maintenance of an environmental mosaic managed through a planning that excludes intensive agriculture in some areas, serves to keep an index of biodiversity of the landscape. An articulated landscape supports plant biodiversity, but above all, it supports animal biodiversity.
The intensification of agriculture, the elimination of hedgerows, the reduction of spaces with intermediate naturalness or mosaic elements intersected with each other affect the presence of generalist species, capable of maintaining ecosystem balances, for lack of spaces suitable for the presence of prey. Our results support environmental policy and planning that advocates a biodiversity strategy as fundamental to sustaining the various ecosystem services provided by agricultural and forest lands where agroforestry plays a key role.

Figure 1. Sampling grid and carnivore mesomammals monitored. GREEN line: administrative border of Natural Reserve "Lago di Vico". Background Google Earth

TMonitoring of biodiversity of two selected insect groups in Agroforestry Systems in the Czech Republic

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Theme: Biodiversity

Keywords: biodiversity, Carabidae, pollinators, insect, agroforestry

Abstract

This communication aims to evaluate biodiversity patterns of two selected groups of insects (ground beetles - *Carabidae* and pollinators) in agroforestry systems (AF) compared to conventional agriculture habitat,and nature-near habitat,. Our hypothesis is that agroforestry systems can create transitional biotope between conventional field crop monoculture and biotopes with the least anthropogenic disturbances and thus improve biodiversity of the agricultural landscape.

Carabidae were studied in five localities in Czech Republic (Průhonice, Úholičky, Miskovice, Nová Olešná and Šardice), and pollinators in one of them only (Průhonice).

Ground traps with an adhesive gel–were used to catch beetles that crawl on the soil surface. Each of 5 locations was divided into 3–4 sites representing habitats: (i) the least anthropogenic influence, (ii) agroforestry system, (iv) crop field ecotone, and (v) crop field monoculture. A set of 4–5 ground traps were installed in each site ca. 10 m apart. Each trap was collected three times in each of the years 2019, 2020 and 2021, usually at April/May, July and September, so that the collections could be used to examine the spring, summer and late summer aspects of beetle species occurrence. The beetle group only was further treated and divided into families and species. Later on, we categorized the beetles by ecological requirements (ubiquitous, adaptable and rare). Statistical methods were used to analyse the interaction between locations/sites and occurrence ground beetle groups and species/number of individuals.

Data from the year 2019 were treated to evaluate biodiversity of pollinators in respect to 4 habitats: (i) agroforestry–tree line, (ii) agroforestry–crop line, (iii) open field (conventional agriculture) and (iv) nature-near habitat. At each habitat, 5 traps were collected in 9 consecutive sampling during May-September (twice per a month).

Preliminary results confirm our hypothesis and indicate higher occurrence of adaptable and ubiquitous ground beetles in agroforestry system sites when compared with field crop monocultures (+23% resp. 86%) and lower occurrence of adaptable carabids then in "natural biotopes" (-28%). Some results are statistically not significant (using Poisson GLM model) due to high variability of data from ALS, which is caused by typological and structural differences of monitored agroforestry systems.

Abundance and species richness of pollinators show clear difference between its dynamics for each habitat during the vegetation season. The GMS models distinguished the "open field" (clearly the poorest in species and abundance) against all other habitats. For few months (V-VII) both parameters have even higher values for *Agroforestry-treeline* than for *nature-near habitat*. ***This suggests a preliminary conclusion: that suitable management can support biodiversity of pollinators to an extent comparable to natural systems.*** Based on ordination analyses (DCCA, NMDS) can be concluded: (i) all

habitats differ in vegetation structure, (ii) species variability within habitat (β-diversity) is statistically significant between "open field" and all other habitats, (iii) the lowest variability, i.e. the most homogenous habitat is again "open field", the most heterogeneous is "AF-tree line".

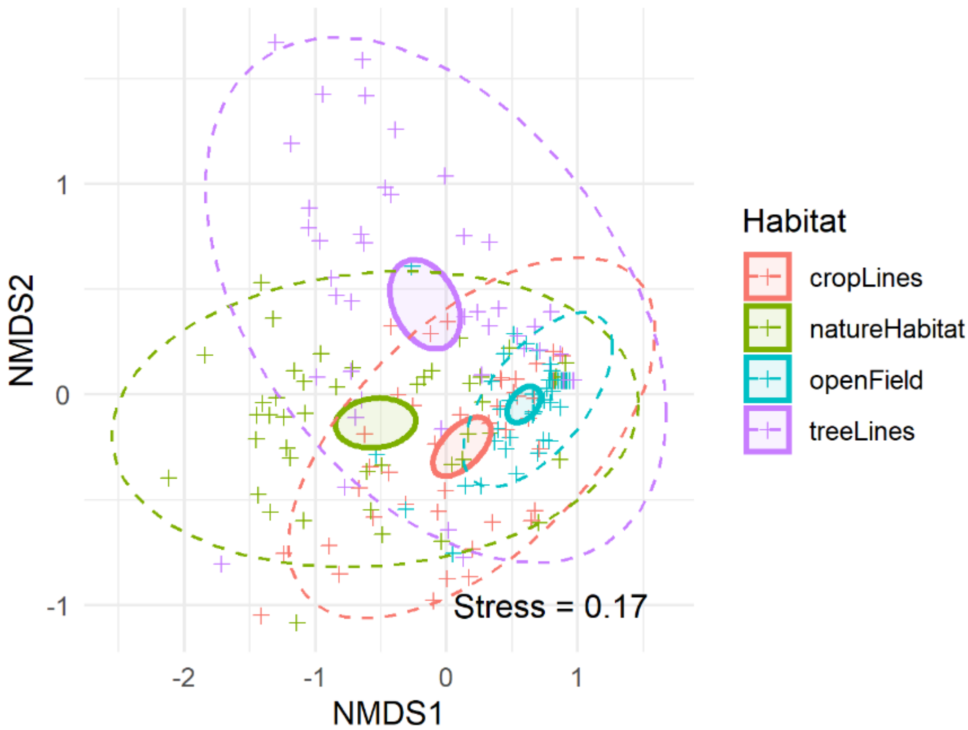

Figure 1: Pollinators - nonmetric multidimensional scaling (NMDS). All habitats differ in vegetation structure; "open field" is the most homogenous and poorest habitat in species. The most heterogeneous is that of tree line in AF.

Acknowledgments
This research was carried out with the help of the Technology Agency of the Czech Republic (project No. TH04030409).

Natural recovery of vegetation in a highly anthropized classified forest in Côte d'Ivoire

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Theme: Biodiversity

Keywords: Deforestation, Anthropic activity, Cocoa farming, Floristic diversity, Natural recovery

Abstract

Ivorian forests have been highly anthropized by agriculture, mainly cocoa farming. The classified forest of Haut-Sassandra (FCHS) has lost 70% of its forest cover to cocoa plantations between 2002 and 2011. The tendency to anthropize classified forests for agriculture raises questions about the future of these forest. In order to guide the government on the approaches to be followed to reconstitute the forest while respecting the aspirations of local populations, permanent plots were installed in the FCHS and were the subject of observations and measurements for 3 years. The objective was to evaluate the capacity of the forest to regenerate naturally following the different agricultural treatments of the infiltrated populations. The experimental system installed in the FCHS is composed of 12 permanent plots of 2500 m² each. These permanent plots received four treatments (T). The first (T1) concerned three cocoa plots subjected to the usual treatments of cocoa farming: weeding, pod harvesting and other agricultural activities. The second treatment (T2) also concerned three cocoa plots, but there was no maintenance, only the cocoa pods were harvested. The third treatment (T3), applied in three other plots, consisted of a complete cessation of activities (no agricultural activities were allowed). The last treatment (T4) involved three other plots located in forest relics that serve as controls. In each treatment, species richness, growth, mortality and recruitment of trees with a diameter at breast height (dbh) ≥ 5 cm were recorded for three years. The results showed that the vegetation changes with cessation of some agricultural activities. Species richness increased by 560% in cocoa farms without weeding and with pod harvesting. In cocoa farms without agricultural activities, density increased by 32.04% and basal area by 119.09%. The high rate of recruitment of individuals (411.23%) and average diametral growth (2.13 cm. year-1) were obtained in cocoa farms without agricultural activities, while the highest mortality rate (35.55%) was recorded in cocoa farms without weeding with pod harvesting. In sum, tree species could recolonize the FCHS provided that clearing is prohibited in cocoa farms. However, the populations could continue to harvest the pods from the cocoa trees already established in the FCHS.

Intercropping of buckwheat (*Fagopyrum esculentum* Moench) with oxytree (*Paulownia elongata* x *P. fortunei)* in Polish conditions

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Theme: Biodiversity

Keywords: buckwheat, oxytree, intercropping system, nectar production

Abstract

The intercropping system allows the use of ecological factors to protect the soil against erosion and excessive drying, and to reduce the volume of pests and the prevalence of some weed species. In the case of alley cropping, also shadiness proves to be beneficial.

Shading interrows by oxytrees may protect melliferous plants from strong sunlight during the blooming period, and thus prevent the deterioration of the quality of nectar (nectar drying). Nectar drying makes the flowers less attractive to insect pollinators, which leads to a decrease in the seed yield. The intercropping of trees and melliferous plants extends the biodiversity of the agroecosystem, yields additional income in the homestead, enhances the development of biological life in the soil, limits the water loss as well as prevents the growth of weeds and the penetration of nitrogen from mineral fertilizers deeply into the soil profile.

Objective: To determine the possibility of cultivating within the same field oxytrees and buckwheat (in interrows between the trees) and to estimate the apiarian value of buckwheat in terms of the amount of the produced nectar, the concentration of saccharides in the nectar, and the sugar mass per 10 buckwheat flowers and per hectare.

In 2019, a strict field experiment was established using the random block method with buckwheat and Oxytree (Clon in Vitro 112). The factor under investigation was the alley cropping of buckwheat. Plots of buckwheat cultivation without oxytrees served as control objects. The oxytree seedlings were planted on May 30, 2019. In the spring of 2020, technical tree pruning was performed and the main shoot was selected (the future trunk). Buckwheat was sown in interrows between the oxytrees on May 11, 2021 in the amount of 250 kernels per 1 m^2. The area of the buckwheat plot was 30 m^2. The trees were planted in rows, in the number of 5 per plot, with spacing between rows of 5 m and spacing between trees in row of 4 m.

The average height of the trees at the beginning of vegetation in 2021 amounted to 145 cm. The obtained results point to a positive influence of alley cropping on the sugar mass and the nectar mass per 10 buckwheat flowers. At the same time, a decrease was observed in the concentration of saccharides in the nectar from the buckwheat cultivated together with oxytrees as compared to the control objects. The availability of sugar raw material was comparable, regardless of the cultivation variant. The primary pollinator of the buckwheat was honey bee (99.8%); bumblebees were observed occasionally. The buckwheat plants cultivated between the tree rows were higher by approx. 4 cm; they also formed more inflorescences and kernels. However, no significant increase in the biological yield of kernels was noticed.

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Long-term taxonomic changes in the species composition of Dokuchaev shelterbelts in the southern steppe of Ukraine

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Theme: Biodiversity

Keywords: shelterbelts, oak, floristic complex, Steppe of Ukraine, tree stand resistance, Docuchaev experiment.

Abstract
The Dokuchaev experiment is a striking example of the optimal forest-agricultural arrangement of agricultural areas in the Steppe zone of Ukraine. This model has been tested for a long time, the system of shelterbelts has a high bioecological efficiency in neutralizing negative climatic effects.
The object of research are shelterbelts on the South Steppe of Ukraine, where the soil moisture deficit is the main limitation factor for successful growth of protective forests. Oak shelterbelts, in harsh climatic conditions of the steppe, retain biological stability even at the age of over 120 years. Due to this, shelterbelts that were created by G.M. Vysotsky (91-93 years), are now potentially capable to perform their functions and provide main ecosystem services for at least 30 years.
According to our results in the stand composition of shelterbelts many species of trees and shrubs have disappeared, such as: *Elaeagnus angustifolia*L., *Gleditsia triacanthos* L., *Cotinuscoggygria* Scop., *Padellus mahaleb* L., *Tamarix tetrandra* Pall. ex M. Bieb., *Salix* L.; *Ptelea trifoliata* L., *Ribes aureum* Pursh and *Populus alba* L. It is established that during the ontogenesis of shelterbelts (age 91–127) there were dynamic changes in the species composition in the direction of increasing the diversity of trees and shrubs. Eight species of trees and shrubs disappeared from the composition, but 23 new species had settled. Currently, the poor floristic complex that was formed in shelterbelts is represented by 44 species of trees and shrubs. The most diverse species composition is represented in the margin parts of shelterbelts (border of the tree stand and agricultural lands). About a half of the described taxonomic list are represented by aboriginal species. Instead, 23 species of trees and shrubs have appeared in the composition of the shelterbelts: *Aesculus hippocastanum* L., *Juglans regia* L., *Carpinus betulus* L., *Celtis occidentalis* L., *Morus nigra* L., *Amorpha* fruticosa L., *Crataegus pentagyna* W. K., *Frangula alnus* Mill. and *Padus serotina* (Ehrh.) Borkh.
The values of Jacquard's similarity coefficients and Serensen's similarity indices, calculated to determine the relationships of dendroflora in different years, indicate dynamic changes in species composition from the time of creation to the present. The range of variation of the Jacquard coefficient in different years is 0.403 <Kj> 0.611; Serensen index - 0.570 <Qs> 0.758 (Jaccard, 1901; Sørensen, 1948). The Koch biotic dispersion index, calculated for all PLCs, is IBD = 88.67, which indicates a high level of their floristic similarity (Neshataev, 1987).
It is established that the common oak in the shelterbelts retains biological stability even at the age of over 120 years. It was found that shelterbelts are characterized by a satisfactory health condition (Index of sanitary condition (*Is*) = I,1-II,2). In the absence of any forestry treatments during a long period (more than 30 years), we found a decrease in the construction of the vertical profile from the designed open structure to dense. According to the results, there are no significant difference ($F_f < F_{crit}$, $p > 0.05$) between

the species composition in the shelterbelts (groups of "mixed stands" and "pure stands") and forestry indicators (DBH, protective height, relative density, stock of the stand).
Identified species that naturally appeared in the shelterbelts can be the basis for further study of the possibilities of their use in protective afforestation.

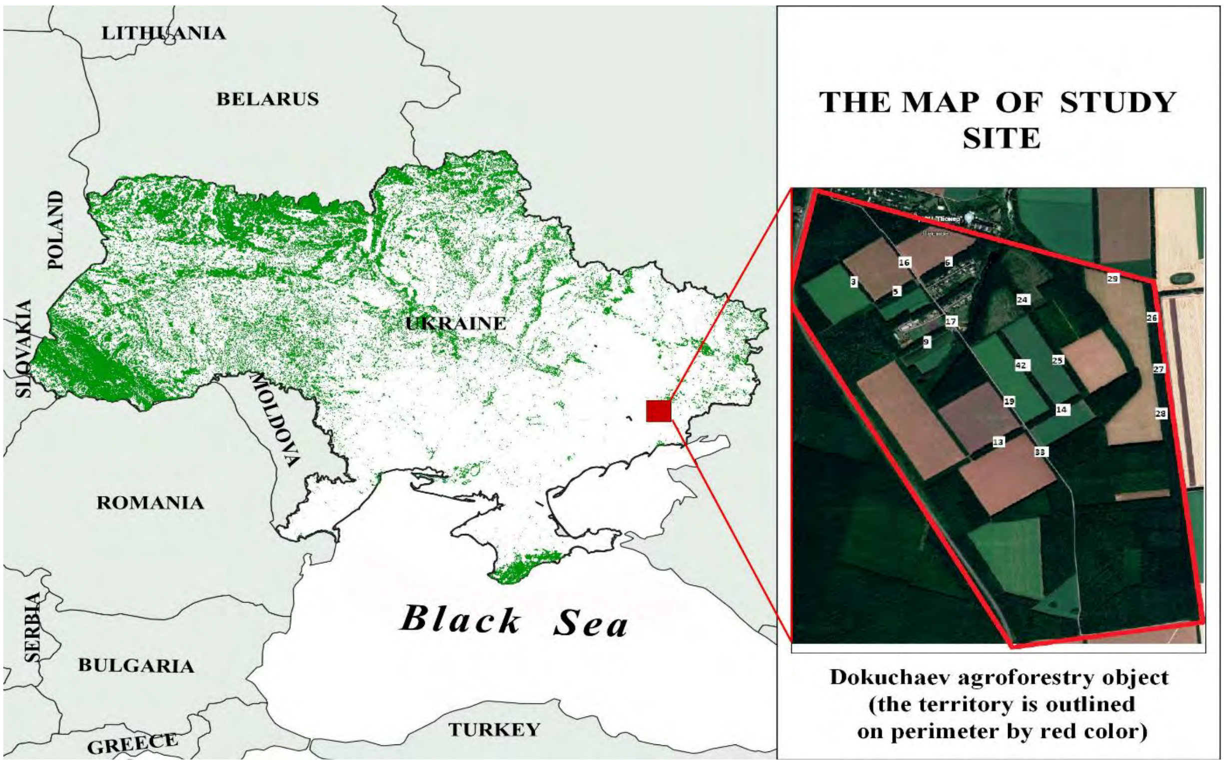

Figure 1. Study area of Dokuchaev shelterbelts in the Steppe zone of Ukraine

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Intensity and channelling of soil microbiological processes under the influence of shelterbelts

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Theme: Biodiversity

Keywords: shelterbelts, soil biogenesity, microclimate

Abstract
The area of arable land in Ukraine has increased by more than 25% over the last quarter of the century, so soil protection from degradation is an imperative need. As a result of the natural soil disturbances, changes in the soil processes are activated leading to the transformation of microbial communities (Bardgett and van der Putten, 2014; Wall et al., 2015). Shelterbelts have a significant influence on the microclimate and affecting the soil environment indirectly (Gu et al., 2002), initiating changes in soil microbiome and activating soil-forming processes. The study of soil bioactivity makes possible to understand and identify patterns in the processes of organic matter transformation, taking into account the anthropogenic influence on the soil and its properties. The forest shelterbelts create favourable microclimatic conditions and can mitigate climate change risks on crops.
Changes in the number and functions of soil microorganisms have been studied, depending on the distance from the forest shelterbelts. Sampling was performed in Kharkiv region on different monitoring plots with different microclimatic parameters at varying distances from the forest shelterbelt. The top (0-30 cm) soil layer was studied, where soil formation processes are intensively influenced by vegetation and aerobic soil organisms. Soil biogenicity was determined by the number of ecological-trophic groups by microbial sowing on solid culture medium (DSTU 7847:2015, 2016). Changes in microbiological processes (intensity and trends) with and without protection of forest shelterbelts have considered. The increasing tendency of microbial activity has been found in the direction from the edge of the shelterbelt to the centre of the field. It was found that microbiological soil-forming processes under shelterbelt and in adjacent shelterbelts edge areas up to two shelterbelt trees height contribute to relevant accumulation of organic matter, and the microbial transformation of the organic matter reaches the level of natural processes of soil (chernozem type) (Fig.1).
However, the total biological activity is increasing with the distance from the shelterbelt. Soil-forming processes for the arable land were optimal for the agro-landscape, since the trend of the microbiological processes in the soil depended on the agrotechnical approaches used in the zone of the most effective influence of shelterbelt (5-10 trees height). Due to the ameliorative effect, a favourable microbiological system is formed, compared to the unprotected field. The trophic composition of aerobic organisms is formed, which is typical to the zone of ecological intensification.

It was determined that along the protective shelterbelts, there is a “depressive zone” with significant crops suppression on distance up to two trees height H from shelterbelt, regardless of their construction. It might be worthwhile to use these non-productive areas (“depression zone”) for growing of shade-resistant crops, both sowing honey and medicinal plants or establishment of mown grassland and rangeland.

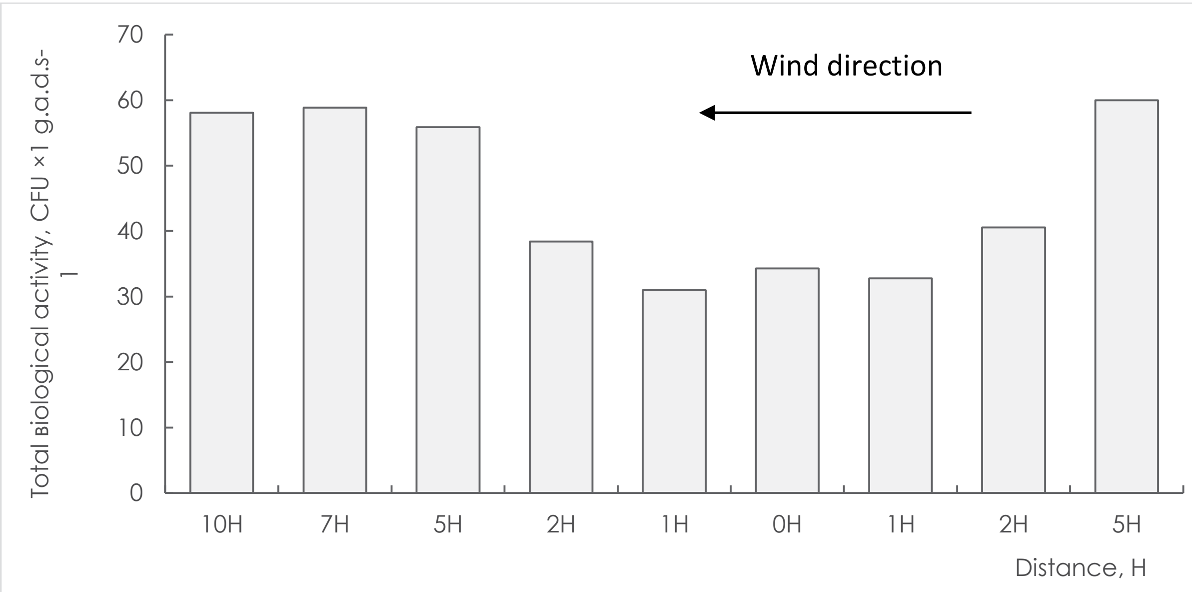

Figure 1. Total soil biological activity (chernozem type) in the field under protection of shelterbelts (CFU – colony forming units per 1 gram of absolutely dry soil)

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LANDSCAPE PLANNING AND MANAGEMENT

Drivers of soil erosion in a Mediterranean agrosilvopastoral system: A comparative assessment of RUSLE model predicted value and perceived soil erosion risk in southern Tuscany (Italy).

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Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry

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Subtopic: Landscape planning and management

Keywords: Land degradation, RUSLE, Fuzzy cognitive map, soil conservation measures, Policy support

Abstract

Soil degradation threatens food security, water quality and climate change mitigation (Bazzoffi 2009; Lugato et al. 2018; Panagos et al. 2020). The implementation of agroforestry systems can cope with this type of soil erosion risk in farmland (Palma et al. 2007). In Mediterranean areas, the predicted soil loss rates are greater than other European regions. Between 2010 and 2016, the increased average soil loss rate in Italy (+2.8%) was coupled by an increase awareness of farmers, claiming the inadequacy of agricultural and environmental policies. Considering both the heterogeneity of the soil erosion phenomena and the frequent inadequacy of soil management plans, new participatory policies with farmers should be developed (Montanarella 2015).

This study aims at investigating the relation between farmers' perceptions on soil erosion, agricultural practices and soil erosion risk among 30 farmers in Southern Tuscany. The study was funded within the H2020 AGROMIX project (Grant number 862993). Fuzzy cognitive maps (FCM) were drawn to catch farmers' perceptions on the causes and consequences of soil erosion in the studied area. Further, the RUSLE model (Whismeyer and Smith 1987) was used to predict soil erosion risk by water at the landscape and farm level. Finally, these two datasets were combined to investigate how farmers' understanding of soil erosion risk was linked to farm management and aligned with RUSLE model outcomes.

FCM results show farmers perceived agro-environmental factors (as rainfall, slope, and soil texture) and management factors (as ploughing) as main soil erosion drivers. Farmers perceive that cropping system management can control soil erosion, being crucial in the provisioning of several agroecosystem services (AES). Furthermore, farmers identify sheep rearing as a key element providing direct and indirect AES, as land maintenance, preservation of agricultural landscapes, fire prevention and soil erosion control. Academic research was perceived as the most important factor influencing agricultural policies, which however are considered ineffective to support semi-extensive dairy sheep farming and land maintenance. Moreover, farmers perceive that reforestation and no-tilling farming, supported by regional agirucultural polcies, reduced cropland productivity and soil erosion risk. A sensitivity analysis of RUSLE parameters identified LS (slope length and steep) and C (cover management) as main determining factors of A (annual soil erosion risk).

Finally, a multivariate ordinal logistic regression revealed that a higher soil erosion lead to higher farmers' perceived severity of the soil erosion phenomenon; higher educated farmers tend to perceive a higher soil erosion risk, while farmers with larger farm size tend to show lower levels of perceived soil erosion risk. Quite intuitively, those farmers picturing more nodes into FCM maps were showing higher levels of soil erosion risk perception; however, interestingly, those farmers with higher soil conservation practices in place reported lower levels of perceived soil erosion risk.
Integrating different research methods, the study offers useful insights able to improve the effectiveness of new agricultural policies. European CAP and its regional policies should include all the relevant stakeholders, starting with farmers and rural community, to co-design the roadmaps of a sustainable and context-specific rural development.

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Recent land cover changes affecting agroforestry systems in Extremadura (SW Spain): An intensity analysis at regional and farm scales

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Subtopic: Landscape planning and management

Keywords: Land cover change, silvopastoral, dehesa, intensity analysis

Abstract

Agroforestry systems (AF), as the dehesa and montado landscapes, have been subjected to contrasted processes of abandonment and intensification along decades, mainly consequence of land use and management changes. Both processes lead to decreased cover of appreciated habitats, reduced landscape heterogeneity and loss of species diversity, while increasing fire risk. The main objective is to study the patterns and intensity of land cover changes (LCC) in Extremadura (Spain) at regional and farm scales, particularly focusing on the abandonment and intensification of the dehesa AF system.

CORINE Land Cover maps (CLC) were used to study LCC at regional scale. Only the first three CLC dates (1990, 2000 and 2006) were used in the study because of the methodological variations that were undertaken from CLC of 2012 onwards. To simplify the analysis, a reclassification was made of the CLC classes to fit into any of these: Silvopastoral, Sclerophyllous vegetation, Burnt, Grasslands, Transitional shrubs, Forest, Agricultural and Others. Besides, land cover changes at local (farm) scale were studied in 5 privately owned dehesa farms. For the farms, aerial images taken in 1956, 1973, 1984, 1998 and 2009 were analyzed and the type of vegetation cover identified by year, classified as: ploughed surfaces, pastures (with trees), built, water, and dense, medium-dense or scattered shrublands.

LCC were studied by two ways: by a simple analysis of the statistics of observed transitions and by performing an Intensity Analysis (Aldwaik & Pontius, 2012). To explore LCC attention was mainly paid to those occurring from/to Silvopastoral areas. Intensification or abandonment transitions that lead to gaining or loosing those areas were characterized and focused. The intensity analysis undertakes land cover changes analysis along several periods at three levels: the interval level indicates which period undergone more changes in relation to its timespan; the category level indicates land cover categories considered as dormant or active to gain or loss area during each period; the transition level indicates whether a category that gain or loss area targets or avoids another one.

Results at regional scale (Fig. 1) indicated that the silvopastoral systems gained surface from 1990 to 2006. LCC were more intense in the period 2000-2006, compared to 1990-2000. At the category level, silvopastoral systems dormant, both gaining and losing area. At the transition level, Silvopastoral did not gain area from any other particular class, while actively lost surface to others by abandonment (towards scrublands) during the first period. In the second period they also lost area by intensification (towards pastures). Trends were clearer at farm scale (Fig.1), in which cultivated lands and wooded pastures lost 38% of their surface between 1956 and 2009. The period during which changes were more active was 1956-1973. Results at the category and transition level clearly indicated the abandonment of tillage and the progressive encroachment of shrubs in the farms.

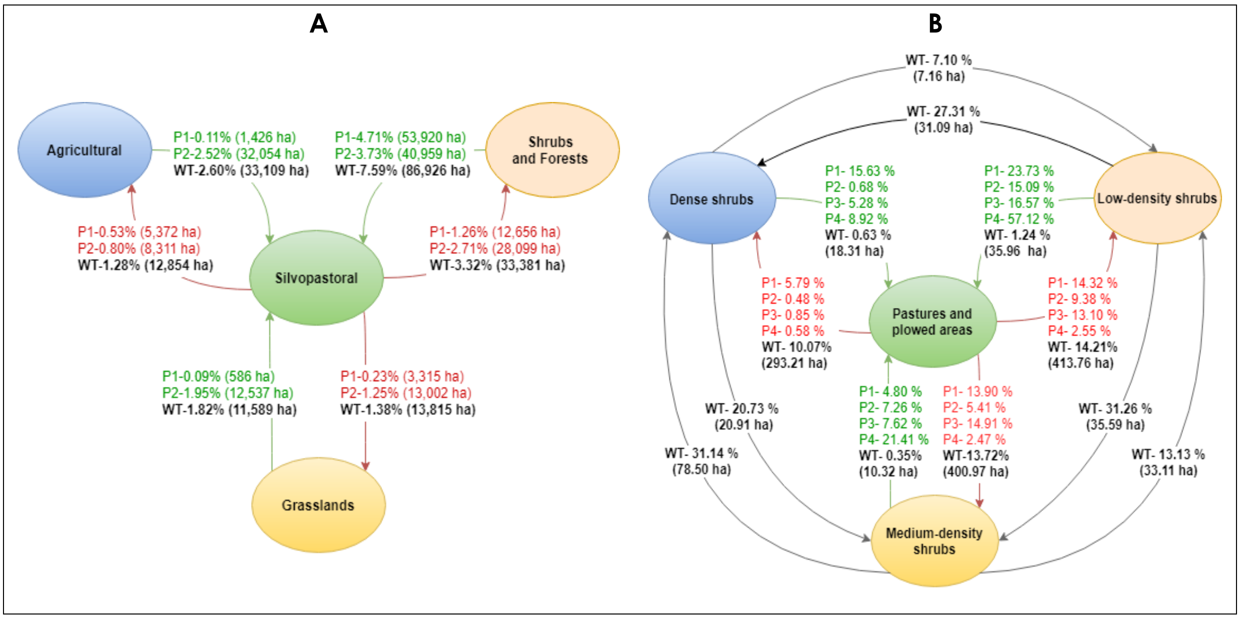

Figure 1. **A:** Main land cover transitions affecting silvopastoral areas in Extremadura. Numbers represent the percentage of area lost by period (P1: 1990-2000, P2: 2000-2006) and during the whole time (WT: 1990-2006). **B:** Main land cover transitions in the studied farms. Numbers represent the percentage of the initial area that was lost by period (P1: 1956-1973, P2: 1973-1984, P3: 1984-1998, and P4: 1998-2009) and along the whole time (WT: 1956-2009).

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UAV-Based Remote sensing technique to detect and analyze Ink disease in a chestnut orchard using high resolution multispectral imagery

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Theme: Landscape planning and management

Keywords: Chestnut decline, Phytophthora, UAV, NDVI

Abstract

High-resolution images acquired by unmanned aerial vehicles (UAVs) have been used for several years for the analysis of vegetation cover in order to derive both spectral and structural variables. The recent technological development which has concerned the image acquisition sector has led to the commercialization of multispectral cameras characterized by 4-5 aligned acquisition channels and with a very high resolution (0.8 cm/pixel at 120 m). The availability of these images allows undertaking new types of object-based analysis (at crown level), through which it is possible to carry out analyses. Starting from the spectral characteristics of every single pixel it is possible to deduce the spectral behavior of the entire tree crown.

For several years, vegetation indices have been widely used to study, extract and model biophysical variables and vegetation dynamics and define the ecological processes in progress. In the scientific literature, it is possible to find that Vegetation Indices (IVs), that can be used for this purpose, are numerous. However, in this study the most commonly used spectral index was analyzed, the Normalized Difference Vegetation Index (NDVI), because it is closely related to several ecological parameters as it is considered a measure of photosynthetic biomass. The NDVI can be considered as an indirect method of measurement of photosynthetic activity and due to its ability to be sensitive to changes in vegetation condition, it can be used with good results to detect plant symptoms related to a certain disease.

In the study area, a mature chestnut orchard for fruit production, located in Castagno d'Andrea, San Godenzo (FI) affected by ink disease (Phytophthora cambivora) from decades, showing plants having different degrees of decline (severity of symptomatology), was monitored.

Starting from the multispectral images acquired through UAV, an image of NDVI has been created. For a sample of chestnut plants a visual classification of ink disease symptoms was performed, the position with GNSS instrument was acquired, and then the crown has been delimited through video photo interpretation. All the features relative to crowns, through an operation of spatial overlay, have been

correlated with the NDVI map and for each crown have been derived the frequency distributions of the pixels that define it.

The frequency distributions obtained have been analyzed in order to investigate the different spectral behavior that characterizes the plants in relation to their symptomatology (symptomatic vs asymptomatic).

This technique allowed to discriminate asymptomatic plants from symptomatic ones based on the average spectral characteristics of the tree crowns (Fig. 1).

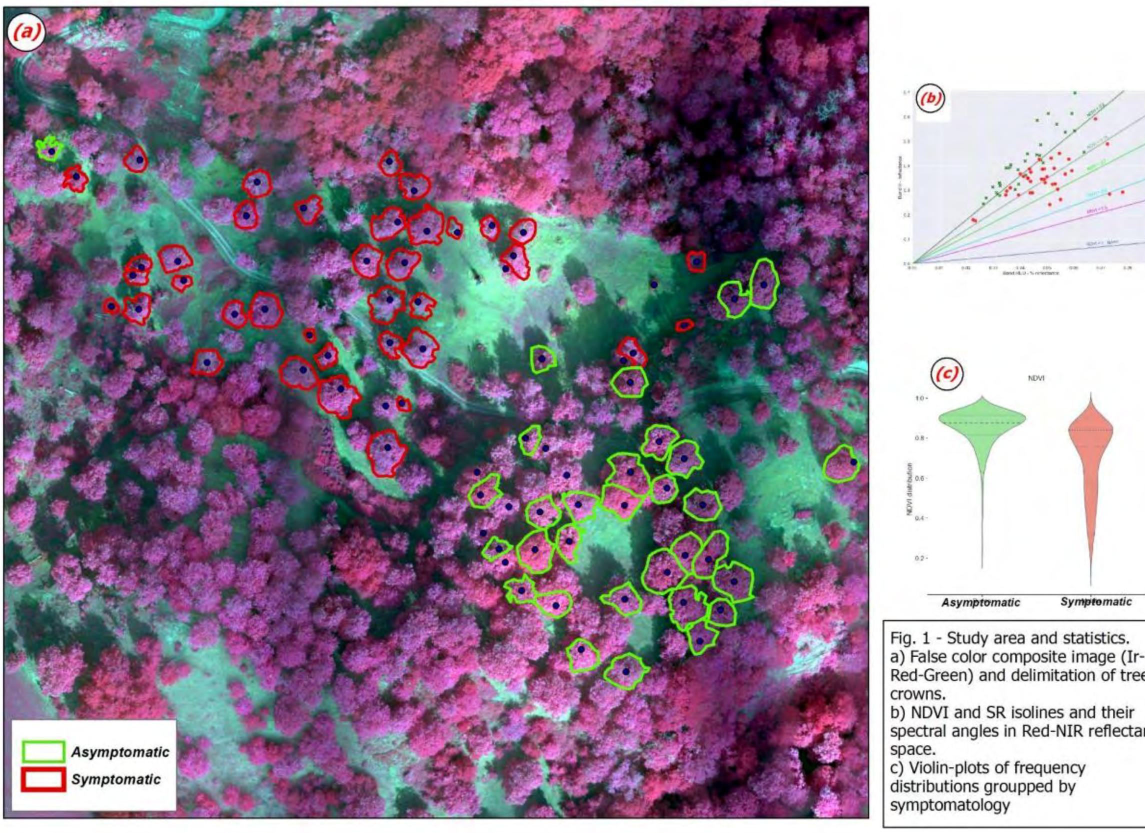

Fig. 1 - Study area and statistics.
a) False color composite image (Ir-Red-Green) and delimitation of tree crowns.
b) NDVI and SR isolines and their spectral angles in Red-NIR reflectance space.
c) Violin-plots of frequency distributions groupped by symptomatology

Aknowledgments

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Recovery of cork forests and enhancement of by-products

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Theme: Landscape planning and management

Keywords: forest management, decline, recovery cork oak forests, *Quercus suber*

Abstract

Cork oak (*Quercus suber* L.) is a tree species native to the western Mediterranean Basin (EUFORGEN 2019). Cork oak forests are human-shaped ecosystems that have to be managed to be preserved in a long-term perspective. Cork oak stands range from closed forests to open woodlands, provide high ecosystem services, mainly through cork production, support high biodiversity and provide carbon storage and water regulation services. Due to their important ecological role, these ecosystems are listed in the European Habitats Directive (Habitat 9330: *Quercus suber* forests, EEC, 1992).
In the last years, especially in Italy, cork oak stands are undergoing a relevant regression due to the decline of traditional management. The most extensive cork oak forests occur in Sardinia, followed by Sicily, Tuscany and Calabria. In Sicily, this tree covers about 19,000 ha (about 7% of total regional forest cover), from sea level up to 1,000 m a.s.l (Camerano et al. 2011). Also in this region, the abandonment of traditional management and recurrent wildfires has caused a progressive decline of cork oak forests and widespread degraded conditions.
In this work, we analysed the recovery of a cork oak forest through the improvement of management in a study area where cork oak is mixed with stone pine (*Pinus pinea* L.). To improve the vitality of cork oak and increase cork production, the thinning of the pine stand was carried out. The silvicultural treatments were carried out without a total removal of pine trees and uncovering of the soil but selecting the pine trees that effectively hindered the cork tree. In the future, the response of the forest system will be evaluated in terms of natural regeneration and other cautious, continuous and capillary interventions may be proceeded.
After felling, trees were processed in 2-meter length assortments while thin material, tree tops and branches were chipped and left on the ground.
We collected data on: 1) site conditions (topography, soil conditions and understory vegetation), 2) stand characteristics (adult tree layer, species composition, density, structure) and 3) time for felling and logging the stone pine. We also evaluated the quantity of the wood material obtained. This study provides technical recommendations that can support sustainable management and restoration efforts in Mediterranean cork oak landscapes. This type of management in addition to produce cork will allow high level of biodiversity and socio-economic benefits.

Figure 1. Example of competition between cork oak and pine.

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Decision support for farmers – a systems approach illustrated by an analysis on the impact of integrating chickens into German apple orchards

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Theme: Landscape planning and management

Keywords: decision analysis, simulation model, Monte Carlo, sensitivity analysis, poultry, fruit orchards, silvopasture, Europe

Abstract

Agroforestry practices are widely considered to have numerous benefits compared to conventional farming on e.g. income stability, ecosystem services and food security, to name just a few. However, there are a range of hurdles linked to integrating tree and livestock systems into agriculture. These include aspects of labour intensity, investment costs, undesirable interactions between trees and livestock etc. so that the net reward of switching from conventional farming to agroforestry is not apparent. Consequently, without successful local examples or reliable assessments of expected benefits, farmers are often hesitant to take the risk of adopting agroforestry practices.

Our aim is to narrow down the uncertainties linked to adopting agroforestry and thereby support farmers in their management decisions. The approach we take is based on the methods of decision analysis. Taking a systems perspective, decision analysis goes beyond pure cost-benefit analysis by seeking to consider all system aspects that may be relevant to the farmer. Therefore, a first step is to collect knowledge on all potentially relevant factors based on literature reviews, expert interviews and/or own experiments. In a next step, farmers, other stakeholders and scientists collaborate to develop a conceptual model of the systems of interest. When translating this model into a simulation tool, the model parameters are supplied as probability distributions reflecting both epistemic uncertainty ('lack of knowledge') and aleatory uncertainty ('variability of the variable'). Using Monte Carlo simulations, this uncertainty is propagated to the model projections and returned as outcome distributions. This tool allows farmers to explore likely effects of alternative decisions on the criteria relevant to them.

We illustrate this approach using an ongoing project, where we work together with German farmers to build a decision tool on the question of whether to integrate poultry into existing apple fruit orchards. The basic conceptual model (Figure 1) of the expected net present value (NPV) consists of two main threads: the first covers the costs and benefits of the already established apple orchard, the second one the costs and benefits linked to the inclusion of chickens. Introducing chickens into the system, we expect a reduction in the costs to control voles, insect and apple scab. These can be seen as synergistic effects of the combined apple and chicken system. In a next step, this basic model will be extended by further factors identified to affect farmers' decisions such as labour requirements, legal hurdles and effects on environmental protection.

In the current state of the model, the results of the Monte Carlo simulations showed that in roughly 60% of the cases the NPV is positive when including chicken into the orchard. However, some uncertainty remains, which is indicated by a wide distribution of projected NPV values, which includes a considerable share of negative outcomes. A sensitivity analysis identified 'egg price' as by far the most influential variable affecting the NPV, suggesting that further research should focus on market trends to allow to further narrow down uncertainty and develop a robust decision tool.

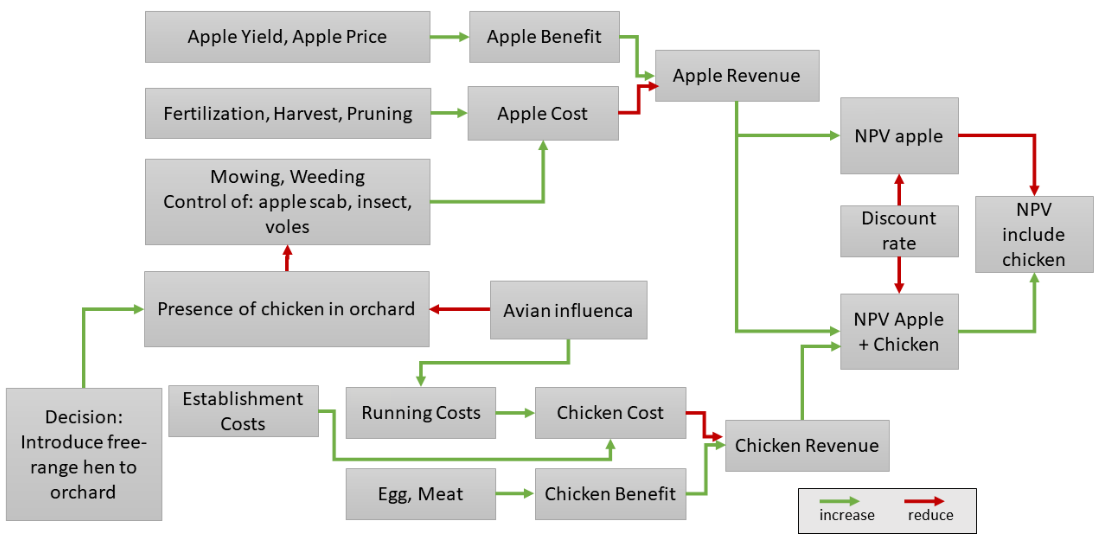

Figure 1. Basic conceptual model of the impact of integrating chicken into an existing apple orchard on the net present value (NPV)

Agroforestry systems in Portugal: is it possible to bring more biodiversity to traditional cropping systems towards sustainability?

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Theme: Landscape planning and management

Keywords: intercropping, natural resources, Mediterranean resilient agriculture, syntropic agriculture

Abstract

Agroforestry systems had been at the core of agricultural practices, until the recent need for a heavily mechanized, intensive agricultural production made them seem obsolete. But the global crises caused by climate change and dwindling water resources is putting pressure on the farming sector to provide alternatives in the way natural resources such as soil, water and minerals are used, so to help mitigate the consequences of the environmental problems we are facing. Keeping this in mind, this work has developed and defined 8 biodiverse agroforestry system modules, territorially adapted, that recombine (multiple)crops adapted to the territory's characteristics. Several main aspects, esteemed important so to make possible their implementation in Portugal, were analysed and discussed, such as a) edaphic needs in terms of soil fertility and physical characteristics; b) labour and crop management needs; c) mechanization; d) water necessities; e) the possible offer of environmental services such as enhanced biodiversity and/or carbon storage, but also: safeguarding of heritage landscapes, some of them in grave danger as in Alentejo (Module1 and 7); mitigation of risks of the increasingly severe and devastating forest and rural fires via mosaic and more resilient permanent soil cover; reducing erosion thus soil and fertility losses, preferably via no tillage practices and introduced crops on contour lines; improved landscape aesthetic value as compared to forest and/or agriculture monocultures; higher entomological and ornithological biodiversity, useful in organic farming pest and disease control; higher tourism value and more varied wine and gastronomical offer, as improving rural life quality. Proposed modules are the following: 1) MONTADO with cork oaks, ilex oaks, biodiverse pastures, and grain crops (typical of Alentejo region); 2) (SUB)TROPICAL SOUTH such as mango, papaya, passion fruit, pineapple on irrigated fields (Algarve region); 3) MOUNTAIN and HILLSIDE: chestnuts, hazelnuts, walnuts, almonds, apples, pears, cherries, small fruits and berries (such as Goji, raspberries, blueberries) and courtyard animals. Irrigated when needed. Possible grain crops. (Inspired by already existing examples in the Trás-os-Montes northerly region); 4) DIVERSIFIED ORCHARDS: intensive combined horti- and fruticulture. Use of greenhouses for Winter production. (Central and Littoral regions); 5) SPICY AGROFOREST: composed by irrigated lines of fruit plants with hot peppers, tomatoes, aromatic herbs and similar in alley cropping (all of Portugal, but in areas close to urban centres and/or industrial food processing units); 6) DRYLANDS CHALLENGE: pistachios, macadamia, Mediterranean pine (for pine seeds, pinecones and timber) combined with biodiverse pastures for grazing animals, and/or grain crops (suggested for Central and Southern regions); CLASSIC OLIVE GROVE: rainfed olive and fruit trees cultures (citrus, figs and others from the Rosacea family), horticulture and arable crop in alley cropping with sheep and/or goat rotational grazing (Continental Portugal); 8) VINEYARD ORCHARDS MOSAIC: In line or Mosaic Vineyard association with citrus and Rosaceae fruit trees, possible saffron or/and horticulture alley cropping (Southern through Northern hinterland).

These modules are an example of a positive adjusted implementation, but a continuous effort must be made to involve farmers in the landscape planning of their territory, enhancing the long-term benefits of adopting agroforestry practices.

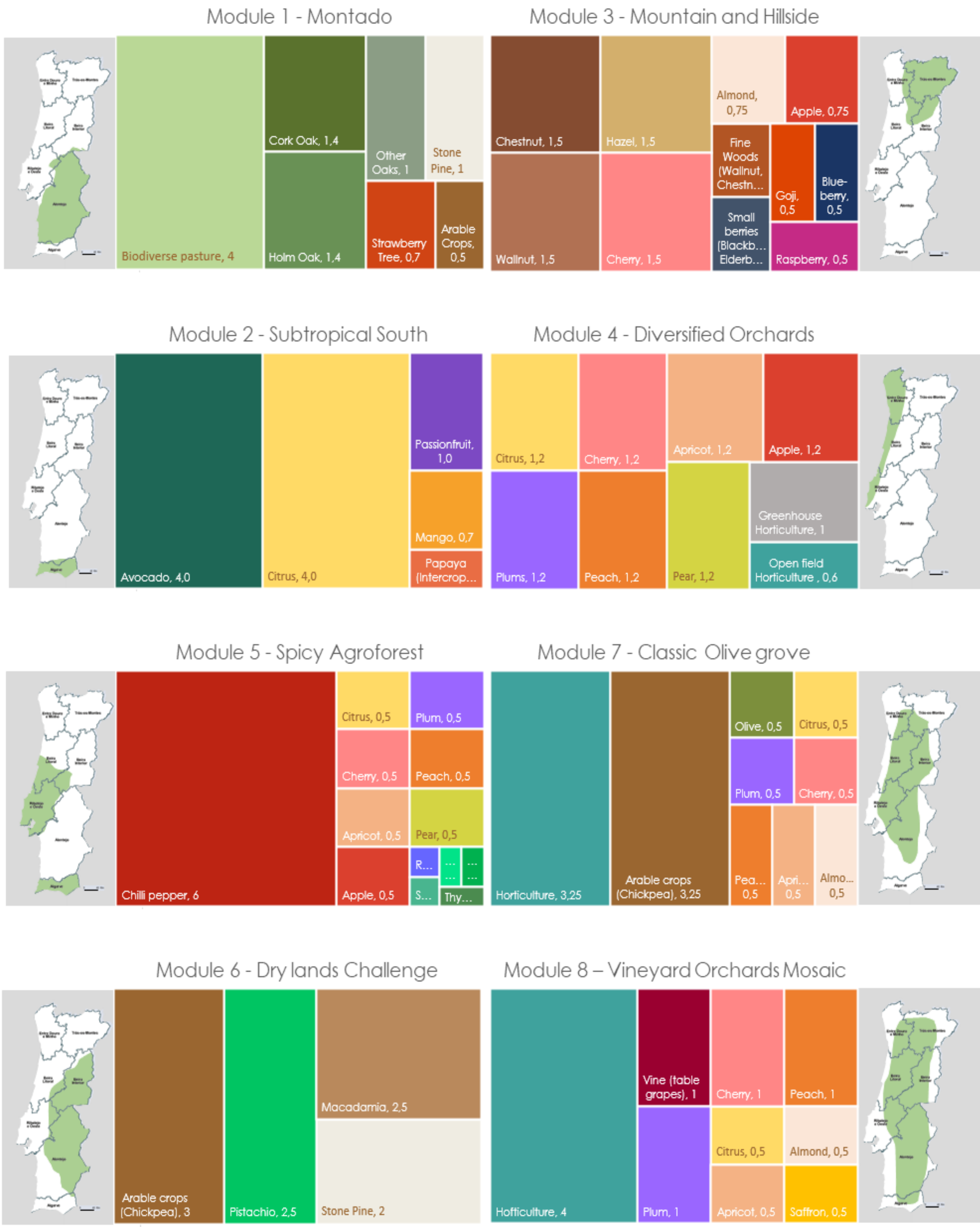

Figure 1. Territorially adjusted modules' distribution maps and corresponding modules' crop distribution graphs

Agroforestry systems: an important tool for environmental restoration and connection of Atlantic Forest remnants in the State of São Paulo-Brazil

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Theme: Landscape planning and management

Keywords: Atlantic Forest, ecosystem services, public politics, biodiversity

Abstract
In Brazil, the Legal Reserve by law is an area located inside a rural property that must maintain native vegetation but can be exploited with sustainable forest management. In the State of São Paulo, Legal Reserve should be at least 20% of the property. Brazilian Forest Code – Law nº 12.651/2012 establishes as an alternative for the recovery of degraded areas the consortium of native and exotic species in agroforestry systems. Therefore, in São Paulo state properties where a Legal Reserve needs to be regularized, this can be done by interspersing native forest species and exotic species plantation as agroforest systems but exotic species must not exceed 50% of the recovered area. This is an opportunity as the liability in the State of São Paulo is 865,391 hectares for Legal Reserve that need to be restored. For small and medium-sized properties or rural family ownership, the legal reserve area can be maintained with fruit, ornamental or industrial tree plantations, composed of exotic species cultivated in an intermediate system or in association with native species. The agroforestry model should prioritize the use of diverse native species to promote biodiversity interspersed with crops of commercial interest. In the FAPESP 201817044-4 project, actions that promote these plantations in the Paraíba River Valley were monitored and encouraged. The restoration projects and conservationist productive systems were calculated: 11.5 ha planted of agroforestry, 5 ha direct sowing in 60 properties and also support for the seed collection network of native species. There is also a great potential for the use of crops of

commercial interest such as rubber trees, bananas and cocoa, interspersed with native species, which has been occurring in the northwest of the state of São Paulo, and these proposals are the subject of economic study.

Figure 1. Distribution of inputs, seeds and seedlings, planning and planting efforts for agroforestry systems in Paraiba River Valley

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Conversion of a Conventional Arable Land to a Multifunctional Landscape through Research by Design

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Theme: Landscape management and planning

Keywords: research by design, agroforestry system planning, rural renewal, multifunctional landscape

Abstract
The need to fundamentally change the approach to the landscape has been discussed in Slovakia for several decades. This need is growing, be it due to the loss of biodiversity, the huge problem of soil erosion or the disruption of the landscape water regime due to its extensive drainage in the last century. Nevertheless, the Slovak agricultural landscape is still mostly about monotonous fields with monocultures and systemic solutions are in sight. This contribution focuses on contemporary trends in landscape design and agrosystems, as well as on finding "green" connections between rural, peri-urban and urban structures through research by design (Čibik et al., 2021; Tóth, 2020). The presented study is based on a compromise between contemporary human needs, in the form of high-quality public space, the values of original landscape and the local landscape character. The project of adapting an area of approximately 90 ha to climate change in the eastern part of the municipality Preseľany (Slovakia) shows that a quality transformation of the landscape through agroforestry practices is possible and promising. The current land use of the case-study area is arable land that borders on the residential area of individual housing construction. In the immediate vicinity is the Preseľany Municipal Office, the Parish Church of St. Elizabeth and a reconstructed historic watermill is delimited by the river Nitra on the northwest and west side and part of Dlhé Lúky on the east side. On the southern side, the area borders on a field road. In terms of ecological stability, the case-study area is relatively unstable and does not use its significant potential. The predominant land use is production greenery in combination with a commercial-recreational function. The space consists of areas of permanent grasslands, orchards, non-forest tree and shrub vegetation (linear, areal), commercial buildings, and sports/recreation. There are many woody plants in the studied area, but fields and large areas of monoculture plantings still prevail. Woody plants in the area have an environmental, eco-stabilizing and aesthetic importance (Rusko and Korauš, 2004). There are mainly deciduous tree species typical for floodplain forests (poplars, elders, alders, willows, and lindens). The design presented in this paper will bring multi-layered activities to the locality. Due to large groundwater reserves and high soil quality, efforts are being made to enhance diversity, mitigate the negative impacts of climate change, retain water in the landscape through bio-corridors and lakes, while raising awareness and creating suitable conditions for recreation and education. Through demonstrations of agri-environmental-climate measures, visitors will learn about the possibilities of increasing the adaptive capacity of ecosystems affected and used by humans to the expected negative consequences of climate change. The area also demonstrates examples of the use of renewable energy sources such as small hydropower or photovoltaics. Residents and visitors will be able to use hippotherapy and horseback riding, a petting zoo for children, seasonal fruit pick-up and they will have the opportunity to spend their free time meaningfully in an area that is sustainable, naturally scarce and supports biodiversity.

Figure 1. masterplan of the selected case-study area in Preseľany, Slovakia (Čibik, 2020)

Acknowledgement

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Forest cover changes under agroforestry program in dryland of Sudan

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Theme: Landscape planning and management

Keywords: Forest cover changes, Agroforestry, dryland, Sudan

Abstract

Forest cover in the dryland of Sudan has witnessed a massive change due to deforestation, agricultural expansion, and forest overexploitation caused by rural communities surrounding the forest. To halt deforestation as well as to rehabilitate the degraded forest, many interventions and schemes have been developed and introduced by The Forest National Corporation in Sudan (FNC). One of these schemes is the Taungya agroforestry system, where the farmers can cultivate their subsistence crops with forest trees simultaneously at the early stage of tree establishment inside the forest reserve.

Taking Nabag forest reserve in South Kordofan State in Sudan as a case study, this paper attempt to detect and analyze the forest cover changes over the period of 30 years (1991-2021) by using remote sensing and GIS techniques as well as a ground-truth survey. Four satellite images of Landsat 5 Thematic Mapper (TM), and Landsat 8 Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) from the years 1991, 2001, 2011, and 2021 were selected respectively. The images of 1991 and 2001 were used to detect the status of the forest cover before starting of Taungya agroforestry program while images of 2011 and 2021 were used to detect the status after the program by applying a post-classification comparison technique. Three classes of vegetation cover were detected in the study area namely, forest cover, bare land, and agricultural field. The results revealed that through the Taungya agroforestry program, there was a substantial increase in forest cover by1041.73 ha and a considerable decrease of bare land and agricultural field by 409.79 ha and 634.52 ha respectively during the addressed period. The findings of the study indicated that the Taungya agroforestry system could be a feasible land-use alternative for forest rehabilitation in the dry land of Sudan.

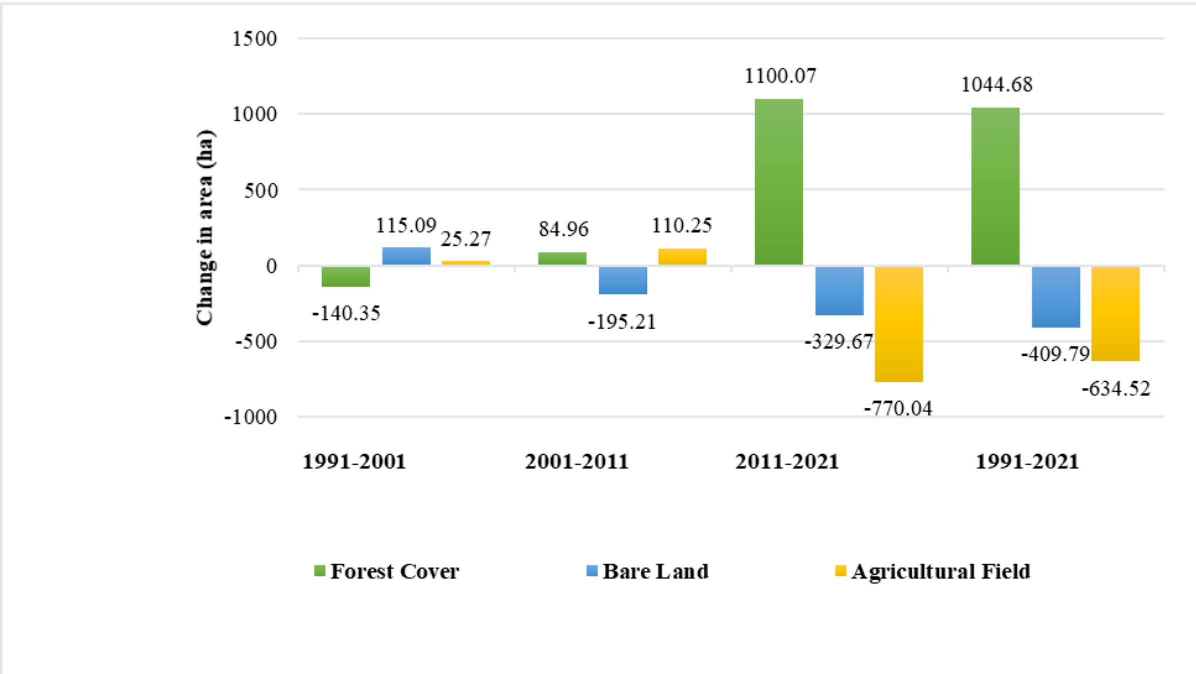

Figure 1. Overview of Forest cover changes in different classes (ha) between 1991 – 2021

Acknowledgments
The authors would like to thank the Tempus Public Foundation, Hungary for the scholarship.

Dehesas as high nature value farming systems: A social-ecological synthesis of drivers, pressures, state, impacts, and responses

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Subtopic: Landscape Planning and Management

Keywords: Dehesa; Montado; HNV farming; DPSIR model

Abstract
Dehesa and montado are Mediterranean agroforestry systems characterized by scattered oak trees with an understory grazed extensively by livestock and, in some cases, periodically cropped. A long history of traditional management practices has created an open woodland widely recognized for rich biodiversity and multiple ecosystem services. Concerns about challenges to their long-term viability have motivated many disparate scientific studies in recent decades. We provide a synthesis of this growing body of international literature, focusing on the links between land-use and management practices, biodiversity, and policy, from a "high nature value farming systems" perspective. The present review comprises 128 empirical studies carried out in Spain and Portugal. Conservation trends were assessed according to categories adapted from the DPSIR ("Drivers – Pressures – State – Impacts – Responses") framework. Sociocultural factors, economic dynamics, and agricultural policies were found to be key drivers of change, resulting in intensification of livestock production and land-use simplification, among other effects. Insufficient tree regeneration and a broad range of other factors were identified as pressures that have often negative impacts on biodiversity and ecosystem services, moving the system away from its ecological reference state. A variety of management and policy responses were suggested, ranging from specific conservation techniques to landscape-level initiatives. Ecosystem components and management practices were typically studied separately, and mainly from an ecological science perspective, while inter- and transdisciplinary approaches including examination of the role of people were less common. This points to a need to move from single-topic to landscape-level approaches with a broader integration of different disciplines and perspectives.

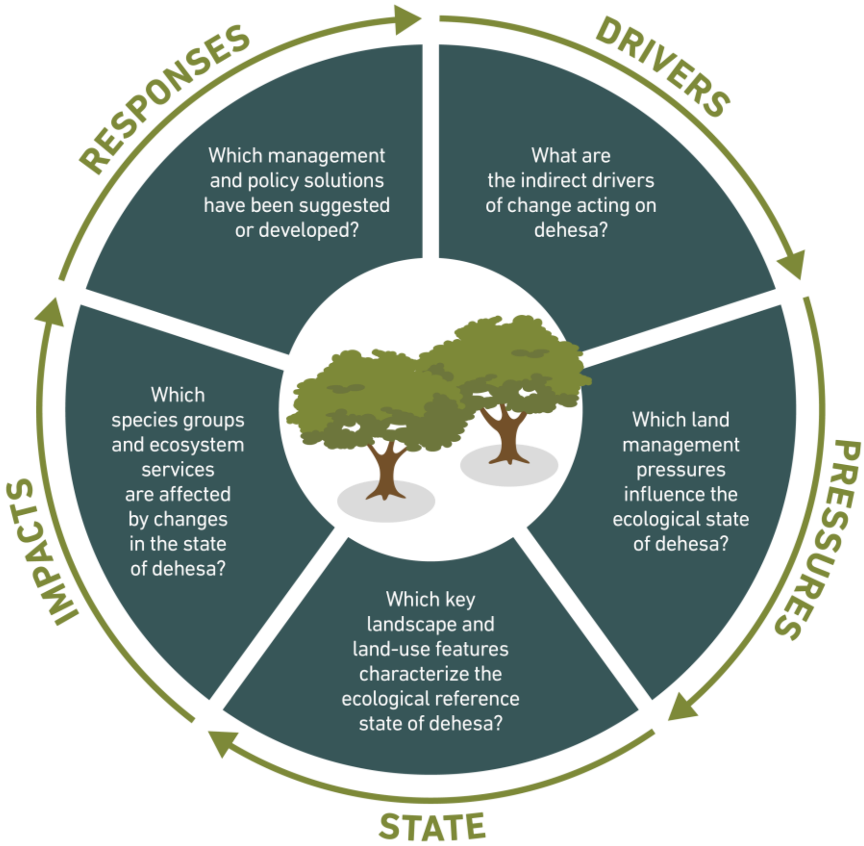

Figure 1. Research questions organized within the DPSIR framework

Agroforestry systems in the European Union – extent and spatial distribution

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Theme: Landscape planning and management

Keywords: land cover, wooded linear features, land use change

Abstract

Agroforestry (AF) systems in the European Union are analysed based on the LUCAS data set from 4 surveys carried out between 2009 and 2018. We used a similar approach as the one applied by Den Herder et al. (2017) who analysed the extent of agroforestry systems in the EU with data from 2012. The objectives of our research were: 1. A review of AF systems' classification; 2. Determination of the extent and spatial distribution of AF in the EU; 3. Analysis of the usefulness of LUCAS data for studying AF systems. The harmonised LUCAS database provided by d'Andrimont (2020) was used, selecting points for the following AF classes: Silvopastoral, Silvoarable, Agrosilvopastoral, grazed permanent crops, Intercropped permanent crops and Kitchen gardens. Also considered, but analysed separately, were those agricultural areas, not included in the previous selection, and which presented wooded linear features (WLF): Grazed grasslands, Temporary crops and Permanent crops.

In 2018 the total extent of AF in the EU was 125.623 km^2 which represents 7.3% of utilized agricultural land, with Greece being the country with the highest proportion, followed by Portugal, Cyprus and Sweden. Silvopastoral and kitchen gardens are the dominant AF systems with a share of 82% and 13%, respectively. Silvoarable and agrosilvopastoral systems are poorly represented. The total area occupied by AF changed little between 2009 and 2018. However, differences between land use classes were detected: grazed as well as intercropped permanent crops decreased, silvopastoral land uses were stable, and the surface area occupied by kitchen gardens increased. However, within this period remarkable variations in trends were detected, with a strong increase of AF extent between 2009 and 2012, followed by a decrease from 2012 onwards. These changes were particularly notable in silvopastoral systems and were mainly related to changes of grazing activity. Also marked regional differences could be detected.

Agricultural areas with wooded linear features occupy approximately 21% of agricultural used land in the EU, being the most frequent type temporary crops with WLF. Given the abundance of these systems, they need to be taken into account as they constitute important elements which increase landscape diversity and biodiversity.

Limitations in using LUCAS data for the study of AF systems were found, such as the impossibility of recognizing some AF uses. The strong temporal changes detected in grazed AF systems may be related, at least in part, with the identification of grazing livestock by the surveyor in the field. Nonetheless, LUCAS data constitute a valuable source of information which enables the study of the extent and spatial distribution of these systems, as well as their dynamics of change. Furthermore, they can be related to other spatially distributed datasets, including the large variety of existing environmental variables in Europe.

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A grazing experience of Aberdeen-Angus under poplar stand in Italy

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Subtopic: Landscape planning and management

Keywords: Livestock, Poplar, Aberdeen Angus, Silvopastoral

Abstract

Silvopastoral systems are production practices that integrate forestry and livestock production, deliberately on the same land management unit (Peri et al. 2016). A silvopastoral system combining trees and livestock with forage to form a carefully designed system has gained popularity in recent years as an environmentally friendly alternative land use that is economically viable.

The Mezzi farm of CREA (Research Centre of Forestry and Wood) in Casale Monferrato (Italy) is located in a bend of the Po river at about 105 m above sea level, covers an area of about 180 hectares. The fields are used for germplasm conservation of poplars and willows, experimental nursery activities and experimental and demonstrative poplars stands besides some meadows and agricultural crops in rotation with nurseries and tree plantations. The soils are of alluvial origin, sandy or sandy-silty located on a predominantly gravelly substratum.

Poplar stands five years old require weed control usually performed by shredding; a different agroforestry system involves cows grazing under poplar crowns. A ten-year experience in the farm Mezzi of Aberdeen-Angus grazing under poplar stands, with more than 5 years old shows advantages and benefits of this system. Starting from 1 bull and two cows in calf, thanks to the rustic characteristics of this animal, the herd has developed and reached 40 cattle in ten years. Experimental and demonstrative poplar plantations, consisting of *Populus xcanadensis* Mönch. clones planted at 278 trees per hectare with ten-years rotation, have been planted to produce high quality material for the industries of veneering and plywood production. All the poplar clones were resistant to the most important leaves diseases. These characteristics give a low environmental impact due to the absence of chemical treatments and allow cow breeding in the plantation. The herd, consisting of about 40 heads (30 adults and 10 calves), has grazed about 20 hectares of poplar stands grassy undergrowth with 15-days rotation. An economic evaluation of traditional weed control under poplar plantations was compared with the silvopastoral system. The live weight increases of the herd and the costs deriving from the grazing period were taken into consideration; in the same way the costs for the control operations of the herd and those deriving from the supplementary food management of the herd were counted.

The greenhouse gases footprint of the silvopastoral system was also assessed through the estimation of the greenhouse balance due to the gases emitted overall by the metabolism of the whole herd with

respect to that saved with the reduction of mechanical interventions for weeds control and that absorbed with storage of Carbon in the wood of poplar trees during the period considered.
The experimental activity was suspended in 2017. The whole herd is being sold and an important income has been obtained for the farm. The experience appeared interesting to produce wood from intensive poplar plantations together with the breeding of rustic beef with low environmental impact.

Figure 1 – The herd in the experimental farm Mezzi in Casale Monferrato - Italy

Use of remote sensing data and GEE (Google Earth Engine) for detection and monitoring of cork oak decline caused by Phytophthora cinnamomi

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Theme: Landscape planning and management

Keywords: Mediterranean Oak Decline, *Phytophthora cinnamomi*, Sentinel-2, Copernicus

Abstract

Over the last decades the role of pathogens in natural forests has gained increasing attention due to an exponential increase in the number of emergent diseases in worldwide forests. Exotic pathogens are now threatening forests where pathogens have not traditionally been considered as major ecological drivers of tree demography, such as water-limited Mediterranean forests. The oomycete *Phytophthora cinnamomi* is one of the most aggressive plant pathogens on earth, which has been identified as the main biotic driver of the severe decline and mortality of evergreen oaks in southern Europe. In the Mediterranean Basin, *P. cinnamomi* is decimating populations of cork oak (*Quercus suber*) stands representing a problem of paramount ecological and socio-economic importance, since cork oak is a major structural element in Mediterranean forests providing economic and cultural services.

Identifying and mapping declining forests is highly relevant for management, however, this is often difficult and costly. The trend of the vegetational index, other environmental conditions being equal, can represent a valid proxy for deriving the state of health and evaluating how external disturbances affect productivity. In this context, the analysis of the time series of the vegetation indices represents a valid tool for evaluating the vegetation dynamics and deriving various phenological parameters. Nowadays the progress achieved by AI (Artificial Intelligence) and the availability of cloud computing platforms (e.g. Google Earth Engine), allows the processing of long time series of geographic data at low cost.

The objective of the work was to advance in the use of machine learning approaches to the processing of remote sensing data for the detection and monitoring of cork oak forests impacted by *P. cinnamomi*. Using harmonic analysis of time-series vegetation indices data, it is possible to better understand the evolution of symptoms in time and severity of the disease. Two sites, one *P. cinnamomi* infested and one disease-free, were selected in the area around Tempio P. (Sardinia, Italy). Fifteen circular plots (five for the disease-free site and ten for the infested site (Fig.1) with a diameter of 12m, were randomly selected and the geographical coordinates acquired with a GNSS receiver. The time series of three vegetation indices (NDVI, SAVI, EVI) were derived from multispectral satellite images with high spatial resolution (10m), acquired by the Sentinel2 satellite in the period January 2016 - December 2020. Whereas the canopy transparency was monitored in two consecutive years using a spherical densiometer.

For each plot and for each vegetation index a single continuous trajectory was derived. This novel approach of combining harmonic analysis with cloud computing of massive data with GEE allowed deriving and analysing the most significant phenological parameters, among which the date of onset and end of the vegetative period, annual peaks and troughs of the vegetation indices (Fig. 2-3).

The analysis of differences in the vegetation intra-annual seasonal cycles, in the various sites affected in different ways by the infection, has shown that the phenological phases appear profoundly different, both in terms of temporal shifting and in amplitude.

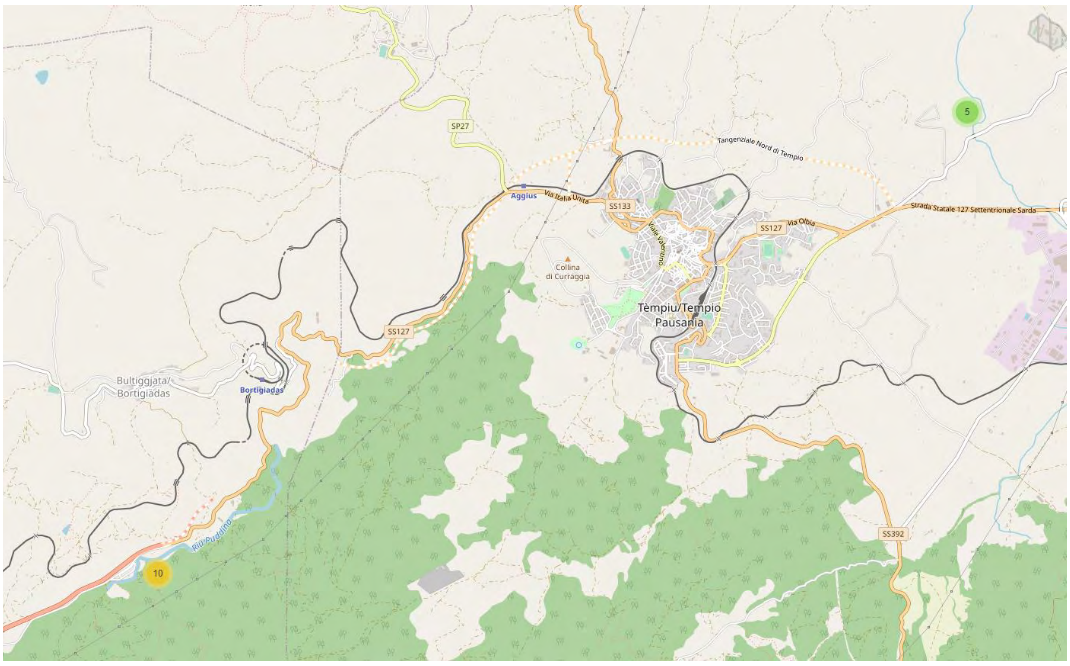


Figure. 1 - Area of Interest

Fig. 2 - NDVI-Seasonal variation

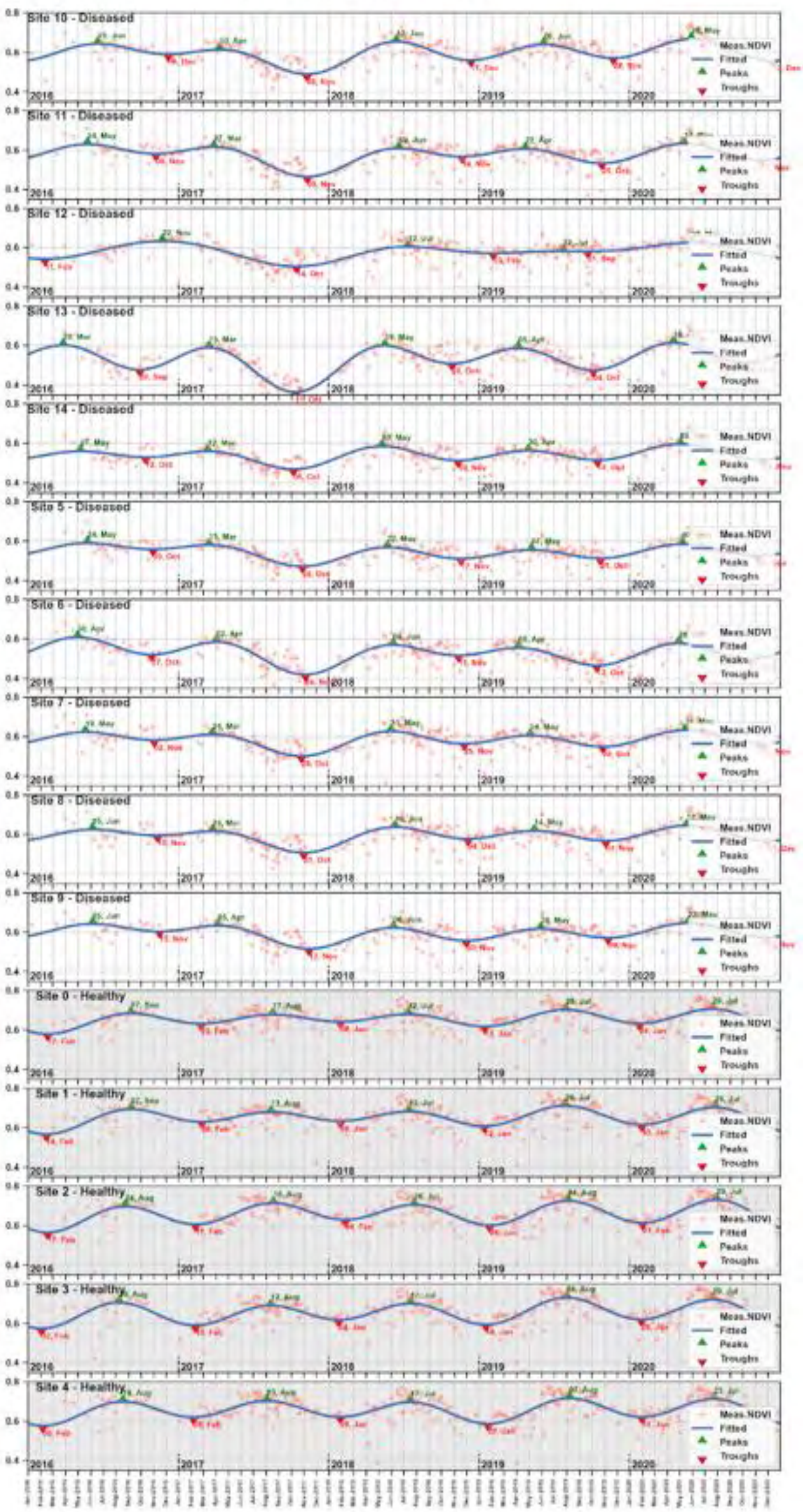
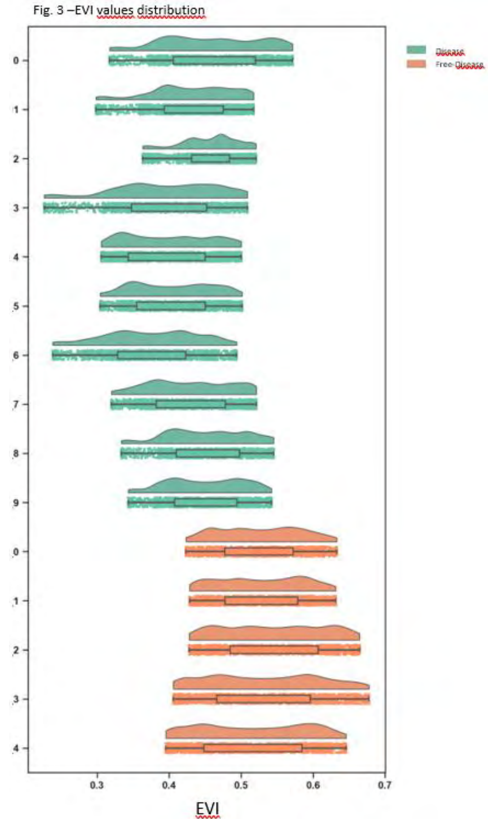


Fig. 3 –EVI values distribution



Agroforestry component of ecological optimization of agro-landscapes within Gully Steppe of Ukraine

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Theme: Landscape planning and management

Keywords: afforestation, field forest cover, land category, windbreak, design

Abstract

Current agro-landscapes of Ukraine are characterized by a number of negative phenomena for agricultural production due to natural and anthropogenic factors: unbalanced ratio of arable land, natural forage lands and forests; lack of a set of agroforestry measures; exacerbation of global problems of climate warming, etc. This problem is especially acute in the south-eastern part of Ukraine, the so-called Gully Steppe zone (Shvidenko et al. 2017; Bila et al. 2018).
The aim of the study was to analyze the agroforestry component of the agro-landscapes of the Gully Steppe and to identify ways to optimize their forest cover. The research was conducted in 2013-2015 within the territory of Luhansk region - an area with significant experience in afforestation, as it houses the classic historical object of the Dokuchaev expedition Yunitsk forestry. Landscape and ecological principles of forest amelioration in current agricultural landscapes include: optimization of the composition and ratio of agricultural lands by removing degraded and unproductive lands from arable land; afforestation of steep slopes, sands and parts of coastal protection strips; implementation of a set of agroforestry measures; protection of inter-strip space of field lands, which is differentiated depending on the number of land users, slopes of the surface and the state of the soil cover, specialization of farms, etc. (Yukhnovskyi 2003). The state of shelterbelts was studied based on the results of a detailed survey of more than 70 windbreaks in farms of various forms of ownership. The windbreaks of the blown design are 12.5%, sieve-looking - 16.9% and dense (not-blown) design - 70.6%. Since the dense design reduces the ameliorative efficiency of the planting, it is necessary to do thinning to ensure optimal aerodynamic properties of windbreaks (Yukhnovskyi et al. 2021).
The species composition of windbreaks includes nine species of trees, which act as the main species. *Quercus robur* L. is common in 19.8% of the total area of windbreaks, *Fraxinus excelsior* L. - 8.0; *Robinia pseudoacacia* L. - 39.8; *Betula pendula* Roth. - 1.5; *Ulmus parvifolia* Jacq. - 3.2; *Populus alba* L. - 3.9; *Acer platanoides* L. - 1.8; *Fraxinus lanceolata* Borkh. - 14.7; *Acer negundo* L. - 7.2%. More than half of the windbreaks were planted in the 40-50s of the last century.
The recommended field protection forest cover for Luhansk region is 3.7%, which is ecologically justified in current conditions and under the existing land structure (Bila et al. 2018). Field protection forest cover (ratio of windbreaks area to arable land area) is currently 2.1%, which is much less than the environmentally justified standards. The total forest cover of the region is 12.7%, while to achieve the most effective impact on climate, soils, water bodies and air, it is necessary to reach 16% of the forest cover. All this must be taken into account in the planning of measures for forest amelioration of

agricultural landscapes of the region, as the excessive amount of eroded lands indicates the presence of large areas of land for the creation of multi-purpose protective forest plantations. This will ensure the optimization of areas of protective forest plantations of the linear type on a zonal basis and will be an ecological prerequisite for the balanced development of agricultural landscapes (Yukhnovskyi 2003).
Calculations show that in addition to the existing 26.7 thousand hectares of windbreaks, it is still necessary to create 20.3 thousand hectares of windbreaks. At the same time, their total area will be about 47 thousand hectares, and the protective forest cover will reach the design level. Complete forest amelioration protection of agro-landscapes of the region is provided by other categories of protective plantings, which are located within their boundaries. The main elements of this structure include agroforestry plantations of various categories, which form the ecological framework of agricultural landscapes and are the basis for providing favorable agro-ecological parameters for field crops, hayfields, pastures and more. Quantitative parameters of the minimum required protective forest cover of agricultural lands are established by our calculations on the basis of scientifically approved standards, which are determined by the requirements of landscape-ecological agriculture (Table1). The required number of protective forest plantations is calculated at the regional level by improving the spatial structure of agro-landscapes. The obtained quantitative indicators of the use of forest amelioration in current agricultural landscapes serve as a benchmark for achieving the level of protective forest cover of 12.4%, which is extremely important for sustainable development of agro-landscapes of the Gully Steppe.

Table1. Components of protective forest cover of agro-landscapes of Luhansk region

Land category	Area, thousand hectares
Agricultural land	1907.2
Arable land	1275.4
Windbreaks	26.7
Protective forest plantations in ravines	14.4
Protective forest plantations in railway lanes	7.6
Protective forest plantations in highway lanes	13.1
Protective forest plantations along rivers and around water bodies	9.5
Massive afforestation of eroded pastures	81.7
Protective forest plantations of linear forms on eroded pastures	5.1
Massive afforestation of eroded hayfields	3.1
Protective forest plantations of linear forms in gardens	0.6
Protective forest plantations on rocky lands	75.0
Total area of protective forest plantations of agro- landscapes in the region	236.7
Prognosis of forest cover of agro-landscapes, %	12.4

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Common walnut (*Juglans regia* L.) – a promising tree species for agroforestry systems

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Theme: Landscape planning and management

Keywords: Growth functions, aboveground carbon sequestration, biomass, LIDAR, terrestrial laser scanning

Abstract

Due to multiple benefits regarding ecological and economical functions, modern agroforestry systems (AFS) in temperate zones have been heavily promoted in recent decades. Nevertheless, farmers are often reluctant to implement AFS on their land. This is due to several reasons, one being knowledge gaps about the trees' impact and their management. While much is known about broadleaved forest tree species in temperate zones like European beech (*Fagus sylvatica* L.) or the different oak species (*Quercus* spp.) the knowledge about field grown species like the common walnut (*Juglans regia* L.) is limited. This is especially true considering that trees growing in AFS display other growth patterns than those in forests. To contribute to filling that void, the aim of this study was to collect typical tree parameters of common walnut trees in AFS.

Walnut is known to have a large potential for inclusion in AFS. On the one hand it has a broad distribution area and Reisner *et al.* (2007) were able to show, that walnut trees could productively grow on 14.9% of the European arable land. On the other hand, the stem wood prices for valuable walnut are amongst the highest on the timber market. Furthermore, the nuts are an additional source of income. Borrell *et al.* (2005) investigated the economic potential of different AFS and concluded that the use of walnut trees in AFS can increase the profitability by 10% to 50% compared to a monocropping agricultural system.

For our study we measured more than 200 walnut trees using traditional dendrometric measurement techniques complemented by terrestrial laserscanning, for high precision 3D data acquisition of selected sample trees.

The measured trees cover a diameter at breast height (dbh) range of 6.5 cm– 84.0 cm and heights of 4.0 m– 21.0 m. While the measured crown base heights were between 1.3 m – 5.5 m, we found crown projection areas of up to 259 m². The merchantable branch free bole length until the crown base reached up to a volume of 1.6 m³ for a single tree. Such a stem would yield 300 € or more, depending on the quality. An additional income would be the proceeds of the firewood.

Based on the results of our measurements we will give insights into the high potential of walnut trees in AFS covering the aboveground volume and biomass, their carbon storage potential as well as key numbers on their dimension and space requirements to ease the planning of newly established AFS.

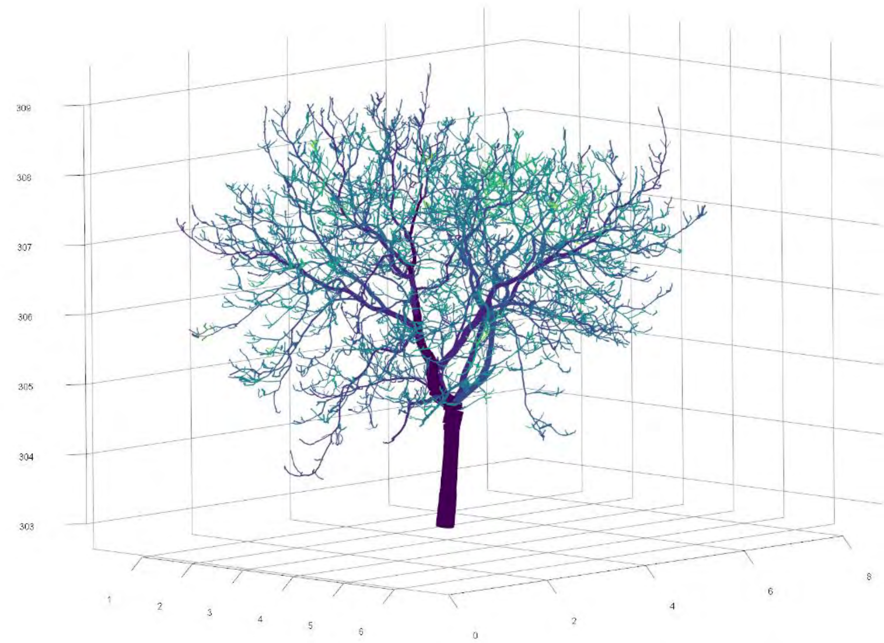

Figure 1. QSM- model of a walnut tree based on 3D data derived from terrestrial laser scanning

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Concept for spatial evaluation of justified implementation potential of agrisilvicultural systems in hemiboreal Latvia

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Theme: Landscape planning and management

Keywords: agrisilvicultural systems, hemiboreal Latvia, spatial evaluation, potential implementation

Abstract

Agroforestry systems as agricultural and forest land management practice (for instance, riparian buffer strips, shelterbelts, windbreaks, live hedges, silvopastoral systems and parklands) have long history in the region, but in the modern sense agroforestry is rarely practiced in the Baltic States. Although, Latvia's national legislation is linked to international policies and strategical plans, it does not define agroforestry, so far. Nevertheless, interest in agroforestry continues to revive due to its benefits in social, economic, and especially environmental and climate change mitigation fields. Agroforestry, particularly agrisilvicultural systems, has a high potential to contribute to achieving the greenhouse gas (GHG) emission reduction target by fixing and storage of atmospheric carbon dioxide (CO_2) in living biomass of trees integrated and maintained in agricultural landscapes and consequently by increase organic carbon stock in soils (e.g., Aertsens et al., 2013; De Stefano, Jacobson, 2017; Mosquera-Losada et al., 2018).

The objective of this study is to provide a concept for spatial evaluation of implementation potential of agrisilvicultural systems in marginal agricultural land in hemiboreal Latvia. The concept involves development of method for geospatial analysis based on spatial selection of agricultural land with a low land quality value (25 points or less) according to the quality assessment of land (Republic of Latvia Cabinet Regulation No. 103 "Regulations Regarding Mass Appraisal"). The total area of agricultural land with a low land quality value (≤ 25 points) is 11412.32 km^2 in Latvia. Further steps include coverage of selected area with other geospatial data layers including information on soil type and texture, declared agricultural crops, underground drainage systems, road net, spatial location of power lines and metal poles, Quaternary sediments, modelled groundwater depth, predicted soil moisture, etc. In total, the method involves 12 layers of geospatial data. Geospatial data layers are processed in the QGIS 3.22 environment. The developed concept for spatial evaluation of potential of economically viable and environmentally friendly implementation of agrisilvicultural systems in hemiboreal Latvia will contribute to the assessment of agroforestry systems as integrated land management tool to combat climate change.

Acknowledgments

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A systematic approach to agroforestry system planning, case studies from Slovakia

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Theme: Landscape management and planning

Keywords: Pannonian region, agroforestry system planning, case study

Abstract

Agroforestry systems (AFS) are an integral part of the cultural landscape, oftentimes linked to historical landscapes as well. An indisputable advantage in the application of integrated landscape management is that it teaches us to see the context, which prevents us from looking at the individual elements of the landscape system as isolated elements. From such an approach arises the inherent position of AFS in landscape planning and management.

In order to develop plans for creation of human environments with successfully implemented AFS, assessments and studies referring to these systems need to enter the process of land use (or spatial) planning. Land use planning should be a synthesis of environmental, social, economical, technical, cultural, and aesthetic approaches to our environment (Salašová, 2007). The aim of the project is to assess and apply an optimal scope and depth of a landscape study. This would thus enable a conceptual and multidisciplinary approach to a planning and decision-making process in landscape, with emphasis on long-term sustainable landscape management solutions, particularly in rural areas.

Two case studies from Pannonian region in Slovakia are demonstrated for the purpose of linking theory into practice. One in Danubian Flat and one in Danubian Hills.

The study areas in Danubian Flat and Danubian Hills belong to one geomorphological region Danubian Lowland. Nevertheless, the natural conditions interconnected with establishment of AFS vary among and even within both areas. The landscape of Danubian Flat was dramatically reshaped thorough history by man and lost its previous diversity. Land which was in medieval times often accessible only by boat suffers from droughts. Nowadays, water remains as the primary factor for determination of agroforestry system design just not on the surface but mostly below ground.

Danubian Hills area has higher share of woody vegetation and maintains its typical landscape character. The natural conditions differ mainly in higher precipitation, lower annual temperature and most importantly in hilly relief. Steep slopes without trees or shrubs are endangered by extensive water runoff.

There is no exclusive AFS design for the study areas. Site-specific conditions and requirements defined by different stakeholders can bring different outcomes. In context of historical background, state of the environment, current and especially future prospects connected to climate change, optimal designs were proposed for both study areas. Silvoarable AFS with shelterbelts for Danubian Flat as a sustainable agricultural land management solution with ability to combat climate change impacts, preserve natural resources, increase share of non-forest woody vegetation, landscape connectivity and aesthetics. Silvopasture for Danubian Hills able to halt down extensive water erosion, provide habitat for cattle grazing and eventually become a high natural and cultural value system.

In an effort to develop a systematic approach to AFS planning in landscape of Slovakia and Czech Republic, more case studies are to be conducted.

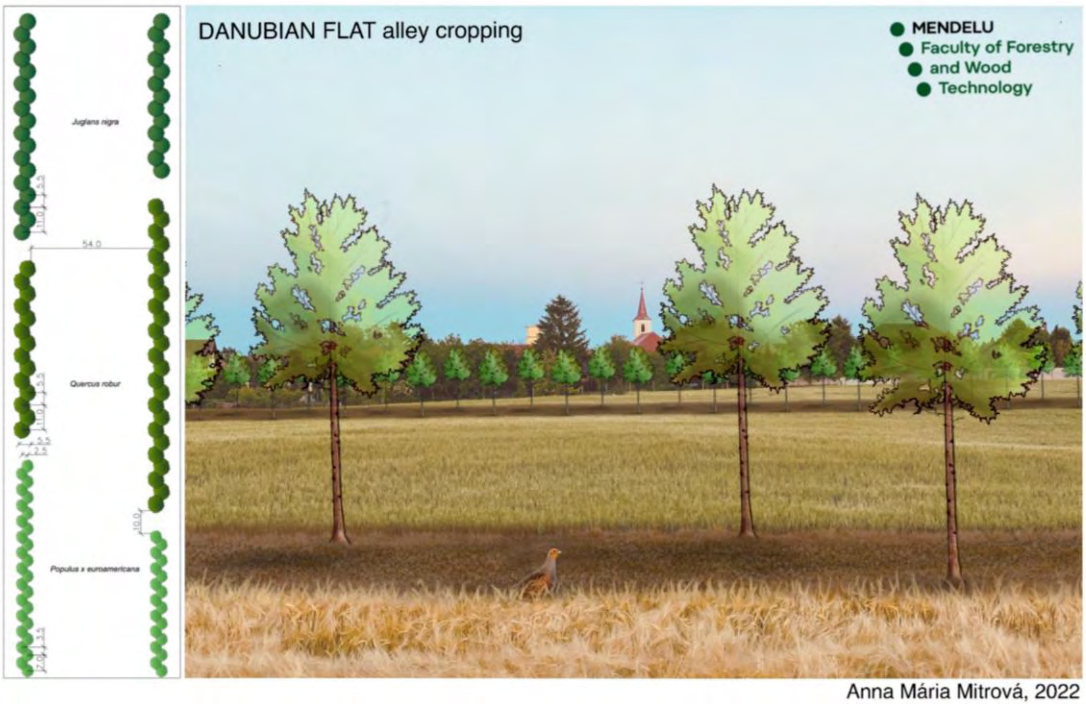

Figure 1. Case study Danubian Flat, alley cropping design

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Agro fluvial park of calore salernitano. Restoration and valorization of historic and landscaped heritage of fluvial area in the territory of aquara

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Theme: Landscape planning and management

Keywords: agro-fluvial park, requalification, agri-environmental system, active protection

Abstract

Calore river is the protagonist of the agro fluvial project whose aim is to built in order to requalify an area placed inside the impressive historic-naturalistic contex of Parco Nazionale del Cilento and Vallo di Diano including it with the nearest urban area of Aquara, a small village in Valle del calore, in the Lucano Sub-appennine, on the slopes of Monti Alburni.

The proposed intervention, being of extensive nature, is fully part of "ordinary maintenance of the territory" and its purpose is to prevent the degradation of soils, the abandonment of rural areas and to contain the phenomena of instability, like erosion and landslides, together with the resulting costs. Moreover, it provides an "active preservation" of the landscape which can contribute to the socio-economic development of the territory in a sustainable way,through the experimentation of good farming practice capable of improving biodiversity in the agro-environmental system and to reduce the polluting pressure on the fluvial ecosystem.

The itinerary experience is used as modality to assimilate and promote high value elements of naturalistic heritage located in the area which is partially site of community interest (Rete Natura 2000).

The landscape background of the peruvial range is composed by a varied set that offers, at the edges of the wood riparian, a mosaic of small fields with woody crops, mainly olive trees, vineyards alternated with crops and wooded strips. The hedges and vineyards create an important ecological connection among the natural inland vegetation, the agricultural environment and riverside vegetation, preserving the biodiversity of agro fluvial ecosystem.

Through the different planned actions those concerning vegetation aim to requalify the system of existiing connections , by a forest improvement of riparian stands, with integration of natural vegetation where it is quite almost assimilated by the growers, with reinforcement of the system rural filiar hedges, with the introduction of sustainable farming practices, designed to reduce the pressure on the fluvial ecosystem. The institution of a perifluvial agricultural park intends to be an useful management instrument of the entire system, able to involve the farmers in the located area.

The proposed project consists in a series of micro procedures,compatible with the high naturalness of the site, which allow to promote or improve accessibility of the mentioned places chosen as focal points of the whole area; the actions of the project can be summed up:

- creation and recovery of connection paths and frequentation af the park
- conservation of agricultural activity and integration with equipped spaces dedicated to recreational activities (agri camping)
- requalification of ecological network
- conversion to organic farming and production of crops typical of the area
- promotion of local agricultural production with the construction of a market for direct sales
- restoration of shore vegetation
- safeguarding of water resources
- organization of visits to the park

Figure 1. Rendering of agri camping. In the foreground the platforms in the larch wood for the tends are connected by walkways. The pitches which are raised from the ground about 20-50 cm, are anchored to the ground by wooden supporting pylons fixed to the ground with steel foundation screw poles .The photo illustrates the restoration of the lawn the planting of trees and shrubs for the enhancement of local landscape elements,in particular vegetation of riparian environment.

Traditional and Innovative: A Review of Diverse Agroforestry Systems across European Landscapes and Cultures

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Theme: Landscape planning and management

Keywords: agroforestry landscapes, green infrastructure, landscape architecture and planning, landscape policy, non-forest woody vegetation

Abstract

Forestry and agriculture have developed throughout centuries as the two main productive land uses and landscape types. Both have generated significant ecosystem services and created living for people and communities for centuries. In many cultures and regions, valuable multifunctional and multi-layered landscape systems and structures have been created and developed that have often become valuable landscapes and environments. Oak forests have been used for breeding pigs for centuries and this traditional agroforestry system is still in active use, for instance in old Portuguese cork oak plantations. Grazed olive orchards in Spain have become important NATURA 2000 sites. Meadow orchards (*Streuobstwiesen*) have become significant traditional landscape elements in German speaking countries. In Slovakia, there are also many historical landscape structures that include agroforestry systems (Jankovič and Pástor 2021), such as grazed orchards, traditional vineyards with fruit trees, and non-forest woody vegetation structures in agricultural landscapes of different types, forms, and structures (Supuka et al. 2020), for instance black locus grows in arable landscapes used for apiculture. Since the 18th and 19th century, allotment gardens have been established all over Europe, where horticulture and agriculture were combined with planting ornamental, firewood, and fruit trees (Tóth et al. 2018). Thus, historical, and traditional agroforestry systems have been cultivated and preserved through ongoing cultivation in many diverse historical landscapes and have become important natural and cultural heritage sites that enhance local and regional landscape identities and characters. Agroforestry landscape systems have had an important role also in landscape planning and management since the late 19th and early 20th century. Today, these systems play a key role in achieving the global Sustainable Development Goals, as well as the goals and objectives of the European Green Deal, the EU Biodiversity Strategy to 2030, the EU Green Infrastructure Strategy, the Common Agricultural Policy, and many related landscape policies at international and national levels. Agroforestry systems play an important role in an integrated landscape management and there are many good examples and best practices of landscape plans and policies across regions and countries. This paper aims to review traditional and innovative models and schemes of agroforestry across European landscapes and cultures and analyse their integration in landscape planning strategies, concepts, eco-schemes, as well as landscape policies, to find inspirative approaches and experiences for future sustainable development of agroforestry landscapes.

Figure 1. Hriňovské lazy (lazy in Slovak means a remote hilly settlement type with scattered dwellings) in Central Slovakia represents a traditional Slovak agroforestry landscape (source: regionpodpolanie.sk)

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Effects of Unplanned Space Utilisation on Water Resources of Serbia

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Theme: Landscape planning and management

Keywords: water resources, protection of space, spatial planning

Abstract
The activities of man have been concentrated around water resources since the dawn of civilization, water being his primary existential need and a precondition for all other activities, such as agriculture, transport or tourism. Only recently have water resources been considered in the context of specific and highly significant landscape value of space to be taken into account in space planning and management. However, in the Republic of Serbia, the last decades, considered transitional towards standards of developed countries in all social areas, have witnessed mostly unplanned development and the so called investor planning, having serious negative implications for water resources, space, landscape, and the environment. In addition to the devastation of landscape and water resources, there is also a reversible effect of water resources on space, such as frequent flooding, especially by rivers with unregulated riverbeds. Climate changes reflect in the changed distribution and intensity of precipitation, just contributing to the negative effects and processes. Space planning and activities in the areas rich in water should be complex and primarily based on taking stock of hydrological characteristics of space and their interaction with composite elements planned in the particular space. Such complex consideration of space in which the elements of the environment (water, forests, land, air, anthropogenic activities) are considered separately as well as in symbiosis, enables the management of water resources, space, and landscape in line with the principles of sustainable development. One of the basic planning measures in protecting people and property from floods is the spatial distribution of activities in the areas close to water resources in line with the hydrological and other spatial analysis of the wider area. Space planning in the immediate surrounding of water resources should be based on comprehensive hydrological studies and their integration in various space planning and management documents. The focus of such an approach to space planning should by all means be preventive protection of water resources, which can be realised in the planning process only by the implementation of strategic environment assessment as a universally accepted environment management document in spatial planning. This can be done by taking into account the broader context, including the analysis of the entire drainage basin in the first phase, and then the implementation of an array of planning measures and technical activities on the regulation of water bodies in the second phase. Since the largest portion of land in drainage areas of significant water bodies in the Republic of Serbia is forest and/or agricultural land, the process of planning should be directed towards the protection and preservation of sylvan and agricultural resources, and/or the improvement of infiltration characteristics and preventing surface runoff and land erosion. Taking care for the existing forest stands, new forest plantings, afforestation of steep grounds affected by erosion are but a few of activities on the biological regulation of river basins against

the buildup of erosion deposits. The protection of forests include preservation and improvement of stands structure, their vitality, and/or management in line with the intended purpose of forests. It is the determination of sylvan stands as protection forests that is being considered the most important measure in preventing land degradation. Financial and educational stimuli in agriculture, directed towards defining and implementing anti-erosion and melioration land use methods, improve the infiltration capabilities of land and reduce the risk of surface runoff. Planting perennial cultures, the cultivation of land parallel to contour lines, and the enhancement of physical and chemical characteristics of land by implementing agrotechnical measures, are but a few actions with beneficial effects to preventing devastation of land structure and the incidence of surface runoff.

Satellite imagery for land classification and detection of agroforestry systems: a study case of Olive trees classification in Tuscany

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Theme: Landscape planning and management

Keywords: Satellite monitoring, hyperspectral imagery, land-use classification, agroforestry systems

Abstract

In Italy, one of the most important agricultural systems is Olive trees. This cultivation has always played a central role in the agricultural sector due to its landscape and economic value. However, in the last decades, changes of economic interests and climate change impacts have strongly influenced the cultivation of this crop, resulting in olives and olive oil production decrease and land abandonment increase (ISTAT 2021, Zavalloni et al. 2021). In Italy olive tree systems are usually characterized by small scale farming, with an average farm size of 1.5 ha (Colombo et al. 2017). Thanks to its characteristics, this cultivation can be considered an agroforestry system, since it allows the growth of herbaceous vegetation, vegetables and various crops (Mantzanas el al. 2021, Camilli et al. 2018). The fragmentation of this cultivation makes it hard to have a complete overview of the regional existing olive trees realities, as well as to discriminate manged to un-managed or abandoned cultivations (Villanueva etl a. 2017). However, this information is crucial for governments to develop an efficient plan for land management and to correctly allocate agricultural funds. To solve this problem, approaches able to detect and classify specific land-use would be essential. Specifically, remote sensing may play a key role since it would be able to provide information about changes in cultivation over time and specific spectral signs for land-use characterization (Lazzeri et al. 2021, Vangi et al. 2021, Viana el al. 2019). In this context, CNR-IBE and Tuscany region are collaborating to develop a classification method for Olive trees through satellite images able to discern the information from an agroforest system, disentangling the spectral signature from ground and tree layers. The first phase of investigation has been carried out in the province of Grosseto. The methodology was mainly based on NDVI, and reflectance data extracted by satellite images at different spectral and spatial resolution, and temporal recurrence. Specifically, in this study were used: a) hyperspectral images from PRISMA (30 m resolution, 2019-2021); b) multispectral images from Seninel-2 (10 m resolution, 2017-2021); c) multispectral images from Landsat 5-7 (15-30 m resolution, 1984-2021); d) multispectral images from Modis (250 m resolution, 2000-2021). These images were used to detect the spectral signatures and NDVI seasonal trends of olive trees in both managed and abandoned cultivations, assessing their changes over the years.

Preliminary results indicated that NDVI patterns from Landsat showed considerable differences between managed and abandoned olive trees cultivations, with the highest difference during summer season likely due to the effect of agronomic practices usually applied in springtime within managed systems (figure 1). The NDVI was generally higher in the abandoned cultivations, where the lack of management increased the whole biomass in both trees and grass layers.

This study will be further addressed in the next years by means of hyperspectral airborne images at higher spatial resolutions, which will help to determine a specific spectrum signature for both managed,

and un-managed cultivations. This information will be fundamental to develop a more detailed classification model for agroforestry systems.

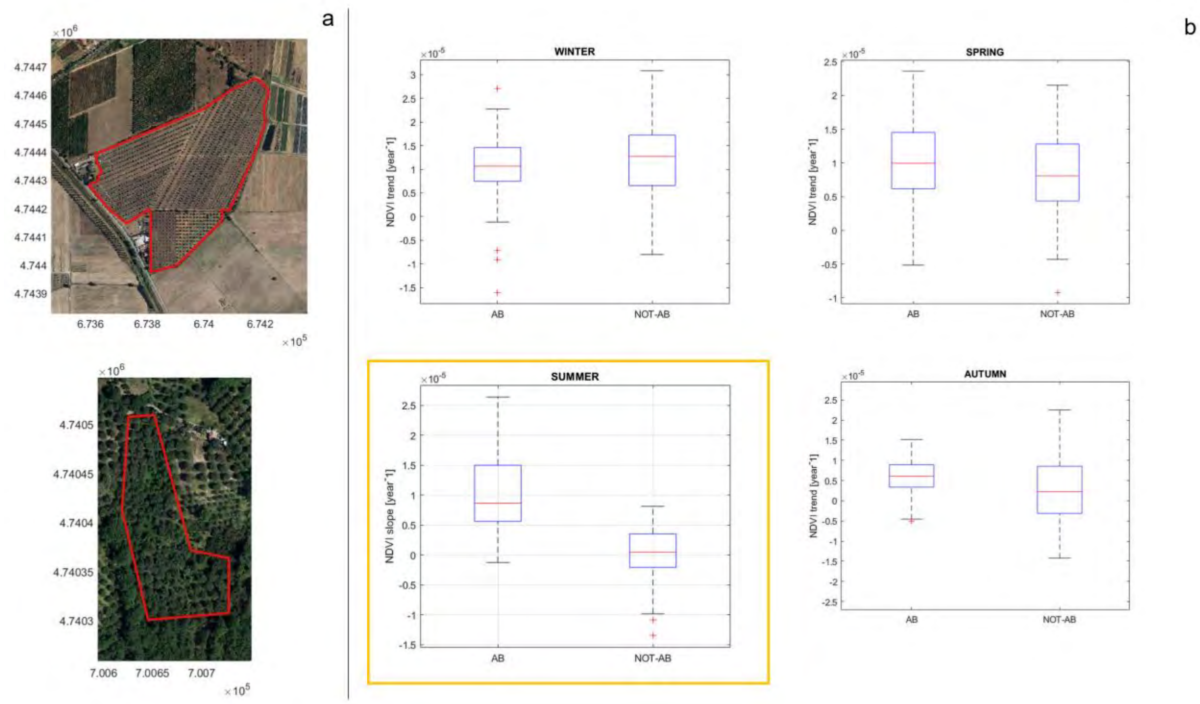

Figure 1. This figure shows (a) examples of managed (top) and abandoned (bottom) olive trees both located in Grosseto province; (b)boxplots of olive trees seasonal NDVI between 1985 and 2021 obtained by Landsat. Springtime (orange contour) shows the highest differences between abandoned and managed olive trees. *AB: abandoned olive trees; NOT-AB: not abandoned (managed) olive trees.

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Developing row planting structures in agroforestry practices taking into account their potential for air phytoremediation.

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Theme: Landscape planning and management)

Keywords: agroforestry practices, phytoremediation, micrometeorological CFD models, landscape planning

Abstract
Agroforestry practices, in addition to many benefits considering agricultural production, allow the use of the phytoremediation potential of plants due to their natural capacity to remove air pollutants. The row structures of agroforestry crops involving trees, shrubs, and cultivated plants allow the outer rows to be used as a naturally shaped buffer zone, which exhibits particulate matter insulation and filtering properties.
However, proper implementation of row plantings, which also serve as passive structures to improve air quality, requires recognition of many aspects, including the mechanisms and processes that occur between barriers and the pollution stream. These aspects should be recognized based on the specificity of the plant material, their arrangement, meteorological parameters, and the morphological conditions of the area. Applying both an appropriate species composition and properly designed structure of the rows, can significantly affect air quality efficiently changing the dispersion pattern, and, therefore, the amount of pollutants penetrating deep into a given area.
The paper presents the stages of programming the phytoremediation process in a row planting structure on the example of an analysis of the interaction of $PM_{2.5}$ with vegetation. To intensify the restorative processes of the plant, a model was introduced in which the dispersion and deposition of particles were activated simultaneously. An integral part of the study is the evaluation of the effectiveness of the designed solutions, carried out for hypothetical options of row plantings with the introduction of appropriate species composition, taking into consideration the individual morphological and structural properties of plants (LAI and LAD parameters).
The impact of greenery on the dispersion of particulate matter was carried out by assessing the horizontal and vertical variability of the $PM_{2.5}$ concentration using micrometeorological Computational Fluid Dynamics models (ENVI-met software). As a result of the study, a variant of the row structure with

increased phytoremediation efficiency was developed, which activates the entire scope of phytoremediation possibilities of such a greenery structure, considering both the dispersion and deposition activity and taking into account site-specific conditions of the place.
The study determines the methodology for designing row plantings, enhancing their ability as a passive air quality control measure. These solutions can find applications, especially in crops in the vicinity of traffic routes, as a method of shaping outer rows or buffer zones for various purposes, e.g., to separate traditional and organic crops.

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Strengthening agroforestry facilities through ecological restoration work to improve biodiversity and carbon storage: the example of the La Condamine urban farm

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Theme: Landscape planning and management

Keywords: ecological restoration, assisted natural regeneration, hydraulic facilities

Abstract
Located at the gates of the city of Montpellier, the “La Condamine” collective urban farm is a 5 ha site, a former agricultural estate divided into market gardening below, vines, orchards and intensive wheat cultivation. This type of conventional farming widespread in the 1960s with major environmental impacts on tree cover, soil condition and more generally on local biodiversity.
The 4 cooperators who currently practice agriculture in agro-ecology, market gardening and organic fruit production, food processing and cultural and educational activities on the site, want it to also become "a support for arranging a set of biological corridors forming places of reception of the living diversity, around which will be organized an educational course enhancing the discovery and awareness of this natural heritage”.
An agroecological diagnosis was carried out upstream. Regular exchanges with the project leaders and joint visits to the site have enabled co-construction work on a development project to complement other ongoing projects. An original approach based on a diversity of skills and techniques supplemented by bibliographic work has made it possible to identify technical solutions adapted to the context (limited material and human resources and agro-ecological constraints).
The project presented and adopted is based on a few major axes:
Combining hydraulic development and forest restoration: The difference in level was used to set up (and restore) a system of drains supplying three ponds and allow on the one hand to respond to the initial order but also to promote a microclimate necessary for the establishment of forest habitats to be restored.
Rely on the existing and the natural dynamics in progress: The diagnosis revealed an interesting natural dynamic on which restoration work could be based: abundant regeneration of pubescent oaks, a wooded belt along with the natural regeneration of holm and pubescent oaks, but also ash trees and shrubs, the persistence of remnants of a rural hedge and finally the close vicinity of a preserved wooded area and including a pond, the Grammont pond, rich in biodiversity.
Restoration of diverse natural habitats: the establishment of 3 different but complementary habitats will promote greater biodiversity: a xerophilic oak grove with holm oak (Quercus ilex) and its procession of companion plants, a pubescent (mesophilic) oak grove (Quercus pubescens) with the installation of 'a diversified undergrowth, and an ash forest enriched with other hygrophilous tree, shrub and herbaceous species.
Technical innovations in assisted regeneration: (a) the prior installation of brambles by cuttings and layering in order to facilitate the transplantation and recovery of the oaks, (b) the establishment of a diversified undergrowth under the downy oak forest by supporting the recreation of a litter, (c) the creation and protection of micro-enrichment plots allowing the resettlement of species of interest and currently little present and their recolonization of the environment, and (d) biological restoration will be reinforced by mycorrhization of the soil and the use of mycorrhized plants.

Work is in progress, and the first developments (digging of ponds and wetlands and drains) were carried out in December 2021. Transplantation and enrichment work must follow. The proposed approach is resolutely innovative and at the crossroads of different issues and techniques: ecological engineering, agroforestry, forest restoration. The work is planned for a period of 3 years with readjustments and adaptations depending on the results of monitoring.
Monitoring and support work must be carried out with the implementation of a monitoring protocol. The issue is important because it could make it possible to propose a restoration proposal at a lower cost and accessible to many sites, particularly in a context of agricultural abandonment and redefinition of CAP aid and its conditionalities.

Exploiting the Google Earth Engine platform for mapping agroforestry in Italian rural landscape

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Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Landscape planning and management

Keywords: GIS; Trees Outside Forest; Remote Sensing; Sentinel Imagery; Vegetation Indices; Land Cover; Land Use

Abstract

As agroforestry systems have a high potential for food security, biodiversity and socio-economic sustainability and climate change adaptation and mitigation, they are currently being promoted or traditionally maintained in many regions of the world. In fact, agroforestry promotes multifunctional and resilient agriculture, with positive results in terms of ecosystem services. Due to the complexity of the tree-based agricultural systems an appropriate knowledge of its components, both in terms of spatial extent and functional relationships is fundamental. The mapping and monitoring of such complex systems are essential for a proper and sustainable management of resources as well as for planning of mitigation and adaptation measures against the rising environmental risks.

The current estimation of agroforestry in European Union, according to LUCAS database (Eurostat 2015) is about 15.4 million ha, corresponding to about 3.6% of the territorial area and 8.8% of the utilised agricultural area (den Herder et al., 2017). Going down to the national level, 4,7% of total Italian area has been estimated as agroforestry, with main distribution in Central and Southern Italy. In this study, we aim to estimate agroforestry with more accuracy by exploiting the Google Earth Engine (GEE) platform. In order to achieve this target, we took a case study within a rural area in Central Italy, belonging to the "Bolsena Lake Bio-District". A bio-district is a civil local agreement, recognised by national and regional regulations, targeted to foster sustainability in rural areas by means of organic and high natural value farming systems.

The Google Earth Engine cloud-computing platform (GEE) allows users a quick and seamless access to the standard satellite imagery without downloading the actual scenes, thus providing the means to build time series of indices counting hundreds of records in almost no time. GEE allows users to perform geospatial analysis from local to planetary scale based on Google's cloud infrastructure in a very short time, by accessing data from a large repository of publicly available geospatial dataset, including more than forty years of historical imagery, such as the entire Landsat archive as well as the complete Copernicus Sentinel archive and a variety of earth science-related datasets.

In order to estimate and map agroforestry in the study area, we developed and tested an openly available GEE script, based on our previously studies for mapping Trees Outside Forest (TOF) in agroforestry landscapes (Chiocchini et al. 2019; Sarti et al. 2021). The workflow, in a nutshell, consists in singling out trees from a temporal series of images via optical indices thresholding, then extracting trees out of forest polygons (TOF) and classifying them according to their size and shape.

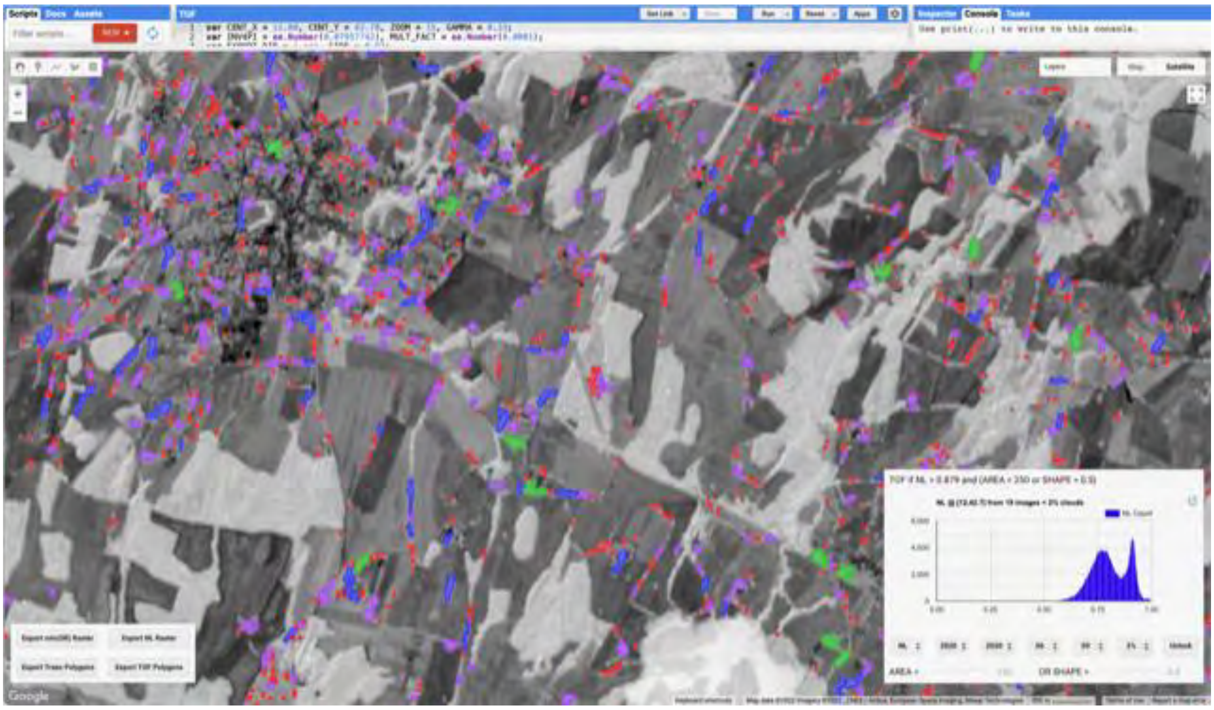

Figure 1. The script running in the GEE user interface: TOF polygons are classified as isolated trees, hedgerows and small groves; they can be exported as a shapefile.

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Approach for prioritizing areas for watershed restoration through agroforestry systems

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Theme: Landscape planning and management

Keywords: Ecological Restoration, Land Vulnerability, Land Use Policy, Payment for Environmental Services

Abstract
The restoration and management of watersheds in agricultural areas is a major challenge for ecosystem sustainability. Reconciling the multidimensional aspects of landscape in agroecosystems requires combining strategies to restore habitats and promote more sustainable production systems. Nature-Based Solutions (NBS) - which include ecological restoration with Agroforestry Systems (AFS) and Payment for Environmental Services (PES) initiatives - are crucial instruments for mitigating the negative effects of habitat destruction and engaging social actors in ecosystem conservation. In recent years, environmental policies and investments associated with the restoration of the Atlantic Forest have directed the Paraíba do Sul River Basin (PSRB) to restore/conserve its natural resources. The PES programs have a prominent role in environmental agendas through the Atlantic Forest Connection Project, an initiative led by the Global Environment Facility (GEF), the Brazilian National Government, the São Paulo State Department of Infrastructure and Environment (SIMA / SP) and the São Paulo State Funding Agency (FAPESP). However, despite these initiatives and institutional apparatus, the efforts to implement and manage agro-ecological practices, as a tool for ecological restoration and watershed recovery, are hindered by the lack of tools that support decision making for the effective allocation of resources and operationalization of reforestation projects with AFS at the landscape level. Assessments at a spatial scale are key to establishing environmental restoration strategies, the development of more efficient metrics, and also provides inputs for the adoption of environmental services control and planning practices (Pacheco et al., 2018; Parras et al., 2020; Pissarra et al., 2021). To achieve the restoration goals in the Paraiba Valley, it is necessary to prioritize areas that direct restoration interventions, promoting operational optimization with good cost-effectiveness and implementation time. The definition of priority areas is crucial for the success of active reforestation interventions and prioritization criteria should be aligned with specific restoration modalities (Carvalho Ribeiro et al., 2020; Chazdon, 2019). Although some studies support landscape-level forest restoration projects (Lopes et al., 2020; Valente et al., 2021), specific tools are not proposed for prioritization in the process of

implementing SAFs as an active watershed restoration strategy. In this sense, this work highlights the importance of the ongoing investigations in the Paraíba Valley, since it considers the multi-aspects of the landscape to identify which regions are more vulnerable in the PSRB and therefore in need of immediate recovery. Given the various benefits of implementing AFS for the recovery of the PSRB and the strategic gaps for its establishment, this brief synthesis highlights the development of multi-criteria spatial models in order to support decision making regarding the identification of priority areas for environmental recovery and sustainable agricultural exploitation in the Paraíba Valley. This approach can be delimited from the multi-criteria decision analysis and combination of several criteria at scale level, such as environmental factors: geomorphology, soil type and biophysical characteristics and anthropogenic factors: landscape metrics and land use capacity for agroforestry, as well as socioeconomic aptitudes of local stakeholders. These aspects combined can be a viable route for the recuperation of areas already in degradation process or to promote the conversion from traditional land use to AFS. The conditions indicated represent factors relevant to the planning and management of forest restoration initiatives, including the simulation of strategic scenarios in the face of climate change. An integrated assessment can provide metrics that support decision making (Guo et al., 2020; Li et al., 2021). This approach will result in the creation of a specific and effective toolkit to restore and conserve water resources as a policy tool and its contributions to environmental, social, and economic sustainability.

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Analysis of current changes and future scenarios for a correct management of agro-forestry systems in a protected area in Lazio: the example of the Lago di Vico Natural Reserve

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Theme: Landscape planning and management

Keywords: landscape transformation, agriculture intensification, agroforestry practice loss.

Abstract

The Lago di Vico Natural Reserve (RN-LV) (Lat. 42°17'N, Long. 12°07'E, WGS 84), established in 1982, covers an area of 4,109 hectares. The territory of the RN-LV lies between 510 metres above sea level (water level of the lake) and 965 metres above sea level of "Monte Fogliano", where ecologically different environments alternate. The lake, with an extensive reed bed, the wetland with rushes and flooded meadows of vegetation interest, intensive hazelnut plantations (about 30% of the surface of the protected area) on the flat and low hilly area, chestnut groves growing in the areas with the steepest slopes, and forests, mostly of high trees and coppice, surround the entire caldera.

The presence of a volcanic lake has conditioned the historical and present-day landscape: from a historical landscape, strongly characterized by agro-silvo-pastoral uses and agro-forestry practices, to intensive hazelnut monoculture. The considerable fertility of the soil has favored the intensification of agriculture, with the abandonment of the use of woodland and traditional chestnut growing systems. These cultural changes in agriculture and the transformation of the landscape have led to an increased risk of fire due to the increase in dead wood biomass in many areas of the forest.

Knowledge of past land-use dynamics is essential to understand the changes that have occurred and to model the medium- and long-term effects on the management of agroforestry systems for management and prevention purposes. The study of landscape transformation was carried out diachronically, using two different photographic sources. The historical landscape of the 1950s was described through the photo interpretation of IGMI (Istituto Geografico Militare Italiano) photos - GAI flight, while the current landscape was outlined through the photo interpretation of Google Earth images.

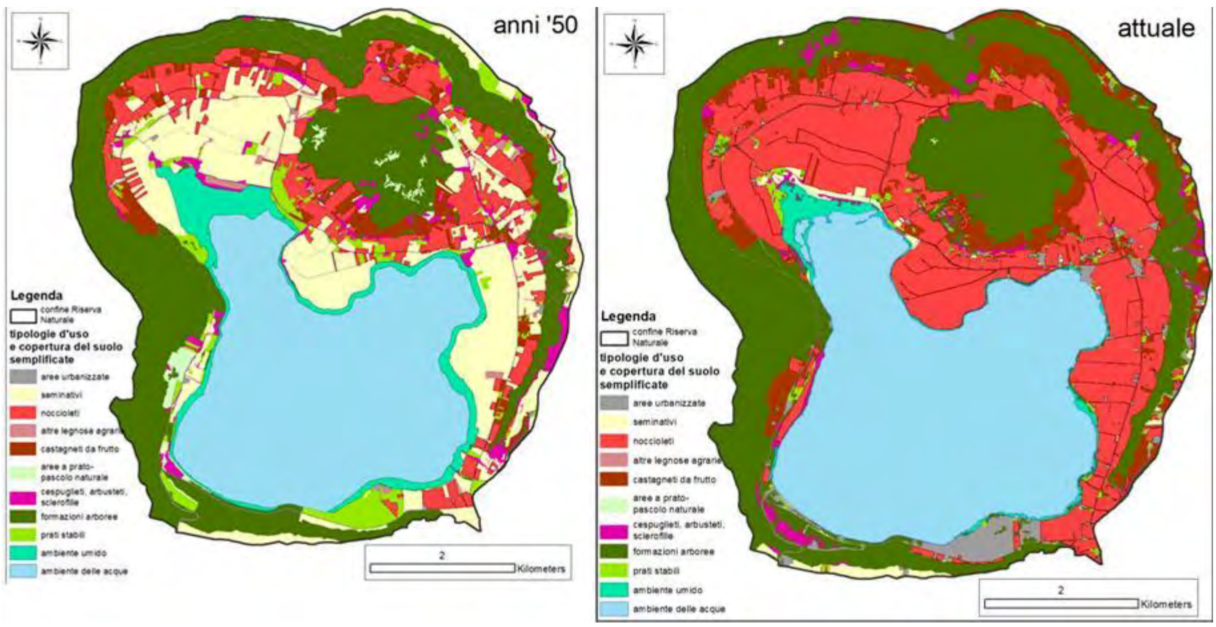

Figure 1. ***Historical land cover mosaic (left) and existing landscape (right).***

The land use that has had a strong decrease in terms of surface area is arable and grassland, which in 1954 had an area of 740 ha compared to 39 ha today. Most of the previous arable and grassland are now hazelnut groves (about 595 ha, in addition to those already present), while 49 ha have become chestnut groves. Chestnut and hazelnut trees (traditional tree cultivation) have suffered a double fate: they intensified where land was most favorable; while mostly abandoned over land with steep slopes (land characterized by subsistence farming). Abandoned chestnut today presents a recovery of naturalness, with an increased associated fire risk. Part of the arable land has been transformed into urban land, increasing the risk linked to the human-forest interface.

Pastures and shrubs are rapidly converting to woodland, with a loss of biodiversity associated with open environments and an overall transformation of an area with a high agro-silvo-pastoral suitability into an industrial agro-ecosystem with an exclusive interest for hazelnuts. The poorest and least profitable land is being abandoned, with an increased risk of fire due to the lack of adequate land management.

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Quantification of shade cast by windbreaks of different sizes in South Africa

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Theme: Landscape planning and management

Keywords: Shadow, Agroforestry, *Casuarina cunninghamiana*

Abstract

Despite the long-standing history of agroforestry around the world, such systems are still far behind being commonly utilised. Nevertheless, a palpable re-emergence of interest in integrated alternative land-use management systems has been observed in recent times leading to an increased awareness of agroforestry systems. To meet the demands of stakeholders, one of the aims of agroforestry systems is to combine ecological benefits with economic returns, i.e. to integrate the cultivation of trees with the purpose e.g. to reduce wind, with regular farming activities. Trees on farms can provide on-site and off-site benefits that support the development of sustainable land use (Sheppard et al. 2020).

In the Cape region of South Africa, it is common to utilise trees as windbreaks within vineyards and fruit orchards. Such windbreaks are largely aligned perpendicular to the prevailing wind direction to shield crops. The net effect is a reduction in wind speed and crop evapotranspiration coupled with an increase in humidity, air and soil temperature, culminating in an increased cropping yield potential (Sheppard et al. 2020). Tree species such as *Casuarina cunninghamiana*, *Eucalyptus cladocalyx* or *Populus simonii* are commonly utilised for this purpose.

Besides the reduction of the wind speed, the shade cast by windbreaks may affect the growth of agricultural crops or trees grown in the alleys, due to a reduction in direct solar radiation. Research to gauge the magnitude of the shading effect of windbreak systems is still lacking. Here, the utilisation of hemispherical photography is proposed as one method of obtaining parameters that describe the light regime in such systems. Binarized hemispherical photographs collected on transects perpendicular to established windbreaks can be analysed to obtain variables describing the light regime (cf. Bellow and Nair 2003). In this way, the influence of different parameters such as distance to the windbreak, size and type of the trees within said windbreak can be modelled.

Pilot studies have shown a distinct depression in light availability at ground level (Global Site Factor; GSF: 1 = full light, 0 = no light) near the tree rows as a result of the windbreak trees (*C. cunninghamiana*); light availability, is furthermore, dependent on windbreak size. Figure 1 shows for the small windbreak A (height 9.0 m, width 4.0 m) that less than 10% (GSF = 0.9) of available light is shaded out over a complete day on both sides of the windbreak. For the large windbreak B (height 25.3 m, width 11.6 m) the shading is more intense, especially close to the windbreak peaking at approximately 87% (GSF = 0.87) available light on the NNW side and remaining under 80% on the SSE side for up to 20 m from the windbreak. Future efforts will be devoted to modelling shading as a function of different structural windbreak parameters (e.g. tree size) to provide decision support to farmers who wish to utilise windbreaks while balancing the positive and negative effects that their utilisation bring.

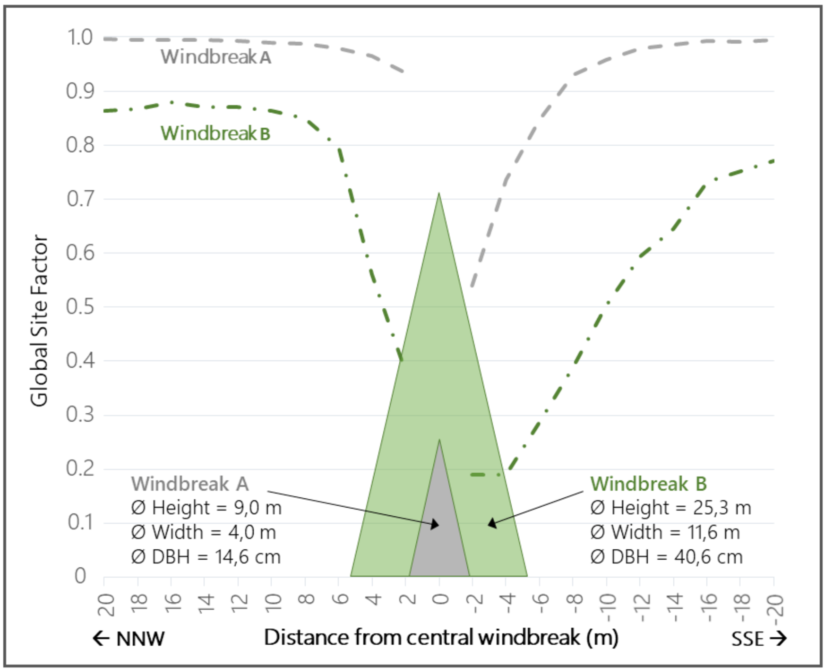

Figure 1. Different shading effects (Global site factor; GSF: 1 = full light, 0 = no light) on either side of a small (Windbreak A) and large (Windbreak B) *Casuarina cunninghamiana* windbreak (grey dotted line = GSF of small windbreak, green dotted line = GSF of large windbreak,) with a NNE to SSW orientation also showing scaled dimensions of the target windbreaks.

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Detecting stemflow-induced preferential flow pathways through time-lapse ground-penetrating radar surveys

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Subtopic: Landscape planning and management

Keywords: GPR, water infiltration, stemflow

Abstract

Research over the past several decades has shown that preferential flow is more the rule than the exception. However, our collective understanding of preferential flow processes has been limited by a lack of suitable methods to detect and visualize the initiation and evolution of non-uniform wetting at high spatial and temporal resolutions, particularly in real-world settings. In this study, we investigate water infiltration initiation by tree trunk and root systems. We carried out time-lapse ground penetrating radar (GPR) surveys in conjunction with a simulated stemflow event to provide evidence of root-induced preferential flow and generate a three-dimensional representation of the wetted zone.

We established a survey grid (3.5 m × 5 m, with a local slope of 10.3°), consisting of ten horizontal and thirteen vertical parallel survey lines with 0.5 m intervals between them. The horizontal lines were downslope-oriented. The grid was placed around a *Quercus suber* L. We collected a total of 46 (2 GPR surveys × 23 survey lines) radargrams using an IDS (Ingegneria Dei Sistemi S.p.A.) Ris Hi Mod v. 1.0 system with a 900-MHz antenna mounted on a GPR cart. Two grid GPR surveys were carried out before and after the artificial stemflow experiment. In the experiment, we applied 100 L of brilliant blue dye (E133) solution on the tree trunk. The stemflow volume of 100 L corresponded to 63.2 mm of incident precipitation, considering a crown projected area of 201 m^2 and a 1.3% conversion rate of rainfall to stemflow. Trench profiles were carefully excavated with hand tools to remove soil and detect both root location and size and areas of infiltration and preferential pathways on the soil profile.

The majority (84.4%) of artificially applied stemflow infiltrated into the soil, while the remaining 15.6% generated overland flow, which was collected by a small v-shaped plastic channel placed into a groove previously scraped on the downhill side of the tree. The 3D diagram clearly demarcated the dimension and shape of the wetted zone, thus providing evidence of root-induced preferential flow along coarse roots. The wetted zone extended downslope up to a horizontal distance of 3 m from the trunk and down to a depth of approximately 0.7 m. Put all together, this study shows the importance of accounting for plant and trees trunk and root systems when quantifying infiltration.

Thirty-year Trend of Forest Seedling Production in Croatia in Respect to Agroforestry Needs and Opportunities

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Theme: Landscape planning and management

Keywords: poplars, forest reproduction material availability, agroforestry systems establishment, production increase.

Abstract

The research aims at analysis of long term trend of seedling's forest production in the nurseries throughout the Republic of Croatia. The analysed period includes thirty-year continuous monitoring of the quality of seedlings produced in all registered nurseries in the country. The basis for data collection is expert supervision of nursery production, which has been done by scientists of Croatian Forest Research Institute (Division of Silviculture) from the year 1992. Nursery production is based on the control over quality, number of produced seedling and the technology used. Data are presented per clone and individual nursery. The focus is given to poplars in respect to their share in total seedling production, production per nursery and individual clone, as well as the possibilities of their use for establishment of agroforestry systems. During the year 2021, 19 clones have been used for the production of poplar seedlings, with a total amount of 188,461 seedlings grown in five nurseries (out of 19 nurseries in total in the country). Historical overview of poplar nursery production will be given, together with insight into agroforestry issues in respect to poplars in Croatia. Agroforestry systems have been neglected as an efficient and economically viable solution in the past in Croatia. Nevertheless, ideas emerging in the concept of sustainability and enhancement of financial efficiency of poplar plantations raises interest in establishment of new agroforestry systems. The research will present availability and the use of poplars at present providing the estimation of seedling availability for initiation of such agroforestry systems in Croatia. Planning of poplar seedling production should suit biodiversity aims as well as supporting selection of native poplars.

Incorporating ecosystem services in evaluating the sustainability of innovative organic farming systems using the Public Goods tool

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Theme: Landscape planning and management

Keywords: Human nutrition, social well-being, biodiversity, farm-scale sustainability assessment, sustainable food production

Abstract

Rethinking the organisation of sustainable and organic food systems value chains is necessary to increase the sustainability and efficiency of food systems and to reduce trade-offs between production and distribution stages. The European project FOODLEVERS (www.foodlevers.org, SUSFOOD2 and CORE Organic Cofund) will analyse several European case studies of innovative organic food systems and innovative sustainable systems including agroforestry systems (Table 1) and identify best practice processes from multiple perspectives of resource efficiency: environment, economy, social and governance.

In earlier studies, a tool was developed to assess the sustainability of farming systems – the Public Goods Tool (PG-tool) (Gerrard et al. 2012). This tool was developed predominantly for use in food farming and in the current study it will be adapted for innovative examples in organic farming. To achieve this, new indicators were identified in addition to those already in the PG-Tool. Special attention was given to incorporating indicators which could capture provisioning of ecosystem services by farming systems, in particular those with a focus on biodiversity, human nutrition and social well-being - areas that are also currently underrepresented in the PG Tool.

To ensure that everyone's views are included we used a participatory approach. This approach uses the 'power of the crowd' and the principle of consensus through feedback to get to the result that is most 'right'. For this to work, it is necessary to have several stages of desktop research and feedback:

1. Structured literature review by the project partners (mainly researchers) to identify ecosystem service indicators responding to the specific characteristics of the partner case studies.
2. Ranking and prioritizing indicators by the project partners (mainly researchers).
3. Survey in each case study country to identify the most important sustainability indicators according to the perceptions of national stakeholders (farmers, advisors, retail, other value chain actors, decision makers) based on factors such as relevance, comprehensiveness, interpretability, data quality and efficiency.
4. A practical workshop with stakeholders closely involved in the case study (mainly practitioners) in order to further reduce the list of indicators and select those indicators which capture the essence of each case study as much as possible.

The aim is to add about 50 new indicators to the PG-tool. To assess the sustainability of the selected innovative organic farming systems, interviews with the farmers will be carried out in spring-summer 2022. During the assessment, the farmer and the researcher will go through the assessment together. During the assessment, immediate feedback is provided on which sustainability aspect the farm is performing well and on which aspects improvement could be made. Farmers learn about their farm's overall sustainability and the role of distribution channels. The results are expected to provide information on the sustainability performance of our selected innovative organic cases. In addition, the performance of each innovative organic case will be compared to its conventional organic counterpart.

No.	Innovative organic food system/innovative sustainable system	Study location
1	Biodynamic city-farm cooperating with a large network of regional organic farms, consumer-driven decision making, innovative method of distribution	Frankfurt am Main, Germany
2	Organic farm managing silvopastoral systems where walnut plantations and olive orchards are grazed by laying hens	Orvieto municipality, Italy
3	Network of local farms to strengthen market access and get a "grass-fed" standard for beef, to improve short value chains and create a joint shop for community farmers	Poland
4	Community supported farm with over 350 members and innovative governance structure	United Kingdom
5	Biodynamic farm cooperating with a large network of regional organic farms, consumer-driven decision making, innovative method of distribution, volunteer program, on site learning for local school children	Romania
6	Forest farming: Mushroom farms cultivating organic edible mushrooms in forests and indoors, more efficient use of forestry, agriculture and urban side products and waste streams (small diameter trees, grain husks, coffee grounds etc.), courses to farmers and start-ups interested in mushroom cultivation	Region of Uusimaa and Southern Savonia, Finland
7	Community-Shared-Agriculture providing organic meals for a local hospital	Flanders, Belgium

Table 1. Selected European case studies of innovative organic food systems

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Assessing the benefits and functions of urban agroforestry and the potential for the city of Budapest

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Theme: Landscape planning and management

Keywords: planning, design, urban trees

Abstract

This article is part of a PhD research on urban and peri-urban agroforestry. After the analyses of several strategies in planning edible landscapes in France, Belgium and Germany, this article brings out on the one hand the impact of agroforestry regulations on planning and design of agroforestry systems in cities and on the other hand the impacts of regulations and planning policies on the development of urban agroforestry. Furthermore, the visit of several test-plots in urban agroforestry in the South of France help in making a clear picture of the benefits and functions of this practice compared to urban agriculture and urban forestry. Finally, this article ends with the analysis of a potential development of an agroforestry corridor along the Rákos creek from Budapest to Szada in Hungary with the cooperation of several actors, citizens, NGOs and experts.

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Do distance-dependent competition indices contribute to improve diameter and total height growth estimates in undebarked cork oak trees

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Theme: Landscape planning and management

Keywords: Quercus suber L.; Cork; Montado; Growth models; Richards function; Lundqvist-Korf functions; Age-dependent; Difference equations; Tree competition.

Abstract

Montado is a silvopastoral ecosystem characteristic from countries of the Mediterranean basin. Highest asset generated is cork, but additional animal related products are obtained, which typically graze on natural or improved pastures. Cork oak (Quercus suber L.) management implies the optimal tree distribution that minimizes tree competition for natural resources such as water and light, finally promoting tree growth, vitality, and cork production.

Considering the spatial relations of each tree and its competitors, it is crucial to understand individual tree growth and support tree management regarding tree spacing in this silvopastoral system. Integrating competition indices into cork oak growth models may increase the growth prediction accuracy, while this provides information regarding competition patterns (Faias et al. 2019). Distance-independent and distance-dependent competition indices differ in the resources required for their computation and application. These indices hardly have been included when modelling cork oak stands, since existing models were developed for low density stands (Sánchez-González et al. 2005; Tomé et al. 2006). This study focuses on juvenile stands, with models developed for undebarked trees. It aims at assessing the enhancement of including distance-dependent competition indices into tree diameter and total height

growth models, when compared to distance-independent indices that do not require the spatial position of each tree to be known.

We used a group of 39 rectangular permanent inventory plots measured at least three consecutive periods of three years, summing at total of 6773 individual tree measurements. Inventory plots were installed in young cork oak plantations (6 to 22 years old), ranging between 80 to 877 trees ha-1 and covering the cork oak distribution in Portugal. Tree diameter and total height growth models were fitted as non-linear difference equations, using Richards (Richards 1959), Lundqvist-Korf (Lundqvist 1957) and Mcdill-Amateis (McDill & Amateis 1992) growth functions. The process started by fitting base models, defined as individual tree diameter/height estimators for variables at age t+1, depending solely on respective measurement at age t. This step allowed to identify the most suitable growth function considering model performance (e.g., mean square error) and model validation: mean PRESS residuals (MPRESS), mean absolute PRESS residuals (aMPRESS) and model efficiency (Myers 1990). On a second phase, we added one competition index (distance dependent or distance independent) to the model parameters and assessed the performance improvement and biologic interpretation of generated estimates.

For both diameter and total height growth estimates, base models were improved by adding competition indices. Tested distance-dependent indices showed higher improvement than distance-independent ones. The best model considering diameter growth estimates was the Lundqvist-Korf function, when this included the size difference proportional to distance index (Moravie et al. 1999), showing a $R2 = 0.980$ (MPRESS = 0.086; aMPRESS = 0.540). Total height growth was modelled with McDill-Amateis function and a nearest neighbour multiplied by plot density index (Clark & Evans 1954), showing a $R2 = 0.981$ (MPRESS = 0.022; aMPRESS = 0.165).

Results successfully provide models for predicting the two most important tree measured variables in juvenile cork oak plantations, while considering a spatial component of competition.

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Tree-based agriculture on Mediterranean terraces: continuing the story by renewing practices

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Theme: Landscape planning and management

Keywords: Cultivation of Mediterranean terrace, Interaction orchard/intercropping, Trees spatialisation, research-action approach, Cevennes

Abstract

Terraced agriculture in the Mediterranean basin is very old and induced mainly by mountainous reliefs, violent rainfall occurring at the end of the summer, when the vegetation cover is minimum. Terraces make it possible to get flat land in the mountains, to fight against erosion, to better manage water resources, to create microclimates, to maintain local agriculture in remote areas, and to maintain an important agrobiodiversity. Beyond quality food production, it provides many other ecosystem services (Gravagnuolo and Varotto 2021, Contessa 2014).

For a long time, these terraces were planted with the traditional Mediterranean trilogy wheat/olive/grapevine often combined with a more diverse polyculture including vegetables, other cereals, other fruits trees (figs, citrus fruits, nuts, etc.), even mulberry trees as part of a self-sufficient mountain economy that collapsed at the turn of the 19th and 20th centuries. Since then, the terraces have been massively abandoned and then degraded, paradoxically at a time when the Mediterranean area is more affected by intense meteorological events due to climate changes, and when the current trend towards the relocation of agricultural production is growing fast.

With regard to tree farming, the terraces offer specific advantages by providing trees with deep, more humid soils from which surplus water can be drained via dry stone walls (Harfouche 2006). In December 2020, we have started a research-action within the framework of a collective project done on 7 ha of farmland in the southern Cévennes (France). The target is to study the interaction between orchards and associated crops to develop a revisited model of agroforestry on terraces. We have dedicated a 50 acres plot named « Ramdam Bio » (10 linear terraces of Cevenol-type - as defined by Blanc 2018 - 5÷10 m wide, elevation 300÷350 m), to create a nut orchard (almonds, walnuts, hazelnuts, pistachios, pecans) composed in the medium term of a hundred trees. The first 24 trees have been planted in January 2022. This orchard will produce fruits for a community of 10 people and for direct exchanges with other local collectives. In the coming years, we will measure and analyse the synergies in the interactions between fruit trees and terraced crops, experimenting on 3 to 6 different varieties of each species of nut trees, introducing different spatialization of the trees and alternation of species on the terraces. We will varying the crops under the trees (green manures, aromatic plants, dye plants, cereals, buckwheat , vines, melliferous hedges) and continuing the tree planting program in an iterative way, making use of the results of the previous stages. This experimental and productive system in progress is very open to any collaboration.

In parallel, our research is questioning about (i) the relevance of rebuilding the terrace walls identically, as the maintenance of these walls is very costly in terms of labour time (Reparaz 1990) (ii) the notions of autarky and autonomy, as the autarkic agriculture of the 19th century with its extensive optimisation of spaces could partly inspire new agro-ecological approaches aiming at food autonomy in small territories via local exchanges.

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Agroforestry and landscape planning, a territorial transition

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Theme: Landscape planning and management

Keywords: planning, territorial transition, landscape

Abstract

"Beauty is a criterion, social equilibrium, work and the hardness of life are also important to appreciate an era" (Chabason, 1989)
The poster does not propose here to portray a fantasized idyll between farmers and planners, or a supposedly ideal model of a farming practice that would respond to all the problems of a structural crisis. Nor does it propose an aestheticizing or monographic vision of trees and hedges at all costs. Its objective is to provide a thinking on the essential transversalities between the complementary fields of planning and agronomy in the future of metropolitan territories. Its ambition is to offer a landscape and projector's view, on the possibilities of percolation and discussion between different worlds that have grown apart, sometimes opposed and whose recent history tries to tighten the links.
Urban areas have sprawled and expanded on agricultural lands for the past 50 years (Agreste and Teruti 2015). This sprawling had rapidly led the public authorities to regulate and manage territories with zoning plans, conceived as soil protection policies. This zoning led to a specialization of landscapes.
Peri-urban areas developed in logistics and commercial zones, creating urban fringes sprawling on agricultural land in a complex peri-urban grid (Sieverts, 1997). In the same time the high mechanical optimization and deep changes in agricultural practices also led to massive changes in rural landscapes, a specialized and more productive lands where trees rapidly disappeared (Dupraz, 2008).
This situation in Europe locally generated the implementation of agricultural protection zoning, regionally managed by the CAP since 2007 and Rural Development Programs (RDP).
Environmental concerns appear in the CAP documents since 1992, with an indication about planting trees and hedges. This greening awareness (Latour 1997) has led to understand that urban and rural areas need a complexification of landscapes and a territorial 'despecialization' specially in peri-urban areas.
Agroforestry questions agricultural production, forestry, wood industry but also all the local ecosystem.
When mentioning rural, urban or peri-urban areas, the planting of trees deeply modifies landscapes and ecosystems. Agroforestry involves an economical, sociological and landscape approach of the territory. It mobilizes different local actors like stakeholders, farmers, foresters, land planners and public authorities. It necessarily questions a local culture, in terms of sectors, land and ecological expertise, local knowledge. This field transversality needs a field governance which involves a management by the local economic actors rather than the public authorities, which also means involving farmers in territorial planning operations (Piraux et al., 2010).
Farmers are thinking rationality, yields and profitability, naturalists are thinking protection, conservation and biological diversity; planners and public authorities are thinking territorial development. Integrated in a territorial system, agroforestry drives to a despecialisation of activities and a necessary collaborative work between field actors, pursuing a common goal of a territorial efficiency. Applied to European

urban areas scale, this theory could be compared to the establishment of Agricultural Parks, created to limit urban sprawl and soil consumption.

Territorial transition needs structural instruments and institutional framework different from the existing ones. Agroforestry offers a hybrid solution for a transversality of actors and sustainable resources but can it also be a hybrid solution of planning, a new way of shaping the territory, in an innovative and reasonable way?

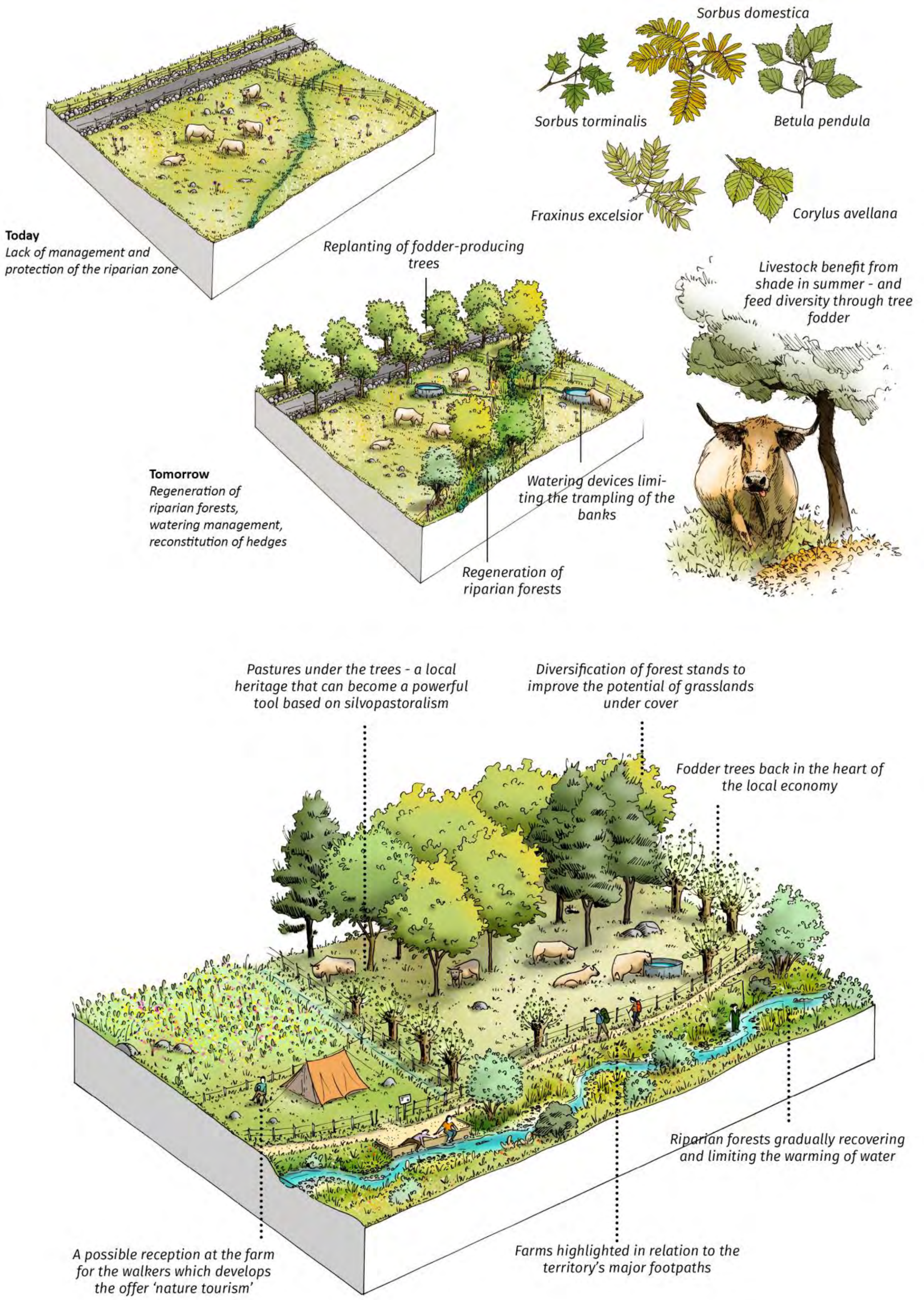

Figure 1. xample of a territorial project including landcape planning and agricultural practices (from Lacourt and Caudex, 2019)

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WILDFIRES

Using satellite images and GEE to monitor post-wildfire forest vegetation response in Monte Serra (Tuscany, Italy)

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Subtopic: Wildfire

Keywords: abiotic disturbances, Sentinel-2, vegetation index trajectories, forest management

Abstract

Wildfires are a cause of forest disturbances, disrupting the structure, composition, and function of forest ecosystems, and changing resource availability or the physical environment at any spatial or temporal scale. Quantifying and characterizing post-disturbance forest dynamics is important to understand how a forest is recuperating over the years in relation both to different levels of undergone damage, the previous health, its resilience, and the forest management interventions carried out after the event. Among the remotely sensed products, time series of satellite images allow obtaining detailed information of vegetation changes and responses after a forest fire by recognizing the spectral signal that forests have in all phenological stages. The study here presented was carried out to characterize and assess the responses of forests, composed of oaks (*Quercus spp.*), stone pine (*Pinus pinea* L.), European chestnut (*Castanea sativa* Mill.), to a large fire that occurred on 25th September 2018 in 600 ha of Monte Serra (Pisa province, Tuscany region, Italy). We used data from Sentinel-2 Multi-Spectral imager (MSI), characterized by a good trade-off in spatiotemporal resolution (10 m pixel size for Red-Green-Blue and NIR bands, 20 m for SWIR21, and a 5-7 day revisiting). Using a natural colour RGB composition pre-event image, we classified the vegetation into 6 classes and the area affected by the fire into 4 classes of damage based on the ΔNBR (Normalized Burn Ratio) calculated from two images, one acquired before and one after the event. We derived an array of images by a process on the Google Earth Engine (GEE) cloud computing platform for the area of interest with an extension of 4 years, being the period pre-fire January-September 2018 and that post-fire October 2018-December 2021. To obtain a continuous trajectory, starting from the measured NDVI and NBR values, a linear interpolator has been developed and applied to each pixel along the time dimension. Then, from the produced array of images, for every single pixel and for each day of the time series, we calculated the values of the Normalized Difference

Vegetation Index (NDVI) and NBR. Applying statistical functions, such as average, median, maximum, minimum, quartile, per each class of vegetation and fire damage, we derived the distribution of the vegetational indices both according to the spatial and temporal dimension (i.e., resampling by month, season, year). Finally, to evaluate the diversity in vegetation responses, we assessed the difference between the distribution curves of the two vegetation indices by measuring their similarity (Bhattacharyya index). The results achieved in this study suggest that the application of the approach here proposed, based on the reconstruction of a continuous trajectory of vegetation indices from Sentinel-2 imagery, represents a valuable way to assess and monitor the ecological responses of forest vegetation to abiotic disturbances.

Managing wildfire risk in mosaic landscapes: A case study of the upper Gata river catchment in Sierra de Gata, Spain.

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Theme: Wildfires

Keywords: Wildfire, Risk assessment, Agroforestry, Landscape approach, Forest Management, Firebreak

Abstract

Fire prevention and suppression approaches that exclusively rely on silvicultural measures and containment infrastructure have become increasingly ineffective to stop the spread of wildfires. As agroforestry landscape mosaics consisting of a mix of different land cover and use types are considered less prone to fire than forests, novel approaches that support the involvement of rural people in land management have been proposed (Otero et al. 2018). However, it is unknown whether farmer land use interventions will nudge fire-prone landscapes towards a more fire-resistant one in the current socio-economic context. We report on a case study in the upper Gata river catchment, Spain, a high fire risk area that has recently been a pilot site for Mosaico Extremadura (MosEx), an innovative participatory fire risk mitigation strategy. MosEx was triggered by a wildfire that in the summer of 2015 burned nearly 8,000 hectares and forced the evacuation of 3 villages in the study site. Our purpose is to investigate the potential of farmer agricultural, forestry, and livestock interventions supported by the MosEx project to function as effective fire breaks and their effect on fire risk. FLAMMAP 6.1 software (USDA, 2021) was used to conduct simulations of fire behavior on the landscape in 2010 (reference landscape), with and without project interventions and in two climatic scenarios (called L10 and VL35). Moreover, a relative fire risk index was developed, which combines the concepts of hazard and vulnerability.

Change in fuel model type will occur in nearly 90% of the 732 hectares covered by project interventions. The largest change would be from fuel model type 7 (trees with understory shrubs) to type 9 (forest with a thin litter layer), occurring on 300 ha (41,1% of the total area under intervention), mostly due to forestry interventions. Project interventions resulted in improved extinction capacity (efficacy level 1 to 6) on 84% and 76% of the simulated area for scenarios L10 and VL35, respectively. The largest changes (efficacy level classes 4 and 5) are observed in climatic scenario L10, particularly for livestock interventions. Forestry interventions are the most efficacious, with improved extinction capacity on 87% and 82% of the simulated area for L10 scenarios and VL35, respectively, followed by livestock (78% for L10 and 65% for VL35), and agriculture (58% for L10, and 43% for VL35).

There are four (4) levels of risk in the study area. Most interventions (15 out of 23) are found in sub-catchments with fire risk level 3, covering 414 ha (4,4%) of the total area of these sub-catchments. Sub-catchments with the highest relative fire risk index (level 4) include 13 interventions, covering 285 ha and 5,3% of the total study site area. Forestry covers 78%, livestock 15%, and agriculture 6% of the area under intervention in these sub-catchments.

Our results support the assumption that agricultural and forestry interventions can be effective fuel breaks, especially when implemented in hazardous areas and can contribute to risk mitigation. Therefore, public administrations should bet decisively on adopting collaborative strategies for sustainable land management.

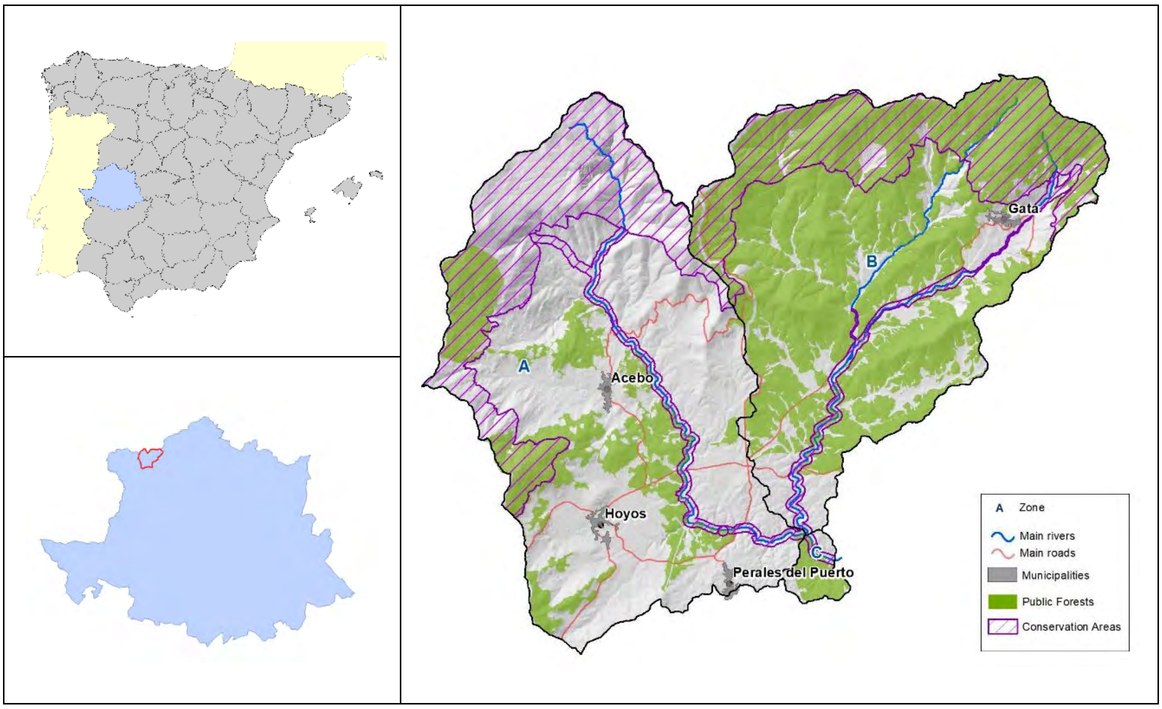

Figure 1. General location and overview of the study site

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Mapping forest stands using Sentinel-2 data to realize a fire management plan

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Subtopic: Wildfire

Keywords: Quercus suber, agroforestry systems, landscape mosaic

Abstract

The Natural Reserve of Tuscania (NR-T) (Lat. 42.20°N, Long. 11.54°E, WGS84) covers 1.901 hectares and is characterized by the presence of the homonymous town inside its perimeter. The elongated shape of the protected area includes a stretch of the river Marta and its valley, before and after the town.

The NR-T is for 60% occupied by agricultural areas (olive orchards and arable lands), while forests cover 30% of the surface. remaining land uses include water bodies, wetlands and urbanized areas (10%). The landscape mosaic is composed by fields separated via hedgerows that alternate gorges and the valley excavated by the Marta river, which is rich of hygrophilous vegetation. The deep tuffaceous valley hosts vegetal and animal communities of great conservation interest, which represent refuges to vegetation and local wildlife as well as fundamental ecological corridor. A particular aspect of RN-T is the presence of a Natura 2000 site (SAC IT T60100036), due to the presence of Tyrrhenian cork-oak forests.

For an effective fire management planning, an accurate characterization of the forest stands is needed. In the past, this was done by carrying out forest surveys in the field and spatializing the data in an approximate way by means of Geographical Information Systems (GIS). Nowadays, we can use free access to multispectral and radar data, acquired by Sentinel-1 and Sentinel-2 satellites, which have a high temporal resolution, combined with a good spatial resolution. Moreover, the satellites have been launched in 2015, so they start to become useful even for diachronic studies. These allow to obtain a characterization of forest canopy cover: dominant tree species and biometric properties. Together with field measurements, used for validation and to a proper delimitation of the training-sites of semiautomatic classifications, it can lead to data more close to reality and accurate.

Likewise, the availability of historical aerial photographs allows to highlight how much the landscape has changed during the last decades. In particular, in the study area ICCD photograms has been used captured by the Royal Army Force (RAF) during the flight of the 1944, which covers the northcentral sector of the RN-T. From a quantitative comparison between the land use and cover, photo-interpreted, results have become evident that while the forests in steep slopes have increased a little bit in terms of density, forest stands located in flat or ondulated lands in 1944 were extremely more limited both in terms of tree cover and density due to grain cultivation and grazing. The last represented the most common activity for local agricultural management practices and its gradually abandon has caused the cessation of the territory maintenance. Especially the wood-pastures have suffered from the land abandonment that caused their closure because of a strong re-growth of shrubs. All these phenomena have contributed to increase exponentially the fuel load and so the fuel load factors, as it is easily observed in Fig. 1.

Fig. 1. On the left an aerial photo of the Royal Force Army flight from 1994;
on the right a Google aerial photo from 2019

Poor roads, lack of water and sighting points: planning for fire defence in suboptimal conditions

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Theme: Wildfire

Keywords: Biodiversity loss, Field abandonment, View analysis, Fire protection

Abstract
One of the biggest problems that has affected agroforestry systems in recent years is forest fires. Destructive events have occurred worldwide, raising awareness among policymakers of protecting against fires and the biodiversity they threaten. The World Health Organization (2007) has also alerted that effective risk and crisis management measures are urgently needed.
In this study, the main objective is to point out the main problems arising from fire prevention planning in a protected area. The method is shown through an example in the Natural Reserve of Monte Casoli di Bomarzo (RN-MC). The lack of infrastructure, abandonment of agroforestry practices, and biodiversity management are critical planning challenges. The RN-MC (Lat. 42.493384, Long. 12.227965: WGS84) is located in the Viterbo province, an area strongly characterised by a very heterogeneous landscape directly related to multiple land use (e.g., grazing, forestry, and extensive agriculture). The reserve has a total agroforestry land use with broad-leaved forest (69% of the area), non-irrigated arable land (19 moors and heathland (9%), natural grasslands (2%), and less than 1% permanent crops and pastures (Fig.1).
A characteristic of the protected area is the presence of floristic emergencies that can be traced back to the Habitats Directive (e.g., *Ophrys passionis*, *Ophrys argentaria* and *Ophrys sphegodes*) and *Quercus virgiliana (Ten.)(*Onofri 2013).
Planning the area from the perspective of forest fire prevention, we found no adequate road service, no observation points, and a great distance of water points. Based on the surveyed roads (Hippoliti 2003) and water points, accessibility times for the entire protected area were calculated. GIS processing of the Digital Terrain Model (DEM) was used to determine the correct number of viewpoints for viewing as much of the protected area as possible (Cuckovic, 2016). The analysis shows that the areas with the highest ecological value of the agroforestry system in the protected area are most threatened by the risk of fire with possible loss of natural capital and ecosystem services.
This danger is linked directly to the abandonment of traditional agroforestry practices and the consequent increase in biomass. Considering the area's intrinsic criticality, the reintroduction of agroforestry management practices (e.g. grazing and forestry) is complementary to the installation of fixed observation points on the territory: this makes it possible to reduce the risk greatly reduces the reaction time of firefighting teams.

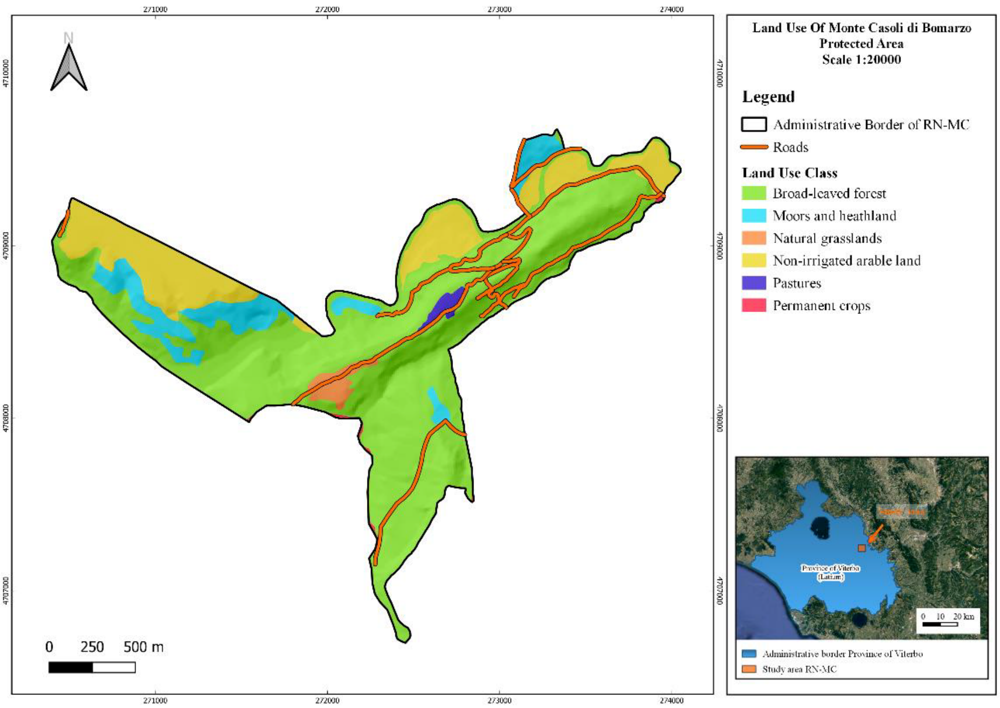

Figure 1. Land Use of Natural Reserve Monte Casoli di Bomarzo

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Interferences between man and forest in a small-protected area: Natural Reserve Valley of Arcionello and the fire hazard.

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Theme: Wildfires

Keywords: rural-urban interface, wildfire risk, erosion phenomena

Abstract:
Forested areas close to cities provide a wide range of ecosystem services (ES): environmental and socio-economic. On the other hand, the nearness to urbanized landscapes requires an accurate planning and management of the natural resources and the forest infrastructures because of the negative effects of the ecosystems on humans, termed Ecosystem Disservices (EDs). Wildfires and the risk associated are one of those EDs that could occur.

Natural Reserve Valley of Arcionello (NR-VA) is a small-protected area located in Viterbo, central Italy (Lat. 42.39°N, Long. 12.11°E, WGS 84). The Province of Viterbo manages the Reserve, but private parties own the lands. The area is about 439 hectares, characterized primarily by volcanic soils and sedimentary deposits, at an elevation ranging from 340 m of the "Fosso Luparo" to 802 m of the Palanzana Mount peak. The site is part of the basal-Mediterranean belt. The climate is a transition between the temperate and Mediterranean zone, and it has a mean annual temperature of 21.9°C, a maximum of 32.5°C, and a minimum of 3.5°C. The average annual total precipitation is 784.8 mm.

The land cover is composed as follow: artificial surfaces (10%), agricultural areas (8%), forests, and semi-natural area (82%), of which 79%, equivalent to 347 hectares, are actual forests and 3% are scrubs and herbaceous vegetation associations. Most of the stands among the area are coppices-with-standards of chestnut (56%); then coppices of turkey oak (23%), transitional woodland-shrubs of pubescent oak (14%), mixed coppices (14%) and hygrophilous vegetation (9%). Finally, there is a chestnut orchard for fruit production (1%), holm oak stands (0.5%), and a plantation of conifers (0.5%).

The abandonment of management practices such as coppicing, wood-pasture, and traditions like collecting fallen wood have contributed to increase fuel loading. Poor management of the strip roads, the extended rural-urban interface and a large number of people visiting the NR-VA, hugely increased fire risk. In addition, the lithological substrate, the impact of tourism, and the issues related to maintenance of the forest infrastructures lead to water erosion phenomena.

This study aims to present the agroforestry activities to manage wildfire risk and control the surface runoff, provided by the fire management plan of the NR-VA. The actionable tactics to minimize fire risk to people, resources, and assets and mitigate the erosion phenomena have to face the conflicts between the Reserve and the private owners. They indeed criticize the conservation scheme because of the limitation of their ownership rights.

Figure 1. Coppice-with-standards of chestnut with stumps close to a strip road subjects to water erosion phenomena

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A spatial analysis of wildfire risk factors in agroforestry areas under climate change: a case study from Monte Pisanu, Sardinia (Italy)

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Theme: Wildfires

Keywords: climate change, wildfires, burn probability, risk factors

Abstract

In recent years wildfires of unprecedented scale and duration occurred in different regions of the world, a phenomenon that is expected to be exacerbated by climate change.
Although burned areas generally decreased in the Mediterranean Basin during recent decades, a current increase of extreme wildfire events represents a potential threat to human and natural systems.
Since scholars have highlighted the potential of Agroforestry (AF) systems to contribute to fire risk reduction in Mediterranean environments, this study aimed to examine whether lower wildfire risk factors could be found in AF areas under simulated climate change conditions.
Fire behaviour simulations were performed on FlamMap using historical (1996-2005) and simulated climate data (2036-2045 and 2066-2075) from a Euro-CORDEX regional climate model and two climate change scenarios (RCP4.5 and RCP8.5). Burn probability, conditional flame length and fire size were simulated in the Monte Pisanu forest, central Sardinia (Italy).
Extreme fire risk days were defined as days exceeding the 95th percentile of the Fire Weather Index (FWI) and used to assess future changes in Seasonal Burn Probability (SBP). A spatial analysis (QGIS) of simulated outputs was performed to compare agroforestry areas to other natural or semi-natural areas.
Results showed that wildfire risk factors in agroforestry areas were generally lower than in shrublands and forests. However, results were highly dependent on input parameters, specifically wind direction, ignition patterns and climate change scenarios, limiting the final assessment of SBP in agroforestry areas. Nevertheless, lower values of SBP were found in agroforestry areas under low-risk climate change scenarios, suggesting that higher efforts for climate change mitigation might enhance the efficacy of agroforestry systems in reducing wildfire risk at Monte Pisanu.
In conclusion, efficient fire reduction in central Sardinia might depend on the integration of agroforestry areas into wildfire management planning and strategies for climate change mitigation and adaptation.

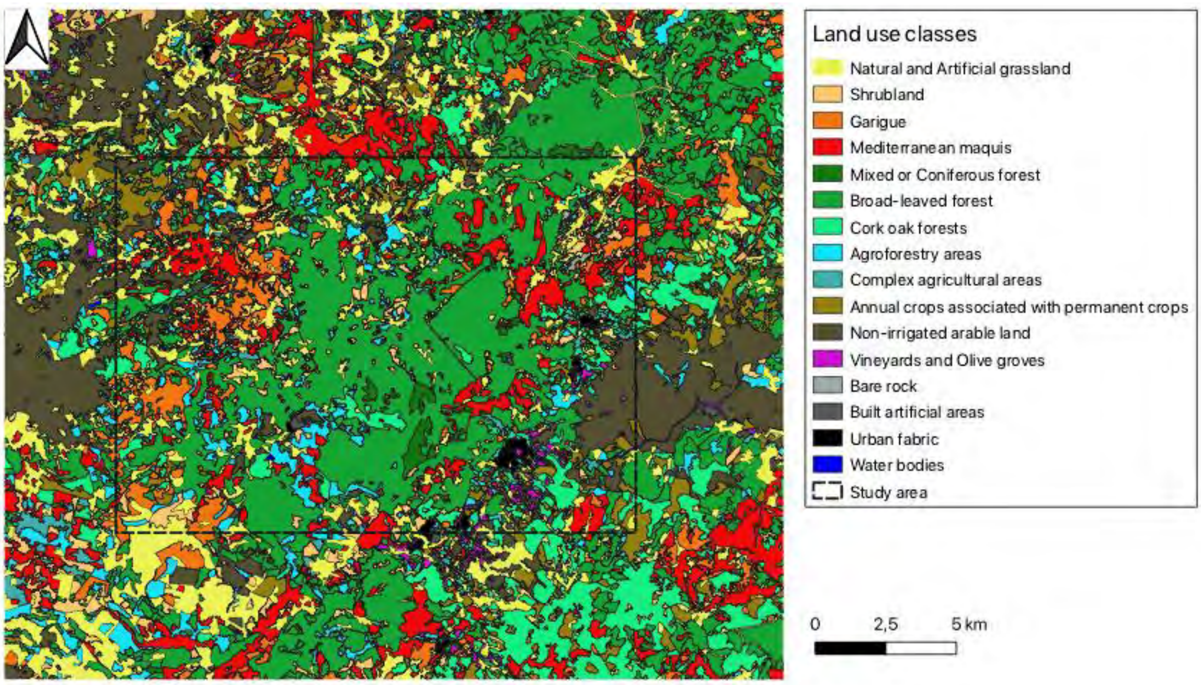

Figure 1. Main land-use classes in the study area at Monte Pisanu, Sardinia (Italy)

TOPIC 2

QUALITY, SAFETY AND SUSTAINABILITY OF AGROFORESTRY PRODUCTIONS

2

T 2.1

CROP AND GRASSLAND PRODUCTIONS

2 .1

Effect of shade on persistence of sown legumes under silvopastoral conditions

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Theme: Crop and grassland productions

Keywords: shade, seed bank, persistence, legumes

Abstract

In the last 20 years, the sowing of persistent annual self-reseeding legumes, in pure stands or in mixture with grasses has been recognized as a key agronomic intervention to increase grassland productivity of agro-silvopastoral systems in semi-arid Mediterranean areas (Moreno et al., 2018). Shading can be a limiting factor for pasture productivity, being known that tree canopies reduce light transmittance and slow photosynthesis, reducing overall herbage production (Feldhake et al. 2010). On the other hand, benefits from tree canopies (i.e. protection from desiccating winds, reduction of soil surface temperature and of evapotranspiration) can be effective only if combined with the selection of appropriate forage species, capable of increased levels of seasonal productivity (Dibala et al. 2021). However, at present there is not a specific availability of shade tolerant pasture species in the market. To address this knowledge gap, we conducted an experiment at farm scale condition with the main goal of studying the effect of shading on the establishment and persistence of two annual legume-based mixtures in a silvopastoral system. The experimental site is located within a private farm at Monti (OT, Sardinia, Italy). It is a cork oak silvopastoral farm of about 100 ha, with tree density ranging from 10 to 40 trees ha-1 and tree crown covering less than 10% of the total surface. Dairy sheep are bred, for selling milk to the cheese industry. In an extensification perspective of transition from temporary (cereal cropping/hay production) to permanent grasslands, we have carried out an experimental trial comparing three pasture types (F = pasture oversown with Fertiprado commercial legume mixture; I = oversown with ISPAAM mixture based on native pasture species; N = unsown pasture) under and outside of the tree canopy, in a completely randomised design with three replicates represented by three different silvopastoral units, each one consisting of a single cork tree with its understory pasture area and a crown of outlying pasture area (18 4x4m plots in total). For three years, the composition of the transient and persistent seed bank was observed. Transient seed bank, namely seed germination that generates autumn seedling establishment,

was estimated counting the seedlings within 3 soil cores collected for each plot. Persistent seed bank was estimated after dormancy breakdown treatments on the ungerminated seeds buried into the same 3 soil cores collected, as described by Franca et al. (2018). Shading affected positively and significantly the percentage of legumes from the Fertiprado commercial legume mixture into the persistent seed bank for the two years of self-reseeding after the sowing (Figure 1). Three years after the sowing, the persistent seed bank under tree canopy is largely richer in legumes than outside the tree canopy, whatever the sown mixture. More complex and biodiverse legume mixture seemed to be more conservative in terms of legume species persistence than the simple autochthonous mixture. These results clarify how important would be the selection of shade tolerant species to be sown in agroforestry contexts, in order to improve the persistence of rich-legumes permanent grasslands.

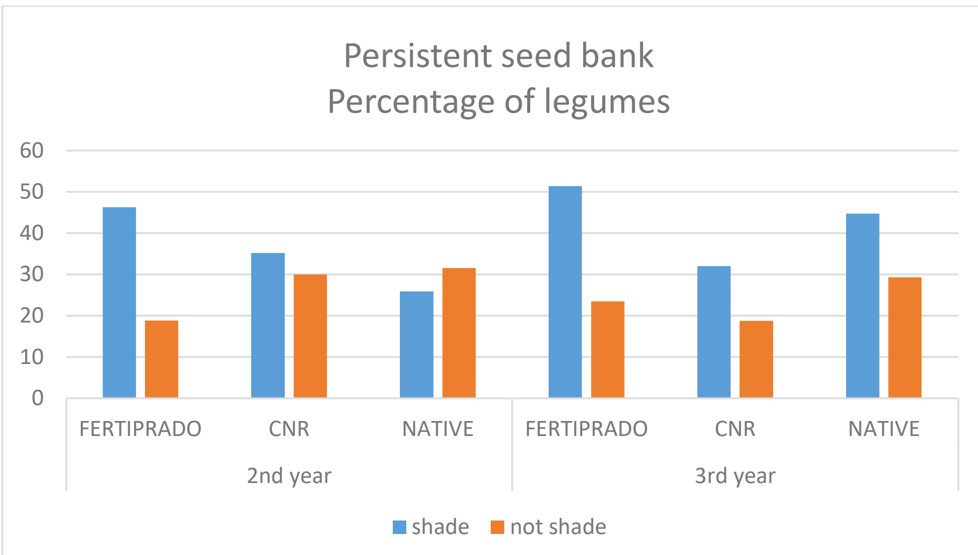

Figure 1. Percentage of legumes in the persistent seed bank, two and three years after the sowing

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Optimising productivity of silvoarable agroforestry systems in the temperate zone: screening crop species and varieties in an artificial shade experiment.

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Theme: Crop and grassland production

Keywords: silvoarable agroforestry, alley cropping, shade, crop production, crop variety, grass clover

Abstract
To further increase the adoption of silvoarable agroforestry in Europe, system optimisation to improve productivity and performance at field level is key. This encompasses e.g., improved tree-crop combinations, selection of adapted crop and tree varieties, smart design and proper management of trees and tree rows. In North-Western Europe, light is likely to be the principal limiting resource for understorey crops, and most agronomic studies show a systematic reduction of final yield as shade increases (Artru et al. 2017, Pardon et al. 2018). Whereas this effect itself has been thoroughly assessed in previous research for a range of arable crop species and both through empirical studies and modelling work (Dufour et al. 2013, Artru et al. 2017, Pardon et al. 2018, Dupraz et al. 2019), more work remains to be done on gaining practical insights in how to adapt agroforestry system composition to reduce this negative effect of shading. One important aspect in this quest, is the selection of adapted crop species and varieties (Arenas-Corraliza et al. 2021). Context specific climate conditions but also other aspects such as soil conditions, nutrient availability, pest and disease risks need to be considered in this search for adapted varieties.
Thereto, in 2021, ILVO together with Inagro and Praktijkpunt Landbouw Vlaams-Brabant set up a program to start field screening of crop species, varieties and mixtures for agroforestry conditions typical for Belgium. In a long-term experimental setup, we have installed an artificial shade construction at a long term research site, mimicking a mature agroforestry system through the use of military camouflage netting to provide discontinuous light through the day (based on Artru et al. 2017). The construction is made of vertical concrete poles (representing the tree stems) with a height of 3,5m and with a metal crossbeam of 3m long attached on the top of the poles. These poles are installed in a straight row of 110m on the field, approximately North-South oriented, with a spacing of 5m between the individual poles and with the camouflage netting fixed on top of the crossbeams (see Fig. 1a). In the alleys East and West from this construction, nine crop plots of 12m long (along the row of poles) and 12m wide

(perpendicular to the row of poles) are installed, enabling us to have three crop treatments in three replicates per season (see Fig. 1b).

The light reduction is monitored at six positions in the field, i.e., at 2, 4 and 8m East and West from the row of poles, using pyranometers (type SP-110, Apogee Instruments). At the same positions, also air humidity and temperature (type CS215, Campbell Scientific), soil water content (CS616, Campbell Scientific), soil temperature (type 107, Campbell Scientific) and soil water potential (type Teros21, Meter Group) are assessed.

Hence, starting from the growth season of 2022, we will evaluate the impact of the partial shade conditions on crop productivity for a range of well-selected crop varieties, and with a focus on cereals (wheat, barley and/or triticale), grasses or grass-clover mixtures, as well as leguminous crops (e.g., soybean). First methodological experiences and the trial with grass-clover mixtures currently in place will be presented at the EURAF 2022 conference.

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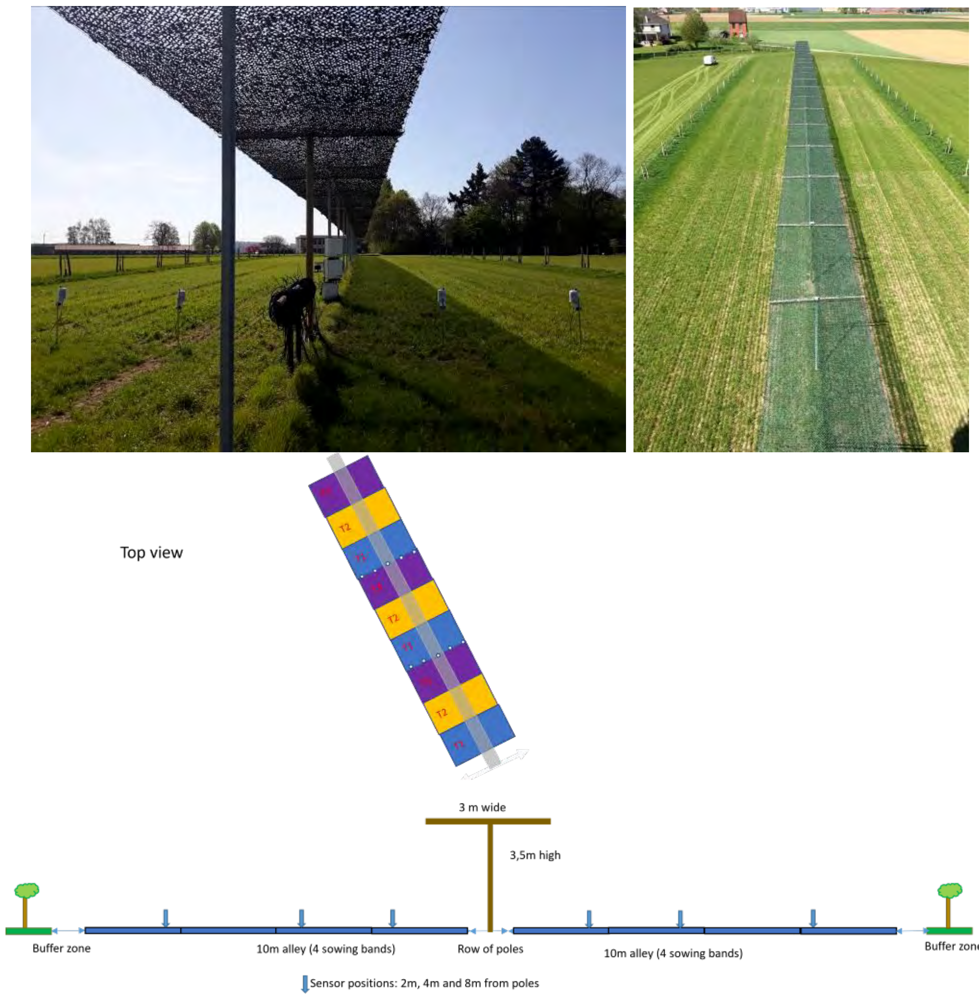

Figure 1. Artificial shade construction at the ILVO experimental site (Merelbeke, Belgium). Top: Field view with three treatments of grass-clover mixtures in the understorey crop Bottom: Experimental design showing the shade structure (grey bar) and the crop plots with their respective treatments.

Effect of trees on the phenology of dehesa grassland in the western Iberian Peninsule

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Theme: Crop and grassland productions

Keywords: Growing season, NDVI, PSRI, SAVI, Sentinel 2, Vegetation index

Abstract

The Iberian dehesa, a spatially heterogeneous system with strong seasonality, especially marked in the herbaceous stratum, has been identified as an example of adaptation and mitigation of the effects of climate change on Mediterranean pastures. In this system, the woodland facilitates the conditions for grass development, especially by lengthening the vegetative growth period of the grass. However, the balance between the positive or facilitating effects of trees and the negative or competing effects depends largely on soil and climatic conditions, varying between sites, seasons and years. Contrary to expectations, some studies suggest that, in drier conditions, the balance may be more negative. On the other hand, it is of interest to know to what extent trees can modulate the effects of increasing aridification of the climate on pasture productivity and quality. Therefore, large-scale spatial and temporal studies are needed to assess the net effect of woodland on grassland phenology.

The seasonal variability of pasture has been assessed in dehesas in the western Iberian Peninsula with a gradient of climate and structural complexity in terms of tree density. The study determines the influence of trees on pasture phenology analysing phenological metrics calculated from time series (period 2015 – 2020) of Sentinel 2 images: 12 metrics obtained using the derivative method from the NDVI (Normalised Difference Vegetation Index) and SAVI (Soil Adjusted Vegetation Index) indices and 3 calculated using the 50% amplitude method from the PSRI (Plant Senescence Reflectance Index) index.

The results show that (1) Sentinel 2 images are suitable for the determination of phenological metrics of dehesa grasslands and, (2) the greatest influence of trees on the phenology of dehesa grasslands is concentrated in a strip of 5 m from the crown perimeter, where the growing season starts earlier, with a difference of more than 11 days compared to grasslands more than 10 m from the crown. Moreover, the

length of the growing season is always longer for grasses located within 5 m of the canopy perimeter, with significant differences of between 14.2 and 21.4 days with respect to those located more than 10 m away. We conclude that trees do not reduce grass yields compared to bare pastures, but prolongs the growing season and stabilises grass yields over the years. By extending the analysis to woodland, the optimal stocking density for pasture production and woodland in different soil and climatic regions.

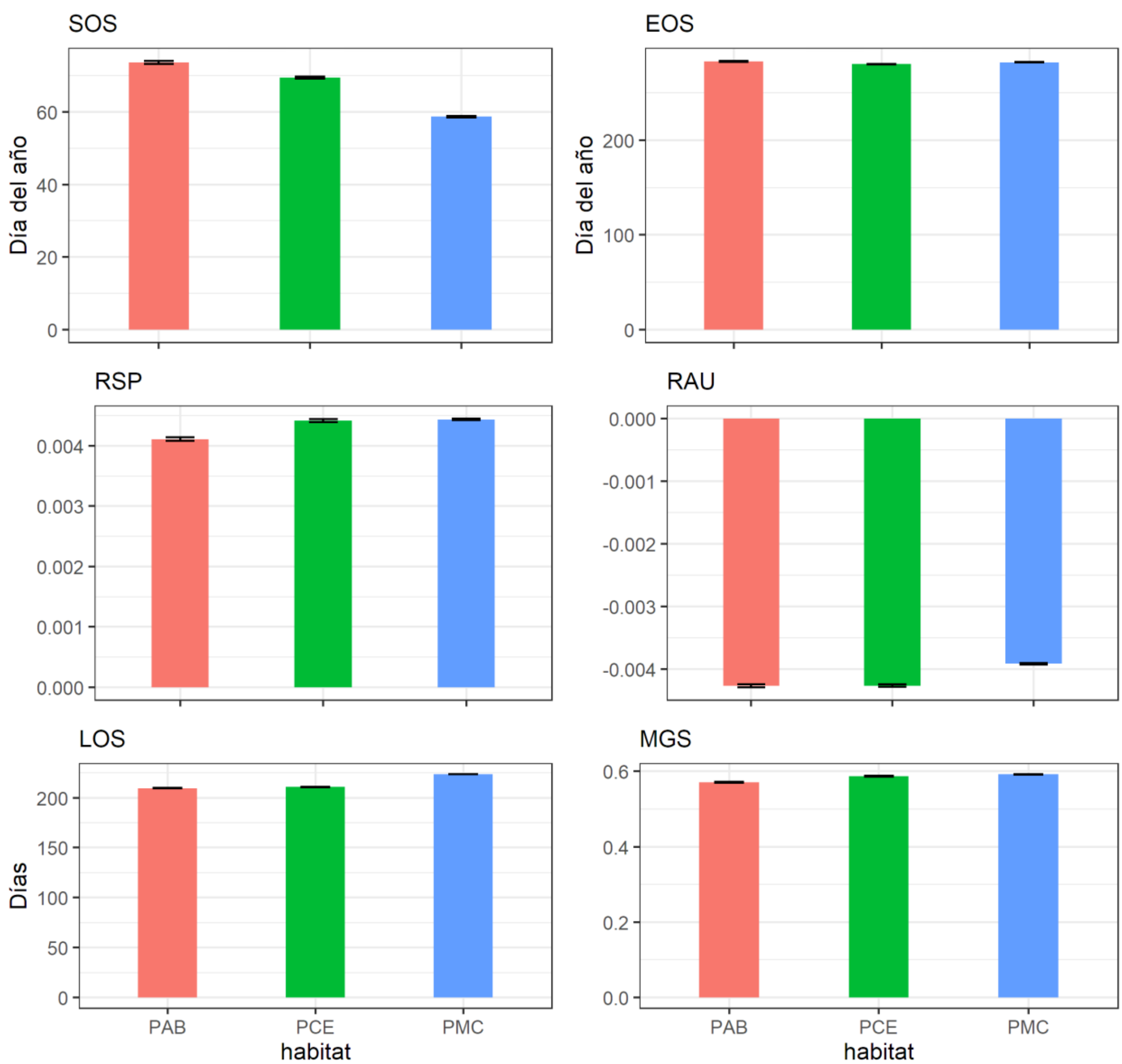

Figure 1. Mean value of SOS (Start of Season), EOS (End of Season), RSP (rate of greenup), RAU (rate of senescence), LOS (Length of Season) and MGS (mean growing season value) obtained from the SAVI time series, in open (PAB), near (PCE) and very near to trees (PMC) grass pixels of the Iberian dehesas

Light reduction affected agronomic performance and nutritive value of temporary grassland swards in a Mediterranean rainfed plot trial

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Theme: Crop and grassland productions

Keywords: Intercropping, slats, shade, sulla, forage, transmittance, alfalfa

Abstract

In Italy, traditional olive orchards are characterised by low tree density (100-300 ha^{-1}) allowing the cultivation of forage and crops under the tree canopy (Paris et al., 2019). Eichhorn et al. (2006), reported that in Central Italy there are 20000 ha of farmland identified as a silvoarable olive orchard. The intercropping of perennial legumes and trees is a key strategy to improve nutrient cycle of silvoarable systems, due to the higher amount of nitrogen (N) accumulated in stable forms in soil due by biological nitrogen-fixation (Hernandez-Esteban et al., 2019; Sanna et al., 2019), leading to a request for reduction of inorganic N fertilisation. Perennial legumes can also provide a continuous soil cover during the entire year reducing soil loss risk (Vallebona et al., 2016). In the Mediterranean basin, the most important perennial legume is alfalfa (*Medicago sativa* L.). Previous studies reported that alfalfa nutritive value was not negatively affected by tree presence (Mantino et al., 2021), whereas legume production was reduced due the competition for resources such as water (Nasielski et al., 2015), nutrients (Isaac et al., 2014) and light (Mantino et al., 2021). In Tuscany, sulla (*Hedysarum coronarium* L.) an autochthonous biennial legume is appreciated for its rusticity, productivity, and quality and it is intercropped with Italian ryegrass (*Lolium multiflorum* Lam.) for a better utilisation as pasture.

In 2019, a rainfed field plot trial was established to evaluate agronomic performance and nutritive value of different perennial forage species grown under different levels of light reduction, aiming to start a selection of shade tolerant forage crops. In October, the plot trial was established in Pisa, on a clay-loam soil with pH of 8.1 and 2.5 % w/w of organic matter content in the topsoil (0-0.3 m). Before sowing, 100 kg ha^{-1} of P_2O_5 were applied. The experimental layout complies with a two-factor randomized complete

block design with four replicates (18 m^2 sizing each plot). The first factor included five different swards: i) sulla cv. Silvan, (ii) ryegrass cv. Teanna, (iii) mix of sulla cv. Silvan and ryegrass, 50:50 (iv) mix of sulla cv. Silvan, sulla cv. Chiara Stella and sulla cv. Bellante 33:33:33 and (v) alfalfa cv. Messe. The second factor included three increasing shading levels: S0) the control representing full light availability, S25) and S50), corresponding to a reduction of potential light availability of 25 and 50% respectively. As previously tested by Varella et al. (2011), shading was provided by woody slats, N-S oriented, 2.0 m long and 0.10 m wide, with a distance between each slat of 0.10 m for *S50* and 0.20 m for *S25*, covering a total surface of 4 m^2. After sowing, slats were placed at 0.8 m above ground level. Yield and nutritive value of herbage mass and N^2 fixation were evaluated for two consecutive years. Herbage biomass was not affected by the reduction of the 50% of light in ryegrass and ryegrass-sulla mixture while it was negatively affected in alfalfa and sulla. Conversely, the 25% of shade level had no effect on legume yield.

Figure 1. Picture of the experimental site (from L.G. Tramacere, 2020)

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Grazing sheep in commercial orchards after bud break: technical lockups and challenges regarding damage to trees and risk of copper poisoning

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Theme: Crop and grassland productions

Keywords: sheep, orchard, fruit trees, organic, crop-livestock integration, chronic copper poisoning, fodder tree, grazing/browsing transition

Abstract

Associating sheep grazing with fruit growing can provide benefits on both sides, helping reduce the recourse to mechanical or chemical weeding, and providing additional feed to the animals. While this practice is readily implemented in traditional 'pastured orchard' systems, it is yet to be applied at wide scale to commercial, low-stem orchards. Moreover, while grazing orchards during the vegetation period (bud break to leaf fall) optimizes ground cover management and resource use, trees are then vulnerable to browsing or barking damage by sheep, and the animals could be subject to health issues linked to the use of plant protection products.

In order to help develop this practice, we studied the behavior of shropshire and prealpe sheep in orchard conditions, trying to decipher the factors that lead to tree consumption, and testing several tree protection setups. On the other hand, we performed blood and pasture samplings to monitor the risk of chronic copper poisoning, which has already been identified as a potential danger for sheep grazing in organic vineyards during plant dormancy (Trouillard et al., 2021). We also estimated the additional expenses or savings triggered by the sheep/orchard association.

Our first results indicate that branch-borne electrical devices have good efficacy to prevent leaf consumption by sheep, but that this setup is expensive and time-consuming, and the induced inhibition only persists for a few days. Olfactory repellants based on sheep feces slightly delayed leaf consumption, which can be of major importance if sheep are introduced in orchards at high stocking rate during a short period. Copper concentration in the cover vegetation of organic orchards can be very high during

spring (up to 156.9 mg Cu/kg dry matter), but this did not induce a long-lasting increase of chronic copper poisoning indicators.

Figure 1. Shropshire sheep grazing and browsing organic apple orchards at the EPLEFPA Le Valentin, France

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Yield and quality of arable crops in temperate alley cropping systems during the first decade after tree establishment.

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Theme: Crop and grassland productions

Keywords: silvoarable agroforestry, alley cropping, maize, wheat, barley, potato

Abstract

Whereas agroforestry has often been suggested as a tool to combat several of the issues encountered in sole cropping agriculture (Bergeron et al., 2011; Torralba et al., 2016), new implementation remains limited in large parts of NW-Europe (Reisner et al., 2007). One key factor is the lack of a detailed estimation of expected production levels and profitability (Borremans et al., 2018). As shown in previous research in temperate climatic conditions, combination of woody features with annual crops may result in reduced yields of the latter (Pardon et al., 2018; Reynolds et al., 2007). Besides the delivery of other ecosystem services, one of the premises of agroforestry is the potential to (at least partly) compensate for these reduced annual crop yields by the production of marketable goods by the tree component (e.g. fruit, nuts, wood). However, the production of the latter often does not occur during the first years after tree establishment, resulting in a lag phase where the farmer is confronted by net production losses. Hence, estimation of the crop yield reductions during this initial lag phase is key to assess the financial viability of foreseen agroforestry implementations for the farmer on the one hand, as well as to aid in estimating desirable levels of governmental support throughout the initial stage after tree establishment on the other hand.

In NW-Europe, maize (Zea mays L.), potato (Solanum tuberosum L.), wheat (Triticum aestivum L.) and barley (Hordeum vulgare L.) are among the most frequently cultivated arable crops (FAO, 2018). In this study, we assess the yield and quality of these main crops when cultivated in an alley cropping system throughout the first decade of tree growth. Six arable alley cropping fields were selected (year of plantation varied from 2011 till 2014). On each field, three transects are established between two neighbouring tree rows (Figure 1). The transects are located perpendicularly to the tree rows and consist of six measuring plots located in the arable zone at 2, 5 and 12 m of the closest tree row. In each sampling plot a yearly measurement of crop yield is conducted (tonne ha^{-1} and crop-relevant quality parameters). The results of both crop yield and quality are expressed as a function of tree height and distance to the trees (Figure 1).

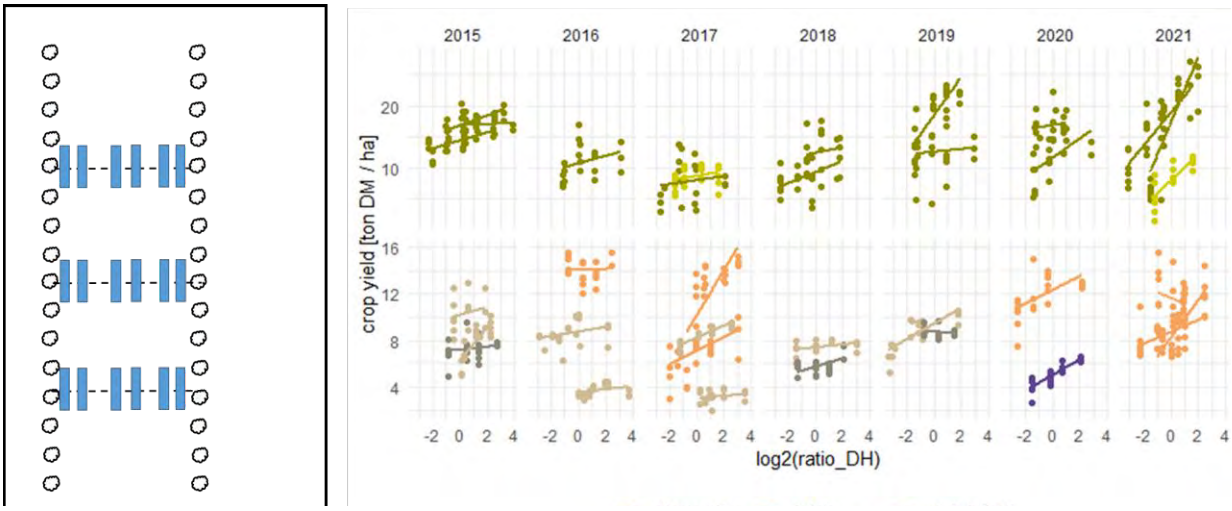

Figure 1. Experimental setup for crop yield measurements (left, after Pardon et al. 2018) and preliminary yield results (shown for tonne DM ha^{-1}) for each crop as function of distance to the tree row x height of the tree row^{-1} (right).

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Grafting: a sustainable agricultural tool to face climatic stressful conditions in hazelnut (*Corylus avellana* L.)

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Abstract

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Theme: Crop and grassland productions

Keywords: Crop management, Corylus colurna, root system, ecophysiology

Abstract

The hazelnut is an economically important tree in many countries, with an average world annual production of about 865,000 mt. The European hazelnut (Corylus avellana L.) is the most widely cultivated species in the world, showing an increasing trend of geographical expansion caused by the strong demand from the confectionary industry. This species is sensitive to water stress given its low capacity of stomatal control and its shallow root system mainly spreading in the top 0.4–0.5 m of soil depth. Therefore, climatic summer stress is detrimental to hazelnut yield, especially in the second part of July and in the first half of August, when maximum oil accumulation in the kernel occurs.

Commonly, C. avellana produces many suckers from the base of the trunk, and this natural sucker production must be regularly controlled (de-suckering using herbicides or mechanical tools) to attain efficient agricultural practices. This has negative effects on production cost, the environment, and the spreading of diseases. In contrast, the Turkish hazelnut (Corylus colurna L.) is a large single-trunk tree with no sucker production (Figure 1). The use of low/non-suckering rootstocks, selected from C. colurna, for propagation of C. avellana can permanently reduce the need for mechanical or chemical de-suckering. Experiences with C. colurna grown in the USA have shown that forms of this species are more drought tolerant and cold hardy than C. avellana cultivars due to a very sturdy root system and a vertical pile root

distribution that can reach a depth of 3–4 m. While hazelnut plants are mainly propagated by rooted suckers and layering, in recent years the use of grafting on rootstock propagated by seed has been growing. Existing studies related to hazelnut grafting practice have focused on plants agronomic aspects, propagation techniques, or yield and fruit quality, ecophysiological aspects of grafting have not been addressed up to date. There is still a lack of mechanistic understanding on how grafting on C. colurna rootstock affects the vegetative development nut production and ecophysiological variables related to water uptake and carbon assimilation and allocation in C. avellana. Considering the complexity of the interplay between plant physiology, plant productivity and environmental conditions, the integration of multiple tools is crucial to understand hazelnut growth dynamics.
In this study, grafted and own-rooted young hazelnut plants of three high-quality cultivars were cultivated in Central Italy to investigate possible differences in growth, fruit and flower production, and physiological processes encompassing water uptake, photosynthetic variables, and non-structural carbohydrates (NSC) allocation. Gas exchange measurements and stable isotopes characterization were used to study carbon and water fluxes in plants.
The grafting combination improved the photosynthetic performance that was related to the possibility of access to deeper soil water layers, supported by variation in NSC allocation to belowground organs. In terms of acclimation and adaptive processes, the higher stomatal reactivity to the seasonal gradient of environmental conditions observed in the grafted plants suggests that these plants exhibit higher phenotypic plasticity and have the potential to better tolerate thermal variations and drought conditions during the vegetative season. On the contrary, the lower capacity of stomatal control makes the own-rooted plants more vulnerable to climate changes. At the same time, the higher storage carbohydrate content observed in root of grafted plants is a particularly positive trait in the view of the role of belowground carbon stocks in mitigating events causing unbalance at the source–sink level. This carbon ensures survival when the supply of carbohydrates is lacking due to prolong stressful conditions, allowing to avoid C starvation.

Figure 1. Own-rooted plant (on the left) and grafted plant (on the right).

A remote sensing approach to assess the stability of forage production from legume-rich mixtures oversown in Mediterranean wooded grasslands

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Theme: Crop and grassland productions

Keywords: legume oversowing, silvopastoral systems, NDVI stability

Abstract

Grassland improvement by sowing legume-rich mixtures is gaining importance since this practice can enhance forage availability (Hernández-Esteban et al. 2018), improve soil fertility (Bondaruk et al. 2020), and enhance microbial diversity, thus N fixation and C sequestration (Moreno et al. 2021). Legume oversowing can be expensive to implement in silvopastoral farms due to the high cost of seeding mixtures. Nevertheless, legume-based forage systems can represent a means facing the raising input costs (e.g. fertilisers). The hypothesis of this study is within the insights of satellite Remote Sensing as a tool to estimate grassland forage availability. The objective of this study was to assess, through Landsat time-series, the impacts of legume-rich mixtures oversowing on the forage production and temporal stability in Mediterranean silvopastoral systems.

The study was conducted at six Dehesa farms located in Extremadura, Spain. Wooded grasslands are managed through continuous grazing of mostly cattle, pigs, sheep, and wild cervids. In each farm, legumes-rich mixtures (*Trifolium subterraneum*, *Ornithopus sativus* L., *T. incarnatum* L., T. michelianum Savi, *T. resupinatum* L., *T. vesiculosum* Savi, and *T. glanduliferum* Boiss) have been sown over years (from 2002 to 2015) in large fields. Vectorial objects identifying trees were created processing PNOA orthophotos with the eCognition© software. At least three per year spring Landsat uncloudy images (USGS, https://earthexplorer.usgs.gov) were collected starting from 4 years before the first sowing to 2019. The Normalised Difference Vegetation Index (NDVI) values were calculated and pixels with at least 70% of open-grazing-area were identified using the functions of the "raster" package within the R environment. A mixed-effect model was run to test the effect of both period (before vs after sowing) and age (years to/from the sowing) on NDVI. NDVI stability analysis identifying pixels having Stable-High (SH), Stable-Low (SL), and Unstable (U) NDVI was performed according to Basso et al. (2019). To test how long the

differences between stability classes lasted after the sowing, a sensitivity analysis was carried out by performing a paired t-test (before vs after) one age at a time.

The period significantly ($P<0.001$) influenced the NDVI, which was significantly higher after than before the sowing, while any significant trend of NDVI was observed. The sensitivity analysis highlighted that significant differences between periods (after>before) in the SH area can be observed up to including the 6th year after sowing. Significant differences (after<before) between periods in the U area can be observed up to the 4th year after sowing. The stability map referred to the Farm1 is reported in Figure 1.

The lack of significant trends of NDVI suggests that the positive effect of legumes oversowing could be persistent for a long time (>10 years). However, the increase of stable and high-productive areas is significant only in the short-mid term after sowing, suggesting the presence of environmental factors (e.g. P availability) affecting the spatial variability of forage production. These preliminary results suggest that the impacts of the legumes oversowing could be an effective long-term strategy to improve forage production and thus to enhance ecosystem services in Mediterranean wooded grasslands.

Figure 1. Stability Class map at the Farm1 (Atoquedo) in sown areas before (left) and after (centre) sowing, and in control areas. The map reporting the stability classes after sowing refers to the period from sowing to the 4th year after sowing, according to the sensitivity analysis. SH = Stable and High NDVI; SL = Stable and Low NDVI; U: Unstable NDVI.

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Effect of reclaimed water on corn plants' height intercropped with trees in a silvoarable alley plot.

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Theme: Crop and grassland productions

Keywords: agriculture, water scarcity, circular economy, water management,

Abstract
Water represents the limiting factor of agricultural production in the Mediterranean basin due to its increased demand irreversibly to its availability. This limited availability has increased the past few years, mostly due to climate-induced factors. Agriculture represents in the Mediterranean the major water consumer, requiring more than 70% of the total available water. This situation demands uptake of immediate actions before water scarcity results in irreversible conditions to agricultural production and to natural resources, such as soil. Water reclamation represents a viable and promising solution in particular for agricultural use. Under the framework of the HYDROUSA (HORIZON 2020) project, an experiment was established in the island of Lesvos. An agroforestry experimental plot (silvoarable with trees in alleys) was established where trees were planted in rows with annual crops. Trees included quince, apple, fig and almond trees while annual crops included sweet corn. The experimental design was a split-split plot design. Reclaimed water was used to irrigate half of the crops while tap water was used for the other half. The experiment was concluded by the harvest of the annual crop (corn). All parts of the corn plants were measured (counted and/or weighted). The use of reclaimed water had a positive effect on corn height. In particular, corn plants were, on an average, 70 cm higher that the ones irrigated by tap water. The results are promising for the use of reclaimed water in water demanding crops such as corn. A major challenge that needs to be overcome is public acceptance by the end users and particularly the farmers.

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Promising growth and yield results in two contrasting wheat varieties within a poplar alley-cropping system: effects of distance from the tree row

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Theme: Crop and grassland productions

Keywords: agroforestry, wheat varieties, poplar clones, morphological key traits, leaf senescence, grain protein

Abstract

The implementation of high-productive alley-cropping systems will be achieved through a deeper knowledge on the multiple tree-crop interactions that affect growth and yield of crops. A field trial was conducted during the 2020-21 growing season at the "Sasse Rami" pilot farm of Veneto Agricoltura (VA), located in Ceregnano (Rovigo, NE Italy). The aim was to investigate the impact of an alley-cropping system with N-S oriented 40-m apart rows of poplar trees planted along drainage ditches, on growth, yield and quality of two common wheat varieties with different grain protein content.

Two common wheat varieties were sown in the inter-rows of poplars, i.e., var. Arkeos (CGS Sementi, Terni, Italy), classified as biscuit-making wheat, and var. LG Ayrton (Limagrain Italia, Parma, Italy), classified as ordinary bread-making wheat. Each variety was intercropped with two poplar clones (*Populus* × *euramericana*) type HES (High Environmental Sustainability) differing for the timing of leaf sprouting, i.e., early in Moncalvo and medium-late in Mella. For each wheat variety × poplar clone, 1-m^2 area of wheat was sampled and/or observed along transects orthogonal to the poplar rows towards both east and west directions, at three distances from trees, named ½H (+6m), H (+12m) and C(+20m), where H is the tree height and C is the centre of the alley (control).

From the flowering stage, a higher leaf greenness (NDVI) was measured in wheat plants at ½H and H distances as compared to controls, significantly for the var, Arkeos. The leaves-to-culms DW ratio was increased by 28% in the var. Arkeos and by 11% in the var. LG Ayrton, as an average of ½H and H positions vs. C. Similarly, the leaf area index (LAI) was significantly higher in ½H and H, with the largest variations again in Arkeos (+43% vs. C) compared with LG Ayrton (+14%). Interestingly, grain yield was not reduced in proximity to trees, rather showing a trend as compared to controls, i.e., +4% for LG Ayrton and +13% for Arkeos ($p \geq 0.05$). Grain protein was generally low (grand mean 9.7%DW), although a clear improvement

was measured close to tree rows (average of ½H and H), with the greatest variations in Arkeos (+2.1 vs. C, absolute value) than in LG Ayrton (+0.9).

Arkeos showed higher plasticity for many morpho-physiological parameters in response to the distance from the tree row and poplar clone (centroids more spaced apart in MDA), rather than LG Ayrton (Figure 1). With regards to the var. Arkeos, higher yield and grain quality parameters were associated with intercropping with the poplar clone Mella (medium-late), than Moncalvo (early), possibly due to lower competition for solar radiation.

There is reasonable scope in screening wheat ideotypes for agroforestry, since contrasting responses to tree proximity were highlighted depending on variety choice. In this case, the "biscuit-making" variety showed higher adaptability to intercropping, on account of the magnitude of both yield and quality increases and morpho-physiological plasticity exhibited close to trees. Some morphological traits studied here, such as the leaves-to-culms biomass or area ratio, and a delay in leaf senescence, can be proposed as key traits in future selection for efficient agroforestry systems.

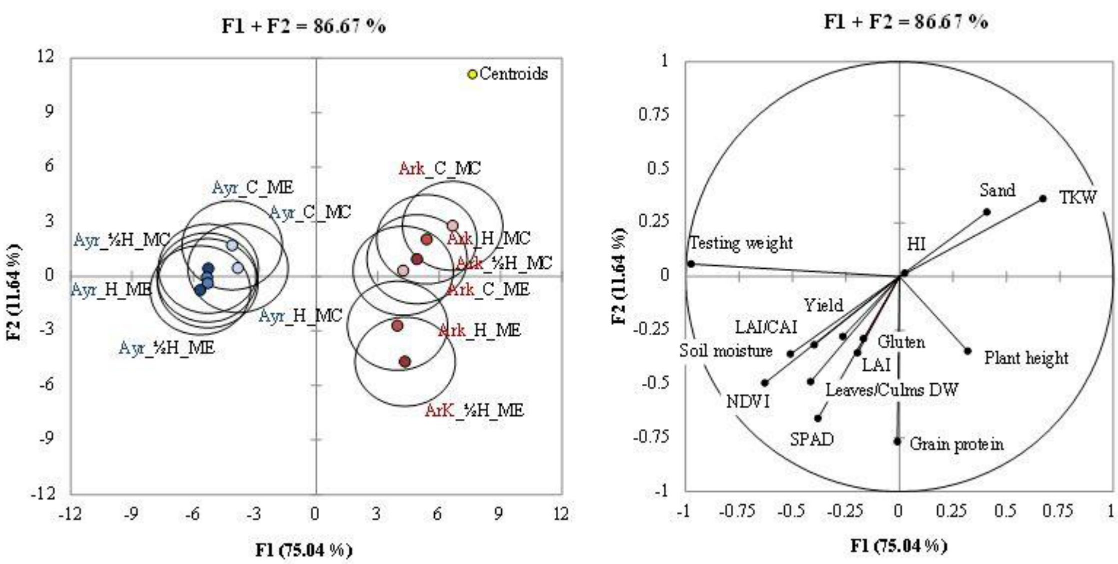

Figure 1. Multigroup discriminant analysis (MDA; left) and principal component analysis (PCA; right) for yield and quality parameters, and soil moisture and percentage of sand in soil texture, of wheat varieties Arkeos (Ark) and LG Ayrton (Ayr) within the sampling points at ½H, H and C distance from the tree row of the two poplar clones Mella (ME, medium late foliation) and Moncalvo (MC, early). TKW: thousand kernel weight; HI: harvest index. LAI: leaf area index. CAI: culm area index

Moderate Shade Effects in a Temperate Silvoarable Agroforestry System in Switzerland

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Theme: Crop and grassland productions

Keywords: temperate agroforestry, silvoarable, shade, understorey growth, barley yield

Abstract

The potential of silvoarable agroforestry systems has not been exploited in temperate climate. One major impeding reason for adopting agroforestry in non-tropical regions is the competition for light. This study addresses light competition in a temperate agroforestry system in Northern Switzerland. Summer barley (*Hordeum vulgare* L.) was grown as an understorey crop under 90%, 40%, and 0% artificial shade nets, respectively, with and without irrigation and/or fertilisation. The 40% and 90% shade treatment reduced yield by 11% (2.46 ± 0.63 SD tons per hectare) and by 26% (2.04 ± 0.63 SD tons per hectare), respectively, compared to the control treatment (0% shade). Heavy shade reduced barley yield significantly, while the decrease of medium shade was not significant. This study demonstrates that moderate shade may not be a limiting factor for understorey crop yield in silvoarable agroforestry systems.

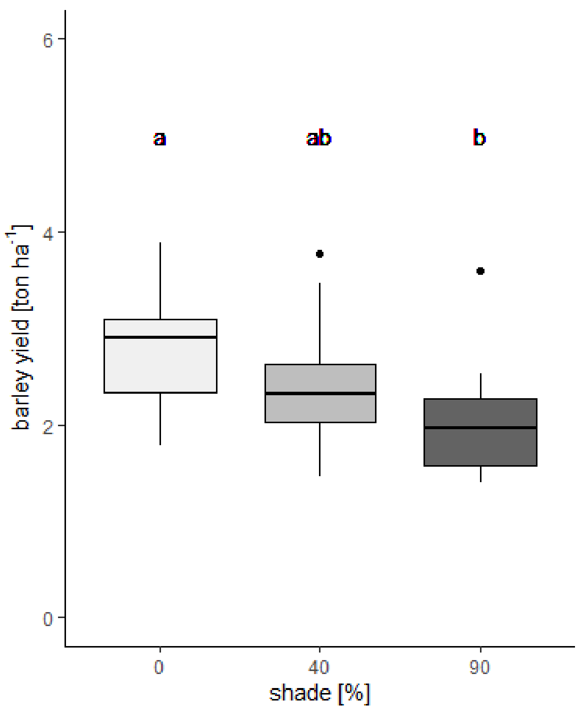

Figure 1. Barley yield in an agroforestry system in Northern Switzerland (Windlach). Yield decrease was significant between 0 and 90 % shade treatments and not significant between 0 and 40 % and 40 and 90 %, respectively

Agroforestry with mixed character: latex, fruit and wood production: income diversity and agricultural occupation

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Theme: Crop and grassland productions

Keywords: *Hevea brasiliense, Theobroma cacao*, agricultural revenue diversification

Abstract

Rubber tree (Hevea brasiliense) is a native species with great potential to exploit latex, which is demanded by countless products with highlights for the production of tires and gloves and other essential artefacts especially in this moment of pandemic that the world is living. In addition to latex, the rubber tree has the advantage of being able to use its wood or for chip production or for the furniture industry (a sector that is developing in the country and new research in the area is being carried out). Its cultivation in an agroforestry system – AFS (agroforestry) can become more advantageous due to the long period of immaturity of the culture for entry into bleeding. Your systems presented are agroforestry diversification in simple AFS, with the banana culture in the region of Araçatuba/SP and with cocoa in the region of Olympia/SP. SAF is added to a crop such as the dwarf banana (Musa acuminata 'Dwarf Cavendish') and cocoa (Theobroma cacao) in these systems to anticipate the return on the investment made with the rubber tree implantation. Crops planted in the middle of the rubber tree, were implanted at low cost (banana seedlings purchased from neighbours to low values and seedlings made through fruit seeds brought from Pará (cocoa) using the labour already existing in the properties for planting, fertilising and conducting these cultures, and the Rubber tree. The systems used are providing extra income and advance for the properties and better occupation of the area (diversification); this document serves as a formatting template for authors submitting an abstract to the EURAF 2022. It contains all the necessary

style elements for you to prepare the abstract in the selected format. This abstract will be used to assist the organisers in selecting papers for presentation and in designing the programme.

Figure 1. Rubber tree and banana above and Rubber tree and cocoa below

Effect of mixed sheep and goat grazing on the structural dynamics of *Ulex gallii* plants.

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Theme: Crop and grassland productions

Keywords: shrublands, heathlands, gorse, grazing livestock, small ruminants

Abstract

Ulex gallii (gorse) is the predominant woody species in the Atlantic heathland of northern Spain. Its presence in the bush as a dominant species indicates poor livestock use, a reduction in biodiversity and a clear risk of causing fires with adverse ecological effects. Its dominance and strong growth also indicate soils capable of supporting productive herbaceous pastures for extensive livestock farming.

The almost disappearance of grazing by small livestock (sheep and goats) is one of the possible causes of the heavy shrubbing by *U. gallii* in the Atlantic heaths of northern Spain. In this work we analyse the effect of mixed grazing by sheep and goats on the structural dynamics of this plant species, with the aim of studying its plasticity and tolerance to defoliation of its shoots.

The experiment was carried out from 2019 to 2020, and the grazing season was from May to October. Periodic destructive sampling of *U. gallii* branches was carried out in transects in two contiguous areas, one with active sheep-goat grazing since the previous year, and the other with residual grazing by cows and mares. Branches and different components of their stems and shoots were measured (heights, weights and counts). Multifactorial analysis of 18 of these variables grouped into 6 structural units explained 70% of the total variance with the first 3 axes. Axis 1, related to the number of flowering shoots/fruit, was the one that best separated the plants according to the type of grazing and throughout the season, with higher values in the branches without goat-sheep grazing and at the end of the season.

Microclimate analysis of an alley-cropping system of biomass poplars and corn in a Mediterranean coastal area.

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Theme: Crop and grassland productions

Keywords: wind attenuation, soil analysis, soil moisture, leaf water potential

Abstract

Due to climate change, environmental challenges such as heat waves, drought and exceptionally strong winds are posing greater risks to agriculture (Van Meijl 2017). Many studies have demonstrated how agroforestry systems can help farmers face such challenges, as they improve soil fertility and reduce evapotranspiration (Awazi and Tchamba 2019; Tsufac et al. 2019). However, the extent to which these systems reach greatest crop productivity depends on knowledge related to the environmental conditions within these systems and the ecophysiological performance of the intercrops.

This study assesses environmental conditions in an alley-cropping system with rows of hybrid poplar short rotation coppice, and their effects on soil and plant water content inside the alley. It was conducted at the Centre for Agri-environmental Research "Enrico Avanzi" of the University of Pisa (Lat. 43.68, Long.10.34), located in the Arno river plain close to the Mediterranean coastline. In the alleys corn was sown in May 2021 and harvested in September (Figure 1).

Micrometeorological conditions were analysed outside (control) and inside the alleys: wind speed and direction were measured with bidirectional sonic anemometers, and exposure to short-wave radiation in the alley was calculated according to the 3-D solar and tree geometry. Soil moisture was measured continuously at a depth of 0,2m, and manually at three depths, along a transversal transect. The water

status of the corn was assessed by measuring leaf water potential from pre-dawn to late afternoon, over three days during its growth period.
The area is characterised by a NW sea breeze from 12:00 to late afternoon, and results showed that relative to an upwind reference point, the first row of poplars reduced wind speed by approximately 20% and the second row by 50-70%. In addition, the main wind direction was diverted by 45° during these hours, creating a westerly flow within the alleys. Due to the growth in tree height, the shading effect increased over the course of the summer: from June to September, the proportion of ground in shade (average from 9:00-17:00) increased from 23% to 41%, with the two external thirds of the alley most affected. Soil moisture was highest in the central part, where the corn was larger in height and volume, while soil in the eastern part was drier and warmer.
Corn in the control plot showed lower water potential than the plants in the alley. In addition, the poplar shadow contributed to the plants' recovery in water status later in the day, especially on the west side of the alley which became shaded earlier in the afternoon. Prolonged shade in the external sides of the alley has counteractive effects, especially in the eastern part which is exposed to more direct sun and higher temperatures, mainly resulting in scarce crop and soil cover.
Therefore, in order to guarantee optimal growth conditions for crops in such alley cropping systems, the management of associated trees on the basis of their height is crucial.
This work is part of the EIP-AGRI Operational Groups (Tuscany RDP 2014-2022) "NETWork for agroforestry in TOscaNa - NEWTON".

Figure 1. Photo of the alley cropping system: corn intercropped with poplars for biomass production (Centre of Agro-Ecological Research "Enrico Avanzi" CiRAA CIRAA, University of Pisa)

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A user-friendly decision tool for facilitation of fruit trees choice

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Theme: Crop and grassland productions

Keywords: decision tool, fruit trees, design

Abstract

In France, farmers are getting more and more interested in integrating trees in their agroecosystems, thanks to the French plan called « Plantons des haies » giving substantial subsidies for plantations. Breeders also consider the multiple interests of trees for broilers or even ruminants. Fruit trees are among the preferred tree species, as they deliver multiple services like all trees, but they can also produce fruits for animals, for farmers themselves, or for diversification of the farm incomes.

However, choosing fruit trees is a tougher job than choosing timber species, as fruit trees (including their rootstocks) are more sensitive to a great diversity of pests and diseases, making it much more complicated to have regular yield when an inappropriate choice is made. Additionally, few advisors are able to help the farmer willing to plant fruit trees, in regions where such crops are not well spread. For these reasons, members of the French 'RMT AgroforesterieS' (a network devoted to information-sharing about all agroforestry systems) decided to work on the development of a decision tool to help farmers in species, rootstocks and cultivars choice.

The tool was developed in 2021 by a group of students and fruit experts of the RMT network. The tool has specific objectives, as it is dedicated to (i) systems where fruit is a secondary production, not the main one, and (ii) agroforestry systems where determinants will not only be technical, but also socio-economical.

The main knowledge gathered helped to identify and order the main criteria that will have the most decisive impact on choice relevance. Soil quality, climatic conditions (drought/frost risk level) or technical complexity to grow the species have been sorted as most determining criteria. Other socio-economical traits had to be considered and added for such specific systems: labour requirement, harvest period, post-harvest constraints… as farmers have to manage other crops or livestock in priority. All criteria have been gathered and weighed under an algorithm, using R software. As a final output, experts gave a cultivar list for all 6 rosaceous species considered (apple, pear, peach, apricot, cherry, plum), according to the region where the grower is from: these cultivars are already known to be rather tolerant to pests and diseases, therefore more adapted to a low-input system, as growers in general won't be willing/have time to spray fruit trees.

The decision tool is now accessible on a R-shiny App, very easy for farmers to understand and use. It gives a ranking of a couple fruit species/rootstock according to the farmer's answers.

Next development stages will be the achievement of an optimal answer from the tool, with the use of secondary criteria when necessary.

Tree-bordered agricultural field in a temperate region: competition for light and water between crops and poplars (*Populus sp.*).

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Theme: Crop and grassland productions

Keywords: silvoarable agroforestry, tree-bordered field, tree-crop-soil interactions, light and water competition

Abstract

A central agroforestry hypothesis states that in order to have a performant agroforestry system trees should acquire water and nutrients that would otherwise not be used by the crop (Cannel et al. 1996). Although the amount of field studies about agroforestry is increasing lately, the research that quantifies the interaction between trees and crops in terms of water uptake and light is still limited, especially in temperate climates. Trees can both increase and decrease the water availability for the crops by different mechanisms (hydraulic lift, root water uptake, etc.).

A field located in Ypres, Belgium with an adjoining row of mature poplars (*populus sp.*) was used to observe competition for water and light in agroforestry systems during the growing season of maize (2016) and cauliflower (2018). A plastic barrier up to 1.2 metres deep was buried along a part of the tree-bordered zone between the tree roots and the field (Figure 1). In this zone most competition for water was excluded since the water uptake by the tree roots was cut off.

Measurements were performed on three treatments; reference (no trees), trees (competition for light and water) and plastic barrier (mainly competition for light). Granular matrix sensors (Watermark, Irrometer Co, VS) were installed to observe soil water potential in the agricultural field. Soil samples were collected on which volumetric soil water content was measured in the laboratory.

Both the data of the granular matrix sensors and soil samples during the growing season showed a significantly slower drop in water potential in the plastic barrier treatment compared to the reference treatment at 3.5 m and 9 m from the tree border. At a distance of 29 m from the trees, the poplars no

longer affected the soil moisture in the agricultural field. The magnitude of evapotranspiration by the trees during the growing season of the crops was calculated with the water balance model AquaCrop (Raes et al. 2018). Since AquaCrop can only calculate the water uptake of one crop, an artificial crop was defined that combined the water uptake of both the tree and the crop. The competition for light and water also had an impact on crop development and yield, with a yield decrease up to 90% for cauliflower and 73% for maize. When the growing season of the crop and the tree largely overlap (as in the case of maize), both the competition for light and water have an equal impact on yield. A crop planted later in the growing season in a dry summer, such as cauliflower in 2018, is mainly affected by the competition for light.

Water uptake by trees causes a significant lower soil water potential in the root zone of agricultural crops near the trees, leading to a yield decline of water-sensitive crops such as maize and cauliflower. As the age of the trees in agroforestry systems increases, it will become more important for the farmer to choose crops whose growing season overlaps as little as possible with the growing season of the trees.

Figure 1. polyethylene foil as a barrier between the tree roots and the field (Coussement T., 2016)

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Above ground biomass of intercrop according to the tree spacing

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Theme: Crop and grassland productions

Keywords: alley cropping, above ground biomass, intercrop, tree spacing

Abstract

Choosing the right tree species, the appropriate tree spacing, and the right crop which perform well in between the tree rows are the keys for a successful agroforestry farm.

In Hungary, it is subsidized to establish new agroforestry systems, yet the call has not performed very well so far, mainly because of the unfamiliarity of farmers of such systems, the complexity and lack of good examples. To address this issue, an alley cropping experimental site has been established. Some of the findings of this study may encourage decision makers to support, and farmers to consider applying agroforestry farming practices, as an alternative, sustainable land-use system in the region. This paper shows an insight to the above ground biomass of the intercrop which was grown in 2018 and 2019, when the trees were 4 and 5 years old, respectively.

A former energy plantation of black locust (*Robinia pseudoacacia* L.) was transformed to an alley cropping system in 2017 in Gödöllő, Hungary. Nine different planting spacing were acquired by removing certain tree rows, and some trees within the remained rows. No chemicals (no pesticide, nor fertilizer) have been applied since the plantation of the original stand in 2012 up until 2020. The intercrop was triticale (x Triticosecale), Maros variety, bred for human consumption. The control field was a site of triticale without trees (replacing the black locust stand). The site is located in an eroded undulating area, mainly characterized by Arenosol.

The treatments were the tree spacings and there were 6 of them in 2018 and 9 in 2019, as follows:

9 x 1, 9 x 2, 9 x 3 (only evaluated in 2019);

15 x 1, 15 x 2, 15 x 3;

21 x 1, 21 x 2, 21 x 3,

where the first number stands for the row spacing in meters, and the second to the in-row spacing. There were 4 replications.

There was no significant difference (p=0,05) between the treatments and nor the control, in the above ground biomass in 2018. In 2019 in the case of 21 x 1 the biomass was significantly lower (p =0,05) than the control, (and then the rest of the treatments), and it is likely to be an error. 15 x 2 and 15 x 3 were significantly higher than the control. This means, that the presence of the trees did not reduce the above ground biomass of the intercrop, but the actual space which was occupied by the trees in the field were the reason that the crop's biomass production per hectare was less than the control agricultural field, and even in some cases, the intercrop performed better between the trees. The highest above ground biomass (dry matter) in 2018 was 938,76 g/m2 observed at the 15 x 2 tree spacing, and the lowest was 703,40 g/m2 at 21 x 3. In 2019 the highest values were 679,69 g/m2 also at the 15 x 2 tree spacing, and the lowest values were noted at 9 x 3 yielding 307,63 g/m^2.

Exploitation of the GEE platform to monitor pastures in a Mediterranean silvopastoral system

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Theme: Crop and grassland production

Keywords: Forage monitoring, Google Earth Engine, Remote Sensing, Vegetation Indices

Abstract

Agroforestry ecosystems in marginal areas of the Mediterranean region are widely used for grazing, and play a primary role in enhancing the traditional landscape, as well as in achieving sustainable production (Bernués et al 2011) and maintaining biodiversity (Porqueddu et al 2016). Moreover, the study of forage resources (quality and production) in agroforestry ecosystems is essential to monitor wildlife movements and to manage livestock dynamics with reduced costs (Moreno et al 2018, Jose et al 2019). Optical satellite sensor imagery, which is increasingly available and free of charge also thanks to the Copernicus program (Showstack et al, 2014), provides an important contribution to grassland quality and production estimation. With the spectral configuration of the Sentinel-2 (S-2) optical sensor, with additional bands in the red-edge region, it is now possible to calculate several Vegetation Indices (VI) exploiting also these spectral ranges. In addition to the well-known Normalised Difference Vegetation Index (NDVI), the Normalised Difference Water Index (Serrano 2020), the Soil-adjusted Vegetation Index (SAVI), the Wide Dynamic Range Vegetation Index (WDRVI) (Lugassi et al,.2019), and Normalised Area Over Reflectance Curve (NAOC) showed high correlation with vegetation chemical parameters, along with an integrated multi-sensor approach (Raab et al, 2020). As satellite imagery has become more accessible, platforms such as Google Earth Engine (GEE) have been developed for fast, simple, and powerful data processing. GEE enables global data analysis by exploiting a large catalogue, as well as disseminating results to a wide audience through a simple web link (Gorelick et al, 2017). Our study is developed as part of the Boscolamento project (http://www.tellus.srl/boscolamento/), supported by GAL Maremma, on PSR funds, which involves the integrated use of grazing herd management innovative technologies, known as Virtual Fencing collars (Bishop-Hurley et al. 2007), with information on pasture status. The study area is a silvo-pastoral system in Maremma (Tuscany), with permanent grasslands in open woodlands exploited by beef cattle of Maremmana breed. Our contribution involves the development of a code on the platform GEE, which allows, starting from the coordinates of a single point, the computation of several VI for different buffer areas, the automatic time series visualisation through interactive plots, and the downloading of the data in .csv format. Thus, the vegetation indices are correlated to observed data (e.g. biomass, LAI, species composition, fPar, height, biomass and forage quality) measured along two grazing seasons (2020-2021). With our study, a code for pasture quality monitoring activities in agroforestry systems will be presented and disseminated freely. By this code, constantly updated VI are calculated so as to constantly monitor and estimate pasture growth, quality and production in a Mediterranean agroforestry system. Future perspective of this research will be the availability of information on pasture quality and production directly from the field via tablet or smartphones, by the development of Apps or WebApps integrated with the GEE system.

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The assessment of grasslands with trees and their extension in areas affected by prolonged drought during summer

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Theme: Crop and grassland productions

Keywords: Grassland with trees, grassland wit

Abstract
In the intra-Carpathian area and in the northern half of the Dobrogea plateau, which corresponds to the central part, respectively eastern part of Romania, there are frequent pastures with trees. These have resulted through a gradual reduction in the density of forests (usually oak).
For the evaluation of the grasslands, two neighboring grasslands were analyzed, one with trees (oaks) and one without trees. Within these were made determinations regarding the soil characteristics, evaluations on the composition of grassy and forest vegetation, quantity and quality of grass production, animal living conditions. The most obvious finding was that the diversity of herbaceous species and their quality as animal feed is higher in wooded grassland than in tree-free grassland.
Outside the Carpathian arch, in the hill and plain area, within the administrative area of any locality, there are areas classified as grasslands, but these are without trees. These are areas where the climatic conditions during the growing season are characterized by high temperatures, low rainfall, dry winds. Thus, during the summer, due to the frequent periods of prolonged drought and irrational grazing, the grassy forage production and its quality decrease, the animals being deprived of adequate food and shelter during grazing.
The introduction of trees on a grassland is difficult, especially since they have to be protected from animals and cope with the soil and climatic conditions specific to the open ground. It is, however, one of

the solutions for increasing the productivity and quality of tree-free grasslands and the only one in terms of improving microclimatic conditions.

The introduction of trees on grasslands is also an objective in the case of grasslands with trees, which tend to turn into grasslands without trees, as many of them have a small number of specimens per hectare, many of the trees are very old, make seeds rarely and they cannot regenerate any longer.

In a grassland without trees, located in the area affected by prolonged summer drought, on grassland were introduced to assess the costs and problems specific to afforestation. It was decided to introduce the trees in groups, because this option has the advantage both to create a microclimate favourable to their growth and to choose the trees that will remain in the pasture for a long time. These groups of trees are easier to protect when the grassland is grazed and as a result of competition between species, tree growth is more active, ensuring the expected protective effect in a shorter time. Also, this variant ensures a higher biodiversity, in groups being used by different species of trees as oak, ash, silver lime, maple.

Due to economic and social changes in the last three decades in Romania, not all grasslands with trees are properly cared for. However, these silvopastoral systems can serve as a model for tree-free grasslands in terms of their functions. The trees`installation on grassland contributes to the development of silvopastoral systems in Romania and increases the share of forest vegetation, which is very low especially in the plain area.

Acknowledgements

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Quantification of agroforestry effects in Denmark

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Theme: 2.1 Crop and grassland productions

Keywords: Temperate agroforestry, Shelterbelt, Biomass, Organic

Abstract

The role of temperate agroforestry (AF) for transition to sustainable food production is gaining increasing attention, both politically and academically (FAO, 2021). Research into AF systems across Europe, has documented several benefits of AF over conventional agricultural practices, including: increased production (Lehmann et al., 2020), better water and nutrient cycling (Quinkenstein et al., 2009; Zhu et al., 2019; Pavlidis et al., 2019), increased carbon (C) sequestration (De Stefano & Jacobsen, 2018) and increased biodiversity (Bentrup et al., 2019). While the area of farmland cultivated using AF practices is increasing, AF systems are only applied to a limited extent in Denmark, and the above-mentioned effects are yet to be assessed under Danish conditions. This research project will quantify the impact of AF on crop production, C sequestration, nitrogen (N) leaching, and biodiversity of soil organisms. Data collection takes place within a grass field and a grain field, both of which have a shelterbelt of mixed woody species located across the centre of the field. Data is collected on aboveground biomass production in fields and shelterbelts; C and N content in biomass, soil and soil water; and microorganisms in the soil. To quantify how far from shelterbelts the potential advantages or disadvantages of the trees affect the agricultural environment, samples are collected both from within the shelterbelt, and from the fields at distances of 2, 7, 15 and 25 m to the shelterbelt. The 3-year research project runs from 2021 to 2024, and data collection includes annual biomass harvests, monthly soil water sampling, shelterbelt biomass measurements, and analysis of two sets of soil samples. Preliminary data from 2021 on crop biomass production, and N content in soil, soil water and crop were analysed. The results indicate a huge effect of the shelterbelt on crop production at both sites. By 2024, the project will contribute to the assessment of the potential for AF systems in Denmark, and add to a solid, research-based foundation for optimising the design of temperate AF systems going forward.

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A global experimental dataset of intercropping and agroforestry studies in horticulture

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Theme: Crop and grassland productions

Keywords: agroforestry; intercropping; horticulture; data paper

Abstract

Intercropping fruit trees and vegetable crops in mixed systems is attracting more and more farmers in Europe (Léger et al. 2018; Lauri et al. 2019). There is also an increasing amount of research being conducted to understand the functioning of these complex systems (Do et al. 2020; Paut et al. 2021). Yet, so far, no dataset has been provided for a systematic synthesis of existing data on intercropping and agroforestry experiments in the specific field of horticulture. Therefore, the aim of the present work is to present a global experimental dataset of intercropping and agroforestry studies in the specific field of horticulture (fruit trees and vegetable crops).

The dataset includes, to date, results of field experiments published in 92 articles published between 1980 and 2017 covering 695 experiments worldwide (crop*field site* treatment combinations). The selected experiments were carried out over five continents on 11 trees and 67 vegetable crop species (Figure 1). We plan to complete the dataset with articles published after 2017. The dataset contains measurements of variables that are considered relevant for the analysis of agroforestry and intercropping experiments:

i. Basic publication information: Title, Authors, year, Country, Site (latitude, longitude).
ii. Crops and trees information: Species, Botanical family, Functional group (legume/non-legume), Plant functional type (C3/C4).
iii. Parameters of the experiment: Soil texture and pH, crop management (greenhouse/field conditions), type of fertilisation (organic/inorganic), Use of pesticides, intercropping pattern (strip, row, mixed), Intercropping design (replacement, additive), Density of each species, Sowing and harvesting dates, N fertilisation, Yields of pure and mixed stands, Standard deviation of yields, Land Equivalent Ratio (LER).

Data was extracted from tables, figures and text. Digitising the data from published scatter plots in the literature was performed with the WebPlotDigitizer tool (https://automeris.io/WebPlotDigitizer/). These data were assembled and harmonised according to the International System of Units. The dataset is

reusable and was designed to be updated. We also aim to establish a set of recommendations to design experiments on intercropping. We believe this will provide valuable data for more comprehensive analyses of intercropping and agroforestry systems in horticulture worldwide.

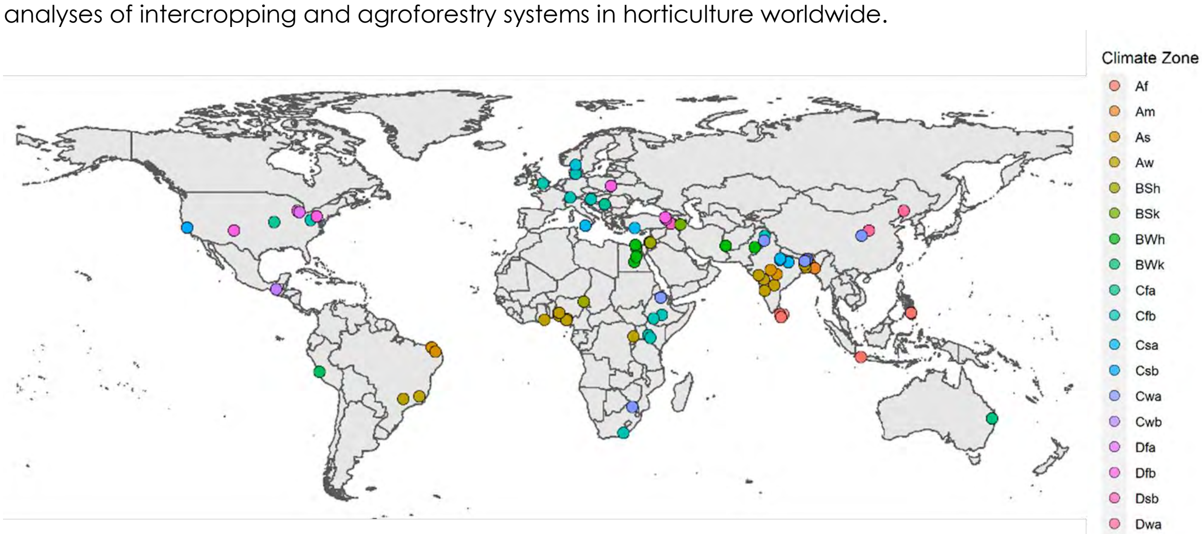

Figure 1. Latitude and longitude coordinates of the field sites included in the database. The Köppen-Geiger climatic classification was used to link each field site to a grid size with a resolution of 0.50 degrees of latitude by 0.50 degrees of longitude. Each Köppen-Geiger climatic subzone is indicated by a colour gradient

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Exploring the potential of late budding walnut (*Juglans regia*) varieties in temperate agroforestry systems: a long-term monitoring study in Flanders and the Netherlands.

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Theme: Crop and grassland productions

Keywords: silvoarable, alley cropping, walnut varieties, late budding

Abstract
Walnut trees (*Juglans regia*) are increasingly gaining interest among starting agroforestry farmers in Flanders and the Netherlands. The relatively open crown and late timing of leafing make them especially suitable in the context of alley cropping systems as this reduces the competition for light between crops and trees. Wood and nuts of walnut trees are also products with a high market value and therefore economically interesting to farmers. The increased attention of consumers for local and sustainable food production further emphasises the economic potential of local walnut production.
Although the range of hardy walnut varieties in Flanders and the Netherlands is expanding rapidly, more knowledge is needed to assess their potential and suitability for agroforestry systems in temperate regions. The timing of budding, for example, is a very important factor that varies considerably between different walnut varieties, ranging from March to June.
About 2% of seedlings are 'late' or 'very late' budding. Late or very late budding varieties could be a great asset to temperate silvoarable agroforestry systems. This variety dependent tree characteristic reduces the negative effect of shading on the underlying crops even more and could make the trees less vulnerable to night frosts. Hence increasing crop and tree production in the agroforestry system.
However, hardly any of these very late budding varieties are commercially available and there is no information available on their agroforestry relevant characteristics. Partners of the Flemish VLAIO project

'AGROFORESTRY 2025', coordinated by ILVO, recently initiated a long-term monitoring study to assess the potential of these late budding varieties in agroforestry systems.

Over the last 2 years, walnut experts screened the Flemish and Dutch landscape to identify very late budding (end of May – early June) walnut varieties. Grafts were collected and multiplied in a local tree nursery. In the winter of 2020 – 2021 these multiplied late budding varieties were planted in agroforestry systems by farmers and research institutions at 5 locations in Flanders and 2 in the Netherlands. In total 185 walnut trees were planted, accounting for a total of 18 different varieties. Each variety was planted in at least two locations and in triplicate. Reference varieties (commercial varieties) were planted at each location. Tree planting, protection and management was done as standardised as possible across experimental sites.

For a period of at least 10 years, and preferably much longer, these trees will be monitored yearly. The aim of this experiment is to compare the phenology, growth, health and finally also the nut production and quality between these different cultivars and commercially available reference varieties in the long-term.

T 2.2

TIMBER, ENERGY AND NON-WOOD FOREST PRODUCTIONS

Agroforestry vs. agrivoltaics: advantages and disadvantages of two approaches to combining food and energy production on the same land

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Theme: Timber, energy and non-wood forest productions

Keywords: Agrophotovoltaics, alley cropping, colocation, ecosystem services, electricity, water food energy nexus, sustainability

Abstract

Providing food and energy for a growing world population, while reducing both the environmental impact of agriculture and the use of non-renewable fuels, and without increasing agricultural land at the expense of forest and other natural systems, is an increasing challenge (Nonhebel, 2005; Rajagopal, 2007). One approach is to produce both energy and food on the same land, with systems that exploit possible synergies between the two productions (Dupraz et al., 2011). Understory crops can be grown under trees from which biomass for fuel productions can be obtained, in agroforestry systems, or under photovoltaic panels in agrivoltaic systems. Here, the advantages and disadvantages of these two approaches are compared in order to provide guidance to producers, policy makers and other stakeholders, and identify research gaps. The main advantages and disadvantages of both systems are summarised in Table 1. The two approaches, agrivoltaic and agroforestry for biofuel production, are very different, with relative advantages and disadvantages for both. Agrivoltaic appears to be more advantageous for energy production, due to producing energy more rapidly, efficiently and in a form directly usable (i.e. electricity). However, the discontinuous production, dependent on sunshine (thus on time of day, weather and season), and the distance from the electrical grid, pose some limitations. Agroforestry for biomass production appears to be more advantageous in terms of additional (i.e. non-provisioning) ecosystem services, such as preventing soil erosion and nutrient leaching, increasing biodiversity, soil organic matter, carbon sequestration and storage. Agroforestry can also provide additional products (quality wood and non-wood products). Agrivoltaic systems, although not directly sequestering and storing carbon, can still result in greater mitigation of climate change, due to their higher efficiency at producing energy, thus offsetting greater amounts of emissions from non-renewable sources. Their much higher efficiency also implies that much less land is needed to produce the same energy.

However, more research is needed to understand their long-term environmental impact. It is not clear if, and how, the components can be reused, recycled or disposed of, and at what cost and impact. In conclusion, the choice between the two systems appears to depend on the main objective of the enterprise and/or of the policy maker. Where energy production is the main goal, or where water is severely limiting, agrivoltaic systems might be preferable, assuming their long-term impact can be clarified, while agroforestry for fuel production might be preferable where other ecosystem services are prioritised/needed.

Table 1. Advantages and disadvantages of Agrivoltaic vs. agroforestry systems for energy production.

Agrivoltaics	Agroforestry for biofuels
Advantages	**Disadvantages**
High efficiency at converting solar radiation into usable energy	Low efficiency of photosynthesis (2-3%) and of biomass conversion into usable forms of energy.
Directly usable form of energy (electricity) with existing grids	Biomass requires expensive transportation and transformation to become usable fuels, with high economic and environmental costs
Radiation availability for energy and crops can be regulated by array design and, with tracking systems, also adjusted at will, according to instantaneous crop needs	Fraction of radiation used for biomass and crops can be regulated only partially with system design (trees grow and change size and shape) and management (pruning), but cannot be adjusted at will to instantaneous crop needs
Panels don't transpire water, nor uptake nutrients, thus not competing with understory crops (other than for light)	Trees often compete for light, water and nutrients with understory crops
Panels can be used to collect rainwater into storage facilities	Trees cannot collect water
Panels can protect crops and animals from sun, heat and the elements, particularly keeping them dry during rain	Trees can shade and cool crops and animals, perhaps more effectively (shade + transpiration) but not necessarily keep them dry
Panels and their supporting structures can be used also for other structures, like netting for hail or for insect protection	Trees can be used for some structures, like holding fencing, but not for others
Disadvantages	**Advantages**
Higher cost of installation and maintenance	Lower cost for planting trees
Higher environmental impact for construction, installation and disposal, but more data needed.	Positive environmental impact
Energy is produced only when radiation is available and cannot be stored onsite	Trees hold their biomass until harvested, and the biomass can be stored and harvested when needed
Some ecosystem services are provided, like energy production or shade, but not others like the ones described opposite for trees	Trees can reduce erosion and leaching, clean water, soil and air, increase biodiversity, sequester and store carbon, provide quality wood and non-wood additional products.
Short lifespan of panels and electrical infrastructure	Some trees are longer lived, although it depends on the species and the technique adopted to produce biomass.
Less attractive and often controversial aesthetically	More attractive and even desirable

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Lessons from physiological monitoring of truffle productive vs. non-productive plants

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Theme: Timber, energy and non-wood forest productions

Keywords: Climate change, truffle production, soil water availability, environmental sensors, plant sensors, tree physiology

Abstract

The ongoing climate changes are altering precipitation patterns causing the increase in the frequency and intensity of extreme events such as droughts (IPCC, 2014). Such climate changes have huge impacts on the productivity and health of plants and forests, and on the agroforestry production dependent on them. One of the most economically important non-wood forest production is truffle production: the market is growing worldwide, and attempts to spread and increase the cultivation of this product have been carried out in every continent (Reyna and Garcia-Barreda 2014). While the demand of raw material in this growing market is increasing, the natural truffle production is contracting (MiPAAF 2018).Climate change, along with land abandonment, is recognised as the main factor causing the decrease in truffle production.

To test the effect of water stress on truffle productivity we monitored trees in a hop-hornbeam plantation which is producing *Tuber aestivum* Vitt.. The trees follow a precise planting scheme and they all have almost the same age. We monitored 4 plants which are truffle-productive and 4 plants that are not productive. The monitored parameters are stem diameter variation (daily and seasonal), sap flow, soil and air temperature and humidity. The sensors used to monitor plants were Granier sensors (to measure sap flow), stem dendrometers (to measure continuous variation of stem diameter and bark shrinking and swelling), hygrometers, air temperature sensors, soil temperature and moisture sensors.

We observed a difference between productive and non-productive plants: the cycles of diameter variation are different between the two groups (productive and not productive). The bark shrinkage and swelling are linked with the cycle of hydration and dehydration and, thus, this suggests that there is a different response to variation in water availability between the two groups.

We believe that it is possible to improve the productivity of plants by applying a management model that considers the stress and recovery cycles of the plant and, therefore, its physiology.

Monitoring the plant means being able to choose when it is necessary to intervene. For example, it would be possible to choose irrigation only when certain conditions occur (soil moisture level that drops below a critical threshold, suspension of transpiration due to water stress). This new approach could save useful resources and make truffle cultivation more sustainable.

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Reconstruction of the tree growth dynamics in an historical agroforestry plot with dendrochronology to validate the Hi-sAFe biophysical agroforestry model

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Theme: Timber, energy and non-wood forest productions

Keywords: Alleycropping, modelling, climate variability, Hi-sAFe model

Abstract

In 1977, Claude Jollet, a farmer of the Charente-Maritime area in western France established a unique agroforestry farm on more than 45 ha, after clearing a forest. He planted wild cherry and black walnut trees and managed annual crops for more than 40 years between the walnut tree rows. Unfortunately, no records of tree growth were ever made until recently. In 2015, some walnut trees were harvested to document tree growth and timber quality. In 2019, we collected 13 stumps from these harvested trees and polished trunk slices. The slices were scanned to measure yearly growth rings width since plantation. Several methods were applied to synchronise the ring data. Several phases in the history of this agroforestry plot are evidenced by the variations of rings width over time, including some very fast growing years around age 20 and 30, and a low growth period in-between (around age 25). Tree growth rate declined steadily during the last 7 years. The collected data will allow a validation process of the Hi-sAFe model. Predicting year to year variations of tree diameter increment is a highly demanding criteria as it both depends on climate variations and crop management.

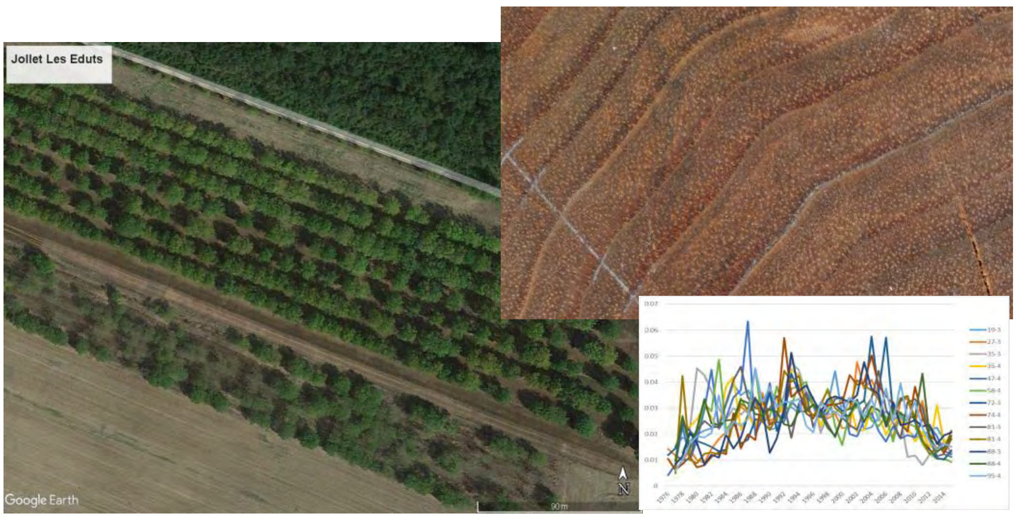

Figure 1. Aerial view of some of an alleycropping plot of the Jollet agroforestry farm (A), details of annual rings of growth (B), and variability of the 13 trees ring width profiles (C)

Light saturation point, radial growth and leaf phenology show the suitability of different species of the genus *Corylus* to live under a dominated tree layer

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Theme: Timber, energy and non-wood forest productions

Keywords: hazelnut, light availability, timber, shade tolerance.

Abstract

The interest in hazelnut cultivation for fruit is spreading among numerous European countries (e.g. Italy, Serbia, Bulgaria) to meet the increasing demand for nuts. Italy is projected to reach 90.000 ha of hazelnut crop by 2025. Still all these plantations remain organised as extensive monocultures that are highly exposed to biotic (e.g. *Haliomorpha halys*) and abiotic threatens (strong winds, atmospheric vapour pressure deficit (VPD) and temperature rise) due to their reduced biological and structural complexity. Adaptive strategies are paramount to prevent a crack in these investments. The hazelnut is a species with a shrub habit, reduced height (about 5 m), sensitive to high VPD and temperatures above 35°C. To associate the hazelnut to other tree dominant species could be a strategy to diversify the investments in agriculture systems, increase the biodiversity and improve plantation resistance to biotic and abiotic disturbances. This work combines observations emerged from recent experiments on the physiological characteristics that show the compatibility of hazelnut with an agroforestry-oriented management.
The effect of shading on carbon assimilation and transpiration of hazelnuts (*Corylus avellana* L.) was assessed through a field trial in the experimental farm of Padova University (Legnaro, PD) in summer 2019. Three hazelnuts over six were covered with a polypropylene net. Tree sap flow was recorded with thermal dissipation probes (Granier's 1985), while carbon assimilation was measured with a LCi Portable Photosynthesis System in July and August. The light saturation curve showed that about 50% of the CO_2 assimilation occurs at 100 μmol $m^{-2}s^{-1}$ of PAR and ceases to increase at PAR > 500 μmol $m^{-2}s^{-1}$, in agreement with Tombesi et al. (2015) and Hogg et al. (2000). Shaded trees benefit from lower VPD while not losing a significant rate in canopy conductance.

The radial growth and leaf phenology of two species of the genus *Corylus* (*C.avellana* and *C.colurna*) have been compared to define the timing of the development phases. While radial and leaf phenology of *C.avellana* have been extensively explored in Pasqualotto et al. (2021), we set an experiment in the

didactic lab of Perugia University (Deruta, PG) in March 2021 to obtain the same parameters for *C.colurna*. The first year of data showed that *C.avellana* and *C.colurna* have the same radial stem growth dynamic: ONSET in day of the year DOY=113±8 and MAXIMUM GROWTH RATE DOY=140±3, one month before the summer solstice. Otherwise, many other high stand broadleaf species have late budburst and MAXIMUM GROWTH RATE at the summer solstice. This anticipated phenology advantages *Corylus* species in the resource acquisition with respect to high stand trees. The study will continue in the next growing seasons to strengthen and acquire more data.

The low light saturation point, the sensitivity to high VPD, together with the early leaf and radial growth phenology make *Corylus* suitable to be associated with other high stand tree species for the joint production of fruit with paper (*Populus*) or wood (*Quercus*). Future research shall focus on the design, development and monitoring of a pilot trial.

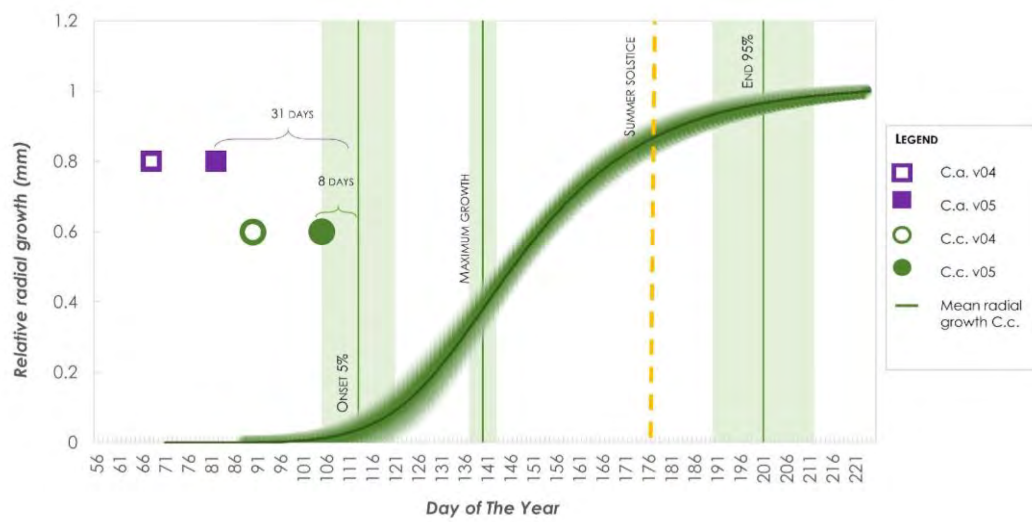

Figure 1. Radial growth and vegetative phenology of *Corylus*. Mean radial growth of *C.colurna* (green line, D.S. as shaded area), solid vertical lines (D.S. as shaded area) show from left to right the phases of the radial growth. Purple and green markers show the vegetative phases v04 (bud burst) and v05 (3rd leaf out) according to the BBCH scale of *C.avellana* and *C.colurna* respectively. The distance between v05 phase and ONSET of both species is highlighted. *C.colurna* data from growing season 2021, *C.avellana* refer to the dataset presented in Pasqualotto et al. 2021

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The production of Edible Wood in a coppice system

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Theme: Timber, energy, and non-wood forest production

Keywords: edible wood, shii-take, coppice

Abstract

Edible wood (mushroom log) enables poor quality wood to be upgraded and by doing so can play a role in a more integrated and expanded use of timber in a coppice system. It has the potential to become an unmissable multifunctional element of a sustainable agroforestry system. Coppice was formerly widespread and has disappeared due to many reasons but could be revived and remodeled as a modern form of agroforestry. A contemporary coppice system can be managed to produce logs for Edible Wood as part of a hedgerow, a production forest or a windbreak.

Edible wood is a log that has been successfully inoculated with the shii-take fungus. The log must be from a healthy broadleaved tree, be inoculated within several weeks after felling and has a diameter that is comparable to firewood. The tree is usually considered to be of poor quality and is often part of a forest thinning regime. The conversion to Edible Wood immediately gives the tree more value. Suitable logs can be harvested from existing forests, obtained in an urban environment or can be grown in a coppice system.

A shii-take log can produce several flushes of shii-take mushrooms each year for a number of years until the sugars in the log have been completely extracted by the fungus. The remains of the log can then become part of the natural lifecycle once more by being turned into compost. Shii-take grows preferably on oaks but can also be grown with moderate results on birch and several other broadleaved species. All broadleaved species are able to be used in a coppice system, oak as well. Coppice is especially interesting because of the volume, relatively fast growth rate, diameter and length of the log and ratio of sapwood to heartwood.

An Edible Wood Farm is created when a large number of shii-take logs are used simultaneously for both mushroom production and Edible wood production. The mushroom logs can be sold singularly to consumers and in bulk to organizations or companies. Costs are kept low by working outdoors in a shaded protected environment, by attuning to prevailing weather conditions and by not having to work excessive hours in the field. It has a low technological input and can be set up anywhere where there is suitable wood, shade and water. Small-scale production with the use of local timber is essential to keep the balance sheet healthy. It is a useful addition to a functioning company, organization and carefarmer. Edible wood is slowly gaining popularity and the consumption of mushrooms is on the rise. The governments of many countries want to plant more trees, improve biodiversity and become more self-sufficient all at the same time. Although harvesting logs for Edible Wood in a coppice system has not yet been carried out, this is the right moment to start investigating the possibilities and to encourage discussion on this subject.

Agroforestry produced hybrid poplar to implement green building with engineered wood products as foundation for the bio-based economy

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Theme: Timber, energy and non-wood forest production

Keywords: Hybrid poplar, engineered wood products, bio-based building products

Abstract

Poplar wood can be the basis for the supply of a range of engineered wood products (EWP) for bio-based building. Combining the need for extra resources for the bioeconomy by means of interaction between the green deal topics 'building with wood' and 'providing resources' can be achieved by producing these poplar EWPs based on agroforestry production systems.

The focus on construction – green building for both the wood component (trees) and technical crops in agroforestry is rather new for the agricultural sector. Worldwide, evidence is growing that green buildings bring multiple benefits. They provide some of the most effective means to achieve a range of global goals, such as addressing climate change, creating sustainable and thriving communities, and driving economic growth.

Hybrid poplar-based Engineered Wood Products are already well established worldwide. In Europe this is mainly the case for plywood. Cross Laminated Timber (CLT) is considered a new and main innovative engineered wood product for green building. CLT is a massive wood construction product consisting of at least three single-layer panels that are bonded together crosswise and has the potential to substitute concrete even for high rise buildings. All these developments are considered in a framework of the New European Bauhaus initiative under the European Green Deal. Similar to the forestry wood industry chain (FWC), there is a need to develop an integrated approach for the poplars produced in alley-cropping systems as key agroforestry systems.

It remains important to demonstrate that hybrid poplar based EWP can be used as a complementary resource for bio-based building. First, the suitability of hybrid poplar trees produced from alley crop

agroforestry for industrial processing need to be assessed, e.g. by underpinning quality and yield levels from those trees and their potential for veneer peeling. Trees not suitable for plywood, or the smaller diameter parts of the trees, are primarily intended for processing to sawn products targeting cross laminated timber (CLT) production. An integrated chain methodology covers EWPs like plywood, CLT, I-joists as well as residual related feedstock or biomass for pulping, biorefineries (including biotechnology) and bioenergy.

Also, technical crops can be produced and designed for building products. Annual fibre crops like flax and hemp but also short rotation coppice and similar crops can be used to develop complementary products for the construction sector and hence expanding the role of agriculture in providing resources for bio-based building.

Hybrid products with other wood species and natural fibre reinforcements or insulation components still need to be demonstrated. Building with bio-based products like poplar EWP's needs also to be further assessed in relation to decarbonization and other green building assets.

The combination of alley cropping of hybrid poplar with well-designed rotation systems of agricultural crops can be implemented European wide as part of the Commission Communication to the Parliament to plant 3 billion trees in the forthcoming decade as part of the Green Deal goals to mitigate climate change.

Peeling of agroforestry walnut: comparison of the deformation of agroforestry vs. forestry walnut veneers

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Theme: Timber, energy and non-wood forest productions

Keywords: Agroforestry, Juglans regia x nigra, veneer, waviness

Abstract

Agroforestry trees grow in very different conditions than forestry trees mainly because of their higher exposure to wind and light, specific competition for water availability, strong interactions with annual crops, numerous human operations on branches (pruning) and root systems (due to the tillage). Production level and quality such as anatomical, chemical and technological properties of wood coming from agroforestry systems have not yet been compared to "conventional" wood. This work is part of a PhD project started in 2020 in order to understand how agroforestry trees adjust to their specific growing conditions and how these growing conditions affect the quality of the wood.

This study focuses on the quality of agroforestry walnut wood and its aptitude for peeling. One of the quality criteria studied here is the deformation of these veneers through the observation of their waviness after hot air-drying, strong waves reducing the quality of the veneers (Merela, Habjan, Čufar 2016).

Sixteen hybrid walnut trees (Juglans x regia x nigra NG 23xRA) from the Restinclières Agroforestry Platform (RAP) (Montpellier, France) were felled in March 2020: 8 agroforestry trees (AF) and 8 forest trees serving as control trees (FC). All were 25 years old. The planting densities in plot AF and plot FC were 100 trees/ha and 200 trees/ha, respectively. The trees were soaked at 80°C for 24 h and then rotary peeled using a light packaging scale lathe. The veneers obtained had a thickness of 1 mm, they were then placed in racks and dried in a dryer at 35°C during 24 hours.

The waviness of the veneers was characterised using the System of WAviness Analysis (SWAN) developed in LaBoMaP, Arts & Métiers. This measuring system is equipped with a camera and a laser line that is deformed following the shape of the veneer. The camera uses laser triangulation when measuring range: the veneer is illuminated with a laser line from one direction, and the camera is viewing the veneer from another direction. The laser line shows up as a cross-section of the veneer on the camera's sensor, and the height of each point is computed from the laser ligne deformation on the camera's picture (Figure 1). The veneers are placed on a conveyor belt, allowing the laser line to scan the entire veneer. Various waviness parameters are then measured to characterise the deformation of each veneer, such as its average height (Sa) or the maximum thickness of the veneer (Sz, difference between the highest and lowest point of the veneer). In total, the deformation measurement was carried out on 321 agroforestry

veneers and 103 forest veneers, the difference being due to the smaller diameters of the walnut trees into the control plot.
The first results obtained indicate that there was significant differences between agroforestry and forestry walnut veneers. The average height of the undulations as well as their maximum height (Figure 2) of the FC veneers are greater than those of the AF veneers (p-values < 0.05). The flatter AF veneers therefore appear to be of better quality than FC veneers considering this criteria. The reasons for these differences remain to be determined, and could be revealed by comparing the number of knots per veneer between trees in the two plots or by other studies on wood shrinkage and anatomy in an agroforestry context.

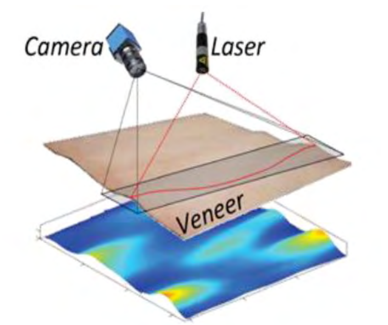

Figure 2. Principle SWAN

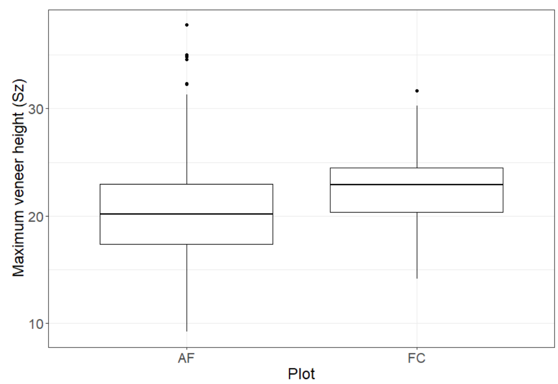

Figure SEQ Figure * ARABIC 1. Maximum veneer height (Sz) in the agroforestry plot and the forest control plot

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Black walnut (*Juglans nigra* L.) as a multifunctional and suitable tree species for agroforestry systems in Slovakia

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Theme: Timber, energy and non-wood forest productions

Keywords: black walnut, energy crop, fast-growing tree, wood biomass

Abstract
In Slovakia, we have several tree species that receive little or no attention. At the same time, it is a very promising and multi-purpose wood, which is, however, largely underappreciated and neglected in our country. Black walnut (*Juglans nigra* L.) is one of the non-native tree species in Slovakia. It was introduced into parks, gardens and arboreta in 1770 and in forests at the end of the 19th century. It covers 535 hectares, i.e. 0.03 % of the Slovak national forests. This tree species is not very known and used in Slovakia, despite the fact that it is a very promising and multi-purpose tree species. Black walnut is a suitable tree species for establishment of agroforestry systems, but up to now its potential for agroforestry systems for agricultural land management has not been used. For agribusiness they can be very interesting and perspective both in terms of nut production and high quality and well-rated wood on the market. The aim of this contribution is therefore to present the potential of black walnut in terms of its use as a useful fruit tree and afforestation tree with fast growth and quality wood. The use of this tree species is really wide and varied. Black walnut wood is sought after and popular for its beautiful color, high strength, durability and it is easy to machine and it resists weather conditions well. The quality of wood surpasses many other fast-growing tree species such as poplars, willows or Paulownia and it is also a suitable tree species for agroforestry systems. Its disadvantage in Slovakia is the fact that it is not included in the group of fast-growing tree species. Sap in the spring is used to make syrup, which is similar to maple and is used in the food industry. Dried leaves are processed into infusions and teas. The unripe walnuts with the green husks are used in the production of tincture, liqueur, pickled walnuts, soap and extracts used in cosmetics and food industry. Kernels are used as an ingredient in ice creams and other confectionery products. Excellent oil is obtained by pressing the kernels, which is used in the kitchen and in the pharmaceutical industry. Nuts have been used in alternative medicine for a long time and now are presented in various forms as healthy organic products and also as functional foods that have preventive or supportive functions, thus helping to prevent some diseases. Shells are used for grinding and sandblasting of buildings and metal structures. Their calorific value is equal to brown coal briquettes, which can be used for heating in solid fuel metering boilers. Black walnut is also used as a rootstock for bred varieties of English walnut. As this multifunctional tree species begins to become more and more famous, agroforestry systems with black walnut are gradually being established in Slovakia.

Figure 1. Black walnut is a combination of perspective fast-growing tree, which provides a very valuable wood biomass and forgotten fruit tree with edible tasty and nutritious nuts (Photo: M. Pástor)

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Mechanized pollarding of poplar trees in an alley cropping system

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Theme: Timber, energy and non-wood forest productions

Keywords: Agrophotovoltaics, alley cropping, colocation, ecosystem services, electricity, water food energy nexus, sustainability

Abstract
Providing food and energy for a growing world population, while reducing both the environmental impact of agriculture and the use of non-renewable fuels, and without increasing agricultural land at the expense of forest and other natural systems, is an increasing challenge (Nonhebel, 2005; Rajagopal, 2007). One approach is to produce both energy and food on the same land, with systems that exploit possible synergies between the two productions (Dupraz et al., 2011). Understory crops can be grown under trees from which biomass for fuel productions can be obtained, in agroforestry systems, or under photovoltaic panels in agrivoltaic systems. Here, the advantages and disadvantages of these two approaches are compared in order to provide guidance to producers, policy makers and other stakeholders, and identify research gaps. The main advantages and disadvantages of both systems are summarized in Table 1. The two approaches, agrivoltaic and agroforestry for biofuel production, are very different, with relative advantages and disadvantages for both. Agrivoltaic appears to be more advantageous for energy production, due to producing energy more rapidly, efficiently and in a form directly usable (i.e. electricity). However, the discontinuous production, dependent on sunshine (thus on time of day, weather and season), and the distance from the electrical grid, pose some limitations. Agroforestry for biomass production appears to be more advantageous in terms of additional (i.e. non-provisioning) ecosystem services, such as preventing soil erosion and nutrient leaching, increasing biodiversity, soil organic matter, carbon sequestration and storage. Agroforestry can also provide additional products (quality wood and non-wood products). Agrivoltaic systems, although not directly sequestering and storing carbon,

can still result in greater mitigation of climate change, due to their higher efficiency at producing energy, thus offsetting greater amounts of emissions from non-renewable sources. Their much higher efficiency also implies that much less land is needed to produce the same energy. However, more research is needed to understand their long-term environmental impact. It is not clear if, and how, the components can be re-used, recycled or disposed of, and at what cost and impact. In conclusion, the choice between the two systems appears to depend on the main objective of the enterprise and/or of the policy maker. Where energy production is the main goal, or where water is severely limiting, agrivoltaic systems might be preferable, assuming their long-term impact can be clarified, while agroforestry for fuel production might be preferable where other ecosystem services are prioritized/needed.

Table 1. Advantages and disadvantages of Agrivoltaic vs. agroforestry systems for energy production

Agrivoltaics	Agroforestry for biofuels
Advantages	**Disadvantages**
High efficiency at converting solar radiation into usable energy	Low efficiency of photosynthesis (2-3%) and of biomass conversion into usable forms of energy.
Directly usable form of energy (electricity) with existing grids	Biomass requires expensive transportation and transformation to become usable fuels, with high economic and environmental costs
Radiation availability for energy and crops can be regulated by array design and, with tracking systems, also adjusted at will, according to instantaneous crop needs	Fraction of radiation used for biomass and crops can be regulated only partially with system design (trees grow and change size and shape) and management (pruning), but cannot be adjusted at will to instantaneous crop needs
Panels don't transpire water, nor uptake nutrients, thus not competing with understory crops (other than for light)	Trees often compete for light, water and nutrients with understory crops
Panels can be used to collect rainwater into storage facilities	Trees cannot collect water
Panels can protect crops and animals from sun, heat and the elements, particularly keeping them dry during rain	Trees can shade and cool crops and animals, perhaps more effectively (shade + transpiration) but not necessarily keep them dry
Panels and their supporting structures can be used also for other structures, like netting for hail or for insect protection	Trees can be used for some structures, like holding fencing, but not for others
Disadvantages	**Advantages**
Higher cost of installation and maintenance	Lower cost for planting trees
Higher environmental impact for construction, installation and disposal, but more data needed.	Positive environmental impact

Energy is produced only when radiation is available and cannot be stored onsite	Trees hold their biomass until harvested, and the biomass can be stored and harvested when needed
Some ecosystem services are provided, like energy production or shade, but not others like the ones described opposite for trees	Trees can reduce erosion and leaching, clean water, soil and air, increase biodiversity, sequester and store carbon, provide quality wood and non-wood additional products.
Short lifespan of panels and electrical infrastructure	Some trees are longer lived, although it depends on the species and the technique adopted to produce biomass.
Less attractive and often controversial aesthetically	More attractive and even desirable

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Mediterranean species *Myrtus communis* L. and *Castanea sativa* Mill., as natural source of bioactive compounds

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Theme: Timber, energy and non-wood forest productions

Keywords: wood, myrtle berry, leaf, tissue extract, extractives, antioxidant activity

Abstract

The European chestnut (*Castanea sativa* Mill.) tree has been intensively cultivated for centuries in several countries of the Mediterranean region (López-Sáez et al., 2017). According to the latest data, in 2017 there was an increase in chestnut production in Europe, corresponding to 151,904 tons in a total of 17 countries, among which the main producers were Italy (34.5%), Greece (23.7%), and Portugal (19.7%). Despite the fact that several food processing by-products and/or agriculture wastes are being discarded, numerous studies have been demonstrating that they can be an attractive and cheap source of bioactive compounds with high interest for the food, cosmetic, and pharmaceutical industries (Esposito et al., 2019) In this way, the use of agro-forestry residues to obtain added-value molecules or products is increasingly being suggested as part of the concept of a circular economy.
The economic and scientific interest as well as for the chestnut is also directed towards various other Mediterranean species such as *Myrtus communis* L., both known for their high content of polyphenolic compounds. Myrtle plant extracts, including those from berries and leaves, attract consumers and researchers for the high concentration of phenolic compounds involved in the scavenging of ROS (reactive oxygen species) and RNS (reactive nitrogen species) which have been associated with Parkinson's, diabetes, and cardiovascular disease. Antioxidant activity (AA) during two development stages, 0 DAF (days after flowering) and 120 DAF, by using FRAP, ABTS, DPPH, β-carotene assays, and spectroscopic method (EPR) of Myrtle both tissues was evaluated. While, from wood samples of chestnut were extracted natural compounds by using different techniques (Faraone et al., 2021): maceration (ME),

ultrasound assisted extraction (UAE) and accelerated solvent extraction (ASE). All types of the extracts were tested to evaluate the content of polyphenols and flavonoids along with the in vitro antioxidant activity. In general, leaves showed with DPPH assay, the highest AA during autumn season, while with FRAP and β-carotene assays it was higher at 120 DAF corresponding to summer season. Chestnut wood extractives showed a different behaviour, in terms of RACI, highlighting the effects of the different types of the extraction methods used. According to obtained results, the extraction technique had a determinant role in the antioxidant efficiency and, consequently, on the potential application of chestnut extracts. Cultivars analysed selected during the myrtle domestication program by Mulas (2012) and the obtained data should be considered in the light of a further breeding objective for the selection of plus variant cultivars with high antioxidant value to destine to pharmacological and food uses. Thus, this study showed that all types of extractives could be used as a natural compound in different fields, from food to nutraceutical.

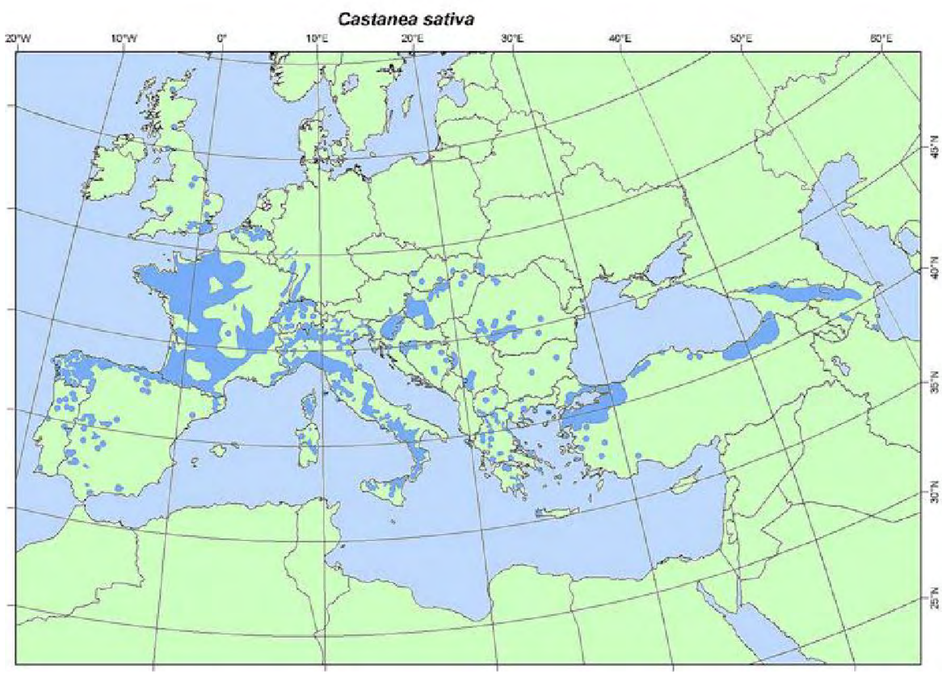

Figure 1. The distribution map of *Castanea sativa* Mill. including both natural and naturalized occurrence (from EUFORGEN 2009)

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Harvesting options for medium-rotation poplar plantations established on ex-farmland

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Theme: Timber, energy and non-wood forest productions

Keywords: Poplar, Fiber, Farmland, SRC

Abstract

Tree farms have been a common solution for the temporary medium-term exploitation of marginal farmland for many decades. Among the many different farm models proposed over the years, the one that is currently most popular is a medium rotation (5-8 years) tree plantation established with poplar, eucalyptus or acacia, depending on the ecological regions. The plantation is often managed as a coppice and kept on site for 3 to 4 rotations (app. 20 years) before the eventual return to farming. These plantations have attracted the interest of conventional wood industries which are leading the resurgence of short rotation forestry on ex-arable land. In Europe, much new planting is occurring East, in countries such as Poland, Romania or Slovakia, which offer an ideal combination of good soil conditions, moderate land price and a rapidly developing economy. So far, low labour cost in Eastern Europe has allowed the widespread use of manual or semi-mechanized work techniques for establishment and harvesting: however, the rapid development of these regions generates a growing concern about the future availability of cheap labour, which determines a strong interest for mechanisation. Furthermore, mechanised harvesting offers distinct advantages in terms of simplified logistics and enhanced work safety.The main challenge with harvesting these plantations is presented by the small individual tree size. Even the smallest tree harvesting machines are designed for trees with an optimum size around 0.2 m3, and productivity declines very quickly when stem size is smaller than that [12]. In such instances, the most common solution lays with mass handling, whereby more trees are harvested in one cycle in order to compensate for their small size. This presentation reports about the results of full-size controlled field experiments conducted by CNR for IKEA over four harvesting seasons, from 2018 to 2022. These trials allowed testing a full range of techniques and technologies, including cut-to-length harvesting, whole-tree harvesting, all implemented with different machines and models for side-to-side performance comparison. The goal was to find the system that resulted in the highest productivity, lowest cost and maximum value recovery for any given conditions.

Figure 1: One of the many different machines tested for IKEA Industry in Slovakia

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Applying the Principles of Syntropic Agriculture to Mediterranean Situations

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Theme: Timber, energy and non-wood forest productions

Keywords: syntropic agriculture, succession, stratification, disturbance, training

Abstract
Syntropic agriculture emerged around three decades ago in Brazil, with pioneer farmer Ernst Götsch, and recently spread out in various continents. Although its development is still limited in Europe, it meets a growing interest from diverse stakeholders. Such diversity was epitomised in the context of a one-week training session in November 2021, with 25 participants, including co-authors of this paper. The approach was active pedagogy, while "learning by doing" in a field on the training site, located in the South of France (Eygalières, Provence). In this presentation, we account for main lessons learned from this session and possible developments in agroforestry. Syntropy contrasts with entropy. It focusses on energy concentration and complexification of agroecosystems through high density knowledge-based polyculture planting as opposed to input-based less complex monoculture or alley cropping. It values solar energy through photosynthesis in plant succession and stratification; each species having its own

light requirements, and its function(s) in a given sequence and layer. After land preparation, all species are planted or sown at the same time and covered with a mulch. While mimicking forest ecosystems, syntropic agriculture acknowledges the role of disturbances (such as pruning) to stimulate agroecosystems functioning and dynamics. As a result of regularly adding new layers of organic matter derived from pruning, the permanently covered soil regenerates and nourishes the plantation. Three important outcomes of the training session were (i) familiarisation with the principles of syntropic agriculture, (ii) design and plantation of prototype successions, (iii) research agenda for monitoring such intentional successions in Europe (labour requirements, crop yields, biomass production, soil fertility …). Such dynamic systems provide a unique opportunity for an open-ended perspective in agroforestry, within which both target and pathway can somewhat be adapted in the course of action, based on observation and experimentation of implemented patterns and processes.

T 2.3

LIVESTOCK PRODUCTIONS

Herbage intake, nutritive value and cattle productivity within silvopasture and open pasture systems: a case-study in a Mediterranean livestock farm

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Theme: Livestock productions

Keywords: Agroforestry, Sustainability, Grazing, Maremmana, Livestock

Abstract
Pasture-based livestock farming systems located in marginal areas constitute an important element for maintaining traditional knowledge, agricultural landscapes, and for providing ecosystem services (Rodríguez-Ortega et al. 2014). However, low productivity levels of animal and pasture characterised these systems and therefore, the study of the association between the potential herbage intake and average daily gain helps to increase knowledge about the relationship between animal and pasture (Mantino et al., 2021). A grazing trial was carried out during spring 2021 on 3.69 ha of a temporary grassland and 3.31 ha of Turkey-oak forest. A total of 50 growing steers and heifers of *Maremmana* cattle breed were managed under two different systems: silvopasture (SP) and open pasture (OP). Cattle belonging to the SP system were allowed to access the forest. Both groups were daily supplemented with 3 kg of concentrate and *ad libitum* hay. The grassland area was divided into six paddocks, three for each system, to perform rotational grazing. The grazing period lasted one week, and cattle returned to the same paddock after three weeks; the trial lasted six weeks in total. The two systems were compared by estimating differences in pasture characteristics (pre- and post-grazing herbage mass, herbage allowance, and nutritive value) and cattle productivity (potential herbage intake and average daily gain). Herbage intake and forage allowance were estimated using the exclusion cage technique. The amount of supplemental feed consumed was daily recorded. Cattle were weighed three times: at the start, middle, and end of the experiment. Meteorological conditions were monitored throughout the trial. Pasture productivity was scarce due to cool air temperatures and prolonged drought conditions. Results show that there was no significant difference between systems for cattle herbage intake (SP: 8.75 g DM kg BW-1 d-1 OP: 7.94 g DM kg BW-1 d-1). The two groups had similar pasture conditions (same herbage allowance, nutritive value and potential herbage intake) but they differed in total DM intake (herbage+fodder+concentrate, SP: 27.02 g DM kg BW-1 d-1; OP: 23.63 g DM kg BW-1 d-1) and performances (average daily gain, SP: 1.02 kg d-1 OP: 1.20 kg d-1). Despite SP cattle had a higher DM intake, they showed satisfying but lower performances than OP cattle (Figure 1). This could be due to the higher surface available to express their natural behaviour. These results suggest that rotational grazing is a valuable technique that increases cattle performances, but pasture productivity is a limiting factor. However, we noticed a negative impact on pasture depletion in OP paddocks with higher presence of bare soil after only 6 weeks of grazing. Consequently, when pasture is available, cattle should not be allowed to browse in the forest to increase their performances and reduce feed consumption, but attention should be given to soil and pasture conditions.

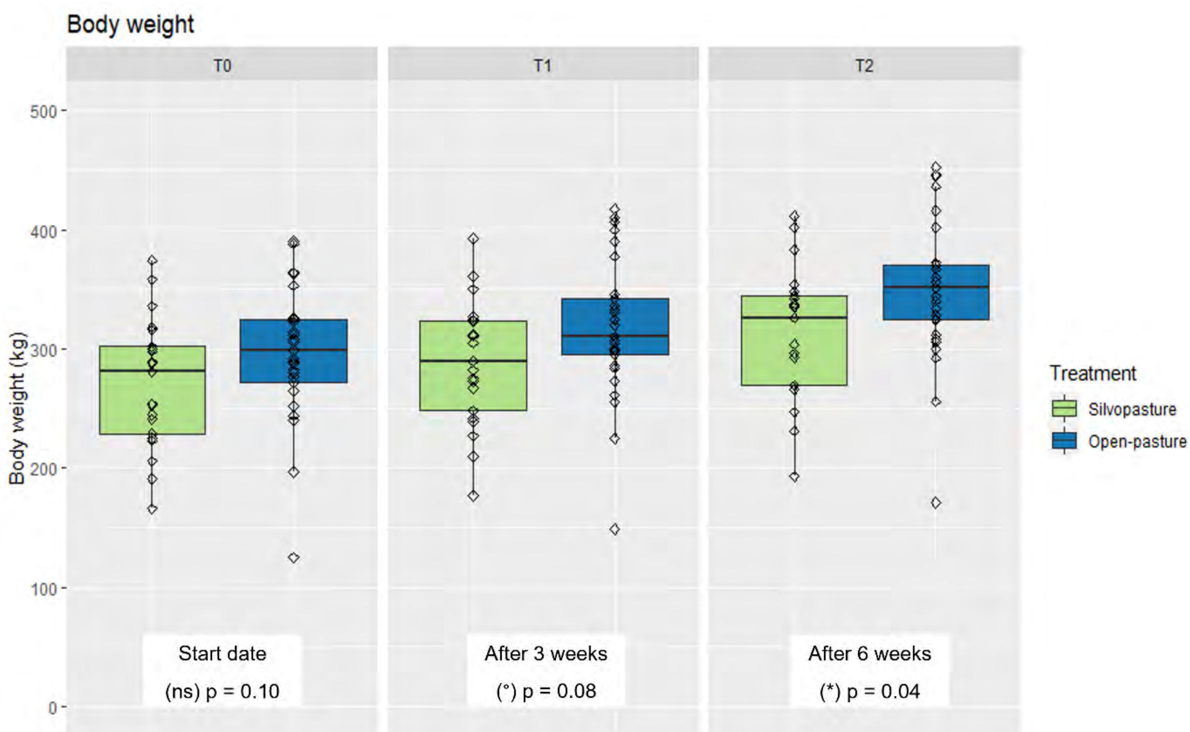

Figure 1. Distribution of cattle body weight in the two treatment groups: at the start date (T0), after 3 weeks (T1), and after 6 weeks (T2) of experiment

Acknowledgments

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Carbon footprint labelling in the agri-food sector: a preliminary study on consumer behaviour for beef in Spain

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Theme: Livestock productions

Keywords: beef meat; carbon footprint; food labelling; choice experiment

Abstract

Carbon footprint has become a reference indicator of the environmental impact of food production. Food and particularly food of animal origin can be considered unsustainable when its production model involves excessive use of resources, consumption of fossil fuels and, in short, the generation of significant environmental impacts, with the livestock sector accounting for 14.5% of GHG emissions (Gerber et al. 2013). In this context, the study of consumers' preferences and their assessment of the carbon footprint levels of food products is crucial to move towards a green and circular economy. However, carbon labels are of limited relevance as they are not found in all products and are very diverse. Moreover, some research results differ in terms of consumers' willingness or unwillingness to pay for such labelling (Van Loo et al. 2015; Onozaka et al. 2016; De Marchi et al. 2016). In this regard, this paper investigates consumers' preferences and willingness to pay for beef with the addition of the carbon footprint label.
To achieve the objective of this study, a choice experiment was designed and applied to a total of 362 Spanish consumers. The questionnaire is composed of four parts. The first part deals with consumer habits, the second part gathers data about carbon footprint of food production and climate change, the third part of the questionnaire develops a choice experiment to analyse the influence of the carbon footprint on consumers' preferences for beef and finally, the fourth part contains socio-economic information.

Additionally, a consumer segmentation was carried out in order to analyse in more detail the respondents' preferences towards carbon footprint and food purchases based on their carbon footprint. The inputs of the analysis were different variables included in the questionnaire that could characterise the

respondents' knowledge, behaviour and attitudes towards carbon footprint and its use in food. Results show that consumers rank "origin" as the most valued attribute, followed by "carbon footprint" and "extensive" production system. In addition, the "organic" attribute and "price" were the least important. Regarding the "willingness to pay" for the different attributes, it is highly biased by the consumer profile and their awareness of climate change. As for segmentation, a final solution of three segments was selected. Specifically, consumers have been defined as: "Conscientious Consumers" with higher purchasing characteristics and environmental attitudes than the rest; "Balanced Consumers" with medium willingness to pay for environmental attributes and attitudes; and "Indifferent Consumers" with lower willingness to pay and low environmental attitudes. As for the willingness to pay per cluster which is shown in table 1, it is worth noting that cluster 1 does not show any values because the price coefficient is not significant. Cluster 2 has a higher willingness to pay than the total sample. Finally, cluster 3 shows a relatively lower willingness to pay. Finally, it should be noted that carbon footprint labelling of meat products can enable the value of high quality, sustainable and environmentally friendly products to be enhanced.

Table 1. Willingness to pay. (From: prepared by the authors)

	Overall sample		Cluster 1		Cluster 2		Cluster 3	
	WTP (mean)	WTP (min-max)	WTP (mean)	WTP (min-max)	WTP (mean)	WTP (min-max)	WTP (mean)	WTP (min-max)
Intensive ⇒ Extensive	5.22	3.34,7.10	*n.s.*	*n.s.*	*n.s.*	*n.s.*	2.76	1.31-4.21
Imported ⇒ Local	14.33	9.60-19.06	*n.s.*	*n.s.*	25.93	4.04-47.88	6.88	4.66-9.11
Imported ⇒ National	9.08	5.39-12.77	*n.s.*	*n.s.*	14.81	0.06-29.56	4.16	2.30-6.02
CF (8 kg CO2/kg beef meat) ⇒ CF (18 kg CO2/kg beef meat)	-5.88	-7.29--4.47	*n.s.*	*n.s.*	-6.08	-9.92--2.25	-4.68	-5.90--3.46
CF (8 kg CO2/kg beef meat ⇒ CF (28 kg CO2/kg beef meat)	-6.49	-8.89--3.99	*n.s.*	*n.s.*	-12.24	-23.58--0.89	-3.04	-4.44--1.65
No Organic ⇒ Organic	5.63	4.14-7.11	*n.s.*	*n.s.*	9.29	3.05-15.52	2.69	1.71 – 3.66

Note: n.s.: not significant. CF: Carbon footprint

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Impact of technical-economic management on the greenhouse gas emissions and carbon sequestration in organic livestock farms

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Theme: Livestock productions

Keywords: farm type; organic cattle farms; life cycle assessment; carbon sequestration

Abstract

One of the main concerns in our current society is climate change and the associated environmental deterioration of the planet, as well as the exhaustion of its natural resources. In this context, agricultural production and livestock production systems are being closely watched on account of being the cause of major environmental impact (Steinfeld et al. 2006; Eldesouky et al. 2020). However, livestock farming has been traditionally assessed by its economic figures, whereas the impact caused by their production models on the environment and on society have been largely disregarded.

Therefore, this paper analyses various organic cattle farming systems from the point of view of their technical-economic management, but also on the environmental impact caused by their greenhouse gas emissions. The area of study was the Extremadura region, located in the southwest of Spain. It is a scarcely-populated large region (41,635 km2 and 1,065 million inhabitants) where over 50% of the utilised agricultural area (2.2 million hectares) is classified as dehesa (Gaspar et al. 2008). The data were obtained through a convenience sampling applied to extensive organic beef farms in Extremadura. Finally, 34 organic dehesa cattle farms were studied. The most outstanding common characteristics in all of them were the fact that animals were reared and fed mainly on pastures and that they focused on the production of weaned calves.

The methodology used was, on the one hand, a principal component analysis which devised four factors that explained the technical-economic management model of these farms in terms of their level of dependence on subsidies, production intensification, feeding practices and productivity. The farms were subsequently divided into three clusters whose main differences came from the size of the farms, the intensification level and the joint rearing of cattle with other livestock species. On the other hand, life

cycle assessment methodology helped calculate the greenhouse gas emissions and carbon sequestration levels for each of these clusters.

The results determined the existence of various production models which, when combined with the results from the calculation of the GHG emissions allowed us to determine their contribution to environmental impact and to make relevant comparisons. These results include the GHG emissions of the three clusters analysed and the carbon sequestration, expressed in kg CO2eq per functional unit (FU), with the UF being the kg live weight, as shown in Figure 1. Cluster 2 have the highest carbon footprint (19.47 kg carbon dioxide equivalent (CO2eq) / kg live weight), and the group with the lowest carbon footprint is the cluster 3 (2.94 kg CO2eq / kg live weight). Enteric fermentation represents the largest source of total emissions on organic cattle farms. In contrast, largely-intensified small farms have lower emissions than more extensive farms due to their higher gross production. The final result in terms of carbon sequestration reveals an amount of 4.73 – 12.02 Kg CO2 eq/UF, which proves the importance of extensive farming (cluster 1), where pastures and animals (dung) play a key role in the agricultural systems. It can be concluded that extensive livestock management of these ecosystems and organic livestock farming are adequate strategies for the mitigation of GHG and the deceleration of climate change.

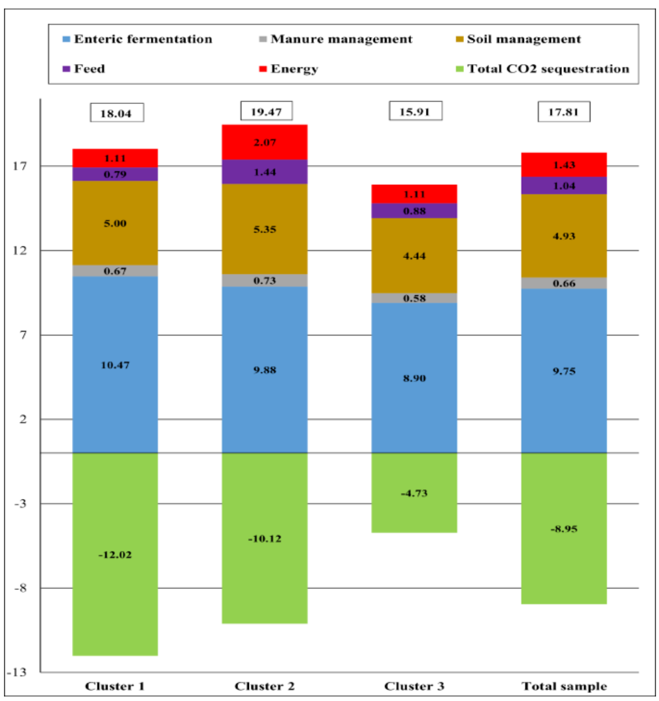

Figure 1. Carbon footprint and sequestration indicators per cluster, represented as kg of CO2eq/FU. (From: prepared by the authors)

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Dynamic of 16 fodder trees' nutritive values from June to October

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Theme: Livestock productions

Keywords: livestock production, feeding value, crude protein, temperate region

Abstract

Trees could help to reduce livestock production vulnerability to climate change by providing a fodder resource during periods of drought. Fodder trees are commonly used in tropical and Mediterranean areas, but they remain poorly studied in temperate regions. Previous studies highlighted that leaves of some tree fodder species have nutritive values close to those of herbaceous forages in summer (e.g. Mahieu et al. 2021). However, little is known about the variation in nutritive value of fodder trees throughout their growing period, from early summer to autumn.

This study focused on 16 tree species sampled in June, August and October, from 2014 to 2017, in 22 French locations (*Acer pseudoplatanus*, *Alnus cordata*, *Castanea sativa*, *Corylus avellana*, *Fagus sylvatica*, *Fraxinus americana*, *Fraxinus excelsior*, *Gleditsia triacanthos*, *Juglans* x intermedia, *Morus alba*, *Paulownia tomentosa*, *Prunus avium*, *Robinia pseudoacacia*, *Sorbus domestica*, *Ulmus minor*, *Ulmus* 'Nanguen'; n = 292). Leaf samples were analysed to determine their *in vitro* dry matter digestibility (IVDMD) and their contents in dry matter (DM), ash, crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). The seasonal variation of these variables was analysed using a linear mixed model and estimated marginal means. Sampling location and year were used as random factors.

Our results highlighted divergent seasonal dynamics depending on the nutritive values (Figure 1). Only leaf CP decreased from June to August and from August to October ($P \leq 0.001$). DM, ash content and IVDMD decreased from June to August ($P \leq 0.001$), but had weak evidence to evolve from August to October ($P > 0.05$). We found no evidence of seasonal variation for NDF, ADF and ADL ($P > 0.1$). The

dynamics of IVDMD, CP, NDF, ADF and ADL were similar to those observed by Vandermeulen et al. (2018), who focused on different temperate tree species.

Castanea sativa was the only species to strongly improve CP (from 140 g/kg in June to 172 g/kg in August). *Robinia pseudoacacia* increased NDF, ADF and ADL from June to August and *Fraxinus americana* decreased mineral content from August to October, while other species mainly remained constant. *Robinia pseudoacacia* behaviour was similar to the results of Papachristou et al. (1999), but few studies focused on the seasonal variability of the studied species. However, the effects of species could be higher than those of season, as previously shown (Wood et al. 1994; Ravetto Enri et al. 2020).

Our results as well as bibliography references highlighted specific dynamics between the different components of the nutritive value, as well as diversity among species in the seasonal variability. More studies are now required to better characterise the variation in nutritive value of tree fodder species across seasons, their biomass production and palatability.

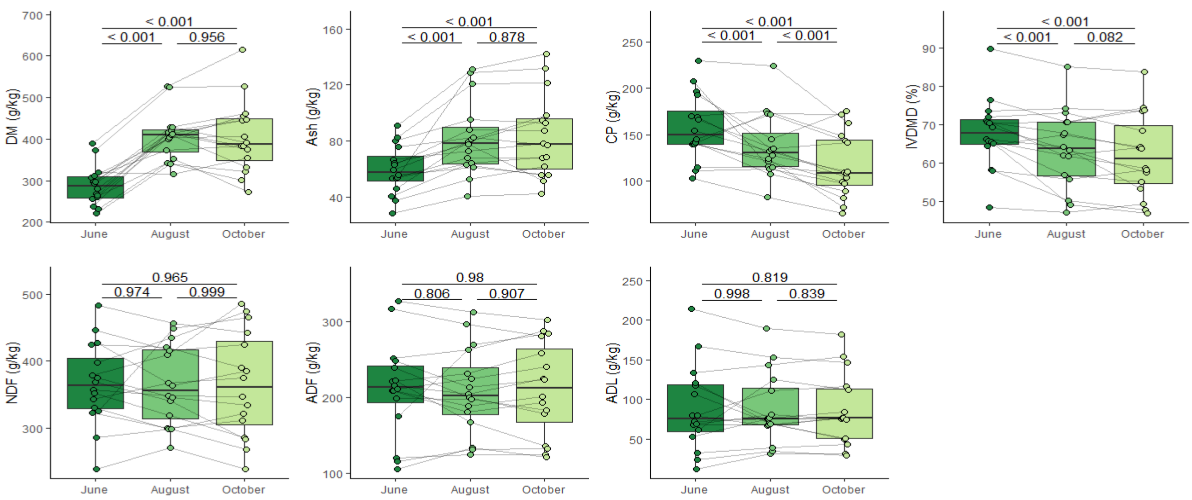

Figure 1. Chemical composition (g/kg) and IVDMD (%) of the leaves of 16 tree species across seasons. *P*-values evaluate seasonal effects on nutritive values. Dots represent monthly mean values of the 16 studied species.

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Feeding preferences of Highland cattle reveal their attitude to exploit woody vegetation in mountain environments

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Theme: Livestock productions

Keywords: Highland breed, Plant species selection, Woody encroachment

Abstract

Since the 1950s, the area occupied by woody-encroached pastures, shrublands and forests in European mountains has dramatically increased due to agro-pastoral abandonment. The exploitation of these habitats by livestock is challenging due to low forage quality and difficult accessibility. However, if grazed by robust breeds, such as the Highland cattle, these habitats could represent a valuable resource for sustainable livestock productions. Indeed, Highland cattle are characterised by low maintenance energy requirements, low grazing selectivity and great agility on rough terrain (Pauler et al. 2020; Berry et al. 2002). However, the feeding behaviour of this breed has been poorly investigated in mountain environments. To fill this knowledge gap, the objective of this study was to analyse Highland cattle diet composition and feeding preferences in contrasting mountain sites encroached by woody vegetation.
The study was carried out at four sites in the Western Alps, representative of different mountain vegetation communities: Almese (480 m a.s.l., Italy), Casteldelfino 1 (1380 m a.s.l., Italy), Casteldelfino 2 (1280 m a.s.l., Italy), and Bovonne (1750 m a.s.l., Switzerland). Cattle behaviour was recorded at regular intervals through direct observations of 29 focal animals. For each observation, the plant species consumed and those available in a 1-m buffer area around the animal were identified and their relative consumption and abundance recorded in a percent scale. Herbaceous plants were included in a broad category, while woody plants were identified at the species level. From these data, (i) the diet composition, (ii) the Jacob's Selectivity Index (JSI) (Jacobs 1974) of woody plants, and (iii) the relation between species consumption and abundance were investigated.

Overall, 11'356 observations were made during 150 hours. The Highland cattle diet included a large proportion (15-46%, Figure 1) and a variety (45 different species) of woody plants. For instance, *Rubus idaeus* and *Alnus viridis* accounted for 40% and 12% of the diet in Casteldelfino 2 and Bovonne, respectively. Interestingly, cattle were also able to forage on spiny shrubs such as *Prunus spinosa* and *Rosa*

sp. According to JSI, cattle expressed a clear feeding selection towards woody plants: *Celtis australis, Frangula alnus, Fraxinus ornus* and *Rhamnus alpinus* were among the preferred species (JSI > 1), *Alnus viridis, Picea abies,* and *Populus tremula* were consumed proportionally to their availability (JSI = 1), while *Corylus avellana, Crataegus monogyna, P. spinosa* and *Sorbus aria* were among the avoided ones (JSI < 1). The relation between species consumption and their abundance differed depending on their preference index. For instance, cows consumed *F. alnus* (preferred species) even at low abundance, whereas *Rubus* sp. (avoided) was highly consumed only at high abundance.

The remarkable consumption of woody plants by Highland cattle could encourage the use of this breed to reduce woody encroachment, likely enhancing forage quality and other ecosystem services (e.g., plant diversity, landscape quality, and tourism attractiveness). Therefore, Highland grazing could be adopted for the sustainable use and restoration of marginal mountain areas (Svensk et al. 2021). Future studies should explore the forage quality of woody plants and Highland cows growing performances in these environments.

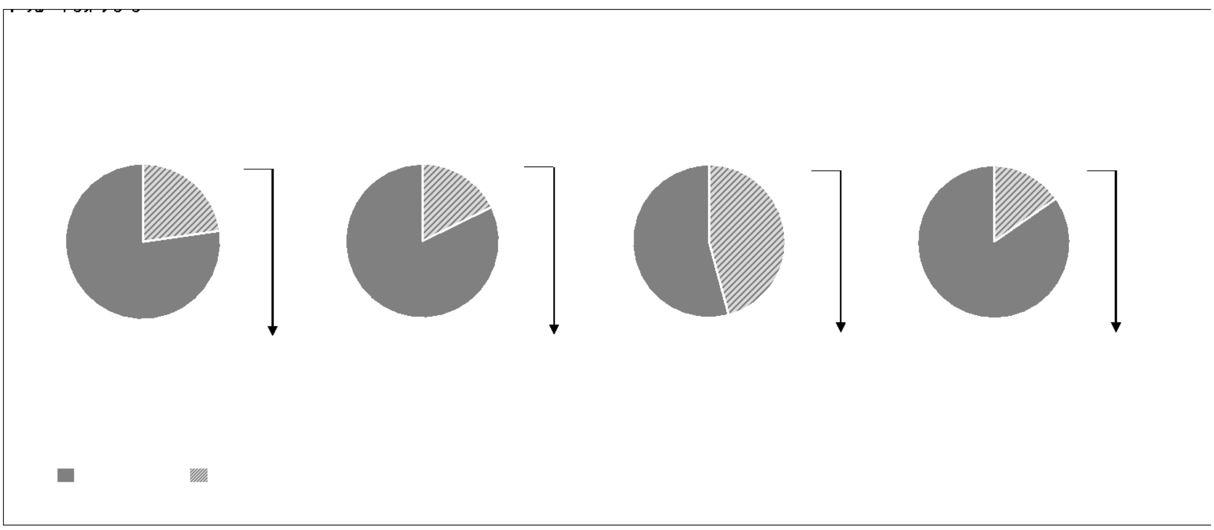

Figure 1. Proportion of herbaceous and woody plant species in Highland cattle diet in the four studied sites

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In France, silvipastoral arrangements in grasslands can mitigate moderate heat stress in sheep

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Theme: Quality, safety and sustainability of agroforestry productions (processes and products)

Keywords: Heat stress, ruminants, trees, grassland, global warming

Abstract

In the coming years, with the multiplication and intensification of the effects of climate change, the European livestock farming systems will have to adapt and gain in resilience to maintain their production. For those livestock systems that largely rely on grazing, the augmentation of climatic hazards and the associated periods of drought and heat waves (Moreau 2015), will have both direct consequences on animal welfare and production (Polsky et al. 2017; Herbut et al. 2018), and indirect ones on grass production and quality. The presence of silvopastoral facilities in grasslands could be a way of adaptation to climate change by providing a more favourable microclimate and limiting the thermal stress of animals. The objective of this study, conducted in the mid-mountainous French region Auvergne, was to assess the impacts of the presence of trees on the thermal load and behaviour of sheep submitted to different tree arrangements, thanks to the use of a set of different sensors.

The experimental set-up was composed of three 0.8-ha permanent pasture plots: a control plot C, composed of a single tree and two trees plots: HT composed of a hedge (7.6 trees/ha) and IPT composed of an intra-plot tree plantation (60 trees/ha). In each plot, 12 dry adult ewes were grazed during the entire grazing season (2020: between June 6 and September 5; 2021: between May 12 and September 9). During this period, each animal was equipped with a bolus measuring ruminal temperature, an activity collar and a Hobo® light data logger positioned on the animal's withers to assess whether it is in shade or sun. A weather station was installed on each plot to characterise the intra-plot environment. The statistical treatment of the data was based on mean homogeneity tests carried out according to mixed ANOVA or Kruskal-Wallis-tests.

From the 183 days available, we created 4 classes based on climatic conditions: 1=cool and humid day; 2=cool and sunny; 3=hot day (>25°C) and cool night (<19°C); 4=hot day and warm night (>19°C). The main results show that animals in IPT have a lower ruminal temperature (39.4°C) than animals in C and HT (39.5°C) (pvalue =0.001). This is confirmed with the results of Figure 1 below, the ruminal temperature of the animals increases according to the daily classes from 1 to 3 for the three treatments. In class 4, although this is the most thermally stressful class, the ruminal temperature of the ewes is equivalent to classes 1 or 2. The analysis of their activities shows that the animals had a behavioural adaptation between classes 3 and 4 by decreasing their ingestion time (13%) and spending more time in the shade (19%). However, the environment of the IPT plot seems to be more favourable for the animals to effectively decrease their ruminal temperature.

In our context, these results show that agroforestry systems can play a positive role in adapting to climate change by providing a more favourable microclimate for animals, allowing them to better regulate their internal temperature and thus improve their welfare under stressful conditions.

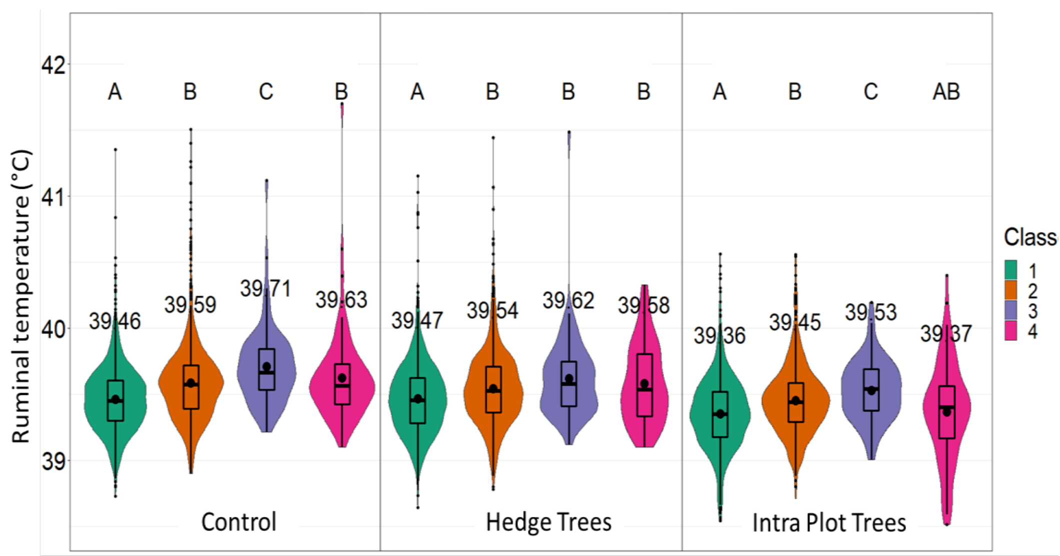

Figure 1. Comparison of the average ruminal temperatures of ewes on the three plots, according to the daily weather classes (statistical comparison by plot)

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Performance of Iberian x Duroc cross breed pigs according to age at the beginning of free-range finishing phase in *Montanera*

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Theme: Livestock productions

Keywords: dehesa, montanera, extensive production system, autochthonous pig breed

Abstract
The Iberian breed pig together with the most widespread agroforestry system in SW Spain (known as dehesa) are the basis of a traditional and sustainable livestock farming system that is unique in Europe; the Montanera system (extensive management at the final fattening phase combined with a feeding strategy based on natural resources). The traditional production system of Iberian breed pigs involves a long production period because of the slow-growth and poor food efficiency of the Iberian breed. This, along with the geographic limitations of the dehesa area and the seasonality of its natural resources lead to the need for a more efficient management of the Montanera production system. The most common practice is the use of Iberian pigs crossed with Duroc breed pigs, since this cross has better production parameters compared to purebred Iberian pigs, and therefore reduces animal age at the beginning of Montanera phase. The aim of this study was to assess the influence of various ages of Iberian crossed with Duroc breed pigs at the beginning of the free-range finishing phase in the Montanera system; 10, 12 and 14 months old, on productive performance after the Montanera stage. For that, three animal batches of Iberian pigs crossed with 50% Duroc (between 15 and 18 animals per batch) were used. The average birth dates of each batch were successive and spaced 2 months from each other in order to start the Montanera simultaneously but at different ages. During the previous phase to Montanera -growth phase-, feed consumption was adjusted in order to adjust weight increases so that all animals reached a similar weight at the start of the Montanera, regardless of their age. Subsequently, the animals were in Montanera for 63 days. After the Montanera, the average daily gain, weight increase and morphometric measurements (rump height, croup width and length) were measured. The results showed that animals that started the final fattening phase at a younger age yielded lower productive performance, height and croup width, thus suggesting a lower growth rate during the Montanera.

Willingness to pay for certification in the case of Iberian ham. Sustainability labels vs. agroforestry attributes

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Theme: Livestock productions

Keywords: Iberian dry-cured ham, dehesa, sustainability, certification

Abstract
In recent years there has been an increasing demand of meat products deriving from autochthonous breeds that are reared in extensive systems. This is the case of the Iberian pork, the products derived from this breed have great acceptance due its traditional link with dehesas and the montados, the most extensive agroforestry system in Europe, since the final fattening phase is carried out in what is called Montanera. But the reality is that there is an enormous heterogeneity of products on the market, ranging from those that are actually products derived from extensive systems to pigs reared in intensive systems, but all can use the Iberian designation and therefore benefit from its good reputation.
The Spanish Iberian Quality Standard came into force in 2014 and it is an example of compulsory regulation which has attempted to provide transparency to the sector establishing a compulsory new labelling system. Thus, four commercial categories (labels) were defined: Black label and Red label (both located in dehesa), Green label (reared outdoor) and White label (reared indoor).

The products marketed under the red and black labels can only be reared in eligible locations: a dehesa map layer established by the Ministry of Agriculture, complying with a strict traceability control system linking the place of production and the maximum density of animals allowed according to the density of trees.

Moreover, today's consumer is demanding other attributes that can replace those that have been the determining ones up to now, such as sustainable production related attributes such as organic, carbon footprint or animal welfare.

The objectives of this work are, firstly, to analyse the importance given to Iberian ham attributes related to origin linked to the agroforestry system of dehesa and the value given to sustainability labels such when purchasing an Iberian ham. Secondly to calculate the willingness to pay for these attributes. For that purpose, a methodological process was designed based on the information collected in a survey of 1,501 consumers in Spain. A discrete choice methodology was applied and hierarchical bayes estimation using the software R ChoiceModelR Package was performed.

Five attributes with its different levels were considered: (1) National Quality Standard label: Black/Red/ Green/ White; (2) Geographical origin (3) Sustainability Label: Organic/Carbon Footprint/ animal welfare /PDO/None; (4) Traceability QR code and (5) Price.

The results have shown that the willingness to pay for those products labelled with a black label is 13.1€/kg higher than what would be paid for the white label, similarly the willingness to pay for the red label is 7.90€/kg higher. In the case of sustainability labels, the highest willingness to pay was observed for animal welfare certification, followed by designation of origin certification, organic production and, lastly, carbon footprint certification.

It can be concluded that the attributes related to the production of pigs in dehesa are the most valued with the highest willingness to pay, but there are certifications that are complementary and can be certified simultaneously on the same hams, which could substantially increase the value of the final product.

Water quality for livestock in semi-arid rangelands of the southwestern Iberian Peninsula

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Theme: Livestock productions

Keywords: Water quality, watering pond, livestock health, faecal pollution, dehesa

Abstract

Rangelands dominate the landscape of the southwestern Iberian Peninsula, where millions of domestic animals (mainly sheep, pigs, cows and goats) extensively graze natural pastures. The most representative land-use system in the area is called dehesa in Spanish language. It is an agro-silvo-pastoral system characterised by the presence of open wooded pasturelands of evergreen oaks (*Quercus ilex* subsp. *ballota* and *Q. suber*). Nowadays, extensive livestock rearing is the main land use in *dehesas*, an activity that plays a key role in the sustainability of these high nature value ecosystems.

In these rangelands, the construction of small ponds that collect and store rainwater to be used for livestock watering has been one of the most widespread adaptive solutions to cope with water scarcity, a problem that has become particularly relevant in recent decades due to the progressive intensification of livestock activity on farms. However, watering ponds can also be a source of health problems due to the consumption of low-quality water by livestock (Canals et al., 2011; Mateo-Sagasta et al., 2017).

We have analysed the physico-chemical and microbiological quality of water from 26 watering ponds located in Iberian rangelands at three different times of the year (February, May and September). The suitability of pond water for livestock consumption was evaluated by comparing the analytical results with internationally recognized water standards for livestock. In addition, seasonal and spatial variations in pond water quality and the influence of some climatic, landscape and managerial factors were assessed by multivariate statistical analysis.

Our results showed a high seasonality in pond water composition. Overall, the quality of pond water was adequate for livestock consumption during the rainy season. However, high bacterial pollution of faecal origin was found in many ponds in summer, probably because of animals defecating into the ponds when entering to drink or cool off. These findings should be of particular concern to farmers and health authorities, given the potential risks associated with the consumption of faecal-polluted water by livestock, not only for animal health and performance, but also for human health due to the possible transmission of pathogens present in water through the food chain.

The presence of crops in the watersheds, the dilution of pollutants by rainwater, and evapo-concentration processes were the main factors and mechanisms that explained the differences detected in the physico-chemical quality of pond water, while in the case of the microbiological quality, the analysis of influencing factors did not yield conclusive results. Despite the evident animal origin of faecal contamination, no significant relationship was found with livestock density, so more research would be needed to further explore the factors that determine the microbiological quality of pond water.

The results of this study highlight the importance of proper control of pond water quality, through timely analytical testing, in order to anticipate potential health problems derived from its consumption by livestock, but also the importance for farms of having access to other types of supply sources (such as groundwater) that provide good quality water during the summer.

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Can we establish mixed cattle herds with small ruminants? Existing Knowledge and expected benefits.

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Theme: Livestock productions

Keywords: grazing, livestock, multi species

Abstract

In Greece, the management of common pastures, mostly silvopastoral systems of oak and fir species, is a point of conflict between cattle and small ruminants (sheep and goats) livestock breeders. This controversy is reflected in a relevant opinion poll in Evritania (Central Greece) where cattle breeders believe that cattle can graze simultaneously with sheep and goats while sheep and goat livestock breeders believe that cattle should be limited to their own rangelands. Can we promote the co-grazing of different species? The international experience as recorded in publications, mainly in the USA, shows that multi-species grazing can yield multiple benefits that have not been particularly prominent in Greece. The main benefits mentioned in the world literature are: reduction of losses from predators, reduction of losses from consumption of non-palatable species (such as poisonous), reduction of gastrointestinal parasites with consequent increase of productivity, better utilization of the available grazing material, promotion of biodiversity, elimination of the invasive plants, potential positive effect on soil and reduction of methane emissions. In addition, such management can bring serious financial benefits and reduction of the business risk mainly due to the variety of economic activity. The purpose of this study is to explore the possibilities of co-grazing cattle with small ruminants and to identify the benefits of this practice.

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A grazed orchard system for the organic production of native breeds of pigs and poultry, and for the protection of old apple varieties

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Theme: Livestock productions

Keywords: old orchard, native breeds, outdoor system, welfare, quality

Abstract

In the Polish National Agri-Environmental Programme, the conservation of animal genetic resources has been a separate package. Since 2015, activities supporting the cultivation of old varieties of fruit trees have also been implemented. For hundreds of years, up to the 1960s, many small farms from southern Poland used orchards to cultivate various crop species in inter-rows, but also to graze animals. This procedure was beneficial for a better balance of the animal's nutritional needs, as well as more intensive fruiting of orchards or their protection against pathogens. Today, these benefits have not disappeared, and even new opportunities have emerged. Unfortunately, the agroforestry system is not officially recognized in Poland as a method of agricultural production, and its elements are divided into various forms of so-called “greening”. The aim of the present study was to determine the effect of different values of the major parameters of the grazed orchard system on the welfare of native pig breeds.

The experiment used a total of 954 sows, piglets and fattening pigs of the Złotnicka Spotted, and Puławska as well as 600 Greenleg Partridge, Sussex and Rhode Island Red native breeds of birds. Animals were kept outdoors in an apple orchard with an old Jonathan apple variety on an area of 0.5 ha with separate hatchers and headquarters - individual for sows with litter, 50 for weaners and fatteners, 100 for laying hens and broilers. They were fed complete diets in accordance with national standards under the organic production conditions and were given constant access to water. Piglets were weaned at 35 days of age and fattened up to a body weight of 110 kg. Chickens were mated naturally from time to time, and the collected eggs were hatched using a small combination setter/hatcher with a capacity of 100 eggs. The whole research was carried out under organic production conditions.

The grazed orchard system had a significant effect on increasing the amount of movement in the daily distribution of behaviours of all the breeds (Tab. 1). Differences in the levels of stress and thyroid hormones proved highly significant throughout the study. The same holds true for the blood count analysis. Thus, the outdoor system turned out to be the most significant and strongest element that considerably increased the welfare of animals. The level of stress hormones in the whole range tested was significantly lower in animals from the grazed orchard system. The results of fattener production from the grazed orchard system showed significantly lower values compared to those from the indoor system. Lower weight gains and higher feed consumption were characteristic of each breed. Statistically significant differences in the level of egg production were found between the breeds, with Sussex achieving the best results at 28 weeks of egg production and Greenleg Partridge the worst. Statistically highest weight gains were found in RIR and Sussex chickens, but the latter consumed significantly more feed. No stereotypic behaviour was observed in pig or poultry keeping. Within each breed, the indoor system provided more favourable production conditions. However, vitamins concentrations and fatty acid profiles were statistically better

(P≤0.05) in both eggs, poultry and pig meat. The yield of Jonathan apples was 15 t/ha, which is many times lower than the yield of modern varieties. However, organic fruit was 25% less infected with apple scab and 18% apple fruit larvae. Undoubtedly, the consumption of fallen fruit by animals had a major impact on this.

The results obtained during the study clearly show that the grazed orchard system had a favourable effect on the welfare of pigs and birds. This response applies not only to the behaviour but also to the physiological indicators. However, the welfare cannot be separated from the animal production results. Thus viewed, the grazed orchard system will not be widely used in standard production, especially under Polish conditions. However, a closed production cycle of pigs and poultry could be a viable alternative to middle and small farms and the native breeds keeping.

Table 1. Average animal results in the grazed orchard system

Item	Results/breeds				
	Pigs		Poultry		
	Złotnicka Spotted	Puławska	Sussex	Rhode Island Red	Greenleg Partridge
No. of piglets born alive (head)	8.87	9.92	-	-	-
Sows moving (% of day)	64.7	64.6	-	-	-
Sows cortisol level (nmol/l)	62.1	68.4	-	-	-
RBC (x/µl)	6.6×10^{12} a	5.5×10^{12} b	-	-	-
Fatteners Daily weight gain (g)	670a	701b	-	-	-
Fatteners Feed consumption (kg/day)	4.4	3.9	-	-	-
Meet PUFA 6/3	10,68	9,92	-	-	-
Daily weight gains broil. (kg)	-	-	0,045 a	0,049 a	0,036b
Daily feed consumption broil.(kg)	-	-	0,181a	0,172ab	0,163b
Mortality broil. (%)	-	-	0,9	1,1	0,9
Egg production at 28 week (%)	-	-	61,5a	59,3b	57,4c
Daily feed consumption lh (kg)	-	-	0,169a	0,158b	0,124c
Mortality lh (%)	-	-	1,7a	1,4a	0,8b
Eggs PUFA 6/3	-	-	4,61a	5,4b	5,7b
Eggs Vitamin E (mg/g)	-	-	51,68	52,31	51,72

ab - differences significant at P≥0.05; AB - differences significant at P≥0.01; broil. –broilers; lh – lying hens

Figure 1. Sows in the grazed orchard system.

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Suitability of a silvopastoral system in organic cattle farming under Natura 2000

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Theme: Livestock productions

Keywords: Silvopastoral system, cattle fattening, organic production, Natura 2000

Abstract

Poland's National CAP Strategic Plan for 2023-2027 implements for the first time an eco-scheme under which agricultural activities are carried out in silvopastoral systems. Considering the aspects of biodiversity conservation, landscape conservation, but also the climatic significance of carbon dioxide capture and storage, such systems are becoming a particularly valuable initiative. Every region of Poland has specific conditions and traditions of combined cultivation or use of trees for optimized agricultural production. One of these is the eastern area of the Low Beskid Mountains, which forms the border between the Eastern and Western Carpathians. The natural assets of this area are well-preserved forest biocenoses with natural species composition (mainly beech woods but also well-preserved sycamore woods, as well as riparian forests and mountain alder woods) and non-forest biocenoses (mountain and lowland mat-grass swards, fresh extensively used meadows, transitional peat bogs and swamps, mountain and lowland alkaline peat bogs, mountain and riparian tall-herb communities). This area is also a forest fauna (e.g. red deer, roe deer) sanctuary with large predators (bear, wolf, lynx). Thirty-eight species of birds from Annex I of the Bird Directive were inventoried in the whole area, in addition to *Eleocharis carniolica*, the species listed in Annex II of Council Directive 92/43/EEC. At the same time these areas are subject to land abandonment while being a historically excellent site for raising small and large ruminants.

The study was conducted on permanent grasslands (220 ha) located in a Natura 2000 area with combined cultivation of trees in the form of belts (4 m wide on average) along the natural slope gradients (Fig. 1). Tree belts mainly consisted of the area's native beeches with an addition of grey alder and natural/wild understory. The silvopastoral system area encompassed south-east oriented slopes with an elevation of 350-650 m. From May to mid-October, a herd of 80 Hereford cattle, including 40 suckler cows, were kept in this area. Stocking density of the pasture was 0.43 LU/ha. Throughout grazing, natural mating was provided through the constant presence of a Hereford bull and cattle were fed exclusively on pasture sward with permanent access to water. Calves were fed milk from suckler cows until 90 days of age, and the feed ration for adult cattle contained at least 60% roughage. During the winter period, the herd was kept in buildings with pasture access. All of the production was managed under certified organic farming. Animal performance, pasture productivity and floristic composition of the pasture (using the Klapp method) were analysed during the study. Rejected herbage was estimated after each grazing. The results of pasture productivity in the paddock and silvopastoral systems are shown in Tab. 1. The observed differences largely resulted from the fact that the paddocks were used more efficiently in relation to free grazing in the silvopastoral system. In the latter system cattle avoided less tasty plants, resulting in greater amounts of rejected herbage and changes in floristic composition. Grasses accounted for 62% in the silvopastoral system and were represented by 12 species, including the dominant *Arrhenatherum elatius* L. (9%), *Festuca rubra* L. and *Poa pratensis* L. (8% each) and *Festuca pratensis* L. (7%). Legumes comprised 6 species with the highest proportion of *Trifolium pratense* L. (6%). Under paddock grazing, a significantly higher proportion was observed for grasses, which formed 69%. The dominant species were *Arrhenatherum elatius* L. (10% of sward), *Festuca rubra* L. and *Poa pratensis* L. (9%

each). Legumes constituted 10% of the paddock sward, of which 7% was formed by *Trifolium pratense* L. Dicotyledons were represented by 26 plant species. The highest proportions were found for *Ranunculus acris* L. (3%), *Mentha arvensis* L. (1%) and *Cirsium rivulare* (Jacq.) All. (1%) as well as *Rumex acetosa* L. Rushes and sedges accounted for 3% of pasture sward in the silvopastoral system. Among the dicotyledons, the largest amounts of rejected herbage were noted for *Ranunculus acris* L., *Ranunculus repens* L. and *Barbarea vulgaris* R. Br. The problem of winter and summer calvings, well known from conventional production, is much more acute in organic farming. With the advent of grazing season, winter-born calves can make full use of the pasture sward and thus grow very rapidly with minimal feed costs. These animals come from summer matings conducted most often in harem groups, which is very convenient for the farmer but at the same time difficult to confirm and control. The summer calving period proved the least beneficial in this respect. It requires as many as 3 pasture seasons for the animals to reach full weight, whereas for summer calvings one pasture season and additional grazing during winter and summer are sufficient. The animal dissection results obtained during the study are presented in table. They differ from the results obtained for conventional fattening of cattle mainly due to lack of concentrates in the diet and harsher environmental conditions. However, when analysing the obtained results against conventional extensive grazing, these results are entirely comparable. Again, winter-calving animals produced significantly better carcass cuts in terms of muscling, fatness and slaughter yield classes.
It should be noted that the silvopastoral system with free grazing produces significantly worse results in terms of natural pasture productivity when compared to the paddock system. This is also reflected in a higher proportion of dicotyledons in the floristic composition, which increases the amount of rejected herbage. Of the different calving seasons for beef cattle, the winter season proved the most favourable in terms of feeding based solely on pasture. However, in the system with suckler cows and organic production requirements it is difficult to carry out inseminations and pharmacological synchronization of estrus is not possible. Such deficiencies cause that silvopastoral systems, which are an element of biodiversity conservation in mountain areas, must be compensated for the loss of benefits as part of the implementation of strategic programs and eco-schemes.

Table 1. Performance test and slaughter evaluation parameters.

Parameter	**Calving season**			**Parameter**	**Type of grazing**	
Calving season/Body weight of fattening bulls (kg)				**Pasture green matter yield (t/ha)**		
Parameter	**Spring**	**Summer**	**Winter**	**Parameter**	**Paddock**	**Silvopastoral**
1st year – May	50	-	110	1st growth	18,7a	15,8b
1st year – December	220	170	270	2nd growth	10,2a	7,8b
2nd year – June	300	270	370	3rd growth	7,4a	4,7b
2nd year – December	450	410	510	-	-	-
Performance test and slaughter evaluation parameters				**Floristic composition of the pastures**		
Parameter	**Spring**	**Summer**		**Parameter**	**Paddock**	**Silvopastoral**
Muscling class	Ra	Ob		Grasses	69a	62b
Fatness class	2,1a	2,5b				
Slaughter yield (%)	53,6a	50,0b		Legumes	10	8
Carcass weight after slaughter (kg)	317,3a	259b				
Round, meat (kg)	36,2a	27,1b		Dicotyledons	19a	27b
Round, gross (kg)	42,5a	33,4b				
Round, bones (kg)	6,2	5,3		Rushes and sedges	2	3
Shoulder with knuckle, meat (kg)	15,0a	13,1b				

ab – significant differences at P≥0.05

Figure 1. Grazing area.

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Resilient and efficient land use in Europe: experiential knowledge and value chain analysis in Polish agroforestry systems

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Theme: Livestock productions

Keywords: Value chain analysis, beef production, resilience, sustainable business models

Abstract
The incorporation of trees and tree planting into livestock farming systems has been proven to provide many production benefits whilst simultaneously enhancing the ecological capital of agricultural land. Yet the adoption of silvopastoral practices in Europe remains limited as farmers often face numerous structural disadvantages when looking to expand their agroforestry enterprises. We are conducting participatory research to find practical solutions on-farm, and in relation to value chains, to drive the transition towards more resilient and efficient use of land. Drawing from the work and expertise of agroforestry researchers collaborating across Europe, we explore opportunities and challenges on-farm and in related value chains in Polish agroforestry systems. We focus primarily on a group of organic farmers who are cooperating in the production of beef and the introduction of a new silvopastoral model to their farms. The farms are located in the Beskid mountains in a region with poor and stony soils, where the most sensible use of land is mowed-grazed grassland production. Organic beef is still a niche product, however a silvopastoral standard behind organic might restore the positive image of meat production as environmentally balanced, climate-friendly and resilient. Farmers managed to achieve a high quality standard of beef production, which is appreciated by aware consumers. This has allowed them involvement in innovative supply chains with diverse customers (e.g., CSA cooperative, restaurants, bio-bazaars, organic shops).

The work looks to draw on the knowledge of experienced agroforestry practitioners as they interact with value chains to negotiate the challenges of sustainable food production, using in-depth interviews. To ensure the depth of study and value of insight, a multi-stage process was adopted for the development of our interview guide. The following measures were taken:

1) A structured literature review was undertaken by researchers to identify the key challenges and opportunities facing agroforestry practitioners in Europe.
2) The literature search results which were entered into a database where we then convened a SWOT analysis.
3) Our interview guide was pre-tested and practitioner feedback incorporated.

Much attention is paid in the region to silvopasture, particularly cattle grazing as a method for improving land use efficiency and soil protection. This interest is expected to grow soon, as advisory units supervised by the Ministry of Agriculture and Rural Environment started first initiatives on promoting agroforestry measures, already approved in the budget plan of CAP Strategic Plan. So far, our analysis has found that for our Polish cases, the silvopastoral system with cattle is successfully used by farmers to improve soil health, animal well-being and productivity, job satisfaction, provision of farm materials and fuel, and some additional revenue but only to a minor extent. But the growth of markets for agroforestry products in these cases are restricted by funding availability, highly bureaucratic regional market

regulation, and gaps in local supply chain infrastructure. The aim is to cross-analyse our results with other agroforestry case study results and identify value chain innovations that could unlock market growth for agroforestry products in the Beskid mountain region.

Livestock Residence Index to monitor Sarda cattle grazing in a Mediterranean silvopastoral system

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Theme: Livestock productions

Keywords: precision grazing, silvopastoral systems, GPS livestock tracking

Abstract

The beef cattle livestock system in Sardinia is based on suckler cows, often belonging to autochthonous breeds such as Sarda, grazing in the context of silvopastoral systems (SPSs). The livestock grazing behaviour and spatial distribution are critical factors for the design of sustainable grazing management in SPSs. The Global Positioning System (GPS) technology allows continuous tracking of cattle position and the estimation of grazing behaviour. This study was conducted within the iGRAL research project (Innovative beef cattle Grazing systems for the Restoration of Abandoned Lands in the Alpine and Mediterranean mountains) which aims to find sustainable solutions to the dramatic abandonment of Italian mountains. We explored the potential of GPS tracking in monitoring the grazing behaviour of Sarda cows in an area characterised by different vegetation types: deciduous oak woods, shrublands with *Rubus ulmifolius* and *Pteridium aquilinum*, and grasslands. Twelve free-roaming Sarda cows were fitted with GPS Knight collars (Knight et al. 2018) for over one year. GPS were scheduled to record positions every 3 min. The distance between two sequential positions and speed were calculated. Following Trotter et al. (2010), an average hourly velocity cut-off of 4.5 m min-1 was used to categorise the GPS locations into discrete sessions of "low" and "high activity". Raw data points of "high activity" were mapped as a Livestock Residence Index (LRI, Trotter et al. 2010) on a 50×50 m grid using QGIS (v. 3.10.14 "A Coruña"). The LRI for any given grid cell x (LRIx) was calculated using: LRIx = ∑x Raw GPS locations count/(∑n∑x) Raw point count, where n is the number of cells in the entire trial field. The proportion of points within each grid cell was calculated and showed as LRI maps. As a GPS fix was collected in a high percentage of attempts, each point was accepted as representing equal time portions and the LRI an assessment of the total time spent by the animals in a certain area.

The "high activity" in the daily pattern of movement by the collared animals during the early morning and evening was associated with the majority of grazing activity of the livestock (Gregorini et al. 2006; Probo et al., 2014). A LRI map (Fig. 1) represented the spatial distribution of the grazing livestock. By combining the grazing time spent by cows in the different grid cells (Fig. 1), with the total nutritional requirements of the herd (MJ of metabolisable energy, MJME), probably met through the grazing activity, we could associate the different grid cells with a specific animal stocking rate, expressed as nutrient requirements of cows (MJME ha-1). Following this procedure, the observed mean, minimum and maximum stocking rate values were 1,809, 0 and 15,150 MJME ha-1year-1, respectively. Supplementary feeding (hay)

covered less than 5% of total suckler cows' requirements. Showing a stocking rate less than 10% of the average value, the area never used by grazing animals was 12.5% of the total area. The grazing spatial patterns were influenced by the season, the spatial distribution of the different vegetation types, the position of water points and supplementary feed distribution points. The GPS tracking devices proved to be effective in assessing the spatial grazing patterns of livestock. Such data represent a robust basis for designing sustainable grazing management strategies to improve the use efficiency of pastoral resources through e.g. the strategic location of water points and supplementary feed distribution points, or attraction points such as salt or molasses. These results represent the first findings concerning the Sarda cow grazing behaviour in silvopastoral areas. Further research is necessary to quantify the correlations between movement data with grazing activity and to better understand the relationship between vegetation dynamics and grazing behaviour.

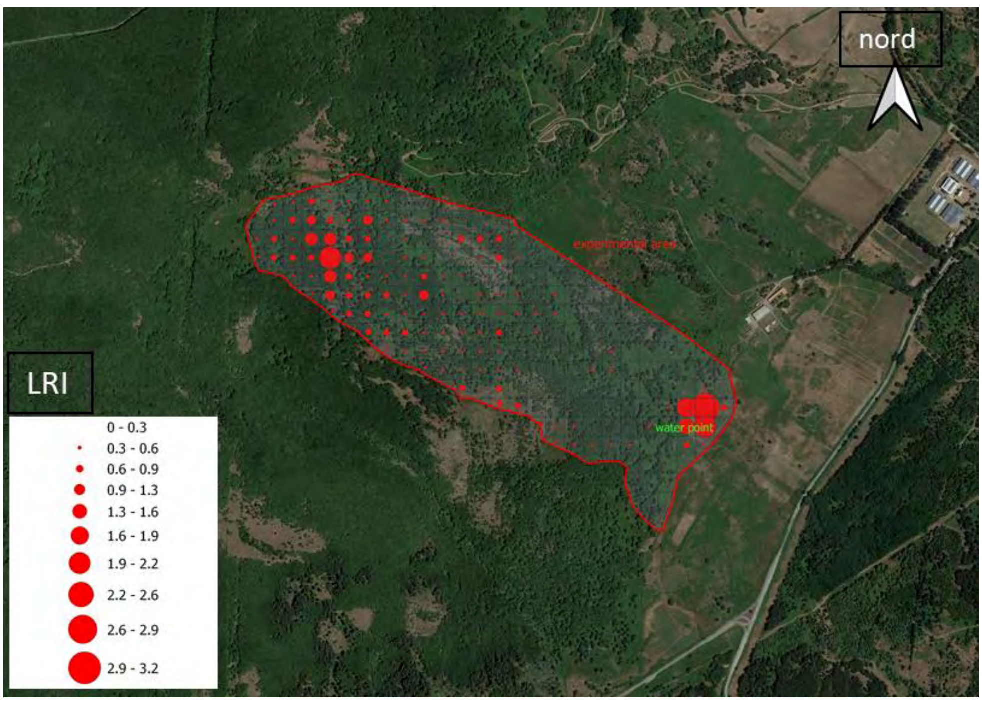

Figure 1. Spatial variation in experimental area used by Sarda cows over one year expressed as a Livestock residence index (LRI×100) map on a 50-meter grid

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TOPIC 3

ECONOMY AND POLICY OF AGROFORESTRY

3

T 3.1

NEUTRALITY CERTIFICATIONS AND CARBON FARMING

3 .1

Agroforestry systems to support carbon neutrality of dairy cow production: preliminary assessment of a carbon insetting scenario in northern Tuscany (Italy)

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Theme: Neutrality Certifications and carbon farming

Keywords: models, silvoarable, neutrality, sustainability

Abstract

Within agricultural activities, livestock husbandry is one of the most impacting sectors in terms of greenhouse gas (GHG) emissions. On the other hand, animal productions maintain economic and social sustainability in both marginal and intensive agricultural areas. Globally, alongside concerns about the environmental sustainability of this sector, improvements of the health of animals, labour and agroecosystems are sought after, to ultimately achieve more sustainable farming systems.
Carbon insetting refers to any activity that a company undertakes directly to reduce their GHG emission or indirectly by sinking carbon from the atmosphere within its own value chain (Banerjee et al., 2013). In this sense, the inclusion of agroforestry systems in livestock farms can help the transition to a low-carbon agriculture through stocking carbon in tree biomass and soil while continuing with the same economic activity (Nair et al., 2011).
Following this approach, a preliminary scenario analysis was conducted to explore the potential of carbon sequestration of poplar alley-cropping systems included in a dairy supply chain. A Life Cycle Assessment (LCA) study was performed using the production of 1 liter of packed whole milk as unit and by following the Product Category Rules for milk of the International Environmental Product Declaration (EPD). The study was conducted from cradle to grave, relying on a subset of the dairy factory suppliers, represented by eight farms located in Mugello (northern Tuscany). The LCA analysis was conducted by collecting primary data at all stages of the value chain, including farming, processes within the dairy factory, and downstream processes. The reference years were 2018 and 2019 (Table 1). The Eco YieldSafe model dashboard (http://www.isa.ulisboa.pt/proj/ecoyieldsafe/#/dashboard) was used to assess the potential of carbon sequestration of the implementation of a poplar alley-cropping system located in Mugello (latitude 44.0064, longitude 11.3649), with a tree density of 66 trees ha^{-1} in lines separated by 30m alley width with a grain maize, winter wheat, oat, and barley crop rotation.
First results showed that for the assessment of the Global Warm Potential (GWP) of l litre of whole milk was 1.515 CO_2 eq L^{-} and the CO_2 emissions per hectare of utilized agricultural area (UAA) varied from 5.48 to 40.85 Mg CO_2 ha^{-1} y^{-1} among selected farms according to cattle stocking rate. Ten years after tree planting, the model predicted a total above-ground production of 21.59 Mg ha^{-1} of timber. The CO_2 compensation of simulated agroforestry system was 3.69 Mg CO_2 ha^{-1} y^{-1} considering a poplar biomass carbon content of 46.66% (Zhang et al., 2020).
These preliminary computations highlighted that an insetting strategy led by the dairy company would allow a compensation of the GHGs emission derived from packed milk production. For the 8 selected

farms, the inclusion of agroforestry systems in the value chain would represent a potential carbon compensation of around 21% of the total GWP produced (17.59 Mg CO_2 ha UAA-1 y-1)

Table 1 – Characteristics and Global Warming Potential (GWP) of the selected farms in Mugello (Italy)

Farms	Agricultural Land (AL)	Utilised Agricultural Area (UAA)	Stocking rate (AL)	Stocking rate (UAA)	Milk production	Productivity per animal	GWP (farm)	GWP (AL)	GWP (UAA)
	ha	ha	LU ha AL^{-1}	LU ha UAA^{-1}	L Milk y^{-1}	L $unit^{-1}$	Mg CO_2 y^{-1}	Mg CO_2 ha AL^{-1} y^{-1}	Mg CO_2 ha UAA^{-1} y^{-1}
1	78	40	0.43	0.84	144,764	6,032	219.317	2.81	5.48
2	120	103	1.60	1.87	820,520	8,729	1,243.087	10.36	12.07
3	284	213	1.46	1.95	1,703,434	8,849	2,580.702	9.09	12.12
4	57	56	1.62	1.65	591,380	9,462	895.941	15.72	16.00
5	44	44	3.88	3.88	737,047	8,620	1,116.626	25.38	25.38
6	54	49	2.33	2.57	846,557	10,923	1,282.534	23.75	26.17
7	156	102	2.85	4.36	1,987,944	9,466	3,011.735	19.31	29.53
8	22	14	3.41	5.36	377,455	9,436	571.844	25.99	40.85
								Mean	*17.59*

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Sustainable management of Agroforestry systems: state of the art of PEFC certification in Italy

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Theme: Neutrality Certifications and carbon farming

Keywords: Agroforestry certification, Sustainable management, PEFC, Endorsement process,

Abstract

The Programme for the Endorsement of Forest Certification (PEFC) is an international, non-profit, non-governmental organization dedicated to promoting Sustainable Forest Management (SFM) through independent third-party certification. Expanding PEFC's scope from trees within forests, to include trees outside forests (T.o.F.), is an important consideration for advancing sustainable landscapes and rural livelihoods. The term ToF refers to all trees that are grown outside the nationally "designated forestland"; and includes both intensive and extensive, agriculture or settlement production systems. Within the scope are trees growing on private lands in fields and on field-boundaries in orchards and in common and state non-forest lands in parks and gardens, along roads, canals and railway lines in rural or urban areas etc. PEFC in general works throughout the entire forest supply chain to promote good practice in the forest and to ensure that timber and non-timber forest products are produced with respect for the highest ecological, social and ethical standards. Sustainable management criteria and guidelines for ToF are now necessary to achieve certification, since this land use is growing in importance, and could represent at least 27% of the global area of tree-based systems. Management guidelines for forestry form the basis of certification of products from sustainably managed agroforestry systems. This approach will bring agroforestry to the attention of consumers, while emphasising its importance for the sustainable production of food, timber, fuel and environmental services from agroforestry systems. Thanks to its eco-label, customers and consumers are indeed able to identify products from sustainably managed forests and ToF areas.

Starting from November 2020, PEFC Italy followed PEFC International standard setting benchmarks to develop a certification standard for Sustainable management of Agroforestry systems, creating a working group with wide and balanced stakeholder engagement. In 2021 the working group had several online meetings (due to the pandemic situation), which led to creation of PEFC national standard for certification of Sustainable management of Agroforestry system in spring 2022. In summer 2022, three pilot tests will be carried out in Tuscany in areas involved in the EIP-AGRI Operational Groups (RDP of the Region of Tuscany 2014-2022) "NEtWork for agro-forestry in TOscaNa - NEWTON". The field tests will verify the feasibility of this certification standard which will be presented at PEFC International for its final recognition and endorsement. The first agroforestry system certifications will be possibly available in summer 2023.

Increased tree root growths due to soil management in agroforestry systems

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Theme: Neutrality Certifications and carbon farming

Keywords: ground penetrating radar (GPR), tree root structure, carbon storage

Abstract

The European Commission proposed agroforestry as a measurement to store carbon and mitigate climate change impacts (European Commission 2021). However, quantifying the amount of carbon stored in agroforestry trees remains challenging (Pellerin et al. 2020). While aboveground biomass is measurable (Kay et al. 2019), limited information exists of belowground biomass especially on root growth and the root system architecture in agroforestry systems. Hence, this underground interaction of the trees and the agricultural crops is crucial as they could either compete with or benefit from each other. Furthermore, quantification of the amount of belowground carbon storage is important.

Using ground penetrating radar (GPR), a non-destructive investigation method that allows for repeating mapping of crop and tree root horizons (Hugenschmidt 2012), we mapped the roots of two 80 year old pear trees on cropland in the Canton of Zürich in Switzerland. We explored the impact of tillage on tree root system architecture based on two hypotheses: a) is tree root growth and structure affected by soil management and b) can trees exposed to soil management grow deeper and open up additional (deeper) soil compartments below the arable production.

Our results revealed that tillage significantly influenced root growth and structure. Ploughing removed tree roots to a depth of approximately 40 cm (plough layer). 74 % of tree roots were developed at a depth of 30–55 cm in the unploughed section, while in the ploughed section 83 % of all roots were found at 60–75 cm. This indication of an overcompensation of additional root growth in the ploughed section was statistical significant. Both measured trees showed similar results.

Overall, we found that in agroforestry systems crop roots and tree roots colonised in different soil depths. Moreover, tree roots were rooting deeper and intensified root growth as if grown without soil management. Thus, the potential volume of water and nutrient intake enlarged, which might enhance the resilience of the combined production systems. In addition, this might also indicate a trend that ploughing reinforces root growth resulting in increased potential for belowground biomass carbon storage in deeper soils.

Figure 1. 80 year old pear trees in cropland (left: in March 2021; right: in July 2020)

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T 3.2

AGROFORESTRY EUROPEAN POLICY

3 .2

A scoping review of the economic competitiveness of temperate agroforestry systems in Europe and North America

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Topic: Agroforestry European policy

Keywords: review, temperate agroforestry, economic performance, profitability

Abstract:
Research on temperate agroforestry has increased in recent years due to its potential to simultaneously contribute to climate change mitigation and adaptation. While there are reviews on their environmental and ecosystem service outcomes, such knowledge synthesis is missing when it comes to their economic performance.
This review aims to fill this gap and to identify research gaps using the JBI methodology of scoping reviews after von Elm et al. (2019). A scoping review protocol was written alongside the review.
Papers reporting on the economic performance of agroforestry systems frequently use indicators of capital budgeting and investment planning (e.g. NPV, EAV, net and gross margins), while few studies focus on risk. Since there are few mature agroforestry test sites, nearly all included studies use modelling. Sixteen of the 43 studies use formalised models (e.g. Farm-SAFE, POPMOD, YIELDPLUS, ALLEY 2.0 and others), fourteen more model without a formalised model, and the rest uses either existing field data or are a review. Of the papers that compare agroforestry with agricultural and/or forestry land use, most come to the conclusion that agricultural production is generally more profitable than agroforestry, which in turn is generally more profitable than forestry. There are however a lot of exceptions to this. Especially at low discount rates, high tree-product prices and low agricultural prices, agroforestry can become more profitable than both other land uses. Additionally, if environmental externalities are internalised and policy support increases, agroforestry systems are likely to be on the same level or more profitable than the two other land uses. There are also some site characteristics under which agroforestry is more likely to be competitive with agriculture, for example marginal land with high erosion risk or nutrient leaching, as well as sites with a high soil suitability for specific tree species. Evidence in regards to risk is very limited but it suggests that for risk-neutral farmers agroforestry could be the preferable land use option. If climate risk and risk of natural hazards increases to the extent that agricultural yields are threatened, agroforestry could also achieve higher economic returns than agricultural production. This review found research gaps especially in regards to risk assessment and the economic assessment of non-traditional silvopastoral practices. Looking at the results from the 43 papers included in this review, the conclusion can be drawn that under current market and policy conditions agroforestry systems are generally outperformed by traditional agricultural production. However, since intensive large-scale agriculture has substantial negative externalities, agroforestry's ecosystem service provisioning lends justification for policies that incentivise implementation to bridge the gap in economic performance. Whilst the future GAP has increased funding opportunities for agroforestry in both pillars it remains to be see if this will sufficiently incentivise farmers to switch production systems.

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Upscaling agroforestry practices from the field to the regional scale: a case study in the Walloon region, Belgium

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Topic: Agroforestry European policy

Keywords: Belgium, hedgerows, orchards, upscaling

Abstract

Our technical understanding of temperate agroforestry systems improved considerably in the last twenty years (Gordon et al. 2018). Alongside to the improvement of our understanding of the processes at play in those systems, recent studies showed that stakeholders, although very aware of the difficulties associated with agroforestry practices, have come to understand their ecological benefits (Burgess and Rosati, 2018, García de Jalón et al. 2018, Teixeira et al. 2019). Policy makers are also increasingly aware of those benefit and agroforestry is bound to take a more prominent place in agricultural policies (COWI Ecologic Institute and IEEP, 2021). One of the main reason for this change is that agroforestry is often seen as a promising tool for building up Soil Organic Carbon (SOC) content in agricultural systems (Chapman et al. 2020, Mayer et al. 2022) and for biodiversity conservation (Jose 2009, Udawatta et al. 2021). However, agroforestry systems should be widespread in order to have a significant impact on several ecosystem services such as carbon sequestration or climate change mitigation. In this regard, focusing on field-level agroforestry is not sufficient and upscaling at the regional or national scale should be considered. Such upscaling requires a contextualized, systemic approach taking into account technical, economic and reglementary considerations along with sensitization of the target groups.
Wallonia has recently (2020) adopted an ambitious plan – called "Yes We Plant" – to develop plantation of trees outside the forest area with an objective of planting 4000km of hedgerows and/or 1 million trees at the horizon 2024. Completion of such plan requires specific actions including strong incentives. One of the pillars of the program is the use of subsidies as incentives for plantation. Those subsidies are also a powerful tool to monitor and assess the success of the program. For instance, data from the first planting season of the program showed an increased of subsidized hedgerows plantation of 26%. The "average hedgerow" was 203 m long and made of 11 different species, 8 of them being of interest for insects populations. As the 2021-2022 planting season reaches it end, about 1 100 hedgerow kilometres and 850 000 trees have been planted, bringing hope for the final success of the program. However, such ambitious plan puts significant strain of several key sections of the chain of value (from seed collection to valorisation of the wooden products). Subsidies, although important, are therefore only one of numerous actions that have to be considered. Consequently, in order to identify priority actions, a seven-step process was established. This process allowed to take into consideration all major steps of the chain of value and the associated actors. This systemic approach included societal, technical, economical and reglementary considerations while taking into account the mentality changes needed from several target groups involved in the process (general public, seed and plant producers, farmers…). Several lessons learned during this program are of high relevance for other contexts. For instance, farmers' concerns of planting trees on agricultural land seem to be more prominent in regions of high pressure for intensive agriculture, which are also regions where the proportional impact (in term of biodiversity connectivity for instance) of new plantations is higher. This highlights the importance of the valorisation of agroforestry both in national and international (e.g. CAP) policies. The main lessons learned from this ongoing 4 year program are presented and discussed along with the main difficulties that arose during the implementation of the program.

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Agroforestry in the agricultural plans of 14 EU Member States plus the UK and Switzerland.

EURAF 2022
Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry

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Abstract

The current CAP Rural Development Regulation (Regulation 1305/2013) defines agroforestry as "*a land use system in which trees are grown in combination with agriculture on the same land*", and EURAF has provided MS with an Agroforestry Typology which recognises the need to identify agroforestry within agricultural parcels, and on their edges, and also on officially designated forest land [1] (Figure 1).

The existing CAP Pillar II budget (€15.3 billion on rural development in 2021) includes spending on new agroforestry and agroforestry restoration in submeasure 8.2 However, by the end of 2019 only 6 countries (PT, ES, IT, FR, BE, UK) and 30 regions (out of 118) had implemented this submeasure, with planned hectares reduced from 84k (2015) to 60k (2019), and planned expenditure reduced from 130M€ (2015) to 64M€. (2019) By the end of 2019 only €3.3M had been spent. Implementation is thought to be poor because of a) lack of information for farmers/land managers, lack of information for management authorities, changing rules, confused announcements, competition from other measures (agri-environment, afforestation), low payment levels or periods [2].

Tree location	Agroforestry System	Agroforestry Practice	
		Agricultural Land	Forest Land
Trees inside parcels	Silvopastoral agroforestry	1 Wood pasture	9 Forest grazing
	Silvoarable agroforestry	2 Tree alley cropping 3 Coppice alley cropping 4 Multi-layer tree-gardens	10 Muiti-layer tree gardens
	Permanent crop agroforestry	5 Orchard intercropping, 6 Orchard grazing.	
	Agro-silvo-pasture	7 Alternating cropping and grazing	
Trees between parcels	Tree Landscape Features (protected by CAP Conditionality Rules)	8 Tree-Landscape-Features : (protected hedges, scattered individual trees, trees in line, small groups of trees)	
Trees in settlements	Urban agroforestry	homegardens, allotments, etc.	

Figure 1: Agroforestry typology for the EU (Dupraz et al 2018)

Agroforestry is stressed in the EU Green Deal, the Farm to Fork Strategy and the Biodiversity Strategy [3]. The EU Forest Strategy for 2030 includes a commitment to plant 3 billion "additional" trees, and recognises that many of these should be outside forests [4]. EURAF provided a methodology to focus tree planting on those agricultural areas which have high environmental stress [5].

Three draft CAP Regulations were published by the Commission in June 2018 and approved by Parliament in December 2021. The Basic Act (Regulation 2021/2115) mentions agroforestry 10 times, with an important recognition in Article 4 that "Agricultural Area" is "arable land, permanent crops and permanent grassland, **including when they form agroforestry systems on that area**". Member States (MS) are expected to provide national definitions for agroforestry on arable, permanent crops and permanent grassland in their CAP Strategic Plans (CSPs), and to record the annual establishment of agroforestry as part of Result Indicator 17 and/or Output indicator 16 in the CAP Performance Monitoring and Evaluation Framework (PMEF) [6]. However, very few MS have clarified how they will identify agroforestry in agricultural CAP returns from farmers and the national CAP geospatial databases (IASC/LPIS).

In the new CAP all MS must protect a minimum area of "non productive areas or features" under the terms of "Good Agricultural and Environmental Condition" (GAEC) 8. This includes "tree-landscape-features" (hedges, groups, lines and individual trees) and farmers in MS are expected to confirm the position and area of these features in their annual IACS/LPIS returns. However, Member States vary significantly in the way they implement this requirement in their CSPs, with some including conversion and weighting factors for all four tree-landscape- features, and others ignoring the option completely.

Ecoschemes are a new component of the CAP post 2023. They comprise 20% (2022-24), rising to 25% of the Pillar I budget (€168.5 billion in 2021). Ecoschemes should provide options to farmers which go beyond the climate and environment commitments in GAEC rules. Both agroforestry and carbon farming are listed by the Commission as options to be used by MS in their Strategic Plans [7]. However only two MS have implemented the agroforestry ecoscheme option, and reasons for this will be considered in the presentation.

The EU is committed in its Climate Law to a 55% reduction in GHG emissions by 2030 compared to 1990, and neutrality by 2050. A major step towards this is proposed by the Commission in its revised LULUCF Regulation. This aims for LULUCF to sequester 310 Mt CO_2 equivalent by 2030, and for climate neutrality in the combined "Agriculture Forestry and Other Land Use" Sector (AFOLU) by 2035. The Commission communication on "Sustainable Carbon Cycles", and its accompanying staff working paper, make several mentions of the importance of agroforestry in meeting these targets [8], An evaluation study of the technical options for carbon farming, funded by DG CLIMA[9], identified agroforestry and conservation of organic soils as the two front-running carbon farming measures for Europe.

The oral presentation will summarise the status of agroforestry in the CAP Strategic Plans (or equivalent in the UK and CH) of the 16 countries (BE,CH,CZ,DE,DK,EL,ES,FI,FR,HU,IT,LV, PT,SE,SI,UK) represented in the recently approved EU DigitAF project, due to start in June 2022.

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European state of agroforestry: an overview of the current policy contexts

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Agroforestry for the Green Deal transition.
Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Agroforestry European policy

Keywords: Agroforestry, policy co-development, policy contexts

Abstract

Agroforestry as a multifunctional system that can address issues around food security, climate change and land degradation is gaining traction and interest amongst farmers and policy makers alike. Despite the known benefits and direct policies aimed at developing agroforestry systems, they remain in a minority, both in Europe and around the world. The AGROMIX project explores how to transform European landscapes with agroforestry and mixed farming systems based on agroecological principles. AGROMIX has compiled an inventory of AF policies available, and serves as a baseline for future policy co-development in the AGROMIX project. The report is based on member state's national policies and other key documents such as the EU's Common Agriculture Policy (CAP), and the European 'Green Deal' including the 'Farm to Fork' and 'Biodiversity Strategy'. 19 European countries (16 EU, 3 non-EU) and 5 non-European were analyzed. Results show that the policy landscape for AF has been incrementally growing in Europe in the last few years. The primary source of support has been found within the CAP during the 2007-2013 and 2014-2020 periods but many state and local policies have also been reflecting this change (see table). Within the 2007-2013 periods only five EU member states (Belgium, France, Hungary, Italy and Portugal) supported AF in the CAP, while it was supported by eight member states (Belgium, France, Hungary, Italy, Portugal, Spain, UK and Greece) in the 2014-2020 CAP. Some member states like Hungary supported this policy within the entirety of the country, while in places like the UK and Italy it was only supported by certain regions. Nevertheless, there has been very little farmer uptake in most of the countries that created CAP AF programs, leaving most member states with large leftover budgets that should have been allocated to AF. AF will continue to find support within the new CAP, as well as major EU legislations around climate and biodiversity. We conclude:

- The few policies that support AF systems directly, approach them with a **specific technical/agronomic aspect** and not with further agroecological principles in mind e.g. failing to incorporate socio-economic aspects.
- There is a **strong lack of financing** for AF.
- The potential for AF is seen in respect to carbon sequestering ecosystem service providers but not as major **food system change driver**.
- Policies specifically related to **gender** were not found, although there is research interest that links (species, mixing crop, landscape and marketing) diversity to the presence of diverse gender role.

Policy coherence and alignment with other sustainability, food security and food sovereignty goals must not be over-looked. AF systems are also agroecological systems and their implementation must adhere to the principles of agroecology in Europe. Those extend into the socio-political aspects of the food

system re-design. Policy makers need to take all these considerations into account when co-developing policy.

Table 1. European Policy Landscape for AF and MF. The yellow represents CAP support; green is national support; while grey is for countries where the CAP doesn't apply. The lighter green found within National Policies represents places that only have AF support when it comes to reindeer husbandry.

Country	CAP implementation of Measure 8.2	Farmer Uptake	National Policies for Agroforestry
Belgium (Flanders)			
Belgium (Wallonia)			
Bulgaria			
Czech Republic			
Estonia			
Finland			
France			
Germany			
Hungary			
Ireland			
Italy			
Netherlands			
Poland			
Portugal			
Romania			
Serbia			
Spain			
Sweden			
Switzerland			
UK			

An agroecological future: which frameworks should we apply when developing agroforestry policy in England?

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Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Agroforestry European policy

Keywords: Policy co-development, agroforestry, agroecology, land-use framework, sustainability

Abstract

Agroecology as a concept for reimagining food systems has grown in popularity and is now used in various food and agriculture policy frameworks around the world. While there is a significant body of research around agroecology, its origins, applications, and as a much-needed transition pathway to sustainable food systems, there is little focussing on which policy frameworks are applied and in what ways agroecological knowledge is used to inform decision-making. This work contributes to the limited literature on agroecological policy by analysing how various frameworks are applied within the policy process and which frameworks may lead to an agroecological future, focussing specifically on agroforestry and land-use in England. As the policy process in England progresses post Brexit, various actors are employing different frameworks to deliver complimentary and contrasting objectives within the agricultural sector (net-zero, diet related health, environmental and economic sustainability and biodiversity goals). As the Environmental Land Management Scheme (ELMs) develops, three frameworks are reviewed to assess which could be most helpful in developing agroecological policy for agroforestry in England. The frameworks are: Ecosystem services (ES); the United Nation's Sustainable Development Goals (SDGs); and, the Food and Agricultural Organisation of the United Nation's (FAO) 10 principles for agroecology. Then, using content and thematic analysis, live policy documents pertaining to agroforestry in England (four European and five national) were evaluated to assess the degree of embeddedness of each framework in the policy process. All three frameworks had a low degree of embeddedness within the policy documents analysed and there was little evidence of knowledge transfer into legislation. Additional agroforestry policy drivers were mapped, highlighting the complexity of the policy landscape and the interconnected nature of policy goals. Results highlighted the following 2 key considerations: (1) Opportunities are presented whereby multiple agricultural, environmental, health and economic goals can be met; achieving co-benefits across sectors, e.g. food security, national health, biodiversity, carbon capture and others, (2) Out of the frameworks analysed, the FAO's 10 principles for agroecology has the most potential to position sustainable food systems as the lever between these policy drivers, and should therefore be used in developing agroforestry policy. This is because it integrates aspects of sustainable food systems in a more interconnected way than the other frameworks. In addition, it provides a more contextualised, place-based approach, which allows users to make comprehensive decisions, maximising synergies between environment, health and economic goals. Finally, given the enormous pressure on land in England and the many competing interests in its potential uses, coupled with the urgent need to restore biodiversity, sequester carbon and ensure everyone has access to nutritious and affordable food, there is no time to waste in making land-use decisions: the framework with the most potential to support agroforestry policy development should be used. This study suggests that such a framework needs to be the FAO's 10 principles for agroecology.

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European Commission (2020) 'Farm to Fork Strategy' available online: https://ec.europa.eu/food/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf

European Commission (2021) 'EU Forest Strategy for 2030' available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0572

FAO '10 Elements of Agroecology' available online: https://www.fao.org/3/i9037en/i9037en.pdf

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The benefits of Agroforestry for the environment, climate change mitigation and agricultural production – a global synthesis

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Agroforestry for the Green Deal transition.
Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Agroforestry European policy

Keywords: agroforestry; meta-analysis; knowledge synthesis; environmental impact; climate change mitigation

Abstract
The European Commission is currently collecting available scientific evidence on the potential of farming practices to achieve the environmental and climate objectives within the Common agricultural policy (CAP), while supporting the EU Green Deal and Farm to Fork strategy. Agroforestry is one of the proposed practices.
Here, we present the results of a systematic review of research-synthesis studies (RSS)(such as systematic reviews and meta-analyses), to provide robust scientific evidence on the environmental, climate, and production impacts of agroforestry systems. We screened over 60 RSS retrieved from Web of Science® and Scopus® databases, from which we selected 32 RSS. Each RSS synthetises the results of several individual studies (ranging from 3 to 140), conducted around the world. Out of 32 RSS, 29 meta-analyses (MAs) included statistical comparisons of agroforestry systems versus conventional farming systems on a large set of environmental and agricultural production outcomes and 12 of them included data from studies conducted in the EU context.
The MAs consistently show that, when compared to conventional systems, agroforestry systems have a wide range of positive effects that support the environmental, climatic, biodiversity and landscape objectives of the CAP 2023-2027. These include the following: (1) Increase soil organic-C stocks, (2) improve biodiversity and increase pollinators, (3) promote pest- and disease-control, (4) enhance soil water retention, (5) decrease soil erosion, (6) decrease greenhouse gas emissions.
Carbon sequestration increases by 18–70% by establishing agroforestry systems (results from 10 different global MAs, 5 of which include data collected in Europe). In particular, it was estimated that a shift to agroforestry can mitigate 27.2 ± 13.5 t CO_2-eq ha^{-1} y^{-1}, at least for the first 14 years after establishment (accounting for C- sequestration in biomass and soil and for changes in net emissions of soil-CH_4 and N_2O emissions) (Kim et al., 2016). Water retention and nutrients stocks in soils are increased by 50-100% and 20-70% according to 5 and 4 MAs, respectively. Agroforestry also substantially limits soil erosion and nutrient runoff (by 50-80%, according to 3 MAs), driven by the presence of trees and shrubs. Biodiversity indexes, covering several taxa like plants, birds, invertebrates, reptiles, fungi, mammals, and amphibians or functions (e.g. pollination), were reported to increase by 20-50% in average, according to 3 different MAs including European data.
Interestingly, when considering co-productions from the same land, agroforestry systems can yield similar or sometimes higher amounts of more diversified food products per hectare. However, results were more

variable for crop yield across different MAs, depending on the type of agroforestry system and other factors (e.g. type of crops, type of perennials, pedo-climate).

We conclude that increased use of agroforestry systems within the EU, supported by relevant policy frameworks such as the CAP 2022-2027, would help achieving European climate and environmental targets, potentially without decreasing productivity. We also highlight a strong need for further scientific evidence in the European context.

Table 1 - List of synthesis studies (systematic reviews and meta-analyses) included in this analysis

First author	Year	Reference	DOI
Shi	2018	Land degradation and development 29 3886-3897.	10.1002/ldr.3136
Bohada-Murillo	2019	Frontiers in Sustainable Food Systems 3, 83.	10.1002/ldr.3478
Bayala	2018	In: Improving the Profitability, Sustainability and Efficiency of Nutrients Through Site Specific Fertilizer Recommendations in West Africa Agro-Ecosystems pp. 51-61, Springer, Cham.	10.1007/978-3-319-58789-9_4
Akinnifesi	2011	Sustainable Agriculture 2: 129-146	10.1007/978-94-007-0394-0_9
Palacios	2013	Agroforest Syst 87:517-523.	10.1007/s10457-012-9571-z
Poch	2013	Agroforest Syst 87:871-879.	10.1007/s10457-013-9603-3
De stefano	2018	Agroforestry Systems, 92, 285-299.	10.1007/s10457-017-0147-9
Felix	2018	Agronomy for Sustainable Development 38, 57.	10.1007/s13593-018-0533-3
Kuyah	2019	Agronomy for Sustainable Development 39, 47.	10.1007/s13593-019-0589-8
Norgrove	2016	Current Forestry Reports volume 2, 62–80.	10.1007/s40725-016-0032-1
Rivest	2013	Agriculture, Ecosystems and Environment 165: 74-79.	10.1016/j.agee.2012.12.010
De	2013	Agriculture, Ecosystems & Environment, 175, 1-7.	10.1016/j.agee.2013.05.003
Sinare	2015	Agriculture, Ecosystems & Environment 200, 186-199.	10.1016/j.agee.2014.11.009
Kim	2016	Agriculture, Ecosystems & Environment 226: 65-78.	10.1016/j.agee.2016.04.011
Torralba	2016	Agriculture, Ecosystems & Environment 230: 150-161.	10.1016/j.agee.2016.06.002
Feliciano	2018	Agricolture, Ecosystem and enviroment, 254, 117-129.	10.1016/j.agee.2017.11.032
Chatterjee	2018	Agriculture, Ecosystems and Environment, 266, 55-67	10.1016/j.agee.2018.07.014
Muchane	2020	Agriculture, Ecosystems & Environment, 295, 106899.	10.1016/j.agee.2020.106899
Staton	2019	Agricoltural systems 176, 102676.	10.1016/j.agsy.2019.102676
Pumarino	2015	Basic and applied ecology 16:573-582.	10.1016/j.baae.2015.08.006
Nichols	2007	Biological Conservation 137 : 1-19.	10.1016/j.biocon.2007.01.023
Rosalien	2017	Ecological economics, 140, 136-145.	10.1016/j.ecolecon.2017.04.019
Ilstedt	2007	Forest Ecology and Management 251: 45–51.	10.1016/j.foreco.2007.06.014
Santos	2019	Forest Ecology and Management 433, 140-145.	10.1016/j.foreco.2018.10.064
Bayala	2012	Journal of Arid Environments 78: 13-25.	10.1016/j.jaridenv.2011.10.011
Sileshi	2016	Journal of Arid Environments 132: 1-14.	10.1016/j.jaridenv.2016.03.002
Plexida	2018	Journal of arid environments, 151, 125-133.	10.1016/j.jaridenv.2017.11.017
Sun	2018	Science of the total enviroment, 626, 1394-1401.	10.1016/j.scitotenv.2018.01.104
Chaudhary	2016	Scientific reports 6:2394.	10.1038/srep23954
Ziegler	2012	Global Change Biology 18: 3087–3099.	10.1111/j.1365-2486.2012.02747.x
Najera	2010	Conservation Biology 24: 319–324.	10.1111/j.1523-1739.2009.01350.x
Basche	2019	PloS one, 14 (9): e0215702.	10.1371/journal.pone.0215702

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AGROFORESTRY BUSINESS ENVIRONMENT MODELS

3 .3

Effects of Agroforestry System Use on Wine Production in the Mosel Valley

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Agroforestry for the Green Deal transition.
Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Agroforestry business environment models

Keywords: Agroforestry, Wine, Sustainability, Mosel

Abstract

The Mosel wine region is one of 13 wine regions in Germany. With its distinct steep slopes and international reputation for high class wines, mainly from the Riesling variety but also with a growing share of Pinot Noir and others, the region produces wines mostly in intensive monocultures that emboss the slaty river valley. However sustainable approaches (biodynamic, biologic etc.) to growing and creating wine are gaining interest in winemakers, since climate change starts to show effects on both wine production and distribution. Furthermore, the intensive cultivation raises concern, especially in younger winemakers, due to the low biodiversity and soil degradation visible in conventional viticulture. To mitigate effects of climate change and monocultures, applications of Agroforestry in European wine production have traditionally been used in north Portugal (Altieri and Nicholls 2002) and lately as tests and regular growing systems in France (Dupraz and Liagre 2008, Dufourcq et al 2017). Researching agroforestry and wine making in the comparatively northern growing region Mosel does posit a novelty both in terms of a focus on climatic and economic aspects. Thus, my research focuses on a small group of Winemakers that has started to cooperatively work on an agroforestry system that engages both Vine (Riesling & Sauvignon Blanc) and Trees (Oak & Poplar). Carina Lang and others (Lang et al 2018) have published on the agronomical and oenological aspects of this system, my research focuses on the effects on production, value chain and business model from an economic geographers' point of view. For this research I conducted 20 Interviews with viticulturists from the region, of which 5 were directly involved in an agroforestry system involving vine and trees while all others were involved in sustainable activities regarding Viticulture and wine making. Apart from the enological aspects of the agroforestry systems (Lang et al 2018) that culminate in one farmers quote: „To say the least, it has no negative effects on the wine ", my interviews show that soil degradation in the agroforestry system is decreased, the biodiversity increased, the application of pesticides reduced while the crop management and pruning adaptions are deemed fit, securing harvests while conventional neighboring parcels suffered around 30% loss through weather conditions. From an economic point of view, the vines are sought after due to their marketing as an ancient growing system whose image associates originality and an artisanal appeal to the end product. Thus the two varieties on offer by the individual wine makers are mostly sold out on an informal basis due to limited amounts and high requests by locals and the tourist information.

For the conference I want to give an inside look into my ongoing research, preliminary results and show wether Agroforestry and Wine Production promise to be a fruitful alliance.

Figure 1. Look Down the Parcel with Oak & Poplar

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Assessing agroforestry options for sustainable land use in Germany

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Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Agroforestry business environment models

Keywords: Agroforestry, Decision Analysis, decision-making, modelling, probabilistic simulation, Germany

Abstract

Introducing trees to faming landscapes represents a risky decision with large uncertainties. In this project we worked with Woodify, a startup that reforests damaged woodlands and sells the CO2 certificates. Woodify offers local carbon offsets through contracts with German forest owners. They bought a plot of land for reforestation in the Eifel region of Germany but could not use it for forest, as the land use plan did not allow it. However, the land use plan would allow for an agroforestry system where agricultural production is combined with trees. We applied holistic modeling processes to support Woodify in determining if such an investment would be economically viable.

Decision Analysis (DA) can be effective in informing such complex decisions. DA includes a set of methods that are applied for supporting well-informed decision-making. It involves identifying and assessing all the important aspects of a decision. The ultimate aim is to inform decision-making so that any actions based on the decision will be most likely to produce a preferred favorable outcome. DA aims to use all relevant and available information to support decision-making processes. It gives decision-makers the option to evaluate and model potential decision outcomes and thereby determine the best course of action based on expected outcomes. DA methods facilitate the development of a holistic understanding of the goals and intended impacts of the decision and the uncertainties involved. The process starts by framing the decision problem of interest and formulating it as an impact pathway. This pathway is then translated to a formal model, most input variables for which are expressed by probability distributions for their true values. This model is run many times in a probabilistic simulation, with variable inputs that are randomly drawn from the specified distributions. The resulting outcome distributions can then be compared across different decision options (e.g. comparing outcomes for agroforestry and treeless agriculture).

We worked with Woodify to model five possible combinations of hazelnut orchards, other trees, truffles, hay and chickens compared to a baseline of arable land with crop rotations of winter barley, rye, wheat, and summer barley. The outcomes of interest included farm profits, environmental benefits, and sequestered CO2 (Figure 1). We programmed this as a probabilistic model to calculate the costs, benefits and risks of the decision and the effects on the expected outcomes over 30 years. Income from hazelnuts, eggs and truffles were considered to be the main sources of farm benefits. Major costs included establishment costs, e.g. setting up fences, and maintenance costs, e.g. labor costs. Risks included the need for additional labor and inputs such as those used to deal with outbreaks of truffle infections.

We subtracted the results of the baseline model from modeled outcomes for the agroforestry scenarios. All model results showed a positive outcome after 30 years compared to maintaining traditional crop rotations. This indicates that the decision to convert the land to agroforestry production is a good one, which is likely to pay off in the long term.

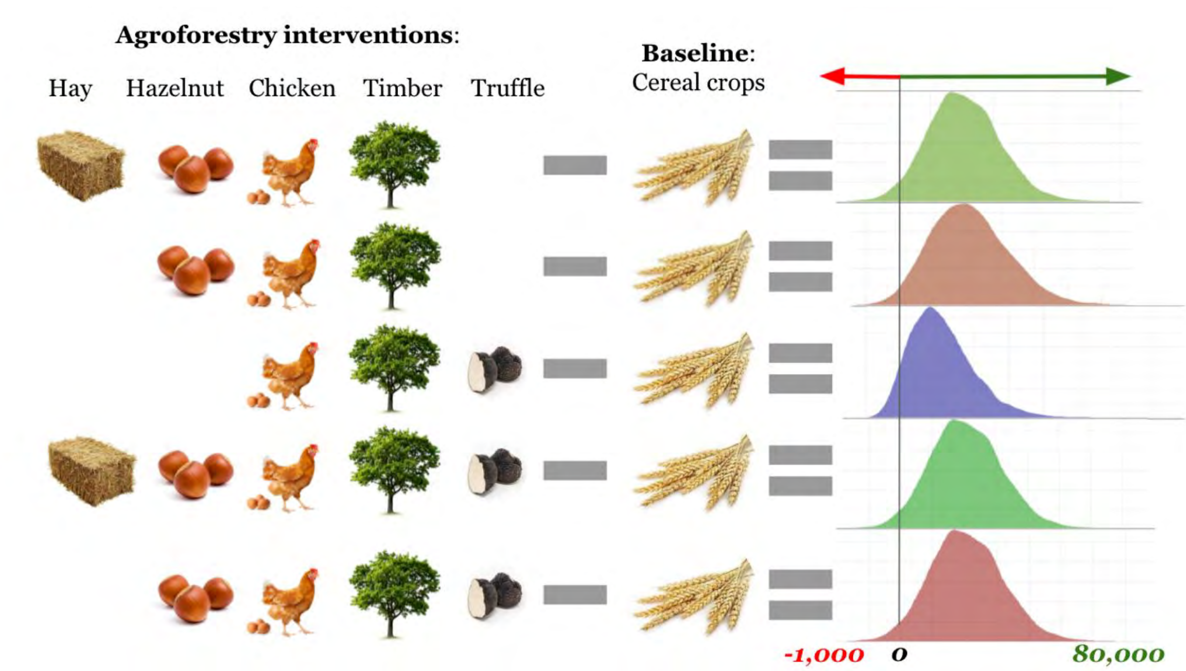

Figure 1. Comparative model results for five agroforestry intervention options on a plot of land in the Eifel region of Germany. All scenarios are compared to a baseline of a cereal-based crop rotations (the current land use)

Assessing the potential of different economic incentives for stimulating temperate agroforestry. A case-study in Flanders, Belgium

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Assessing the potential of different economic incentives for stimulating temperate agroforestry. A case-study in Flanders, Belgium

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Theme: Agroforestry business environment models

Keywords: economic incentives, business models

Abstract
Many studies worldwide point to the social and environmental benefits of agroforestry, also in temperate regions such as Flanders. Nevertheless, farmers do not yet see agroforestry as an equally valuable option alongside other farming systems. Among the identified reasons for this, the uncertain economic profitability and the compatibility of this system with existing market conditions hampers the relative feasibility of agroforestry systems in comparison to more conventional systems.
This paper reports on a qualitative study to identify and evaluate different types of economic incentives regarding their potential to increase the economic feasibility of agroforestry as a production system relative to more conventional systems. The study has followed a trajectory of several years, starting from the early pioneer stage in Flanders, the northern region of Belgium. In a period of 3 years, we performed a series of 3 focus groups with 54 participants, to identify – existing and hypothetical – economic incentives for agroforestry. Further, 11 participatory living labs were set up in which a wide range of actors (e.g. farmers, processors, policy makers, researchers, etc.) were invited to think together about incentives and bottlenecks for agroforestry in Flanders. In these 11 living labs around 100 individuals took part. Each living lab had a particular theme, e.g. cooperative agroforestry, food forests, nut trees etc. In addition to the brainstorms in these labs, discussions were also held with some key stakeholders. The results were analysed qualitatively in Nvivo12 to uncover possible economic incentives and business models, and to assess their strengths and weaknesses regarding their potential to provide effective incentives that increase the feasibility of agroforestry compared to more conventional systems.
Our preliminary analysis shows a number of promising economic incentives for agroforestry. These incentives come from a broad field: opportunities from the government and from the market. We also identified a third group, being community-based systems. Another interesting distinction is the difference between incentives that focus on the products from agroforestry systems and those that use the services provided by AF-systems, such as carbon storage. A classification of economic incentives will be developed and strengths and weaknesses, as well as threats and opportunities for each type have been identified and discussed.

Agroforestry systems in Portugal: economic evaluation of traditional and innovative systems

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Theme: Agroforestry business environment models

Keywords: pay-back time, feasibility, Mediterranean agroecosystem modules, biodiversity

Abstract
Agroforestry systems are increasingly being discussed and studied in Western and Mediterranean Europe. Portugal has an agroforestry tradition, the most famously known being the silvopastoral system Montado, but there has been a resurgence and emergence of other agrodiverse systems. Keeping in mind the lack of studies regarding these emerging agroforestry projects, this work aimed to develop eight simulated territorially adjusted agroforestry modules and to carry out a 40-year financial evaluation of each one. The resulting modules are the following: 1) MONTADO, with "classic" cork and holm oaks, biodiverse pastures and grain crops, plus the inclusion of stone pine and strawberry tree for fruit production, and possibly mushroom production (Alentejo region); 2) SUBTROPICAL SOUTH: irrigated orchards with mango, pineapple, passionfruit, banana and papaya (Algarve region); 3) MOUNTAIN and HILLSIDE: agrodiversification with other suitable nut species (walnut and hazelnut), fruit trees (apple and cherry) and berry shrubs (blueberry, raspberry and goji), with alley cropping arable crops, and small grazing animals in rotation (Northern Portugal, Trás-os-Montes region); 4) DIVERSIFIED FRUIT ORCHARD: semi- and/or intensive, with greenhouse and alley cropping horticulture (Central Portugal and northern coast); 5) SPICEY AGROFOREST: with a diverse fruit tree selection associated to tomato, (chilli) pepper, and aromatic herbs in alley cropping (Regions surrounding agri-food industry centres); 6) DRYLANDS CHALLENGE: rainfed production system (pistachio, macadamia and stone pine), with rotational cropping system of pasture and arable crops (Central and Southern Portugal); 7) CLASSIC OLIVE GROVE: combined with other fruit trees (citrus, figs and others from the Rosaceae family), horticulture and arable crops in alley cropping with sheep and/or goat rotational grazing (Continental Portugal); 8) VINEYARD-ORCHARD MOSAIC: associated with citrus and Rosaceae fruit trees, and saffron or/and horticulture in alley cropping (Southern through Northern hinterland). For all eight modules described, we estimated implementation, operational, and human resources costs, return-on-investment time (ROI), annual and monthly profit distribution at the 40-year mark and compared the latter to the average net monthly income of farm and forest workers. The 4th and 5th modules have higher implementation costs due to tree acquisition and care, and they also have higher expenses with human resources alongside module 3, due to the greater diversification and complexity of these systems. The 5th and 8th module have a shorter return-on-investment time (between 3 to 7 years), in contrast, module 7 is estimated to take 25 years to achieve profit. According to the simulation, modules 2, 5 and 8 would offer a higher monthly profit for the investor at the 40-year mark. This prospective analysis aims to demonstrate the long-term feasibility of multiple agroforestry systems. A more agrodiverse arrangement with the inclusion of exotic species to the regional environment may constitute economically successful agroforestry systems, however it is important to verify these results *in situ*.

Table 1. Modules economical evaluation results (In green top 3 best results and in red for top 3 worst results in each category.

	Module	Module Territorial Distribution	Costs			Profits			
							Distribution at 40-year mark		
			Implemen-tation	Operational	HR - Annual average	ROI (years)	Annual	Monthly	Difference: average farmer's net monthly income
1	Montado (mushroom production)	Alentejo	298 530	212 959	8 186	10	23 399	1 950	1 233
1.5	Montado	Alentejo	177 319	210 790	8 215	6	24 200	2 017	1 300
2	Subtropical South	Algarve	591 382	780 156	105 886	9	163 346	13 613	12 896
3	Mountain and Hillside	Northen Portugal - Trás-os-Montes	358 441	467 948	123 387	11	85 209	7 101	6 384
4	Diversified Orchards	Central Portugal - Northen Coast	753 203	1 656 872	122 068	10	142 257	11 855	11 138
5	Spicy Agroforest	Agri-food industry centers	5 951 228	1 635 013	169 460	3	227 779	18 982	18 265
6	Dry lands Challenge	Centre and South	191 050	374 065	70 384	15	55 624	4 636	3 919
7	Classic Olive grove	Continental Portugal	1 226 402	946 917	83 918	25	12 218	1 019	302
8	Vineyard Orchards Mosaic	Southern through Northen Hinterland	1 031 131	1 261 088	113 961	7	175 685	14 641	13 924

T 3.4

GOVERNANCE FOR TRADITIONAL SUSTAINABLE AGROSILVOPASTORAL SYSTEMS

3.4

Co-creation of sustainable ecosystems and resilient livelihoods in agroforestry value chains: organized shade-grown coffee producers in Mexico.

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Theme: Governance for traditional sustainable agrosilvopastoral systems

Keywords: shade-grown coffee, collaborative research, agroforestry value chains, producer organizations.

Abstract
Smallholder-led, organized agroforestry value chains tend to fall in between the cracks in policy and governance discussions. The increased interest in agroforestry has been combined with sustainability standards and the transition to deforestation free commodity value chains. However, these discussions have focused mainly on largescale production of key commodities (coffee and cacao) as promoted by large corporate actors. On the other extreme, smallholder agroforestry faces challenges in upscaling and becoming a viable livelihood considering the pressures and increased vulnerability. In this sense, an emerging field of discussion lies around consolidating agroforestry value chains that can contribute to sustainable environments and resilient livelihoods for smallholders.
Agroforestry is no “silver bullet” or magic solution to the challenges of global environmental change and inequity (Ollinaho and Kröger 2021). However, when correctly managed, agroforestry systems can provide crucial ecosystem services and social co-benefits. There are few value chains developed for agroforestry products, and one of the most representative agroforestry systems is shade-grown coffee. The increase of commitments for deforestation-free commodities has led to important transitions in agroforestry value chains such as cocoa and coffee (Kubo et al. 2021). Europe’s commitments to climate change mitigation are currently discussing the need to tackle how the EU’s appetite for beef, cocoa, coffee and palm oil drives deforestation beyond its borders – the source of up to 10% of global deforestation (Adams et al. 2021). Europe – the world’s largest coffee consumer – is also worried about the long-term threat to supplies because of climate change, including reduction of the global suitability, lower quality, and higher prices (Grüter et al. 2022).
Sustainable development under climate change calls for increased productivity to feed a growing population without increasing emissions. Coffee value chains illustrate the need to focus not only on yields (i.e. quantity), but also quality, understood widely as the quality of the final product and the social and environmental responsibility of the production process. Consumers also demand sustainability standards and marketing labels which consider producer well-being, seeking value chains that contribute to building equity. Furthermore, organized coffee cooperatives with agroecological

practices are interested in improving their access to digital tools and crop modelling outputs to evaluate the sustainability of their initiatives and facilitate access to market niches.

This presentation will showcase a collaborative research-action program in Mexico which brings together public universities, research centres, coffee cooperatives and coffee value chain stakeholders to strengthen shade-grown coffee and other agroforestry systems. In response to challenges from climate change, pests and diseases, and market volatility, coffee producers' organizations are leading innovative transformations to support sustainable ecosystems and resilient livelihoods. A key component of this bottom-up transformation of agri-food systems lies in e-commerce innovations and promoting new cooperatives of women and youth to diversify livelihoods and empower local stakeholders. As such, coffee cooperatives are now housing women's savings groups and youth-led honey production cooperatives.

The traditional agrosilvopastoral system of beehives within shade-grown coffee fields is becoming a space of opportunity for new participatory researching practices addressing the intertwined ecological and social processes that underlie honey production for export to Europe. In collaboration with local universities, farmers are exploring new apiary practices, including recovering the traditional production of Melipona bee honey, a thick, sweet-sour liquid obtained from stingless bees of the genus Melipona. This honey is known for being less dense than that obtained from honeybees in the genus Apis, with unique nutritional and health benefits.

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Trees on agriculture land in Latvia

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Theme: Governance for traditional sustainable agrosilvopastoral systems

Keywords: tree plantations, agro-forestry, buffer zones, windbreaks, alleys, ancient trees

Abstract

In Latvia, trees on agricultural land, the first association is a tree in the middle of the field, or a ditch overgrown with trees, at the field edge, is associated with positive interactions. But neglected agricultural land is associated with negative associations, where forest fallen in the 20-30s of the last century – recovering as the ecosystem - the forest in its "primary or secondary" stage. With shared feelings, farmers perceive the possibility to grow woody crops on agricultural land for biomass - willows, poplars, aspens, grey alder - perennial tree plantations having a life cycle of up to 15 years, with the possibility to receive a common area payment for crops in a 5-year life cycle if trees are not planted in fields with functioning drainage systems. An unrecognized practice, not defined in the regulations of the Cabinet of Ministers of Latvia, is the agroforestry system - conservation or cultivation of trees during agricultural activities, for example, grazing with trees, tree alleys, buffer zones between fields, huge trees in fields. It is expected that agroforestry will soon be recognized in Latvia as well, as a management system that is an ecologically sustainable practice and the possibility to fulfil the "3 million tree plans" is mentioned in the European documents of the next planning period. On the other hand, among foresters, the harvesting of naturally-forested agricultural land is ambiguously assessed in cases when it already shows the features of a forest ecosystem. By thinning a naturally-grown tree stand, a stable and productive forest stand would often be created in the future. Here, the competition of two agricultural sectors for one of Latvia's production resources - land - is encountered. As a tool for evaluating the rational management of a resource, a land fertility scale in points according to grain yields is proposed, which mainly evaluates soil fertility, but does not cover real-world variables such as infrastructure and the geometric shape of the field. The windbreaks on large, flat terrain and roadsides would be underestimated in the past and would be renewed in the coming years. At one time, in the sixties and seventies of the last century, windbreaks were created by planting fast-growing trees such as poplars, willows. They reached maturity at the beginning of the 21st century, when the process of collapse began, the trees were cut down, but the windbreaks were rarely restored. Latvian landscape architects have the opportunity to introduce more elements of agroforestry into the landscape.

Figure 1. Trees on agriculture land.

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Re-thinking the national supply chain of summer truffle: towards investments structural small-scale on agroforestry

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Theme: Governance for traditional sustainable agrosilvopastoral systems

Keywords: wild food; non-wood forest product; rural economy; rural development

Abstract

The production of wild truffles in Italy has been subject to considerable fluctuations mostly linked to prolonged periods of drought or extreme weather events in the last decade. This production variability is accompanied by a further downward trend in production linked to a gradual abandonment of the traditional agrosilvopastoral system, which reduces the ecological niches useful for the most popular truffle species traded in the market. Inevitably, companies that commercialize or process truffles have tried to make up for the lack of product in the international market, creating an economic bridge to rural areas of Eastern Europe and Central Asia. Annually, the economic players in the truffle supply chain have spent an average of 22 million euros for the purchase of fresh foreign truffles, a figure that can almost double if we also consider frozen and dry truffles imported into Italy.

The misalignment between supply and demand for truffles has its roots in the political inertia of restructuring the supply, favoring the collection of the spontaneous product in forest rather than its cultivation integrated in specific agrosilvopastoral system. Where micro investments have been supported by enterprises or associations of truffle farmers for the design and implementation of truffle and firewood production systems, they have proved to be sufficiently useful to restructure the production and social structure of Italian rural areas. Reporting three case studies, we will try to provide some inputs to redesign of national production based on agroforestry systems, that can allow greater stability of production and consequently improve the ability to adapt the social resilience in rural areas.

A first example comes from the reforestation based on truffle seedlings in medium or steep slopes, demonstrating how the use of marginal land in suitable areas for truffle production can allow the creation of significant incomes for farmers with relative limited investments. A second case reports a management model of the cropland hedges used for the production of white truffles and wood biomass in the Po Valley based on a private payment scheme where both farmers and truffle producers enhance their income. Finally, a third case has tried to replicate the Spanish model, which is based on a massive investment on truffle orchards, in Umbria region through the adoption of specific measure for support the cultivation of truffle. These three examples are all characterized by the adoption of medium-high-income agroforestry models, which could be widespread in the peninsula if suitable management techniques are adopted to reduce the risk of not obtaining adequate production from the plants.

Land Consolidation Associations for the conservation and the restoration of agricultural landscapes

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Theme: Governance for traditional sustainable agrosilvopastoral systems

Keywords: Agropastoral farming systems, Collective management, Land fragmentation, Land owners, Less Favoured Areas (LFA)

Abstract

During centuries, humans have converted European native forests into a mixture of woodlands, grasslands and crops through agriculture and forestry, with benefits to farmers (e.g. availability of food and feed), environment (e.g. increase in biodiversity), and society (e.g. reduction of fire and hydrogeological hazards). However, urbanization and industrialization have triggered the depopulation of the less favoured areas (LFA) since the beginning of 20th century. The reduction of the workforce and the increase of workers' age in the agricultural sector have resulted in a dramatic reduction of farm number, arable land and number of animal heads, so that the least productive areas are now generally abandoned or underexploited. Furthermore, the transfer from the lowlands to LFA of unsustainable business models not based on product quality and link with the territory, and inheritance laws promoting land pulverization are relevant causes of this situation that can be found almost all over Europe. Land fragmentation increases production costs and definitely results in lower profitability for farmers, which is a prerequisite to keep agriculture in the LFA and preserve the landscapes consequently. In this context, updated strategies of collective land management have to be urgently adopted to widen managed farmland, make the management easier, promote quality products, improve farmer profitability, and preserve or restore the landscapes.

Land consolidation associations (LC) are associations of private and public land owners of a given area pooling their parcels to simplify land management while recovering parcel monetary value. Promoted in France since the 70ies, LC have started to establish also in Piedmont (Italy) since 2010, when some land owners decided to join together and collectively manage their parcels for the general interest of the community and to contrast abandonment (Lombardi et al., 2017).

LC have i) to record woodland, crop, pasture or other mixed parcels, such as the agroforestry ones, into a register, ii) to draft a management plan with sustainable agropastoral and/or sylvicultural practices for the conservation and the restoration of the area concerned, and iii) to identify one or more holdings to be entrusted of achieving the goals of the plan in a given time frame. In 2016, Piedmont government enacted law n.21 to promote and support financially LC. The law states the property rights of LC members, limits land parcel adverse possession, and sets the rules to manage those parcels whose owners are unknown or untraceable (*silent land owners*). About 40 LC operate today in Piedmont in agriculture and forestry sectors either, with positive spill over effects on local communities and environment. LC are an important opportunity for the entrusted farms to optimize the management of resources and improve the quality of their productions. In this presentation, lessons learned from the LC established in the region will be presented to promote their spreading in other regions, by providing evidences of beneficial impacts and possible drawbacks to be considered at the planning and implementation stages (Table 1).

Table 1. Beneficial impacts and possible drawbacks of land consolidation associations (LC).

Beneficial impacts	Possible drawbacks
– conservation and possibly restoration of biodiversity – recovery of land productivity – improvement of forage quality – reduction of encroaching-woody species cover – decrease of natural hazards: reduction of fire load, dead mass, improvement of slope stability – easy way to produce grass-fed products – access to CAP subsidies for the farmer (Payment for Ecosystem Services PES-ready system) – RDP support to LC – positive effects on the job market – positive perception of the improvement of landscape quality by citizens – acknowledgement of Natura 2000 conservation measures (inside Natura 2000 areas)	– length of the process to aggregate land owners – small size of the managed areas (in many cases) – no distribution of management profits to partners – farmer expertise not sufficient for an appropriate agropastoral management – cost of the management plan – limited incentives to land owners for parcel pooling – legal aspects not completely defined yet – high costs of the compensations for the conversion of woodland parcels – high cost of the registration in Register for Legal Entities compared to very low costs for the partners to access LC

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Associativism and cooperativism in the rubber trees culture in Brazil

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Theme: Governance for traditional sustainable agrosilvopastoral systems

Keywords: *Hevea brasiliense, agricultural* associativism, producers' group

Abstract
The history of natural rubber in Brazil is divided into different phases. The country Brazil was once the largest producer of natural rubber in the world and today its production does not even represent 2% of world production. Rubber was one of the main products of the national economy between 1870 and 1920, when Brazil was once the world's largest producer of the natural rubber product, but it lost this position in the 1950s and today is a major importer of this product from the Asian continent countries as Thailand and Indonesia. From the heyday of a major producer, to the decline of a major importer, Brazilian rubber producers have been facing numerous changes and unfair competition, which demanded producers to organize themselves for sustainable survival of this important productive chain. Natural rubber is a strategic and development productive chain for the country that lost several benefits and incentives over the years which led to eradication of several rubber plantations. As the producers are the base of the rubber chain, it is difficult to them to add value to their product suffering market anomalies that privilege big pneumatic companies due to inexistence of an efficient agricultural policies that would guarantee fair payment for the price of rubber covering at least the cost of "production Brazil". Currently, the contracts of rubber clot in the field is made between the beneficiation industries and the producers based on the value called GEB - 10 (Brazilian Dark Granulate) denomination given to the final product produced by the Brazilian beneficiation plants, published on the website of a Mixed Association (producers and processors), whose methodology is based on the cost of importing natural rubber from Asia. This value does not take into account the cost of production in Brazil and differs from the value calculated and published by the Institute of Agricultural Economics and the National Confederation of Agriculture and Livestock, called natural rubber import-price-cost index. The cost of producing the clot in Brazil is much higher than the cost of Asian countries that use low-paid labor, do not have labor laws or work safety regulations, do not suffer from a high tax burden like Brazilians and in addition to all these advantages, they have government policies to subsidize production and producers. To ensure the survival of the sector, to equalize benefits and greater transparency in market relations, natural rubber producers from different producing states got together and founded a National Association of Latex Producers (APOTEX BRASIL), a genuine association exclusively represented by producers, to claim for their interests and representation in different discussion forums with common goals, without conflicting interests. In addition to APOTEX other state producers associations were founded in new rubber producing states such as Mato Grosso do Sul and Tocantins, driven by the same ideal: organization of the producers base of the rubber productive chain, seeking to add value to the rubber clots price aiming better market conditions for the commercialization of their product. In addition to the associations foundations, groups of producers came together and founded a Cooperative in the state of Minas Gerais, seeking for the same objective. Such organization provided changes in the market and in the relationships practiced, raising the commercialization clot prices and considerations to levels never before reached in negotiations taken into consideration for example the quantity of dry rubber contained in one kilogram of clot (Dry Rubber Content - DRC). The new market relations were well regarded by the rubber productive sector, leading to the expansion of this model of Cooperative to other producing states: São Paulo and Mato

Grosso do Sul. We now have the creation and emergence of new Associations and Cooperatives whose premise is to defend the interests of rubber chain producers seeking for better markets that takes in to account the value of the Brazilian product, which is produced in compliance with all environmental and labor legislation, without deforesting areas and with minimal use of pesticides, is making that producer manage to survive the market anomalies imposed by large buyers.

TOPIC 4

AGROFORESTRY IN SOCIETY AND CULTURE

4

T 4.1
EDUCATION, TRAINING, DISSEMINATION AND PROMOTION

Agroforestry education in the transition for the new decade: the example of Greece

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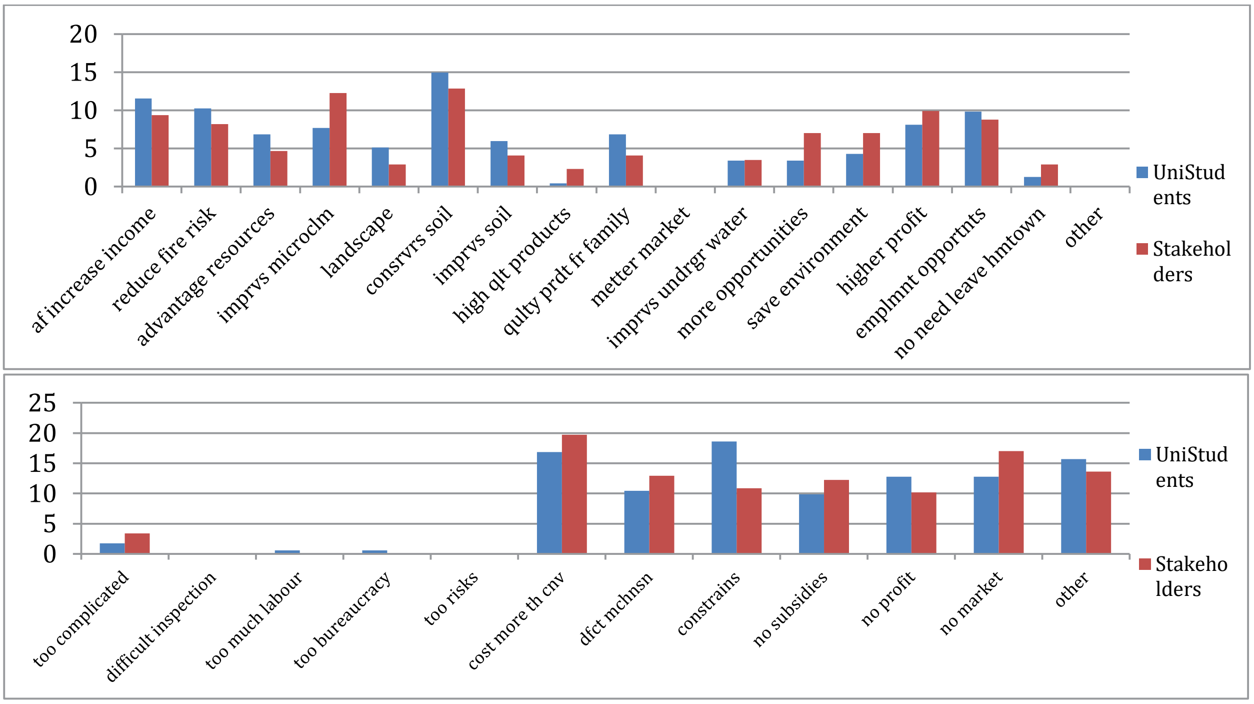
Theme: Education, training, dissemination and promotion

Keywords: training, AGROF MM, stakeholders, higher level education

Abstract

Agroforestry is a traditional land use system that may contribute to the solution of many present and future environmental problems. Agroforestry is "the deliberate integration of woody vegetation (trees and/or shrubs) as an upper storey on land, with pasture (consumed by animals) or an agricultural crop in the lower storey. The woody species can be evenly or unevenly distributed or occur on the border of plots. The woody species can deliver forestry or agricultural products or other ecosystem services (i.e. provisioning, regulating or cultural)". However, many farmers who practice agroforestry do not identity it as agroforestry nor even accept such identification. Education as claimed farmers from 9 countries in the H2020 project Agroforestry Innovation Network, must represent the "alpha" and "omega" to confront this issue but mainly enhance the uptake of agroforestry. This abstract aims to describe the efforts made so far on education and training in agroforestry placing special emphasis on Greece.

On a European level, only three projects on agroforestry training has been organized, the one being AGROFE (ERASMUS KA2), AGROF MM (ERASMUS KA2) and AFINET (HORIZON 2020). The first two included education and training whereas the third one was conceived in a different form, trying to find the farmers needs to overcome the difficulties to lead the transition from conventional farming systems towards agroforestry implementation. In Greece, agroforestry is also taught as a university level course and in as individual thematic unit at M.Sc. course. Greece participated in the AGROF MM (ERASMUS KA2) where five different stakeholders' trainings and meetings were organised in different location of the country and different environments. In total, 246 stakeholders registered, ranging from professional farmers to future farmers and students. In many cases more people attended but they did not register. Additionally, another, one week training, was organized only for University students and a final event that incorporated also a training session. All participants were asked to fill in a questionnaire and the results appear inspiring as they present many ideas and missing points on education and training. In the following graphs only the opinion on the opportunities but also the drawbacks from agroforestry are presented, for two groups: stakeholders and university students, both after the training. It is interesting the fact that all groups had the similar opinion on agroforestry, placing emphasis on specific category based on their interests, employment and previous training.



Figures 1. Opportunities and drawbacks in agroforestry in two different stakeholders groups (values presented are percentage per answer). This project has been funded with support from the European Commission (2015-1-FR01-KA202-015181).

The results are encouraging and indicative of the possible results that can be accomplished by agroforestry trainings. However, this is not enough and more specific guidelines have to be developed for the wider adoption of agroforestry. The results from all European projects provide such guideline available online. More individual issues are mentioned in the literatures such as the adaptability of the training depending on the stakeholder type (I.e age) or the knowledge and previous experience of educators in agroforestry. This is also pointed out by (von Maydell (1990) who stresses that education and training in agroforestry in Europe is very diverse because of the country specific issues regarding land use. In a study that compared the opinion of participants of different ages starting from elementary school (10-12 years) to lyceum (15-18 years), it was obvious the different opinion of the students according to their age (Pantera et al 2013). Hemmelgarn et al. (2019) on the implementation of agroforestry education, emphasizes the importance of teacher-network support network and experimental learning in curriculum and professional development. To conclude, agroforestry education and training has been advanced during the past years in Greece but still more work need to be done for its wider adoption.

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« Club des agroforestiers Sarthois » When farmers become agroforesters

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Theme: Education, training, dissemination and promotion

Keywords: Agroforestry, technical popularisation, sharing of experience

Abstract

From 2014 to 2018, the GIEE (Economic and environmental interest groups) "Agroforestry" led by the Chamber of Agriculture of Sarthe (West of France) had the initial objective of designing a strategy allowing the development of an agroforestry system. This goal has proven to be too ambitious. In fact, the meetings with the "core" farmers of this GIEE made it possible to highlight blocking gaps. They felt in difficulty in managing trees planted in large numbers, or in mastering the technical content of a management plan. For example, the farmers expressed « needs to exchange, acquire, and strengthen knowledge about the Tree. » «In fact, all the facets of the creation of an agroforestry system, from its day-to-day management, to its economic and social development must be reconstructed in the minds of our farmers. » (Guillet P). Thus, it was relevant, as a first step, to meet the acquisition needs of farmers. With this in mind, the "Club des Agroforestiers Sarthois" met for the first time on June 21, 2019.

This Club is made up of agroforestry-motivated farmers, from beginners to experienced, who wish to collectively acquire agroforestry knowledge and skills. The heavy administrative structure of the GIEE having already slowed down the group's dynamics, it was preferable to invest energy in the technical aspect directly. This Club is therefore a "de facto" group, and not an official association. Since 2019, animation has been provided by agroforestry technicians from the Chamber of Agriculture around two popularisation tools:

- 4 annual technical days characterized by three sessions: "botanical recognition", "theme of the day", and "sharing of experiences"
- 4 annual technical letters containing testimonials, agroforestry techniques and news, as well as bibliographical references. The form and style of writing are careful to make agroforestry workers want to read these letters and take ownership of the information.

Currently, around fifty farmers receive technical letters and invitations to the days. Nevertheless, the number of participants in the meetings remains low, even if the participation is qualitative. The group's animation could be improved on the recruitment aspect. To do this, valuing people is essential. In this perspective, three solutions are considered:

- Increase the individual monitoring of farmers by technicians, through personalized support
- Invite regular participants to come with a new participant (sponsorship system)

- Continue to offer times of conviviality during technical days and facilitate the testimony of agroforestry in letters

In conclusion, let us recall that the dynamic agroforestry workers in the Club see their needs met, but also the technicians who support them. Indeed, the team of advisers takes advantage of these privileged moments to share techniques. In addition, the more the farmers develop their knowledge, the more the technicians will be driven to improve! So it's a "win-win" experience.

Figure 1. A technical day of the “Club des Agroforestiers sarthois”, February 2021

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Bringing research, extension and training partners together for agroforestry upscaling: A look at of the French network "RMT AgroforesterieS"

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Theme: Education, training, dissemination and promotion

Keywords: research and development, knowledge gaps, network, partnership, France

Abstract

Supported by the French Ministry of Agriculture and Forestry, the mixed technology networks (RMT) are partnership projects that aim to share knowledge and expertise, and to foster collaboration between research, extension and education stakeholders on specific topics. Among them, and since 2014, the "*RMT AgroforesterieS*" is dedicated to agroforestry in its diversity (alley cropping, scattering plots, hedges, …) in mainland and oversea France. The RMT AgroforestrieS has nearly 100 members from some 40 structures: research organizations and universities, chambers of agriculture, agricultural or forestry technical institutes, agroforestry associations, agricultural or engineering schools, and recently some producer's association.

The renewal of the RMT AgroforesterieS for 2021-2025 is an opportunity to strengthen the dynamics created in the first period of activity 2014-2019, by consolidating collaborations and initiating new ones. One of the obstacles to the development of agroforestry that we have observed is the lack of accessible references on the performances of agroforestry systems. Indeed references are produced by different partners and producers, but very often they are not disseminated and there is a serious need to compile, share and discuss them.

The objectives of the RMT are (1) to better disseminate advances in research, extension and advice, as well as training, through communication tools or actions, meetings, and webinars, (2) to take stock of available resources (knowledge, data, experimental and pilot sites, tools, experts, etc.) for each forms of agroforestry.

To this end, the members of the network meet annually to share their news (results, projects,…) or to cross the points of view on transversal themes to the different forms of agroforestry in France. A website (www.rmt-agroforesteries.fr) has also been created in order to share about projects or recent scientific publications (with French translation for non-English speaking public), and to provide online collaborative databases (open library, spatialized index of agroforestry experimental farms, index of R&D projects).

In addition, the great added value of the network lies in its six operational working groups. Each of the groups (15 to 40 members in each) focuses on a specific agroforestry value chain: Arable crops, Livestock, Vineyards, Tree products, Fruit/vegetables/aromatics, Shade crops (i.e. coffee, cocoa and vanilla mainly in the ovsereas territories). The objective of each working group is to evaluate the multicriteria performance of agroforestry systems at different scales (plot, farm, territory), particularly in economic terms. These working groups are an ideal place for researchers, advisors and teachers to establish together the state of the art of experimental or pilot systems, knowledge and accessible data in order to co-design tools for advice and training and to identify priority research avenues (and partners!) to support the development of agroforestry. A work on knowledge gaps, identified by crossing the needs from farmers and advisors with the literature (Grimaldi et al., in prepration) also provides valuable guidelines for building new co-created projects.
This original partenership modality may be a source of inspiration for other countries wishing to better structure agroforestry research and development.

Participatory serious games: developing a tool to design mixed farming and agroforestry systems

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Them: Education, training, dissemination and promotion

Keywords: Agroforestry, mixed farming, serious game, participatory research

Abstract

The AGROMIX project is a research and innovation project that focusses on the transition towards resilient farming, efficient land use and sustainable agricultural value chains in Europe. AGROMIX aims to deliver participatory research looking specifically at mixed farming (MF) and agroforestry (AF) systems as practical agroecological solutions for farm and land management. Despite policies supporting AF systems in Europe, there has been little farmer uptake. This has been attributed to a lack of knowledge and financing. Working in a collaborative way with researchers and farmers, AGROMIX aims to deliver tools and research that can be used by a wide variety of practitioners and that speaks directly to their needs in user-friendly engaging ways. In collaboration with a group of pilot sites across Europe, AGROMIX is developing a serious game that will directly address farmers' needs and concerns, integrating researchers' contributions as well. The aim of this product is to support the design and implementation phase of AF and MF systems. The prototype will be developed based on an inventory of users' needs. The inventory will determine which needs are met by existing tools and what apps, tools, serious games or models might be the most valuable to continue developing. The AGROMIX pilot sites were surveyed and preliminary results highlighted three key topics that farmers and researchers would value in such a tool. These are: (a) tree and soil / environment interaction, (b) soil and water management, and (c) tree-crop interaction, in the context of a changing climate. Respondents highlighted two key priorities: (1) networking and knowledge sharing and (2) qualitative and quantitative scenario exploration. Respondents cited interest in quantified data to explore real life scenarios, e.g. the effect on soil fertility and micro-climates. Research is on-going in the development of the AGROMIX serious game, that will consider the needs highlighted by the survey respondents. Where these needs are partially met by existing tools and models, we aim to collaborate and build upon such tools, for instance; FarmDESIGN (Groot et al., 2012), SEGAE (Godinot, 2018), GATES (gates-game.eu), DEXi (Martin et al., 2019). The output will be made available on the AGROMIX website and dissemination will take place through conferences, farmer workshops and industry events.

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Regenerative landscapes and communities: assessing socioecological functions of an agroforestry peri-urban system

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Theme: Education, training, dissemination and promotion

Keywords: Landscape ecology, Regenerative communities, Dissemination, Peri-urban belts

Abstract
The complexity of insights and research related to agroforestry (AF) practices makes it necessary to adopt an interdisciplinary perspective and different, yet complementary, approaches and tools of investigation. This paper presents the first results of an interdisciplinary analysis, based both on qualitative and quantitative methods and focused on the structural and dynamic agroecological reconfiguring and cultural reactivation of an agroforestry peri-urban area (southeastern edge of Milan, within the Rural Park South Milan). Different issues are there interrelated: the landscape ecological patterns management, multi-stakeholders training and dissemination approaches, local communities engagement, metropolitan policies.
Robust scientific evidence from meta-analyses is already available on the positive effects of agroforestry systems on a wide spectrum of ecosystem services (e.g. Beillouin et al. 2019; Staton et al. 2019; Udawatta et al. 2017). Interventions linked to the agroforestry management (AFM), can be conceived, designed and interpreted as tools for guiding and modifying the ecological structural and functional patterns of the landscape. Through the insertion of agroforestry units, acting as newly inserted ecotopes within the landscape matrix, multi-level diversification occurs: on the biotic level (composition, texture, structure and diachronic dynamics of faunal and phyto-cenosis); on the abiotic level (micro-climatic patterns). All these different variables concur to the ecological and productive functioning of agroforestry systems, modifying the landscape ecological behaviour and resulting in successional mosaic patterns (Gliessman 2007). The studied area is an example of such diversified design combinations. Hence, landscape ecological indicators can perform useful synthetic analyses (Ingegnoli 2002), able to represent the contributions of AFM to the reinforcement of the ecological functionality and therefore validate its environmental effectiveness and sustainability. Such analyses were applied to the studied area through diachronic comparisons.
Moreover, the peri-urban AF productive landscape was interpreted as a permeability medium, where the ecological processes, impacts and benefits closely meet the cultural ones, that were assessed too. Namely, such contexts can play a relevant role in dissemination, training and education to active citizenship and multi-stakeholder engagement (Dal Borgo et al. 2021). However, the general lack of integrated actions – which would reflect the massive efforts made by the academics to build interdisciplinary dialogues – highlights the presence of flaws in passage between theory and practice. In addition to the barriers to the dissemination of a holistic interdisciplinary approach among the local institutions, another relevant critical issue is represented by the variety of actors (with specific knowledge, competences, desires and visions) who are nowadays involved in the decision-making processes. The framework offered by the concept of place gives access to the possibility to enhance social formation and behavior and consequently to promote the exchange of knowledge and

competences through interpersonal relations (Horlings et al. 2021). Consequently, it permits to break down the barriers imposed by specialistic training, offering the opportunity to develop more holistic disciplinary skills. Local communities are in this sense key actors of the process, since they are able to drop knowledge and competences being at the same time aware of the specific features and values of the territorial context interested by AF projects.

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Revealing the multiple shades of trees in the agroforestry discourse in Quebec, Canada

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Theme: Education, training, dissemination and promotion

Keywords: Extension, discourse

Abstract

The way agroforestry advisors envision the place and roles of agroforestry in the rural landscapes shape their dissemination strategies and the arguments they put forward to encourage farmers to plant more trees on their farms. Conversely, the way farmers relate to various agricultural movements and trends influence their rationale and their decision to adopt agroforestry practices or not. We conducted a series of in-depth, semi-structured interviews with seven key agroforestry advisors disseminated across the province of Québec (Canada) and analysed ten key documents presenting agroforestry systems to understand the advisors' representation of trees on farms and the discourses they use, and identify some key elements conducive to agroforestry intercropping system adoption. Motivations animating agroforestry advisors were diversified, ranging from the need to return to more natural ecosystems to the will to contribute to the construction of multifunctional landscapes and enjoyable, dignifying communities. Agroforestry is, for some advisors, way more than a set of agricultural practices; it is almost seen as a paradigm shift and a step towards renewed, sustainable landscapes and communities. The discourse used by agroforestry advisors to present and convince farmers to adopt agroforestry practices could be divided in four main types along a gradient ranging from "naturalness" to "productiveness": the "natural" discourse, in which agroforestry is framed as a way to get back to more natural ecosystems, the "mixed continuum" discourse, where agroforestry is presented as a way to smooth the transition between forested and cultivated lands at the landscape scale, the "utilitarian" discourse, framing agroforestry systems as ecosystem services providers, and the "productive" discourse, emphasizing on the economic benefits of mixing trees and crops at the farm level. Although most agroforestry advisors used more than one discourse type, the arguments they put forward as well as the arguments that were experienced as the most convincing mainly relied within the "utilitarian" and the "productive" discourses. These arguments were articulated around some key ecosystem services provided by the trees (soil fertility, water protection, climate change mitigation and adaptation) as well as on timber production. Agroforestry advisors also expressed that other elements (aesthetics, birds, etc.) were participating to farmers' decisions to adopt agroforestry, although they had not put these arguments forward. Agroforestry advisors seem to adopt a "reductionist" strategy to reach and convince farmers embedded in the conventional farming model: rather than sharing their will for a paradigm shift, they frame agroforestry systems as a set of practices that can fit within this model. Given that agroforestry practices are still only marginally adopted by conventional farmers, and that farmers appreciate agroforestry systems for more than their environmental and economic benefits, it might be time to try a new approach. We argue that the strategy adopted by agroforestry advisors might become much more inspiring if agroforestry were presented using arguments that would go beyond the utilitarian discourse and that would draw from the advisors' inner motivations and visions to present agroforestry systems in all their breadth, namely as ways to construct renewed and viable communities.

The opportunity, capability and motivation of farmers to expand agroforestry and orchards in England

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Theme: Education, training, dissemination and promotion

Keywords: Promotion, incentives, agroforestry, orchards

Abstract.

Following Brexit in 2020, the UK Government has reduced basic payments to farmers with the plan that the payments will reach zero by 2027. Over the same period, there will be three new schemes to reward farmers and land managers for producing public goods (Defra 2021). At the same time, the UK Government (2021) plans to increase the level of tree cover by 30,000 hectares each year by 2025. Such a large expansion of tree cover requires substantial increases in tree planting by farmers. In 2021, Shropshire Council in the West of England commissioned a group project at Cranfield University to determine which types of support could be most effective to encourage farmers to plant orchards, agroforestry, and trees outside of woodland.

Phase 1 of the project started with the identification of 33 farmers from the South, East, and West of England comprising arable, livestock, and mixed and other farms. The level of interest in this non-random group to expand the area of agroforestry (57%), trees in hedgerows (57%), orchards (45%) or farm woodland (33%) was high.

In the second phase, we undertook a detailed study of the attitudes to expanding tree cover using the Behaviour Change Wheel framework (Michie et al., 2011). The framework, initially developed to identify interventions in public health, focuses on the opportunity, capability (or means), and motivation of behaviours (Figure 1). The framework proposes that an understanding of the limiting stage can guide effective interventions.

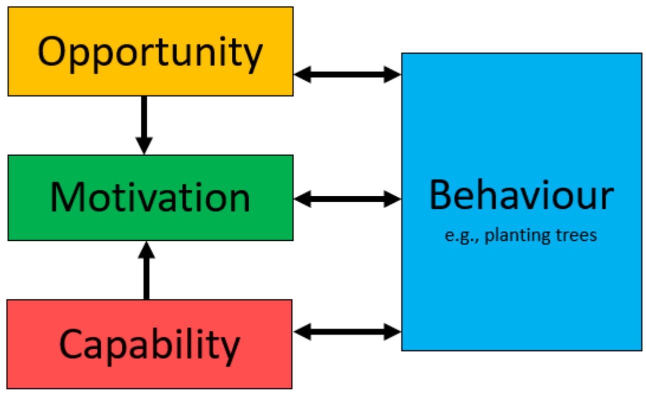

Figure 1. In the Behaviour Change Wheel framework, behaviour depends on opportunity, capability, and motivation (after Michie et al. 2011)

One-hour semi-structured interviews were conducted with nine contrasting farmers from the Phase 1 study including those who expressed an interest in tree planting and those who did not. Before the interviews began, an information pack was sent to the interviewees, explaining different agroforestry (including trees in hedgerows) and orchard systems with photographs.

In terms of opportunity, seven of nine interviewees were able to identify a part of their farm suitable for an orchard, and three could identify an opportunity for agroforestry. In terms of capability to expand tree cover, the key constraints were considered as financial, followed by lack of knowledge and information. The key motivational considerations were financial followed by environmental concerns such as reducing greenhouse gas emissions and soil erosion and improving water quality and on-farm biodiversity.

When asked what incentives would support tree planting, the farmers highlighted finance and information, which matches the sort of incentives required where capability and motivation are limiting (Michie et al. 2011). The financial incentives considered most effective were the presence of businesses who would guarantee to buy tree products and carbon credits. The highest ranked information incentives were free expert advice from a reliable individual, onsite training, and farmer-led research and innovation networks. The behaviour change wheel appears to be a useful framework to identify interventions to achieve behavioural change.

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Increasing tree cover on Irish dairy and drystock farms: the main barriers and perceptions that impede agroforestry uptake.

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Research and innovation towards the sustainable development of agriculture and forestry

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Theme: Education, training, dissemination and promotion.

Keywords: farmers' decision making, agroforestry, theory of planned behaviour, Ireland

Abstract:
Forest cover in Ireland is substantially lower than the European average with current afforestation rates remaining low (Forest Europe, 2020). Although increasing tree cover on farms has been identified as a climate mitigation and adaptation strategy, current policy is failing to entice landowners to convert proportions of their land to forestry. Agroforestry has been cited as a means to increase sustainability and biodiversity at a farm level while allowing farming to continue on the same parcel of land. Within agricultural landscapes, trees can act as important sources of shelter for livestock while increasing nutrient recycling, providing both direct and indirect benefits to all farmers but especially dairy and drystock farmers (Raskin & Osborn, 2019). However, even with profitable financial incentives currently in place promoting agroforestry, uptake remains low. This highlights that farmer decision-making regarding the adoption of agri-environmental measures does not follow the assumed economic rationality. To better understand the factors that influence farmer decision-making with respect to tree planting on farms, the main attitudes, influencers, barriers and intentions of the farmers must be identified. To facilitate this, a current research project with Teagasc and University College Dublin (UCD) has been set up to analyse farmers' perceptions of and attitudes towards tree planting on farms in conjunction with their willingness to plant.
The Theory of Planned Behaviour (TPB) was used as the theoretical framework for the research and is a method used in many social-psychological studies to determine the reasoning behind a farmer's willingness to adopt specific practices (e.g. Ellis-Iversen *et al*., 2010; Beer and Theuvsen, 2019). The TPB states that intention is the most reliable predictor of behaviour and is determined by three independent socio-psychological constructs: attitude, subjective norm and perceived behavioural control (Ajzen, 1985). An online survey of 415 farmers was conducted. This survey is currently in the early stages of analysis but already interesting results are coming to light. The attitude of farmers has the highest direct effect on intention, followed by moral norms. However, subjective norms has the greatest total effect on intention through impacting attitude, perceived behavioural control and moral norms. The results also demonstrate that background factors such as awareness of agroforestry and geographical location have low levels of impact on intention. Furthermore, past behaviour results in a negative effect on intention, albeit insignificant within this sample size.

The results to date demonstrate that farmers are mainly driven by their attitude and moral norms which in turn are shaped through the views of their influential people, such as advisors and local farmers. The current method of increasing agroforestry uptake is mainly top-down driven and focused on the economic incentives currently in place. New methods to increase agroforestry uptake should focus on encouraging influential people within the farming community to promote agroforestry, and through promoting co-design and co-creative systems. Intention rates among the population sample were neutral to slightly positive, with only 13% exhibiting no intention to plant. Through adopting the proposed measures of this study, intention rates could be increased substantially, promoting behavioural change.

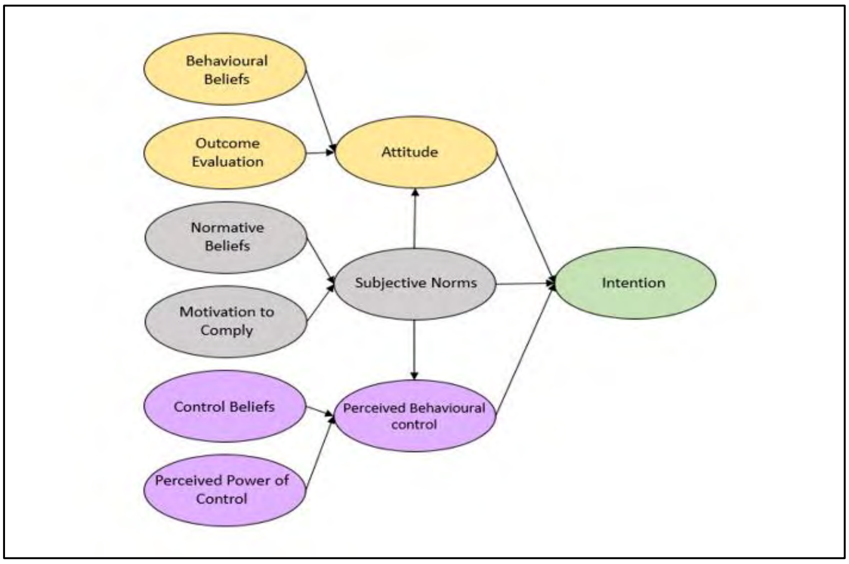

Figure 1. Theory of Planned Behaviour

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Agroforestry dissemination under Organic Farming scope: The I Portuguese Encounter of Successional Agroforestry Systems

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Theme: Education, training, dissemination and promotion

Keywords: Agroecology, Science Outreach, Society, Symposium

Abstract

Agroforestry has a long tradition in Europe, with a greater concentration in the Mediterranean biogeographic region where these integrated systems are better suitable for the harsh climate (Mosquera-Losada et al. 2012). They can make a significant contribution to mitigating and adapting to climate change but further research and dissemination are needed (Hernández-Morcillo et al. 2018). Successional Agroforestry Systems (SAFS) are relatively new in Temperate Climates and since 2018 an Organic Agriculture research team from Coimbra's College of Agriculture (ESAC), has been studying them (Sandes 2019). The potential for agroforestry to improve organic farming sustainability has already been identified (Rosati et al. 2021) and we believe SAFS are also a valuable source of knowledge for promoting climate change adaptation. To foster the discussion and dissemination of SAFS' contribution to organic farming future we organized a nationwide symposium entitled "I Encounter of Successional Agroforestry Systems". Although Portugal has a strong presence of agroforestry in its territory (the *Montado* covers 1 million ha), it's not a "fashionable" topic, which led us to identify the opportunity to organize a conference on this issue and bring science and its stakeholders in.

The event was originally scheduled to take place at ESAC, but due to the pandemic, it had to be rescheduled as a virtual event. It took place on the 15th December, 2021, and was divided into 5 sessions: Science and Research, Agronomy and Forests, Economy and Society, Round Table with farmers and stakeholders, and a Final Comments session. All 27 speakers and moderators were invited considering their background in agroforestry, agronomy, forestry, soil, and/or socio-economic sciences. The main objective was to gather different players, from scientific researchers to agricultural policymakers, and present an overview of the challenges and opportunities associated with agroforestry adoption. The majority of the invitees were professors and researchers from various Portuguese and foreign academic institutions, 4 were from state's agricultural departments, 2 were PhD students, and 8 were farmers or stakeholders, ensuring the diversity of perspectives, as well a high scientific and technical level of the discussion. Farmers and stakeholders pioneers' in SAFS, whether through presentations or round table discussions, provided a valuable practical perspective and helped to drive future research lines. The

event got 323 registrations (it was free) and an average of 135 simultaneous viewers, with a maximum of 161 in the afternoon, which may be regarded as a success when compared to previous similar (virtual) events held at ESAC.

Figure 1. I Portuguese Encounter of Successional Agroforestry Systems Poster.

Throughout the day, the multiple potentialities of SAFS, and agroforestry in general, were highlighted, and the subject's complexity and the need for further research were reinforced. The urgency in changing public policies regarding agroforestry (e.g., tree number limitation in CAP funding) was emphasized, as well as the event's contribution to making it public, which was also corroborated by many of the viewers' opinions.
In addition, a Portuguese Technical Agronomic Journal published a previous article introducing SAFS, and a second one summarizing the event's highlights, helping to raise awareness on the subject and setting the foundation for future events.

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Living Labs for promoting innovations in Mediterranean agroforestry. The LIVINGAGRO experience

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Theme: Education, training, dissemination and promotion

Keywords: Living Laboratories, ICT Platform, multifunctional olive systems, grazed woodlands, Open -innovation

Abstract
The European Commission (EC) defines innovation in agriculture and forestry as "'a new idea that proves successful in practice.' In other words, the introduction of something new (or renewed, a novel change) which turns into an economic, social or environmental benefit for rural practice." The LIVINGAGRO project, funded by the EU under the ENI CBC Mediterranean Sea Basin project, addresses the challenge of knowledge and technological transfer in Mediterranean agroforestry systems through an Open Innovation approach, to achieve and share innovative practices that improve sustainable production and increase profitability in less favoured territories. The project aim is building two cross-border Living

Laboratories across four countries (Italy, Greece, Jordan and Lebanon) on two typically Mediterranean agroforestry systems: Multifunctional Olive Systems (LL1) and Grazed Woodlands (LL2). A Living Lab (LL) is a user-driven open innovation ecosystem based on the opening-up of the innovation process to people other than academia and science. Within this ecosystem, the LIVINGAGRO team invited numerous stakeholders to share their concerns and innovation needs in each LL, then attempted to identify innovations related to those concerns, producing two catalogues of available innovations, to be fully implemented along the lifespan of the project and constantly fed by the ideas and interactions occurring within the stakeholders network. In the first drafting the innovations were grouped in sections: 7 sections for LL1 (spanning from novel agronomic techniques, adaptation to CC, maintenance of cultural heritage, new product development, harvest and postharvest management, health and wellbeing, circular economy) and 4 sections for LL2 (including innovative livestock management tools, landscape and ES valorisation, agronomic techniques and product valorisation)

The survey revealed thirty-three innovations, some more specifically related to the integration of woody vegetation into crop and/or animal systems, and some that contribute to increasing the economic value of individual components of the agroforestry system, and thus the multifunctionality and overall economic viability of such complex management systems, by developing new products, valorising existing products or opening-up new market opportunities for agro-foresters.

In the framework of LIVINGAGRO, further activities will contribute to the co-creation process through:

- A dedicated ICT platform that will be the tool for the creation of a public-private community for the launch of pilot actions aimed at testing innovations in the field.
- Research agreements between universities and research centres in collaboration with the economic operators of the project partner countries.
- Field visits organised by research institutions to assess and identify companies' innovation needs.
- Corporate-scientific brokerage events that organised in Jordan, Lebanon and Crete.
- Analysis and development of ten new products / services for the agro-forestry sector.
- Activation of twenty technology transfer and intellectual property brokerage services for companies, universities, research institutes and the general public.

FOODLEVERS project: Leverage points for organic and sustainable food systems

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Theme: Education, training, dissemination and promotion

Keywords: Agroforestry, organic farm, trade-off, consumers.

Abstract

FOODLEVERS project focuses on how organic and sustainable food systems with long and short distribution chains contribute to reconnecting producers and consumers, to promote a more efficient resource use from farm to fork and to develop economic, environmental, social and governance dimensions of the system's sustainability.

Despite the recent uptake of innovative production systems, food systems continue to move on unsustainable trajectories through a focus on "highly tangible, but essentially weak, leverage points" (Abson et al. 2017). Thus, interventions fail to address key problems and there is the need to focus on three realms of "deep leverage" in affecting change towards sustainability: "Re-connect": reconnecting people to nature to encourage sustainable behaviours whilst shortening feed-backs and improving wellbeing; "Re-structure": re-organising institutions and considering how institutional dynamics can create an enabling environment for sustainability and; "Re-think": considering how knowledge is created and used, shared and validated (figure 1). Research that addresses relationships between the above areas can build an understanding of effective practices and how these interact with the design of and intent behind food systems. Better understanding of how ecology and productivity interact with social processes is also required to influence innovation in ways that address all dimensions of sustainability. Innovative organic food systems may provide models for this holistic framing, but none excel in all aspects. More formal research and assessment is therefore required to better understand these systems, their benefits and the potential for individual socio-technical practices and organisations to facilitate sustainability transitions. Through such an innovative scientific enquiry it is possible to identify "configurations that work" in specific socioecological and socio-economic contexts. To close the gap between production, processing and consumption it is necessary to understand the role of all parts of a food system (FS). This

project aims to analyse different forms of organic and sustainable FSs (e.g. organic, biodynamic, permaculture, agroforestry) in different geographical (rural, urban) and institutional (e.g. community supported agriculture) contexts to understand how different layers of efficiency (e.g. actors, processes, technologies, forms of organisation) can contribute to improve natural and human resource use efficiency. The project applies a multi-disciplinary approach to understand material, organisational and behavioural dimensions of FSs. FOODLEVERS analyses the characteristics of FS case studies in terms of agro-ecological factors, the value chains related to the FSs (food cultivation, various stages of processing/distribution, consumption) in terms of input-output relations and the interaction processes between actors and the decision-making processes in consumption. In particular, the project considers whether the way that innovative organic and sustainable FSs are pushing the boundaries of what is known, what is expected and what is thought to be do-able, contribute to social theory about re-organisation and restructuring FSs. In doing so the project identifies the leverage potential of different FSs to increase the performance of systems and to accelerate sustainability transitions.

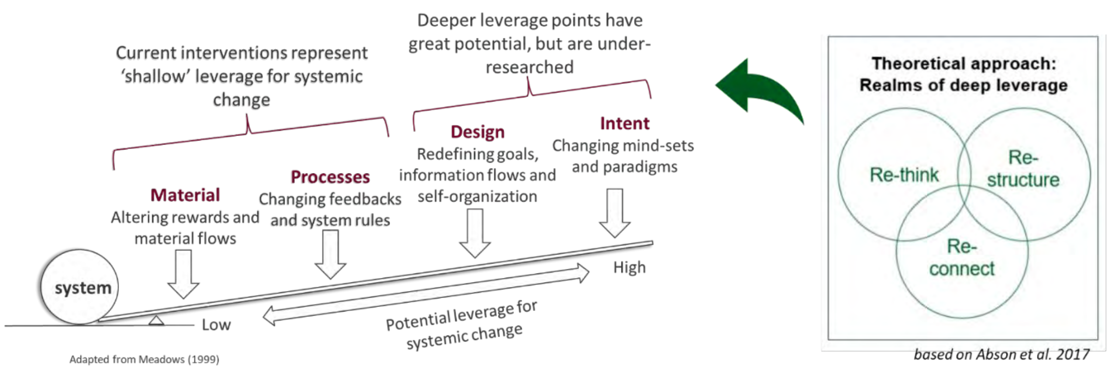

Figure 1: conceptual framework of potential leverage for systematic change

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The Roots of *Tree Crops*: J. Russell Smith and the Origins of Agroforestry

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Theme: Education, training, dissemination and promotion

Keywords: J. Russell Smith, Tree Crops, History, Geography

Abstract
The geographer J. Russell Smith is regarded as the father of agroforestry, yet he has received little attention from historians. The author is in the early stages of a historical study of Smith and particularly his influences in relation to agroforestry. This presentation will share preliminary findings, drawing on Smith's written work and his archived papers held at the American Philosophical Society library. The presentation will pay particular attention to the European influences on Smith's career and interest in agroforestry, and to his practical work experimenting with various tree crops. Smith's 1929 book *Tree Crops* is regarded as a foundational work in the field of agroforestry, and this presentation will place it in conversation with other works of the time period.
While it was difficult to identify the best subtopic for this proposal, the author believes it would be a highly relevant poster to present at this conference and looks forward to feedback that may be received from fellow conference attendees.

Implementation of AGFOSY project – experience from the Czech Republic

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Theme: Education, training, dissemination, promotion

Keywords: Case studies, Methodological sheets

Abstract

Project AGFOSY (Agroforestry Systems: The Opportunity for European Landscape and Agriculture) took place from 2018 to 2020. The main goal of the project was to develop a complex training system for agroforestry (AF). There were 7 project partners from 6 European countries involved in the project: Czech Republic (Association of Private Farming of the Czech Republic, Czech Association for Agroforestry), Slovakia (National Forest Centre), Hungary (Soproni Egyetem Kooperacios Kutatasi Kozpont Nonprofit Kft), Spain (On Projects), France (Association Francaise D Agroforesterie, Des Racines Et Des Cimes), and Belgium (European Landowners Organization). The primary target group of the project were farmers interested in establishing AF. The main output of the project was to build an online educational system, which provides farmers with knowledge and skills that will assist them in implementing various AF systems into practice. This toolbox is currently accessible at www.agroforestrysystems.eu in six language variations and contains the following modules:

1. **Case studies** show real examples of agroforestry practices from the countries of AGFOSY project. They are divided by country and can serve as a source of inspiration and practical help to farmers, which want to start, or already have AF systems.
2. **Study materials** (presentations) contain 10 modules for lectures/trainers in AF but also farmers, with information about major agroforestry systems in Europe, ecological aspects of agroforestry, the historical context to agroforestry systems, the practice of tree planting, economy and the legal aspects in European agroforestry, etc. Participants can test its knowledge gained from presentations in small online tests after each study material.

3. **Methodological sheets** provide information about individual tasks during establishment of particular agroforestry systems, and they are divided into three categories: individual features, linear features, and products and uses.
4. **Videos** provide visual introduction to various AF topics.
5. **Summary agroforestry report** gather and analyse information about the current situation of AF implementation in the partners' countries and also summarizes the results of a questionnaire survey conducted with farmers.

Our experience two years after the end of the project shows, that the project page has been widely visited. The materials were used by media for their programs about AF (Czech National Television, Institute of Agricultural Economics and Information), and by Czech Agroforestry Association for different lectures and presentations. We have positive feedback from Association of Private Farmers of the CZ that various modules have been used by farmers.

In the Czech Republic, there was very little information on agroforestry before the project started and they were often fragmented between several entities. Thanks to the AGFOSY project, we were able to consolidate this information and, in addition, provide it to the public. The second very important advantage of the project was the establishment of close cooperation with other organizations from the partner countries, but also within national farmers associations and educational institutions. This cooperation is still ongoing and has enriched us with a lot of new knowledge.

AGFOSY project has been funded with the support from program Erasmus+ of the European Commission, with the reference number 2018-1-CZ01-KA202-048153

Figure 1. Example of training materials made during the AGFOSY project

Ecosystem services provision and adoption of agroforestry in England

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Theme: Education, training, dissemination and promotion

Keywords: Adoption, temperate, England, ecosystem services

Abstract
Agroforestry adoption in England has been seldom studied and most of the research has focused on the barriers for its implementation. We consulted current agroforestry practitioners in England through an online survey with 21 questions to characterise and map the factors that lead to adoption of each region in the country, as well as the benefits perceived and the intentions to continue the adoption process. We received 29 answers founding that the main reason to adopt agroforestry is driven by environmental concerns rather than maximising profit, specially at the beginning of the adoption process. Higher profits, increase on yield and soil health have not been observed by most respondents after agroforestry implementation, but at least 85% of the participants have noticed an increase in biodiversity after implementing agroforestry, especially during the first 5 years of practicing it. When asked about the educational opportunities perceived by agroforestry, 60% of the participants responded that they have noticed an increase during the first five years and at least 85% of the respondents have perceived an improvement in the aesthetic appearance of their farms after 15 years of implementation, with 65% of the respondents noticed this benefit during the first five years. Support and cultural ecosystem services provided by agroforestry seem to be the most important factors to adopt and continue the agroforestry adoption process in England.

Successional Agroforestry's central role in a project for rural development and climate change adaptation in Alentejo, Portugal

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Theme: Education, training, dissemination and promotion

Keywords: Agroecology, Food security, Network, Organic Farming, Sustainability

Abstract

Mértola is a municipality in the Alentejo region of southwest Portugal and it's one of Europe's most vulnerable areas to desertification. With a semi-arid climate, future projections predict a challenging significant decrease in precipitation (to about 300 mm by 2100). Mértola is also the Portuguese municipality with the second lowest demographic density (4,8 inhabitants/km^2 in 2021) and its socioeconomic indicators are generally very low, with a marked period of decline and rural exodus in the last 50 years (García-Delgado et al. 2020).

The project *Mértola, a Lab for the Future* started being designed in 2017 and is a project of agroecological transition with climate change adaptation, desertification combat, and rural abandonment reversal as its major goals. With an emphasis on food security, the project aims to give to the local community the power and leadership to ensure sustainability in all components of the local food system: ecological, economic, and social (Cortegano et al. 2021).

Agroforestry has been at the heart of the project since the outset. Starting from an organic aromatic plant production background (since 2008) and later with organic vegetable production (2014 onwards), the project's farms "Horta da Moura" and "Horta da Malhadinha" served as testing grounds for the proposed agroecological transition. The gradual conversion of all organic vegetable fields to Successional Agroforestry Systems (SAFS) was one of the first actions promoted by the project (in 2017). This strategy, which is now being adopted by other farmers in the region, was an attempt to reduce irrigation water use and protect vegetable crops from excessively high temperatures and sunlight exposure during the summer peak, and simultaneously promote soil restoration and natural resource conservation. Mértola's

soils are characterized by thin horizons and low organic matter content, resulting in low fertility and limited water storage capacity. By incorporating rows of fruit and multifunctional trees and shrubs (Figure 1) (including regional autochthonous species) across the vegetable production fields SAFS are currently providing profitable and certified organic food production. Data are currently being collected to assess productivity, water use and environmental benefits.

Figure 1. SAFS field (900 m^2) organic certified from the Agroecological Centre headquarters "Horta da Malhadinha" focused on bio-intensive vegetable production in the alleys of mixed fruit and multifunction tree rows (November 2020). Implementation date November 2019. (Photography by Pedro Nogueira)

Apart from the regular production of vegetables, aromatics, and fruits to be commercialized by the Local Food Network, "Horta da Malhadinha" is now the new *Agroecological Centre* (2019) headquarters and a living laboratory used for demonstration, experimentation, and training purposes. This network, which was consolidated in 2020 as a response to COVID pandemics, was one of the project's original goals. It includes other farmers, local associations, collective canteens, and consumers and aims to provide the majority of the food supply for Mértola's municipality. The project also promotes frequent sessions with *Local Food Network* partners and other farmers of the region, where SAFS and local traditional agriculture practices are discussed with the purpose of co-creating knowledge and disseminating it in a peer learning process.

A pioneer program to form new agroecological farmers, "Land Scholarship", which is already in its second edition, together with the popular volunteers' program at the Agroecological Centre, are actively promoting the presence and settlement of young people in Mértola.

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Title: The Knowledge Exchange Hub of the AGROMIX project

Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry

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Agroforestry for the Green Deal transition. Research and innovation towards the sustainable development of agriculture and forestry
Abstract

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Topic: Agroforestry in Society and Culture

Subtopic: Education, training, dissemination, and promotion

Keywords: promotion, dissemination, AGROMIX**Type of presentation (oral or poster):** poster presentation

Abstract The EU-funded project **AGROMIX** has developed an online tool called the **Knowledge Exchange Hub (KEH)**, gathering information about agroforestry and mixed farming in Europe on the project's website. The Hub is an open-access platform that is continuously **updated with new content including educational materials, cutting-edge research on agroforestry and mixed farming, links to regenerative farming networks, relevant projects, books, videos, photos, event announcements, apps, software, and plenty more, all** related to the project's interest areas: agroforestry, mixed farming, regenerative agriculture, climate change resilience, and sustainable land use.

The KEH can be freely accessed by all via the project's website **(Figure 1)** and is continuously fed with both international and local information by AGROMIX's 28 partners from across Europe. Using the page's dropdown menu, the user can navigate between the 12 different hubs, including 11 country-specific hubs, and one international hub with material from across Europe, and beyond. The information is shared both in English, and in the corresponding country's local language.

The content categories considered are:

- i) pre-existent sources of information in the public domain, e.g. online repositories generated by previous or **other relevant ongoing projects**, or by interest groups;
- ii) ii) web links to relevant research projects, e.g. AFINET (Villada et al. 2018), AGFORWARD, (Burgess and Rosati 2018), MIXED, STARGATE;
- iii) links to interest groups and associations, institutions, e.g. EURAF, national farmers **associations**, local associations;
- iv) education: BSc, MSc or PhD **courses**, and other short-term courses;
- v) **events**;

vi) **publications,** such as but not limited to: book, book section, conference paper, journal article, patent, preprint, report, thesis, technical note, working paper;

vii) **software and apps**, such as but not limited to: models, tools, apps, serious games; viii) **audio-visual material** (videos/audio) and interactive materials, such as but not limited to: videos, podcasts, lectures, oral presentations, photographs, figures, plots, drawings, diagrams;

viii) **datasets** in the public domain or links to relevant public datasets.

In the future, the Hub will be adapted to allow users to upload their own material, with a validation process in place to ensure the quality of the information shown. As the volume of materials expand, the Hub is becoming a key platform for all stakeholders interested in agroforestry and mixed farming, thus establishing a dynamic exchange of information that will progress over time (Saetnan and Kipling 2016), bringing together the diverse realities of farming across Europe.

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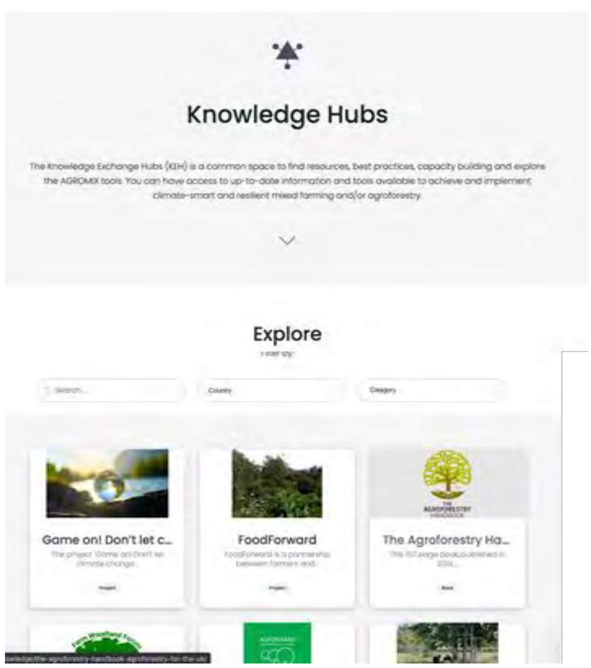

Figure 1. The Knowledge Exchange Hub on AGROMIX's website

Agroforestry in Austria - an EIP-AGRI project: know-how transfer and implementation of silvoarable AFS

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Research and innovation towards the
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Theme: Education, training, dissemination and promotion

Keywords: Austria, implementation silvoarable AFS, know-how transfer, demonstration AFS, European Innovation Partnership for Agricultural productivity and Sustainability (EIP-AGRI),

Abstract

In general EIP-AGRI projects (European Innovation Partnership for Agricultural productivity and Sustainability) are designed for implementing innovative practices, which solve urgent agricultural problems. The particular EIP Project "Agroforestry in Austria" is aiming at implementing different agroforest systems (AFS) to filling the knowledge gap in AFS and thus introduce an agricultural practice, which address several actual agricultural challenges like climate change, biodiversity loss, wind and water soil erosion and nutrients losses.

In Austria the interest of farmers in AFS is growing, but at the moment only very few practical examples already exist. Thus, the know-how transfer of experiences from Switzerland and Germany to Austria is the key objective in our project. Therefore, 6 farmers received intensive advice within the project. The farms which have different branches and different site conditions are located in the eastern part of Austria, where the environmental and economic pressure on arable land is very high. Within the project all six farmers have implemented their individually chosen AFS on plots of their farms. The outcomes so far are, that the farm specific aim of the AFS differed widely: erosion protection, biodiversity improvement, climate change adaption, microclimate improvement, recovery of old varieties, landscape structuring and/or demarcation of fields. The tree species and its type of use differed also: Walnut, oak, true service tree (*Sorbus domesticus*), wild service tree (*Sorbus torminalis*), alder, turkish hazel (*Corylus colurna*), poplar, different fruit trees (even old varieties), rowan, wild cherry, lime tree, elm, maple, chestnut, pecan, almond, pawpaw (*Asimina triloba*).

Besides gaining practical know-how of establishing and cultivating silvoarable AFS, a further objective of the project is to interlink parties interested in AFS in Austria. Workshops on the few AF-farms in Austria (Fig. 1), which established AF at least since 2016, and workshops on AF-farms in Switzerland were organised and people interested were invited to attend (farmers beyond the project, Austrian AF Association and project partners from the University of Natural Resources and Life Sciences Vienna, Chamber of Agriculture, experimental station plant production of Styria and one farmers association Bio Austria). The exchange of AF experiences was deepened during farm visits at the six project farms.

As it is an implementation project and not a scientific project, we will conduct only three accompanying investigations in the last project year: 1) assessing the climate impact of the AFS in

Austria by screening the actual literature and estimate the CO_2eq mitigation potential 2) surveying agro economic issues of two AFS, 3) examining the legal situation in Austria and suggest solutions for the financial subsidies scheme.
The three-year projects ends in winter 2022. Until then the know-how transfer and experiences from the AFS implementation result in Austria specific information materials for farmers and a manual for advisors as well (see also: https://agroforst-oesterreich.at/ and www.fibl.org). Furthermore, an Agroforestry-Conference will be take place in autumn 2022 in Austria. Beyond the project period the farms taking part in the project should function as demonstration farms for others as well as the agroforestry network, which was established during the project should continue.

Figure 1. During a workshop in lower Austria © FiBL / P. Meindl.

T 4.3

AGROFORESTRY AND HISTORICAL LANDSCAPES: HERITAGE IDENTITY AND A DRIVER FOR SUSTAINABLE TOURISM

4 .3

Green Infrastructure governance approaches in the Alpine Space – Synthesis of collaborative mapping approaches for selected case studies

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Theme: Agroforestry and historical landscapes: heritage identity and a driver for sustainable tourism

Keywords: alpine space, orchard meadows, governance, urban green infrastructure

Abstract

Orchard meadows are traditional agroforestry systems in Europe and important elements of the biotope network, home to more than 5,000 animal and plant species, over 3,000 fruit varieties, which makes them rescue islands for the conservation of biological and genetic diversity (Schrapp *et al.*, 2020). While being an actively used component of the cultural landscape, orchards have been and still are subject to constant change. Economic viability, and thus long-term preservation, remains the greatest challenge. Challenging in times of climate crisis and globalisation with new pathogens and insect pests. All this requires new and adapted strategies to preserve the last orchard areas in the long term or to reverse the continuous decline.

In the search for solutions, the INTERREG Alpine Space project LUIGI (Linking Urban and Inner-Alpine Green Infrastructure – Multifunctional ecosystem services for more liveable territories) came up with a number of solutions, many focusing on participatory governance approaches (Hübner *et al.*, 2021). These solutions a clustered around modern governance arangements. With the support of regional experts, 69 interviews in 11 study areas in six countries in the Alps were undertaken, caring for the coverage of a systematic set of stakeholders. Qualitative and quantitative evaluation methods were applied to analyse more than 1,000 pages of transcript, primarily a qualitative structuring content analysis and using thematic coding in MAXQDA. For the analysis of the network structures to relate to the governance model, the outcomes of qualitative content analysis was used as input for social network analysis (SNA).

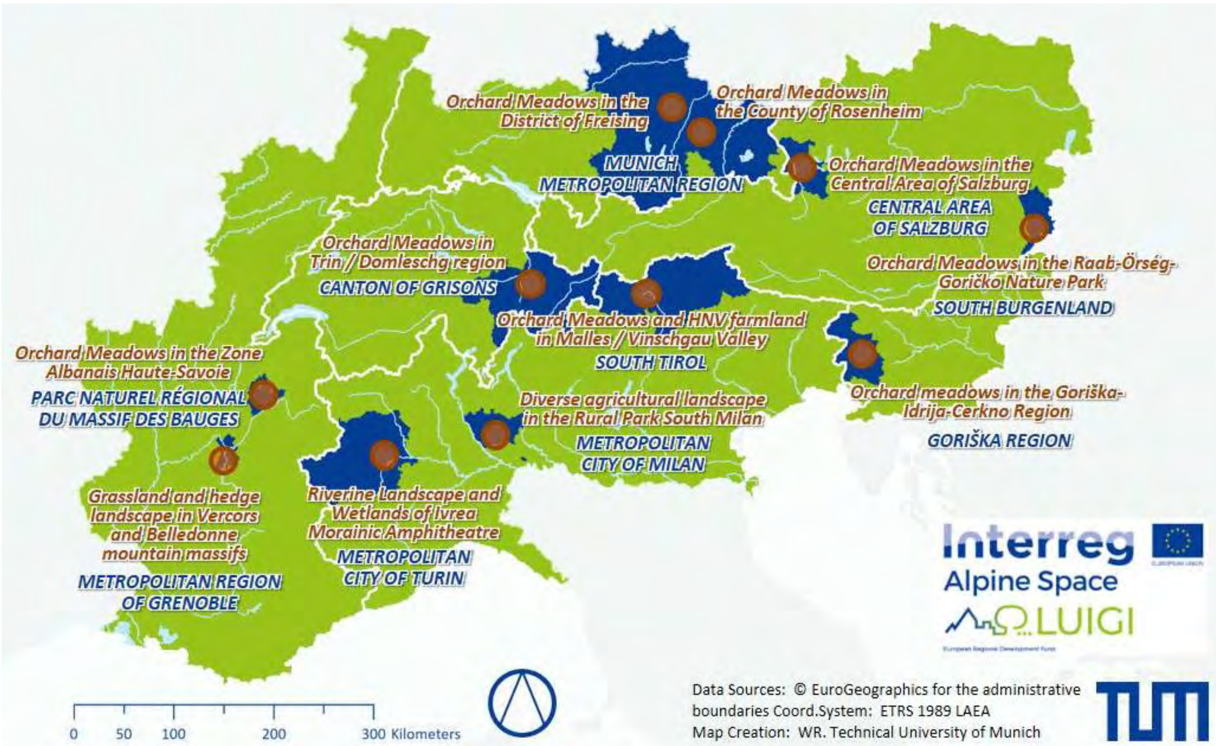

Figure 1. Location of the LUIGI pilot regions (blue) and 11 study areas (red) in the Alpine Space.

The 11 case studies display a number of different governance arrangements. They can be assigned to six types: 1) Government led, 2) Market oriented, 3) Closed Co-Governance, 4) Open Co-governance, 5) Green hub, and 6) Grassroots initiatives.

The aims and objectives of the stakeholders were broadly categorized threefold, in economic values, ecological values (preservation of natural resources, preserve and promote biological diversity, agricultural diversity of varieties), and social/cultural landscape values and objectives, such as identity, education, recreation and aesthetics. Similar to the aims and objectives, the motivations are manifold and could be categorized in seven different classes. Different stakeholders are driven by a variety of motivations. Evidence suggest that overall, rather intrinsic oriented motivations such as joy, quality of life and idealism, play a major role for motivation in combination with rather extrinsic oriented, economic interest and motivation. Finally, another striking aspect is that differences in accentuations can be clearly related to the countries. While the case studies in Austria, Germany and Switzerland are rather driven by few different motivations, the stakeholders' motivation in France and Italy appear to be more diverse.

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Olive agroforestry in Sicily. Insights from the Roman past and the present.

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Theme: Agroforestry and historical landscapes: heritage identity and a driver for sustainable tourism

Keywords: Olea Europea, intercropping agroecosystems, historical ecology, antiquity, circular economy

Abstract

Groves with ancient olive trees (*Olea europea* L.) are remnants of old agroforestry systems that, in Southern Europe, could be even dated back to antiquity. The importance of these intercropping agroecosystems does not rely only on their high nature value, but on the "total" circular system they embody at many levels: environmental (increase in biological diversity, reduction of soil erosion and improvement of soil quality, carbon sequestration potential, nutrient recycling), economic (food security, diversification of products for several purposes), cultural (local identity, traditional ecological knowledge and landscape aesthetics). More importantly, olive agroforestry is the living evidence of an agroecological system able to endure as long as living in a complex symbiotic relationship with humans. Anything but static, these agroforestry systems have undergone drastic transformational processes in the Mediterranean countries, where either abandonment or intensification have been observed as by far more widespread than continuity, expansion or renaissance trends, leading today to environmental degradation of rural areas.

Starting from these assumptions and adopting a cross-disciplinary approach inspired by historical ecology, we look at old-century olive trees as living archives of human-nature interactions, thus proxies of old agroforestry systems. By combining compiled records from Roman agriculturalists and field data collected within the LIFE project "Olive4Climate", we draw a parallel between olive agroforestry in antiquity and today, with a special focus on the island of Sicily.

Our aim is to better understand what drives dynamics of change from intercropping to monoculture, happening today as well as in the past. At the same time, we look at how ecological, spatial and phenological elements of persistence along the centuries could represent one key to ensure the resilience of these agroecosystems and contribute to the re-invention of sustainable forms of their management.

Figure 1: Example of olive agroforestry landscape in Sicily (photo: Vincenza Ferrara).

Chamugrö: An ancestral agroforestry system from the indigenous Bribrí-Cabécar culture in Talamanca, Costa Rica.

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Theme: Agroforestry and historical landscapes: heritage identity and a driver for sustainable tourism

Keywords: Agroforest structure, climate resilience, adoption, biological corridors.

Abstract
Specific knowledge about the management practices and characteristics of indigenous agroforestry systems may result beneficial to small rural farmers and agroforestry practitioners. In this study, we provide a characterization of the Chamugrö, an ancient agroforestry system practiced in the Bribrí-Cabécar territory of Talamanca, Costa Rica, by the farmers from UCANEHU, a local association dedicated to preserving their ancient knowledge in agriculture. We studied the species composition and structure of this system using data from 12 randomly installed temporary plots of 2500 m^2 (Somarriba et al., 2001), where crops and trees were identified to species, mapped and measured. In the analysis, the dataset was adjusted dividing the sample into 60 minimum management units (MMU) of 500 m^2 following the observed minimum workable area by the indigenous farmers. Importance Value Index (IVI) (Curtis & Mcintosh, 1951) was used to determine the most representative tree species in the forest component. One-Way-ANOVAs were used to identify significant differences among group means in the analyzed variables. We found that the agroforestry components in the Chamugrö are distributed in three vertical layers. The first layer (0-7 m above the ground) is mainly occupied by crops (Avg. 46.27 plants/MMU- SD:21.16- n:60- $p<0.01$- 925 plants/ha), including banana (Avg. 40.06 plants/MMU- SD:21.23- n:60- $p<0.01$- 800 plants/ha) and cacao (Avg. 8.36 plants/MMU- SD:5.98- n:33- $p>0.01$- 167 plants/ha) as the most predominant species. These have an average height of 3.44 m (SD:0.55- n:60- $p>0.01$) and 2.83 m (SD:0.77- n:33- $p>0.01$), respectively. The second layer (7-16 m) is composed of subcanopy trees, where *Bactris gasipaes* (10.42%), *Hura crepitans* (8.47%) and *Cordia alliodora* (8.32%) are the most representative (IVI). The average number of trees in this layer is 2.98/MMU (SD:2.01- n:51- $p>0.01$- 59.60 trees/ha). These report a height of 8.90 m (SD:0.77- n:51- $p>0.01$). The average percentage of shade in the MMU is 17.84% (SD:15.96- n:51- $p<0.01$) and the average basal area is 0.21 m^2/MMU (SD:0.23- n:51- $p>0.01$- 4.22m^2/ha). The third layer (>16 m) comprises canopy trees, where the most representative (IVI) species are *Pterocarpus hayesii* (14.79%), *Cordia alliodora* (11.93%) and *Ceiba pentandra* (9.64%). The average number of trees in each MMU is 3.44 (SD:2.81- n:52- $p<0.01$- 68.8 trees/ha). These have an average height of 21.26 m (SD:2.01- n:52- $p<0.01$), and produce an average percentage of shade of

43.76% (SD:39.19- n:52- $p<0.01$). The average basal area of this layer is 2 m^2/MMU (SD:4.25- n:52- $p>0.01$- 37.00m^2/ha). We learned that the indigenous farmers from UCANEHU have a deep respect and appreciation for their landscape and natural resources. The agroforestry that they practice is a tool that allows them to exercise and maintain their values and commitment to preserving nature. We conclude that the Chamugrö is a viable agroforestry application worth studying as an ancestral agricultural production system that may be optimized to help farmers advance towards the restoration of the planet and to address climate change, biodiversity loss, and advance toward sustainable living food systems.

Figure 1. Women farmers play a key role in UCANEHU. Bribrí-Cabécar indigenous territories, Talamanca, Costa Rica. Photo by F. Camacho. 2022.

Aknowledgements
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Vinehills of the Carpathian Basin: the benefits of isolation. Environment, traditions, landscapes and opportunities in tourism

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Theme: Agroforestry and Traditional landscapes: Heritage identity and a driver for sustainable tourism

Keywords: Eastern Europe, vinehill, manyfold land-use, traditional landscape

Abstract

Vinehills in the Carpathian Basin are mixed-farming, fruit and vine producing systems with high agro-biodiversity. Lands of prevalently vine and fruit production, characterized by manyfold land use, integrating vine, fruit, nuts production, even vegetables for household consumption. They also provide firewood, forage, construction material, and are used for grazing.

Vinehills developped parallelly with serf villages, from as early as the XIIIth century, and the system was still alive in the XX century, functionally unchanged since the Middle Ages. The centuries of the vinehills preserved practices based on traditional ecologic knowledge; with their archaic nature they carried a certain cultural, even spiritual significance and were an important part of the life of local communities. According to estimates, there are in total 100.000 hectares of vinehills across Hungary.

Many characteristics of the traditional landscape of vinehills remain intact, their built environment carries archaic elements until today. They are characteristic of knowledge- and labour-intensive, high value crops; agro-biodiversity and mosaic landscapes; and a certain level of isolation and remoteness. It was neither easy, nor profitable to integrate vinehills in modern agricultural production. It was the case in the XVIII century, when large aristocrat estates were organized; in the 1950s when socialist cooperatives were formed, and it is the case in the "second Green Revolution", too.

Today former vinehills are either transformed into residential areas, or are becoming abandoned starting from the second half of the XX century. Abandonment gives way to national regeneration, and the appearance of wild species. What we see today is the result of decades of mostly undisturbed interactions and joint development of wild and cultivated species.

I argue that former vinehills are ideal sites for the establishment of high complexity – low maintenance, fruit-based agroforestry systems, with benefits for the environment and the community. Emerging opportunities in tourism might further diversify the system's outputs. I wish to demonstrate this by the example of Zsörk vinehill of Pápateszér.

Zsörk is located in the foothills of the Bakony, a potential forest-landscape. It became a vinehill in the XVIII. century, for the use of the serfs of the Eszterházy. With its 74 Ha it is among the larger vinehills. With its 3 km distance from Pépateszér on bad quality dust roads, and without utilities, today it is among the most abandoned ones, too.

We started farming in Zsörk in 2015, from that date, on different plots different agroforestry systems have been established, and research activities have been carried out. Vegetation in general and old fruit trees, bird populations were assessed. Natural regeneration and survival of cultivated species of trees and shrubs were researched.

Fruit trees survived in surprisingly high numbers and good conditions after decades of abandonment, and they regenerate naturally in the old gardens. The presence of forest trees and wild plants further increased biodiversity and enhanced the system's natural resilience. Natural regeneration is rich due also to the bird population and frequent visits of wild animals of nearby woods. Forest trees, fruit trees and shrubs, complex plant associations that developed undisturbed through decades, provide habitats

for local fauna, and demonstrate which species are well adapted to local conditions. Based on this knowledge, we apply production methods of manifold land-use, - forest garden patches, wooded pastures and intercropped orchards. Our experiences prove that extensive methods, the inclusion of wide species and high agro-biodiversity add up for a resilient and low-maintanance food production system.

Methods that are successfully applied in Zsörk - and presumably could be applied in many former Hungarian vinehills - include adapting orchard management, permaculture and several agroforestry technologies. Our farm is a complex system, relies on natural biological and ecological processes, and produces food and other products with the least possible human intervention and external input. These techniques have an inherent ecological and social approach, and a positive attitude towards traditional practices. The very diversity that makes our farming methods work, though, carry huge economic challenges, namely the struggle to successfully market a wide variety of products. Economic sustainability is only possible by including small-scale tourism activity.

Development of enclosed gardens across Hungary is driven by different factors, some are abandoned or rediscovered by a new generation of farmers; and some are touristic destinations, particularly because of their isolation, wild and diverse landscape and romantic built environment.

Zsörk, is being gradually brought back to the evryday life of the local community, partly by our sustainable farming experiments, backed by local government's efforts to revive local traditions. The chapel has been renovated, and the centuries old tradition of Saint Stephen's Day's feast have been revived. Zsörk is already popular among excursionist, and with some renovation of the built environment it holds unexpoited opportunities in tourism.

Figure 1. Chapel of Zsörk (own photo, 2017)

Abandonment of traditional agroforestry systems in Northern Greece

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Theme: Agroforestry and historical landscapes: heritage identity and a driver for sustainable tourism

Keywords: intercropping, landscape, heritage, rural development

Abstract

Agroforestry in Greece, as a way of using land resources have been mentioned since antiquity (Ispikoudis 2005). The use of these management methods served the social and cultural needs of the local population and the ecological conditions of an area. They are widely distributed all over the country and constitute important elements of the rural landscape (Papanastasis et al. 2009). The results of the synthesis of this rural and ecological history have shaped notably landscapes and elements of cultural heritage.

The aim of this study is to present examples of traditional agroforestry systems in northern Greece and their degree of abandonment or decline.

The main examples are the following: 1) Xanthi, 2) Ossa, 3) Sochos, 4) Mouries - Chilia Dentra, 5) Kerkini - Sidirochori, 6) Ano Poroia, 7) Volakas.

In different areas of Xanthi the dominant tree species are *Celtis* spp., *Ulmus* spp. and *Populus* spp. They are intercropped by variable arable crops such as tobacco and vineyards or herbaceous plants. In Ossa the dominant tree species is *Querqus pubescens* scattered in the field with individuals of *Pyrus amygdaliformis*. At the boundaries of the fields shrub species exist such as *Paliurus spini-cristi* and *Querqus coccifera*. They are intercropped by vineyards and herbaceous plants. In Sochos the predominant tree species is walnut (*Juglans regia*), scattered throughout the fields. Other species that are present are almond trees (Prunus amygdalus), *Prunus* spp., *Castanea sativa, Corylus* spp., *Sambucus nigra* and *Arundo donax* (reeds). The intercrops consist of wheat, tobacco, alfalfa, maze, sorghum and rapeseed. In Mouries - Chilia Dentra the main tree species of the system are *Querqus* spp. and *Fraxinus* spp. They used to be grazed but since the area was proclaimed as a preserved monument of nature it lost its notably landscape and elements of cultural heritage. This also increased forest fire risk. In the Kerkini - Sidirochori systems the predominant trees are walnut (*Juglans regia*), *Populus* spp., *Alnus* spp and *Salix* spp. They are intercropped by alfalfa and maize. In the system of Ano Poroia the dominant trees are *Celtis australis* and *Ulmus* spp, with individuals of walnuts (*Juglans regia*), *Morus* spp and *Prunus* spp. The dominant cultivars were cereals and vines. Now the understory consists of ferns and *Rubus* spp. The systems in Volaka consist mainly of walnuts and elms. The landscape in the Volaka region shows a typical "zoning" and it shows that it is still active (Sidiropoulou 2011).

Since the 1970s these traditional landscapes in Greece are rapidly declining in number and extent. The most important threats they are facing, are the lack of information on their value and the lack of an inventory plan for their protection and promotion. Another important reason of their abandonment is the intensification of agriculture, which led to the removal of the trees and the enhancement of monoculture.

Moreover, the movement of people from rural to urban areas and thus the reduction of the labour force had as a result the abandonment of the agroforestry systems and their conversion to forest land.

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Adoption constraints to agroforestry systems in the Algarve, Portugal

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Theme: Agroforestry and historical landscapes: heritage identity and a driver for sustainable tourism

Keywords: Traditional rainfed systems, adoption constraints, biodiversity

Abstract
The lack of incentives and profitability led to transitioning changes in the Algarve. Droughts, desertification, water availability are the main environmental drivers of risk witnessed in this region. The mean age increase of farmers and rural depopulation has led to an increase in land being left in abandonment. Previous research has relied on abandoned land being either restored into natural ecosystems or replaced by more productive agricultural systems. How farmers and landowners perceive agroforestry systems and see implications linked to them, has depended on the agroforestry type studies have focused and on the study location. To assess whether farmers and landowners were willing to adopt an innovative agroforestry system, a in the Algarve prevailing traditional rainfed orchard system, also known as Pomar Tradicional de Sequeiro, served as a suggestive example of how agroforestry may be composed by in this region. To evaluate the main constraints towards adoption of such system a survey through an online questionnaire was carried out, being analysed statistically on inference. A qualitative content analysis was conducted to present the results of qualitative data collection. The results showed that the main restricting factors for the adoption of agroforestry systems in the Algarve were the lack of governmental support, followed by long-term investment, labour intensity, knowledge required and unprofitability. Promoting such systems seem to be realistic if further investments and efforts by key actors are made and farmers and landowners awareness remains.

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