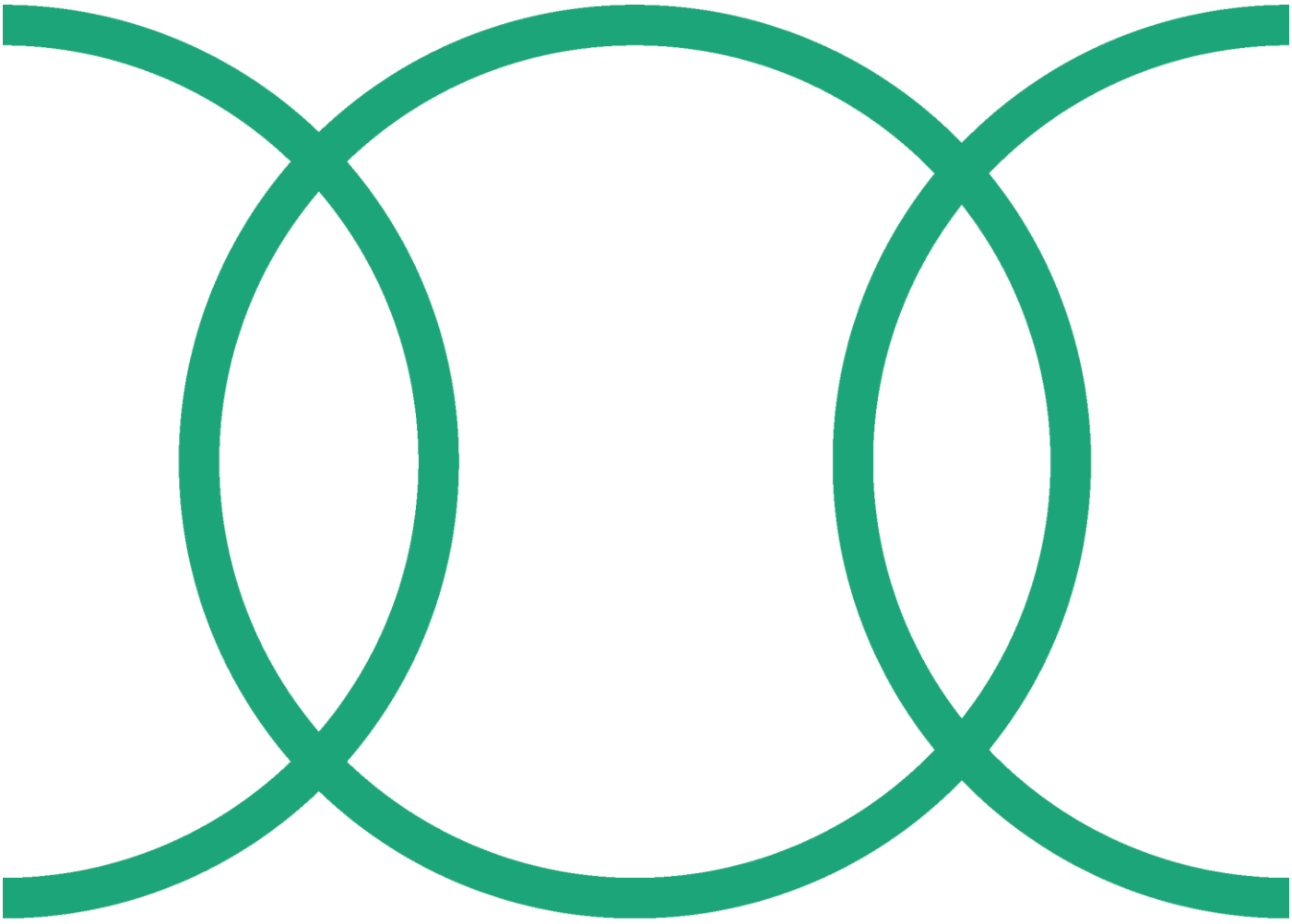
D2.3 First Report on capacity building material and activities

FOREST4EU



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Executive Summary

Deliverable D2.3, "First Report on Capacity Building Material and Activities," outlines the process used to develop the first batch of capacity building material for the innovations selected by project stakeholders as the most relevant from a total of 175 innovations collected within the project's framework. The document provides a detailed overview of the created material, including technical information (length, publication channel, languages of publication, etc.) and content details (i.e., overview of the innovation). Additionally, D2.3 presents the dissemination approach for each created material and the methodology that will be used to evaluate the uptake and impact of these material.

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1. Introduction

The main goal of the FOREST4EU project is to effectively share, at the European level, useful and easy-to-understand knowledge for the forestry and agroforestry sectors. To this end, the project identified and collected best practices and innovations developed by forestry and agroforestry EIP-AGRI Operational Groups (OGs). By facilitating knowledge exchange, the project seeks to promote sustainability in forestry and agroforestry across Europe through the implementation various innovations and new business models, and the adoption of climate change resilience measures. Moreover, through knowledge transfer activities, FOREST4EU envision to favour the formation of new alliances of farmers, foresters, policy makers, practitioners and other relevant stakeholders in the forestry and agroforestry sectors in Europe.

To favour the transfer and dissemination of innovations and good practices developed by EPI-AGRI OGs to relevant stakeholders from European countries it is essential to rely on high-quality multi-language capacity building material. The dissemination of high-quality capacity building material is key as they can contribute to increase the local knowledge and skills and improve the quality of the practices applied in the forestry and agroforestry sectors by the local stakeholders promoting sustainability, supporting policy implementation, empowering communities, fostering innovation, and addressing environmental challenges. In this context, it is evident that the creation of capacity building material based on innovations and good practices developed for the forest and agroforestry sector can contribute to building a more resilient and sustainable future in Europe.

In order to facilitate the dissemination of practical knowledge and innovations across European countries and contribute to the exchange and collaboration between relevant stakeholders, the FOREST4EU project collected and systematized 175 innovations developed by 86 EPI-AGRI OGs from Portugal, Spain, France, Italy, Slovenia, Latvia, Austria, Germany, The Netherlands, and Sweden by contacting the coordinator of the OGs. These innovations were assigned to one of the 5 different ITHubs: ITHub 1: wood mobilization, ITHub 2: Adaptation to climate change, ITHub 3: Sustainable forest management and ecosystem services, ITHub 4: Non-wood forest products and ITHub 5: Agroforestry.

The main goal of D.2.3 “First Report on Capacity Building Material and Activities” is to present a thorough overview of capacity building material created by the FOREST4EU project partners. These materials cover the most relevant innovations and good practices developed by OGs in the forestry and agroforestry sectors. The report also outlines the strategies for developing the material, including the formats, languages, and channels that will be used to convey them to targeted audiences across Europe.

In the upcoming sections, we outline the selection process for identifying the most relevant innovations for which capacity building material were created. We also detail the partners responsible for each material and provide an overview of the material, including the name of the innovation, format, language, and other relevant characteristics.

2. Objectives of the Capacity Building Material

The main goal of the capacity building material created in the framework of FOREST4EU is to contribute to the transfer of information and knowledge on best practices and innovations developed by EIP-AGRI OGs in forestry and agroforestry across borders. The material created, such as videos and articles, will present the innovations developed by OGs to address the needs and challenges identified by practitioners.

3. Selection of innovations and identification of channels and target audiences for the capacity building material

In the framework of the FOREST4EU project, 175 innovations were collected in WP1 (lead by S2i). However, due to

the limited time and resources available, it became imperative the identification of the most relevant innovations for each project partner country (Portugal, Spain, France, Italy, Slovenia, Latvia, Germany, Finland and Croatia). To this end, a three steps evaluation process was implemented (Milestone 4). This process involved assessing the collected innovations and good practices through input from various stakeholders, including 1) project partners, 2) experts, and 3) local stakeholder. Moreover, preferred channels and formats where also identified and evaluated in this same process. The first two steps (i.e. consultation with project partners and experts) were done online and resulted in a reduced list with the 10 more relevant innovations per ITHub and country. Then, this reduced list of 10 innovations per ITHub and country was evaluated by relevant local stakeholders in national prioritization workshops organized in Italy, Spain, Portugal, France, Slovenia, Latvia, Germany, Finland, and Croatia between February and April 2024. During these workshops, the 5 most relevant innovations and good practices per ITHub and country were identified. Additionally, for each innovation, the stakeholders suggested a preferred format, channel, and target audience to convey the capacity building material to be developed for each innovation.

The results of each national prioritization workshop were combined, and the 59 most relevant innovations distributed across the 5 ITHubs were identified. These 59 innovations were distributed by the WP2 leader (EFI) in three batches of capacity building material to be produced by the project partners between May 2024 and August 2025.

The total number of innovations assigned to each batch varied (21 innovations in the first batch, 22 in the second batch, and 16 in the third batch). Similarly, the number of innovations belonging to each ITHub varied, but all the ITHubs were more or less evenly represented (Table 1). The innovations for which capacity building material were and will be developed cover a wide range of different types of innovations (Table 2, Table 3, and Table 4).

Table 1: Number of capacity building material to be created for innovations in each ITHub

ITHub Number	**ITHub name**	**Number of innovations to create capacity building material**
ITHub 1	Wood mobilization	11
ITHub 2	Forest adaptation to climate change	9
ITHub 3	Sustainable forest management and ecosystem services	13
ITHub 4	Non-wood forest products	13
ITHub 5	Agroforestry	13

Table 2: Innovations selected for the first batch of capacity building material*

ITHub	**Innovation name**
ITHub 1	Creating Your Own Estate Plan Via The Online Portal (MojGozdar)
ITHub 1	Software for mobilisation and efficient use of resources involved in transportation of timber from forest to destination location
ITHub 1	LVL (Laminated Veneer Lumber) of *fagus silvatica*
ITHub 1	Prefabricated modular construction system made from Normandy hardwoods

ITHub 2	Educational module 'foresters, it's your turn to play"
ITHub 2	UAV and multispectral camera to map stressed forest area
ITHub 2	The "sustainable bee forest" concept and implementation (Bienenwald) (bee forest))
ITHub 2	Geosuber Tool - Monitorization of the vitality of cork oak stands
ITHub 2	Course on GIS and Remote Sensing Data to monitor forest ecosystem
ITHub 3	Carbon accounting for PES
ITHub 3	Developing a Novel Martelloscope for Assessing Biodiversity and Growing Stock Volume with the Aid of a Digital Twin.
ITHub 3	Community forest arrangement as ideal instance for the realization of the profit-sharing model of PRIFORMAN Project
ITHub 4	Establishing new business models with NWFP
ITHub 4	Geolocation and monitoring of animals to identify possible incidents and improve the management of animals and pastures
ITHub 4	Biological Treatment of cancer chestnut (*Cryphonectria parasitica*) in Portugal
ITHub 4	Mobile kiln prototype for local biochar production
ITHub 5	Criteria and indicators for the certification of the sustainable management of an agroforestry system PEFC
ITHub 5	New and innovative cultivation methods of highly productive apples adapted to northern climates
ITHub 5	Review assesses the state of the art regarding the use of livestock for ecosystem management in Mediterranean landscapes
ITHub 5	Increase and transfer knowledge to producers about the natural regeneration processes of cork oaks and holm oaks in agro-forestry systems in Alentejo region, Portugal.
ITHub 5	Development of an autonomous and digitalized feeding system for pigs of the Celtic trunk in Atlantic deciduous forests

* The first batch of capacity building material finally included 18 different items (see details in section 5).

Table 3: Innovations selected for the second batch of capacity building material

ITHub	**Innovation name**
ITHub 1	UAV to map growing stock volume for sharing forest management plan
ITHub 1	Online tool for quality classification of round-wood
ITHub 1	A System for Quality Assessment of Forestry Contractors
ITHub 1	Standardization of available forest data: the first step to support wood mobilization in Friuli Venezia Giulia

ITHub 1	Di-Gozd Digital Forest Inventory - Mobile app (Di-Gozd)
ITHub 1	Web-based due diligence and traceability system for forest timber assortments
ITHub 1	Growing Stock Volume Map to support forest operation planning
ITHub 2	Chestnut forests management for quality products and promote C sequestration (CASTANI-CO)
ITHub 2	Bioclimsol: a decision support system integrating future climate and ground conditions
ITHub 2	Application of SlideforMap for the hydrological risk assessment in sustainable managed forests
ITHub 3	Efficient Sampling Methodology for Calculating Soil Carbon Credits (CO2MARCHE)
ITHub 3	Biomass accounting for Sustainable Forest Management Plans
ITHub 3	Support multi-object forest management plans through easy-access information (GO-PRI.FOR.MAN)
ITHub 4	Identification of compounds of industrial interest
ITHub 4	Endotherapic treatments with *Trichoderma* spp. to control fungal diseases in chestnut groves
ITHub 4	Resin Data Observatory
ITHub 4	Valorization of a neglected plant
ITHub 4	Diversification of edible wild mushroom cultivation with new native species
ITHub 4	Valorization of a neglected plant
ITHub 5	New management practices in rainfed olive groves
ITHub 5	Are short rotation coppice a solution in future regional biorefineries?
ITHub 5	A feasible step-by-step plan with practical guidelines and concrete designs to enable the application of agroforestry on farms

Table 4: Innovations selected for the third batch of capacity building material

ITHub	**Innovation name**
ITHub 2	Participative simulation game "Foster Forest"
ITHub 3	Decisional Support System to support the revision of forest management plans
ITHub 3	Vigil'encre: Participatory science tool for epidemiological surveillance of chestnut ink
ITHub 3	Technology at the service of forest renewal - mapping with drone and GPS to stake out the stand (PIF)
ITHub 3	Group Certification for Sustainable Forest Management: Promoting Shared Forest Management and Ecosystem Services Enhancement

ITHub 3	Index of Biodiversity Potential (IBP): a practical tool for forest managers
ITHub 3	A User-Friendly Platform for Bridging the Gap between Carbon Credit Demand and Supply.
ITHub 3	The ARCHI method: a tool for diagnosing the vitality of trees
ITHub 4	The Burgundy truffle, a quality product with high added value
ITHub 4	Post harvest cotings from mushroom by products
ITHub 4	Valuate the traditional chestnuts production
ITHub 5	Evaluation of the impact of different grazing intensities of Maremma cattle on the components of the agroecosystem: soil, tree vegetation (structure, natural regeneration and biodiversity)
ITHub 5	Use of Keyline for planting cork oaks and holm oaks in agro-forestry systems
ITHub 5	"Agroforestry in Austria" Network
ITHub 5	Practitioner-oriented consulting for agroforestry systems in Austria (Agroforst in Österreich)
ITHub 5	Local densified log industry

For the above-listed innovations, magazine articles, technical reports or videos were and will be produced as they were the preferred formats indicated by the stakeholders during the prioritization workshops. Moreover, the target audience is specific for each capacity building material. It includes forest owners, forest managers, farmers, public administration, policy makers, forestry advisors and managers, students, etc. (see details of format, channel and target audience in Deliverable 2.1 "Action plan for capacity building material and activities").

4. Capacity building material development process

During May 2024, the FOREST4EU partners involved in the five ITHubs (GIS, ANSUB, LLA, CESEFOR, CNPF, UNIFI, LWF, CEKOM, SOLUTOPUS, EFI, FC.ID BOSCAT y USC) developed the capacity building material following the strategy proposed in D2.1 "Action plan for capacity building material and activities". According to this action plan, each partner was assigned with two capacity building material except the partners from Spain (BOSCAT, CESEFOR and USC) and Portugal (ANSUB, SOLUTOPUS and FC.ID) to whom only one capacity building material was assigned in the case of Spain and Portugal, the effort was shared among the three partners from the country.

For the first batch of capacity building material, each partner with two innovations assigned was instructed to create one comprehensive (long) capacity building material for one of the innovations and one shorter material for the other innovation.

For the first batch of capacity building material, two different scenarios were envisioned (see details in D2.1 "Action plan for capacity building material and activities"). However, in practice, only one scenario was applied as follows:

To develop the capacity building material the partners interested in one innovation were given two distinctive roles:

- Leading partner: The partner to which the innovation was assigned, being responsible for developing the capacity building material in its local language and English.

- Supporting partner: The partner responsible for supporting the leading partner and translating the material into its local language.

In this scenario, stakeholders from several countries indicated interest in the same innovation, wanted the information presented in the same format and tailored for the same target audience. In this specific case, the FOREST4EU partners applied the following approach:

1. The leading partner collected all the relevant information about the innovation by contacting the OG that developed it.
2. The leading partner developed the capacity building material in their local language and English.
3. The capacity building material in English was shared with the supporting partners for them to translate the material into their local languages (e.g. as video subtitles or a version of the technical manual or article).

5. Description of the Capacity Building Material

The first batch of capacity building material developed for the FOREST4EU project included 18 different items (3 technical reports, 9 articles, and 6 videos). One additional material for the innovation "Increase and transfer knowledge to producers about the natural regeneration processes of cork oaks and holm oaks in agroforestry systems in the Alentejo region, Portugal" was developed, but the OG coordinator withdrew authorization for FOREST4EU to disseminate it. Additionally, two additional videos assigned to the partners (CNPF and FC.ID) were delayed due to coordination issues, preventing its inclusion in the first batch. These videos will be included in the second batch of capacity building material.

For the first batch of capacity building material different types of material were developed. The technical reports, journal or magazine articles and the videos were done following the recommendations included in the Annex of D2.1 "Action plan for capacity building material and activities and selected formats, channels and practical knowledge to be transferred as capacity building at national level". In all cases, the material was produced in the language of the partner that produced the capacity building material and in English, being later translated into other languages.

Below a detailed description of the capacity building material created by the FOREST4EU partners can be found. This includes a brief description of each innovation, the type of capacity building material created, the dissemination channels selected or direct links to the material, and information about the languages selected for translation.

Technical Reports

The technical reports are intended to be comprehensive and formal materials designed to present technical information in a clear and accessible way. Typically, they are divided into sections, enabling readers to easily access various parts of the information.

The technical reports developed in the framework of the FORESET4EU project were formatted into a layout developed by the leader of WP4 "communication, dissemination and exploitation" (ETA Florence) to highlight the project's visual identity (Figure 1).

The technical reports were published on the FOREST4EU website in a section especially devoted to all capacity building material named "Capacity building material" under the drop-down option "Resources" in the project website (https://www.forest4eu.eu/). Additionally, the reports will be made available on the EU-FarmBook platform, along with the factsheets developed in Task 1.3 for each innovation as part of WP 1 – Collection, Preparation, and Translation of Practical Knowledge from Forest and Agroforestry EIP-AGRI Operational Groups (Lead by S2i).

Figure 1: Technical report with the project's layout

Below there is a brief overview of the characteristics of the three technical reports created for selected innovations.

1. **Innovation title:** Carbon accounting for PES

Summary of the innovation: Italian Operational group GO.FOR.TRACK developed a decision support system to map forest resources. Besides being the source of natural raw material, forests provide additional services, including habitats for biodiversity, purifying water, and regulating floods, carbon sequestration, provision of cooling effects, source of food, transition to a circular bioeconomy, and benefits to the overall society health. However, the economic aspect of sustainable forest management plays a crucial role in preserving rural areas through support to forest ecosystem services by developing methods for quantifying these ecosystem services.

The latest information on the development of the carbon market and standardised methodologies for accurate quantification of carbon, or on the precise assessment of biomass and the identification of various types of forests, can be found on the following website https://www.innovarurale.it/it/pei-agri/gruppi-operativi/bancadati-go-pei/sviluppo-di-un-sistema-di-supporto-decisionale-la or could be obtained from Francesca Giannetti (francesca.giannetti@unifi.it)

Title technical report: Quantification of Carbon Stock in Sustainable Forest Management Plan

Length: 29 pages

Link to technical report (English): https://www.forest4eu.eu/wp-content/uploads/2024/06/GIS_Quantification-of-Carbon-Stock-_eng.pdf

Link to technical report (Slovenian): https://www.forest4eu.eu/wp-content/uploads/2024/06/GIS_Quantification-of-Carbon-Stock_Slo.pdf

Link to technical report (Portuguese): https://www.forest4eu.eu/wp-content/uploads/2024/06/PORT_Quantification-of-Carbon-Stock-in-Sustainible-Forest-Managment-Plan.pdf

Link to technical report (Croatian): https://www.forest4eu.eu/wp-content/uploads/2024/06/CRO_Quantification-of-Carbon-Stock-in-Sustainible-Forest-Managment-Plan.pdf

Other languages to be translated: Latvian

2. **Innovation title:** Review assesses the state of the art regarding the use of livestock for ecosystem management in Mediterranean landscapes

Summary of the innovation: In the Mediterranean basin, the structure and species composition of traditional landscapes have historically been shaped and maintained by human-driven disturbances, such as extensive livestock grazing. The cessation of these activities, which have partially replaced the role of natural disturbances, may lead to vegetation overgrowth and biomass accumulation, with potential adverse impacts on biodiversity, ecosystem functions and services. This review assesses the state of the art regarding the use of livestock for ecosystem management in Mediterranean landscapes. It examines the association between the regime and duration of grazing interventions and their reported effects on ecosystems. Wildfire prevention and biomass control, biodiversity and habitat conservation and the regulation of soil quality are the main reasons for the use of grazing interventions. The results of this review suggest that the use of domestic herbivores in ecosystem management can contribute to wildfire prevention and biomass control, with these positive effects fading away in long-term grazing interventions. Goats seem to perform better than cattle for biomass control. https://www.unac.pt/index.php/id-i/grupos-operacionais-accao-1-1-pdr2020/silvpast-implementacao-custo-eficiente-de-mosaicos-silvo-pastoris-de-carvalho-negral, contact: nuno.rodrigues@terraprima.pt

Title technical report: Review assesses the state of the art regarding the use of livestock for ecosystem management in Mediterranean landscapes

Link to technical report (English): https://www.forest4eu.eu/wp-content/uploads/2024/06/ANSUB_ecosystem-management-in-Mediterranean-landscapes_eng.pdf

Link to technical report (Portuguese): https://www.forest4eu.eu/wp-content/uploads/2024/06/ANSUB_ecosystem-management-in-Mediterranean-landscapes_port.pdf

Other languages to be translated: Spanish

3. **Innovation title:** Software for mobilisation and efficient use of resources involved in transportation of timber from forest to destination location

Summary of the innovation: Software for mobilisation and efficient use of resources involved in transportation of timber from forest to destination locations - processing facilities, seaport etc. The software allows forest owners to estimate and map the amount of timber available in the different forest's locations. This software tool solves the complex logistic problem that is to transport numerous different kinds of timber from different locations to multiple destinations. The provided solution is a database that is accessible on-line to all involved parties over GSM network. The first input is done by filling a survey, then actual dimensions and number of trees to be cutted is added, next input is made by transporter who delivers cut timber from forest to a stack on roadside stack. Detailed amounts of each assortment and GPS location on the map of each stack becomes known. Customers input requests specifying the type of timber, quantities, and delivery locations. Dispatchers access a database of available transportation resources, which includes detailed technical capabilities provided by truck owners. The dispatcher then plans the most economical routes and tasks for each truck, issues the necessary documentation, and electronically sends it to the truck drivers. The truck driver updates the status of the load by recording the quantities of each type of timber loaded. A final update is made after unloading the timber at the final destination. For more information, contact Guntars Reinfelds (guntars.reinfelds@selflogistic.lv) or Normunds Krumins (n.krumins@gmail.com).

Title technical report: WOODL: Software for mobilisation and efficient use of resources involved in transportation of timber from forest to destination location

Link to technical report (English): https://www.forest4eu.eu/wp-content/uploads/2024/06/LLA_Software-for-mobilisation_eng.pdf

Link to technical report (Latvian): https://www.forest4eu.eu/wp-content/uploads/2024/06/LLA_Software-for-mobilisation_Latv.pdf

Other languages to be translated: German

Videos

Videos were created as capacity building material as they are often chosen among the possible formats since they offer an engaging and dynamic way to convey complex information, making learning more accessible and enjoyable. Videos are an efficient way to visually convey processes and techniques, show real-life examples, and facilitate understanding through the visual and auditory representation of the information. They support various learning styles and can be accessed at any time, allowing for flexible, self-paced learning.

The videos developed in the framework of the project were tailored to the information about the innovation that needed to be presented. However, all of them included a layout developed by the WP4 "communication, dissemination and exploitation" leader (ETA Florence) to highlight the project's visual identity (Figure 2).

Figure 2: Examples of the videos developed using the project visual identity

The produced videos were published in section "Capacity building material" of the FOREST4EU website and on the FOREST4EU project YouTube channel (https://www.youtube.com/@FOREST4EUProject). Additionally, the videos will be made available, if possible, on the EU-FarmBook platform alongside the factsheets developed in task 1.3 for the selected innovations.

Below a brief overivew of the characteristics of the videos created for the 6 selected innovations is presented.

1. **Innovation title:** Geolocation and monitoring of animals to identify possible incidents and improve the management of animals and pastures

Summary of the innovation: Here new technological tools to obtain and manage data from herds with minimal farmer involvement is presented. Geolocation and monitoring of animals use various algorithms to analyze information collected to identify potential incidents and improve the management of animals and pastures. The Operational Group focuses on exploring the full potential of these technologies to overcome the main challenges facing the sector. These include improving the economic viability of farms, adjusting devices to herd activity patterns, providing location and monitoring of animals and herds, ensuring efficient and sustainable use of natural resources, and addressing the proximity of herds to wildlife. The technology will facilitate control of herds, management of technical-health and pasture data, and improve productivity and viability of extensive livestock farms.

Video duration: 14: 06 minutes

Link to video (English): https://www.youtube.com/watch?v=0Rncr5qmpqQ&ab_channel=FOREST4EUProject

Link to video (Spanish): https://www.youtube.com/watch?v=nxXCFR19cg4&ab_channel=FOREST4EUProject

Link to video (Finnish): https://www.youtube.com/watch?v=_bucF66OPu4&ab_channel=FOREST4EUProject

Link to video (Portuguese): https://www.youtube.com/watch?v=ctwNJhIp1D8&ab_channel=FOREST4EUProject

Other languages to be translated: None

2. **Innovation title:** The "sustainable bee forest" concept and implementation

Summary of the innovation: The "Sustainable Bee Forest" project introduces a novel forest management concept aimed at enhancing pollinator habitats and diversifying income streams from non-wood forest products in the state of Hesse in Germany. This initiative responds to the imperative for climate change adaptation in forestry, particularly targeting smallholder farmers grappling with forest decline. With large forested areas experiencing significant disturbances like pests, storms, and fire, there's a pressing need for afforestation measures. However, existing funding options for afforestation typically limit tree species choices. The "Sustainable Bee Forest" concept presents an

innovative approach to forest management, emphasizing multifunctionality and insect-friendly practices, which have been overlooked in Central Europe. This project focuses on integrating honey and wild bee habitats into early-stage forest development, blending profitable stemwood species with pollinator-friendly plants. Unlike conventional approaches that concentrate flowering areas on forest edges, this project aims for a more holistic approach, intertwining economic profitability with conservation goals. Initial afforestation efforts on a 3.5-hectare former spruce-dominated forest involved planting robinia, chestnut, linden, bird cherry, and walnut based on research insights and expert knowledge. Effective collaboration with experienced scientists possessing the necessary methodological expertise is crucial for generating meaningful results. info@comunis-projektbuero.de

Video duration: 8:52 minutes

Link to video (English): https://www.youtube.com/watch?v=UvsXWDJWTLw&ab_channel=FOREST4EUProject

Link to video (German): https://www.youtube.com/watch?v=OgWyFHOTSx8&ab_channel=FOREST4EUProject

Other languages to be translated: Portuguese, Croatian, Latvian and Slovenian

3. **Title:** Community forest arrangements as an ideal instance for the realization of the profit-sharing model of PRIFORMAN Project

Summary of the innovation: Community Forest arrangements are strategic tools in forestry for enhancing business networks and valuing agro-silvo-pastoral lands. They promote ecosystem services and conservation, recommended by the TUFF and other Italian legal provisions for collective forest management. These arrangements enable both companies and small forest owners to collaboratively manage forests, addressing challenges like owner absenteeism, land fragmentation, and gaps in forestry knowledge.

Community forests facilitate a profit-sharing model developed by PRI.FOR.MAN, allowing profit distribution not just from timber but from multifaceted management aligning with stakeholder desires and regulatory frameworks. This model is sustainable economically—reducing costs and boosting profits; environmentally—ensuring proper forest management; and socially—supporting participatory management and helping sustain mountain populations.

Challenges emerged during the project, including difficulties in engaging all forest owners and their hesitancy to delegate management long-term despite solid legal and technical frameworks. Owners preferred immediate high returns from selling timber or short-term contracts over potentially riskier long-term agreements.

The PRI.FOR.MAN project drafted a profit-sharing contract yet to be adopted by owners. The ongoing NET4GO Project in Veneto aims to implement these innovations, moving towards practical applications. https://www.innovarurale.it/it/pei-agri/gruppi-operativi/bancadati-go-pei/gestione-condivisa-delle-proprieta-forestali

Video duration: 3:16 minutes

Link to video (English): https://www.youtube.com/watch?v=2Yjk2YsHaJo&ab_channel=FOREST4EUProject

Link to video (Italian): https://www.youtube.com/watch?v=PjvgJESf1a8&ab_channel=FOREST4EUProject

Other languages to be translated: Portuguese

4. **Innovation title:** Mobile kiln prototype for biochar production

Summary of the innovation: Mobile biochar kiln is an innovation for biochar production in situ on farms. Although the kiln has been developed for transforming wood residues from chestnut cultivation into biochar, it can be used for other types of wood residues as well. The input material for carbonization can be wood with varying diameters and

lengths cut approximately to one meter, or other wood residues coming from the chestnut cultivation or other sources, such as pruning residues of fruit trees or residues of silvicultural operations. Carbonization takes place at a low to medium temperature (below 500 °C) which gives a higher biochar yield compared with rapid and/or high temperature pyrolysis systems. Biochar can be used on the farm or sold, becoming an additional source of income for the farm. Mobile biochar pile prototype is developed by OG INGECA: Solaria Anzilotti, Salvatore Moricca, Rodolfo Picchio, https://www.psingeca.it/it

Video duration: 6:42 minutes

Link to video (English): https://www.youtube.com/watch?v=LBa-uZi9DR8&ab_channel=FOREST4EUProject

Link to video (Finnish): https://www.youtube.com/watch?v=f-pQbHwXwmk&ab_channel=FOREST4EUProject

Other languages to be translated: Italian, French and Slovenian

5. **Innovation title :** Development of an autonomous and digitalized feeding system for pigs of the Celtic trunk in Atlantic deciduous forests

Summary of the innovation: Land abandonment in the north of Spain has increased the number of unmanaged deciduous (chestnuts and oaks) and conifer forest without current economic return. The establishment of silvopastoral systems with pig breeds of the Celtic trunk (Porco Celta, Gochu Asturcelta) can be an option to preserve the pig breeds while increasing the forest profitability by producing high quality livestock products. However, man-power costs reduces the possibility of the silvopasture practices establishment. FORESTCELTA operational group develops an automated mobile system to feed pigs within forests. The automated mobile system was tested in Galicia and Asturias where herds of 55 pigs were introduced in each demonstration area, during two fattening cycles of 11 and 13 months. FORESTCELTA automated system results were i) cost reduction, ii) forest and livestock facilitated management (iii) recovery and maintenance of pig breeds of the Celtic trunk, (iv) high quality pig organoleptic and health product delivered, (v) increase forest sustainability as it increases mitigation while reducing forest fires. From a social perspective it contributes to increase rural development and the increase of rural population.

Video duration: 12:54 minutes

Link to video (Spanish with English subtitles): https://www.youtube.com/watch?v=vLVFVwLOJj4&t=187s&ab_channel=FOREST4EUProject

Other languages to be translated: French

6. Innovation title: Creating your own state plan via the onlne portal (MojGozdar)

Summary of the innovation: The project eGOZD has presented a web-based solution for developing a forest management plan. The solution enables the collection and interpretation of data on forest tenure, forest infrastructure and other data published on different publicly available platforms in one place using interoperability. Introducing the plans on farms owning forests promotes increased planned work with private forests and provides professional support for sustainable multifunctional forest management. A well-prepared management plan will ensure that the timber is properly exploited, contributing to the modernisation and sustainable development of the rural areas. The project "eGozd" has developed new and simplified options for planning, monitoring and carrying out work and for more efficient private forest management. The plan is linked to current prices for forest timber and tools for calculating the costs of timber extraction. Forest owners can monitor the performance of their forest estate and decide on the measures to be taken in the plan. The plan considers nature conservation guidelines and promotes

habitat types' conservation or even improvement. Forest owners can thus optimise their own different production processes on the same site, or the same production process on different sites, or hire a contractor due to their own costs being too high; this serves to decide on the most optimal implementation of the works. One of the key advantages of interactive estate plans is the possibility to organise work, choose technologies and operators, and estimate production costs from forest to timber storage. Management plans ensure the transfer of new knowledge and optimise on-farm activities. gteinfo@gozdis.si https://www.mojgozdar.si/

Video duration: 3:52 minutes

Link to video (Slovenian with English subtitles): https://www.youtube.com/watch?v=zQ6aRtdOqug&t=72s&ab_channel=FOREST4EUProject

Other languages to be translated: Croatian, Italian, Latvian and Finnish

Articles

Articles were written to present the innovations developed by OGs to a broader audience, targeting relevant stakeholders identified during national prioritization workshops. In the first batch of capacity building material, 9 articles were written and will be published before the end of 2024 in various journals, magazines and bulletins across the different project partner countries. Additionally, versions of the articles in multiple languages, including English, will be made available on the project website in the section “Capacity building material”.

When possible, the articles were written following the specific style and structure of the magazine or journal where they were intended to be published. However, in all cases, the articles aimed to be engaging, informative, and well-structured. Below are the specific details for each article, including, when possible, information about the journal or magazine where they will be published and the expected publication date.

1. **Innovation title:** LVL (Laminated Venner Lumber) of *fagus sylvatica*.

Summary of the innovation: OG FAGUS implemented project Adding value to beech trees through innovation and improving the competitiveness of their forest industry value chain which resulted with development and testing of innovative LVL product using beech veneer from Spain. Aim was to reevaluate the beech wood value chain. LVL is a product that consists of the successive stacking of thin layers of wood, veneers, obtained by unrolling. Obtaining the material in this way has the following implications:

- Beech veneers used for the manufacture of LVL was the raw material of high-quality logs, large diameters, straight, with little taper and knots in order to obtain an adequate yield, volume and quality during unrolling. For this reason, it is to be expected that the manufacture of structural products with peeled veneer will offer superior properties to sawn timber of the same species.

- Bending tests have been carried out on small dimension and structural size specimens, as well as tensile tests perpendicular to the fiber. The results of the tests are satisfactory and encouraging, achieving good mechanical properties that indicate that the raw material is suitable for the production of this product. Comparing the properties of LVL tested in bending with those of sawn timber from the same source, the results have been improved in both bending strength and stiffness.

More information can be obtained by contacting joseluis.villanueva@cesefor.com or by visiting https://gofagus.es/ website.

Publication data:

Title of the article (Spanish): Fabricación de LVL (Madera microlaminada) de haya (*Fagus sylvatica*)

Title of the article (English): Manufacturing steps sheet of LVL (micro-laminated wood) of beech (*Fagus sylvatica*)

Journal: Arquitectura y madera https://arquitectura-madera.com/

Editor: Esinal Ediciones https://esinal.es/

Country: Spain

Expected to be delivered in print: next number (nº 48 - June)

Length: 519 words

Translated into: Italian

Other languages to be translated: Slovenian and Finnish

2. **Innovation title:** Educational module “foresters, it’s your turn to play”

Summary of the innovation: Consultation among stakeholders in Normandy's five areas, under the Forestry Territory Charter (CFT), highlighted the necessity for coordinated action and transparency in forest management. EUROFORNORM aimed to establish a regional forest network, with a focus on climate change's impact on Normandy's forests. "Forestiers, à vous de jouer" (Foresters, it's your turn to play) serves as an educational tool, a board game designed to educate primary school students about forest management and climate change adaptation. The game, distributed to 200 schools in Normandy, complements other educational initiatives like the "1000 communes, la forêt fait école" program. Feedback from teachers using the game has been positive, emphasizing its engaging nature and rich educational content, enabling students to learn about forest management and climate change adaptation in Normandy's forests. https://ec.europa.eu/eip/agriculture/en/find-connect/projects/euro-fornorm-14-50-61-emergence-et-animation-d%E2%80%99un.html, laure.ferrier@communesforestieres.org

Publication data:

Title of the article (French): Forestiers, à vous de jouer » Un jeu éducatif pour sensibiliser les enfants de l'école primaire au changement climatique dans les forêts

Title of the article (English): "Foresters it's your turn to play": an educational game to teach primary school children about climate change in forests.

Journal: Forêt & Innovation

Editing: CNPF-IDF

Country: France

Expected to be delivered in print: After October 2024

Length: 4 pages of the magazine

Translated into: Slovenian

Other languages to be translated: German, Latvian, Italian and Finnish

3. **Innovation title:** UAV and multispectral camera to map stressed forest area (GO-SURF)

Summary of innovation: In the context of precision forestry, and to monitor potential issues related to stress on a per-tree basis for forest managers, it is necessary to employ tools capable of rapidly mapping this information in order to implement adaptive silvicultural practices. Within the GO-SURF project, conducted in forests directly, the use of drones equipped with multispectral cameras (Micasense) was tested and implemented to map stressed areas. The use of the drone allowed for the creation of high-resolution multi-temporal orthophotos and the identification of areas

where a reduction in photosynthetic activity was observed. The multispectral cameras and the use of this data have allowed for the prompt identification during GO-SURF of stressed areas, primarily caused by oak forests. In this context, it was possible to monitor these areas affected by prolonged periods of drought. Monitoring with the use of drones allows for the observation of the development of these stresses and the impacts they have on the forests. Moreover, the camera permits to identified not-stressed plant that can be assumed as more resilient. The forest managers have highlighted the ease of using drones. Furthermore, from the analysis of stress at the individual plant level, it is possible to identify the more resilient plants that could be selected as seed plants to produce seedlings for future reforestation efforts. Contacts: Francesca Giannetti francesca.giannetti@unifi.it

Publication data:

Title of the article (English): The Importance of Forest Health Monitoring and the Role of Drones and Multispectral Cameras

Title of the article (Italian): L'importanza del Monitoraggio della Salute Forestale e il ruolo dei droni e delle camere multispettrali

Journal: Sherwood digital https://www.rivistasherwood.it/sherwood-digital-0.html

Editor: Foreste ed Alberi Oggi Sherwood

Country: Italy

Expected to be delivered in print: June 2024

Length: 11 pages

Translated into: Spanish and Portuguese

Other languages to be translated: Croatian, Latvian and Slovenian

4. **Innovation name**: Establishing new business models with NWFP

Summary of innovation: The project "Sustainable Bee Forest" develops and implements a new forest management concept that improves the habitat of flower-pollinating insects during reforestation and afforestation. Besides wood production, emphasis is placed on the production of honey and other non-wood forest products including berries and nuts in bee-friendly forest habitats. The project aims at building better linkages between profitability and conservation aspects of forest management. At the same time, the aim is to diversify and generate new income sources from non-wood forest products for forest owners, many of which are challenged with forest dieback due to climate change. The product innovation – honey, berries, and nuts from managed forests with bee-friendly species – is based on a solid research base. The OG "Sustainable Bee Forest" conducts monitoring and evaluation studies and collaborates with the University of Göttingen to analyze the economic potential of honey as a non-wood forest product. Such research is lacking in the region and is needed for creating a solid knowledge base for interested forest owners, forest managers, and administration. The new business models based on non-wood forest products in the state of Hesse in Germany are developed by OG Bienwald: Comunis Projektbüro, Judith Treis, info@comunis-projektbuero.de, www.bienenwald-hessen.de.

Publication data:

Title of the article (English): Business development for honey from the bee forest

Title of the article (German): Geschäftsentwicklung für Honig aus dem Bienenwald

Journal: LWF Aktuell (print bulletin of LWF for foresters and forest owners)

Editor: LWF

Country: Germany

Expected to be delivered in print: LWF Aktuell No. 149 or 150

Length: 1117 words

Translated into: No translation available at the moment

Other languages to be translated: French, Latvian, Finnish and Slovenian

5. **Innovation title:** Course on GIS and Remote Sensing Data to monitor forest ecosystem (GO-SURF)

Summary of the innovation: To monitor stress and the impacts of climate change on forests, there is a need to enhance the technical analysis skills of individuals involved in sustainable forest management. In recent years, various tools like Sentinel-2 satellite imagery have allowed for almost continuous monitoring of such stress. However, technological progress has not led to a real change because many technicians do not know how to use analysis tools, even simple ones. In this context, within the GO-SURF project, it was decided to organize a tailored 24-hour course to teach forest management technicians how to use these tools and the related GIS (Geographic Information System) tools for analysis. The course has been highly successful with over 50 participants enrolled. The course was structured with practical exercises conducted in classroom settings tailored to the forestry sector. In particular, the Google Earth Engine analysis platform and data easily implementable into the QGIS system were used. This enabled the transfer of analytical capabilities to the technicians who attended the course, many of whom had no prior knowledge of the potential of these tools. The technicians emphasized that courses of this kind are crucial, especially in a forestry context. The strength of the course lay in its practical aspect, with exercises specifically designed to address forestry-related scenarios. Contact: francesca.giannetti@unifi.it

Publication data:

Title of the article (English): GO SURF: A Course on GIS and Remote Sensing Data for Monitoring Forest Ecosystems

Title of the article (Croatian): Uporaba GIS-a i podataka daljinskog istraživanja za praćenje šumskih ekosustava (GO SURF)

Journal: Hrvatske šume, časopis za popularizaciju šumarstva

Editor: Hrvatske šume d.o.o. Zagreb

Country: Croatia

Expected to be delivered in print: September 2024.

Length: up to 7500 characters with spacing (3-5 photos)

Translated into: Latvian

Other languages to be translated: German and Portuguese

6. **Innovation title:** Developing a Novel Martelloscope for Assessing Biodiversity and Growing Stock Volume with the aid of a Digital Twin

Summary of the innovation: The Geoslam ZEB Portable Laser Scanner system was used to survey trees in a transitional beech stand, allowing for the creation of a 3D digital twin. Dendromicro habitats were obtained for each tree, enabling the derived Index of Potential Biodiversity (IBP). This quantification can be used in forest management plans and

silvicultural interventions. The marteloscope also recorded volume and position data for each tree, identifying dendrothelia that may contribute to biodiversity. The use of mobile LiDAR in forestry reduces survey time and costs, providing valuable data for sustainable forest management and ecosystem services enhancement.

Publication data:

Title of the article (English): Developing a Novel Martelloscope for Assessing Biodiversity and Growing Stock Volume with the aid of a Digital Twin

Title of the article (Latvian): Jauna marteleskopa attīstīšana bioloģiskās daudzveidības un augošās koksnes krājumu novērtēšanai ar digitālā dvīņa palīdzību

Journal: To be confirmed

Editor: To be confirmed

Country: Latvia

Expected to be delivered in print: To be confirmed

Length: 1295 words

Translated into: No translation available at the moment

Other languages to be translated: French, Slovenian and Finnish

7. **Innovation title:** Criteria and indicators for the certification of the sustainable management of an agroforestry system PEFC (NEWTON)

Summary of the innovation: The Programme for Endorsement of Forest Certification schemes – PEFC Italy - has been on a path to develop a certification standard for the sustainable management of agroforestry systems. The PEFC analysis had as objectives the study of the tools and standards for guaranteeing the traceability and sustainability of agroforestry production and the related products processed by the project partner companies. During the pilot tests conducted with the company's technicians, it was possible to concretely analyse in the field the guidelines and indicators established during the standard drafting process, highlighting the difficult application of some and improving others. The main results obtained in the study carried out in the partner companies saw the identification of 48 products (or product categories) and 13 processed and manufactured products; these 61 products are potentially subject to certification, some of them with more than 35 different schemes of environmental and quality certification schemes worldwide. Thanks to the cooperation of the project partners, the document 'Criteria and indicators for the certification of the sustainable management of an agroforestry system PEFC ' was produced, the first European-wide certification standard for the tree component of an agroforestry system, available from 2023, to valorise local agroforestry products. https://www.innovarurale.it/it/pei-agri/gruppi-operativi/bancadati-go-pei/network-lagroselvicoltura-toscana, contact: solaria.anzilotti@unifi.it

Publication data:

Title of the article (English): NEWTON - NEtWork Operational Group for agroforestry in Tuscany: Criteria and indicators for the certification of the sustainable management of an agroforestry system PEFC

Title of the article (Croatian): NEWTON – Mreža Operativnih skupina za agrošumarstvo u Toskani: Kriteriji i pokazatelji za certifikaciju održivog upravljanja agrošumarskim sustavom PEFC

Journal: Hrvatske šume, časopis za popularizaciju šumarstva

Editor: Hrvatske šume d.o.o. Zagreb

Country: Croatia

Expected to be delivered in print: November 2024.

Length: up to 7500 characters with spacing (3-5 photos)

Translated into: French

Other languages to be translated: Finnish and Slovenian

8. **Innovation title:** Biological Treatment of cancer chestnut (*Cryphonectria parasitica*) in Portugal

Summary of the innovation: The OG BioChestnut-IBM project focused on combating chestnut cancer, caused by the fungus *Cryphonectria parasitica*, which poses a significant threat to chestnut trees in Portugal. After extensive research, it was found that using hypovirulent strains of this fungus was highly effective in treating the disease. Practical recommendations resulting from the project include conducting comprehensive studies on the population of *C. parasitica*, developing specific bioproducts to combat the disease, applying treatments with compatible strains, and continuously monitoring the effectiveness of these interventions. The success achieved is reflected in the treatment of 4028 chestnut trees and the recovery of 59452 chestnut trees, ensuring productivity for producers, as well as the sustainability and resilience of the high-value chestnut ecosystem in mountainous regions of Portugal. These practices establish a solid foundation for addressing future challenges related to chestnut cancer, ensuring the ongoing health and productivity of the trees. https://biochestnut.cncfs.pt/, contact: ana.santos@cncfs.pt

Publication data:

Title of the article (English): Innovation and Technology Transfer in the Treatment of Chestnut Cancer in Portugal.

Title of the article (Portuguese): Inovação e Transferência de Tecnologia no Tratamento do Cancro do Castanheiro em Portugal.

Journal: AGROTEC – Revista Técnico-Científica Agrícola, nº 51

Editor: Agropress

Country: Portugal

Expected to be delivered in print: 12 of July

Length: ca. 3 pages of the magazine

Translated into: German

Other languages to be translated: Italian and Slovenian

9. **Innovation title:** New and innovative cultivation methods of highly productive apples adapted to northern climates.

Summary of the innovation: To make apple production profitable the focus has to be on quality and value chain rather than tonnage. The profitability for the farmers in the project comes from the connection to an enterprise producing high value ice cider and operating in a global premium market. The project aims to develop new cultivation methods, new varieties, planting arrangements and management options to meet the demands of a new kind of buyer that rewards quality over quantity. This inspires farmers to go beyond business as usual in their operations and traditional agriculture in the area. Each farmer also finds their own way of managing their apple orchard – the whole idea is to learn new things for the future and do observations to do things better in terms of growing apples with high sugar content suitable for ice cider production in Northern Europe. The long-term goal of the project is to contribute to

climate resilient sustainable agriculture and to create favourable partnerships between farmers and food processing companies to develop further products in local, regional and global markets. The new and innovative cultivation methods of highly productive apples are developed by "Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in northern Europe" project in Sweden: Daniel Pacurar (danielpacurar@borealorchards.se), https://www.brannlandcider.se/om-oss/vara-odlingar/commercial-productive-apple-growing-in-a-northern-climate/

Publication data:

Title of the article (English): Northern climate and apple varieties as a source for innovation: agricultural productivity and sustainability in northern apple production for ice cider, a sweet dessert wine in Umeå, Sweden

Title of the article (Finnish): Pohjoinen ilmasto ja omenalajikkeet innovaatioiden lähteenä: maatalouden tuottavuus ja kestävyys pohjoisessa omenantuotannossa jääsiideriä, makeaa jälkiruokaviiniä, varten Uumajassa, Ruotsissa

Journal: To be confirmed

Editor: To be confirmed

Country: Finland

Expected to be delivered in print: To be confirmed

Length: To be confirmed

Translated into: No translation available at the moment

Other languages to be translated: Latvian

6. Dissemination

As mentioned in the previous section, each type of capacity building material has an associated dissemination plan. This plan includes publication on the project website, in relevant international repositories (e.g., EU-FarmBook), and in specific channels such as identified journals and magazines from the forestry and agroforestry sectors. Additionally, all material generated and uploaded to the project website will be promoted through the project newsletter, the project's social media (e.g., LinkedIn), and the social media channels of the project partners.

7. Evaluation and Impact Assessment

After disseminating the capacity building material on the project website, media (e.g., YouTube), and specific channels, the uptake will be evaluated. The evaluation will involve assessing how effectively the audience was engaged with the material and utilized the resources provided. The evaluation process will include:

1. **Metrics:** Track the number of downloads or views of the material.

2. **Feedback Surveys:** Surveys will be sent to project stakeholders to gather feedback on the material, including its relevance, usefulness, and accessibility.

3. **Comparative Analysis:** The information collected about metrics and feedback will be compared across different countries or stakeholder groups to identify disparities in access and inform targeted interventions.

4. **Longitudinal Analysis:** The uptake and usage of the material will be monitored over time to assess its sustainability and long-term impact.

5. **Iterative Improvement:** The information and feedback collected will be used to iteratively improve the capacity building material, making incremental changes and refinements over time after receiving the feedback from the stakeholders about the material produced in previous batches This allows for continuous refinement, learning from previous iterations, and adapting to new feedback.

8. Appendices

Below are the articles produced for the 9 innovations. For each article, we provide the version in the language used for publication in the journal or magazine, as well as the English version for publication on the project website and for translation into other languages.

1. **Innovation title:** LVL (Laminated Venner Lumber) of *fagus sylvatica*.

Fabricación de LVL (Madera microlaminada) de haya (Fagus sylvatica)

La innovación en la fabricación de LVL (Laminated Veneer Lumber o Madera Microlaminada) de haya ha sido seleccionada dentro del proyecto FOREST4EU. Este proyecto ha destacado 20 innovaciones del sector forestal europeo, considerando la fabricación de LVL de haya, realizada por el grupo operativo GO FAGUS, como una de especial relevancia para su comunicación en España. Para más detalles, se puede consultar la web del proyecto.

El LVL es un producto compuesto por capas finas de madera obtenidas mediante desenrollo, un proceso que permite optimizar tanto el rendimiento como la calidad del material. La materia prima para fabricar LVL son trozas de alta calidad, caracterizadas por su gran diámetro, rectitud y baja conicidad, con pocos nudos. El desenrollo convierte las trozas en láminas finas, en un proceso que se inicia con el descortezado y escaneo para eliminar impurezas y metales, seguido de una cocción o vaporización para ablandar la madera y facilitar su desenrollo sin dañar la herramienta de corte.

En este proyecto se fabricaron dos tipos de probetas: vigas de 125x30x2500mm y placas de 500x500mm, estas últimas de las que se obtuvieron probetas más pequeñas. Las chapas de madera fueron aclimatadas a las condiciones de la fábrica para evitar problemas de humedad. Se usó un adhesivo MUF bicomponente conocido como GripPro™ Design, siguiendo rigurosos parámetros de humedad, temperatura y tiempo de fraguado indicados por el fabricante.

El proceso de armado de las probetas comenzó con la mezcla de la cola y el endurecedor justo antes de la aplicación para asegurar un tiempo adecuado al aire de la cola. Se utilizaron dos tipos de prensas: una prensa grande para las vigas estructurales y una prensa de tablero para las probetas más pequeñas. Este enfoque permitió comparar las propiedades del LVL con las de la madera aserrada.

Se realizaron distintos tipos de ensayos para evaluar las características del LVL:

Por un lado, ensayos a flexión según la norma EN 408 en vigas estructurales y en probetas pequeñas, obteniendo los siguientes parámetros mecánicos: resistencia a flexión, módulo de elasticidad y densidad. Los valores de resistencia a flexión característica obtenidos fueron de 46 megapascal (MPa) para las vigas y de 77 MPa para las probetas pequeñas.

Por otro lado, ensayos de tracción perpendicular en probetas pequeñas, obteniendo una resistencia característica de 0,94 MPa, superior a lo establecido para especies frondosas en la norma EN 338. Este resultado confirma la alta calidad del LVL fabricado a partir de haya.

En comparación con las clases resistentes de madera aserrada D40 y D45, el LVL mostró propiedades superiores en resistencia a flexión y rigidez. Esta mejora se debe a la mejor optimización del material y la reducción de singularidades en los productos de ingeniería de madera como el LVL. Además, las probetas pequeñas resultaron ser más resistentes

y rígidas que las vigas estructurales, lo cual se explica por el menor número de defectos y el mayor control en el proceso de prensado.

En conclusión, el trabajo realizado ha demostrado que el LVL de haya de segunda calidad presenta excelentes propiedades mecánicas, superando a la madera aserrada en términos de resistencia y rigidez. Esto confirma que la materia prima es apta para la fabricación de este producto, ofreciendo una alternativa viable y de alta calidad para aplicaciones en construcción y otras áreas.

Troza lista para el desenrollo

Vigas de tamaño estructural

Ensayo a flexión en probetas de tamaño estructural

Ensayo a tracción perpendicular a la fibra

Manufacture of LVL (micro-laminated wood) from beech (Fagus sylvatica)

The innovation in the manufacture of LVL (Laminated Veneer Lumber) of beech has been selected within the FOREST4EU project. This project has highlighted 20 innovations in the European forestry sector, considering the beech LVL manufacturing, carried out by the GO FAGUS operative group, as one of special relevance for its communication in Spain. For more details, please visit the project website.

LVL is a product composed of thin layers of wood obtained by unrolling, a process that optimizes both the efficiency and the quality of the material. The raw material for LVL is high quality logs, characterized by their large diameter, straightness and low taper, with few knots. Unrolling converts the logs into thin sheets, in a process that starts with debarking and scanning to remove impurities and metals, followed by cooking or steaming to soften the wood and facilitate unrolling without damaging the cutting tool.

Two types of specimens were manufactured for this project: 125x30x2500mm beams and 500x500mm plates, the latter from which smaller specimens were obtained. The veneer sheets were acclimatized to the factory conditions to avoid moisture problems. A two-component MUF adhesive known as GripPro™ Design was used, following rigorous parameters of humidity, temperature and setting time indicated by the manufacturer.

The specimen assembly process began with the mixing of the glue and hardener just prior to application to ensure adequate air time for the glue. Two types of presses were used: a large press for the structural beams and a board press for the smaller specimens. This approach allowed the properties of LVL to be compared with those of sawn lumber.

Different types of tests were carried out to evaluate the characteristics of LVL:

On the one hand, bending tests according to EN 408 on structural beams and small specimens, obtaining the following mechanical parameters: bending strength, modulus of elasticity and density. The characteristic flexural strength values obtained were 46 megapascal (MPa) for the beams and 77 MPa for the small specimens.

On the other hand, perpendicular tensile tests on small specimens showed a characteristic strength of 0.94 MPa, higher than that established for hardwood species in EN 338. This result confirms the high quality of LVL made from beech.

Compared to the sawn timber strength classes D40 and D45, LVL showed superior properties in bending strength and stiffness. This improvement is due to better material optimization and reduction of singularities in engineered wood products such as LVL. In addition, small specimens were found to be stronger and stiffer than structural beams, which is explained by the lower number of defects and better control in the pressing process.

In conclusion, the work carried out has shown that second-grade beech LVL has excellent mechanical properties, outperforming sawn lumber in terms of strength and stiffness. This confirms that the raw material is suitable for the manufacture of this product, offering a viable and high quality alternative for applications in construction and other areas.

Log ready for unrolling

Structural size beams

Bending test on structural sized specimens

Perpendicular tensile test on fiber

2. **Innovation title:** Educational module “foresters, it’s your turn to play”

«Forestiers, à vous de jouer »

Un jeu éducatif pour sensibiliser les enfants de l'école primaire au changement climatique dans les forêts

Cinq territoires signataires d'une Charte Forestière de Territoire (CFT) de Normandie se sont réunis autour d'un constat commun : le besoin d'une plus grande coordination entre acteurs et de plus de communication et de vulgarisation des pratiques sylvicoles nécessaires à notre société.

Eurofornorm, un réseau régional des territoires forestiers normands

Cinq territoires signataires d'une Charte Forestière de Territoire (CFT) de Normandie se sont réunis autour d'un constat commun : le besoin d'une plus grande coordination entre acteurs et de plus de communication et de vulgarisation des pratiques sylvicoles nécessaires à notre société.

Cinq territoires signataires d'une Charte Forestière de Territoire (CFT) de Normandie se sont réunis autour d'un constat commun : le besoin d'une plus grande coordination entre acteurs et de plus de communication et de vulgarisation des pratiques sylvicoles nécessaires à notre société.

Créé en 2018, le groupe opérationnel EUROFORNORM est composé des acteurs suivants : le Centre National de la Propriété Forestière (Délégation Haut-de-France – Normandie) ; l'Office National des Forêts ; les Parcs Naturels Régionaux de Normandie Maine, du Perche et des Boucles de Seine ; la Métropole Rouen Normandie et Seine Eure Agglomération. Son coordinateur est l'Union Régionale des Collectivités Forestières de Normandie (URCOFOR), une association regroupant des collectivités normandes propriétaires ou non de forêts dans une structure d'échange et de partage d'expériences proposant des services d'animation et d'accompagnement dans l'objectif de valoriser les territoires forestiers et d'intégrer le milieu forestier au cœur du développement local. L'URCOFOR est organisée en réseau, au service des élus, depuis plus de 80 ans avec une fédération nationale.

Le groupe opérationnel EUROFORNORM a eu pour objectif général de créer et d'animer un réseau régional des territoires forestiers normands, sur une thématique commune prioritaire "L'avenir de la forêt normande au regard du changement climatique". Un programme d'action sur trois ans a donc été élaboré afin de répondre aux objectifs suivants : - sensibiliser et susciter la réflexion sur les évolutions possibles de la forêt dans l'avenir pour s'adapter au changement climatique et atténuer ses effets, - expliquer la forêt d'aujourd'hui, les interventions en forêt et les méthodes mises en œuvre pour essayer d'anticiper les changements, - favoriser les échanges entre les différentes parties prenantes pour comprendre les attentes de chacun et rechercher des compromis, afin de dessiner les forêts normandes de demain.

Durant les deux premières années de travail, différentes actions (sessions de réunions en forêt, colloques - cf. image 1) et outils (ateliers prospectifs autour du jeu de rôles Foster Forest) ont permis de sensibiliser et d'échanger avec de nombreux acteurs identifiés tels que les propriétaires privés, les élus ou encore le grand public.

Objectif de l'innovation

En 2020, les membres du consortium se sont accordés pour travailler à l'élaboration d'un outil pédagogique spécifique au sujet "forêt et changement climatique" avec la volonté de cibler prioritairement les classes de primaire (3e cycle).

Cette cible a été sélectionnée, car les élus communaux ont la responsabilité des écoles primaires et les collectivités forestières réalisent des missions à destination de ces élus.

Image 1 : Réunion en forêt réalisée dans le cadre du projet EUROFORNORM.

En 2020, les membres du consortium se sont accordés pour travailler à l'élaboration d'un outil pédagogique spécifique au sujet "forêt et changement climatique" avec la volonté de cibler prioritairement les classes de primaire (3e cycle). Cette cible a été sélectionnée, car les élus communaux ont la responsabilité des écoles primaires et les collectivités forestières réalisent des missions à destination de ces élus.

Il a été choisi de développer cet outil sous le format d'un jeu, pouvant compléter les autres activités et outils des territoires, mais également être incorporé dans d'autres formats d'interventions proposés par les Parcs Naturels Régionaux, ou les intercommunalités. Enfin, la volonté de rendre cet outil opérationnel dès la rentrée scolaire de l'année suivante a été affichée par les membres du consortium.

Au moment où cette réflexion s'est engagée, en réalisant un tour d'horizon des jeux déjà disponibles sur le marché, la plupart de ceux observés traitaient de thématiques "globales/internationales" telles que la déforestation ou encore les émissions de carbones à l'échelle mondiale. Aucun jeu à l'échelle régionale normande, traitant de problématiques en lien avec le changement climatique n'a émergé de la veille réalisée, ce qui a donc conforté la volonté du consortium de développer cet outil.

Mise en place du projet

Sur la base de ces critères volontairement peu précis, afin d'être en mesure d'explorer un éventail large de propositions, différentes entreprises spécialisées dans l'édition pédagogique et la création de concepts ludiques ont été sollicitées. L'un des critères importants de sélection a été la capacité d'accompagnement à la conception du projet. Le prestataire sélectionné a cadré des propositions de formats de jeux et le consortium s'est mis d'accord pour un format "plateau" avec des questions sous forme de cartes. Le jeu a été choisi sous une forme proche de celui du jeu de l'oie, car les règles du jeu sont déjà connues du public cible. Par retour d'expérience, les jeux aux formats novateurs (tels que "Foster Forest", présenté dans ce groupe opérationnel) nécessitent un temps d'explication des règles conséquent, ce qui n'était pas envisageable auprès d'un public cible de cette tranche d'âge. La thématique abordée étant déjà peu connue, il était important pour le consortium que les règles puissent être facilement intégrables. Un calendrier a été fixé en accord avec le prestataire, programmant la réalisation des différentes planches et propositions graphiques, avec pour consigne une mise en avant du contexte normand, du changement climatique et de la multifonctionnalité des forêts.

Le consortium s'est occupé de la rédaction des cartes scientifiques et techniques. Les questions étaient soumises, aussi bien en amont par liste d'e-mail que lors des réunions, et les réponses à apporter devaient faire l'objet d'un consensus lors de ses réunions. Le consortium se fixait comme objectif la rédaction d'un certain nombre de fiches questions/réponses par réunion et celles-ci étaient ensuite soumises au prestataire qui, de par son expérience dans l'édition pédagogique, pouvait fournir ensuite un avis pour reformuler le contenu s'il ne lui semblait pas intelligible pour les scolaires.

Cette méthode collective a permis de susciter de nombreux échanges au sein du consortium au profil d'acteurs diversifiés. Certaines questions par exemple, bien que pertinentes, ont dû être mises de côté, car aucun consensus sur les réponses à y apporter n'a pu être trouvé par les membres. De plus, la diversité des profils présents dans le consortium a permis de pouvoir aborder à dire d'expert une variété importante de thématiques du milieu forestier sur l'ensemble de la chaîne de valeur. Cela a permis de nourrir les connaissances de chacun des acteurs, mais aussi de comprendre les points de vue et méthodes de travail de chacun.

Presentation of the game

Le jeu « Forestier à vous de jouer » (cf. image 2) s'articule autour de dix grands thèmes que sont : les vieux arbres, la forêt, les jeunes arbres, la coupe des arbres, la récolte du bois, les métiers du bois, les loisirs en forêt, les plantes et les animaux et enfin les utilisations du bois. Le jeu a ainsi une vocation transversale de sensibilisation à ce qu'est l'écosystème forestier, à sa gestion multifonctionnelle ainsi que de mise en avant de l'aval de la filière. Un point de vigilance fut de toujours conserver le lien avec le changement climatique, qui intervient dans des cartes spécifiques "bonus" et "embûches".

Image 2 : Presentation du jeu « Forestiers à vous de jouer ».

Le but du jeu, pouvant se jouer entre deux et six joueurs (ou équipes) est d'atteindre en premier la case arrivée. On y incarne un forestier dont la mission est de gérer le mieux possible la forêt normande dont il (ou elle) a la charge pour la préserver face au changement climatique. Pour ce faire, chaque équipe lance le dé et avance du nombre de cases correspondantes, en choisissant son chemin pour atteindre l'arrivée. Les cases du plateau sont cerclées de couleurs, chacune correspondant à un thème différent, et l'équipe s'arrêtant sur une case doit répondre à une question du thème associé (10 cartes de questions par thème). Selon les questions, il est possible d'avoir une ou plusieurs bonnes propositions. Si l'équipe se trompe elle doit reculer d'une case, si elle fournit une réponse incomplète, elle ne bouge pas et si elle répond correctement, elle a le droit d'avancer d'une case supplémentaire. Deux équipes au maximum peuvent partager une case, si une troisième arrive sur cette case, elle doit s'arrêter à la case précédente. Lorsqu'une équipe s'arrête sur une case « bonus » ou « embûche », elle pioche une carte correspondante, effectue l'action indiquée sur la carte et son tour se termine (20 cartes bonus et embûche au total). Certaines de ces cartes indiquent une action pouvant toucher toutes les équipes.

L'équipe gagnante est celle atteignant la case "arrivée" en première à l'aide d'un compte juste aux dés. Si une équipe dépasse le nombre de cases jusqu'à l'arrivée, elle doit alors retourner sur ses pas.

Des variantes peuvent faciliter ou accélérer une partie, par exemple en rejouant lors d'une bonne réponse ou en atteignant la case arrivée sans le compte juste. Pour un public plus âgé ou expérimenté, les questions peuvent être posées sans proposition de réponse ou bien le maître du jeu peut fixer un objectif spécifique à chaque équipe en début de partie tel que rajeunir la forêt, conserver la biodiversité, ou bien encore de répondre à au moins une question de chacun des dix thèmes.

Difficultés et opportunités rencontrées lors du développement de cette innovation

Aucune difficulté majeure n'a été rencontrée par le consortium. Tout d'abord, le budget fixé a pu être respecté. Le planning et le timing étaient contraints, ce qui est apparu à la fois comme un challenge et une opportunité pour la réalisation de cette innovation. Cela a en effet permis de rendre le travail en groupe dynamique et de maintenir une cadence soutenue qui a évité aux acteurs de s'éparpiller dans le travail à réaliser. Cela a été rendu possible grâce à l'investissement et à la réactivité des partenaires du consortium qui ont répondu aux différentes sollicitations dans un temps très court, aucun membre n'étant à temps plein sur le projet.

Distribution, retour d'expériences et futurs développement du jeu

Le jeu a été distribué à 350 écoles primaires et 50 exemplaires ont été remis aux partenaires du projet et de la filière forêt bois régionale. Son utilisation peut se faire dans le cadre d'un programme pédagogique au sein des écoles, en médiathèque, par des associations, par les communes, ou bien lors d'événements particuliers tels que des salons pour des parties de sensibilisation. Le jeu n'est pas commercialisé pour l'instant, néanmoins de nombreux utilisateurs expriment le souhait de l'acquérir. Celui-ci est aussi distribué et utilisé en support à d'autres actions d'envergures nationales, tel que le programme national « 1000 communes, la forêt fait école » dans lequel les communes mettent des parcelles communales à la disposition d'une école qui prend en charge sa gestion.

Le jeu a été présenté et transmis aux autres unités régionales des collectivités forestières. Sa pertinence et l'intérêt porté par les autres délégations du réseau ont permis d'envisager une version nationale du jeu (en cours d'étude). Pour ce faire, il serait prévu de conserver un plateau de jeu identique, mais que chaque délégation régionale décline, selon ses spécificités, certaines des cartes la thématique « la forêt ». Une version nationale présentant donc l'ensemble des cartes issues des différentes régions pourrait ainsi être envisagée.

Applicabilité Européenne

Une diffusion de ce jeu à l'échelle européenne peut être envisageable, néanmoins une traduction directe du jeu n'apparaît pas comme adaptée, car les questions et réponses dépendent de la législation de chaque pays membre, les réglementations pouvant être différentes. En France, le code forestier a simplifié le travail, car il apporte un cadre à partir duquel le consortium a pu travailler. Néanmoins, si certains pays souhaitent développer un jeu similaire, des échanges ou bien des partenariats peuvent être discutés, si cela peut permettre aux acteurs de gagner du temps et de s'inspirer du travail déjà réalisé.

Interview de la coordinatrice du groupe opérationnel Eurofornorm

Mme Ferrier, quelle est votre vision des groupes opérationnels et de l'innovation en général dans le secteur forestier ? Quelle est la plus-value du travail partenarial pour la mise en place de ces innovations ?

La coopération entre différents acteurs a toujours été pour moi un moyen de créer une émulation très intéressante entre les personnes et particulièrement efficace pour développer des actions collectives. En tant que coordonnateur, notre objectif est de construire des habitudes d'échanges entre les membres du groupe opérationnel; on instaure un climat de confiance qui permet à chacun de s'exprimer librement et d'être force de proposition. Ce travail partenarial favorise ainsi la stimulation et l'émergence de nouvelles idées permettant d'innover dans notre domaine. Je crois beaucoup en ce proverbe africain : " Seul on va plus vite, ensemble on va plus loin ".

Ainsi, au-delà de la création de ce jeu, c'est le développement des relations de travail entre les partenaires que je trouve particulièrement intéressant. Cela permet de connaître et de comprendre les acteurs présents, de s'enrichir mutuellement et de maintenir une dynamique collaborative au sein des territoires. Et enfin, cela favorise le développement de nouveaux travaux en partenariats à l'avenir : peut-être un prochain PEI ?

« Foresters it's your turn to play »

An educational game to teach primary school children about climate change in forests

Five areas in Normandy that have signed a Territorial Forest Charter (CFT) have come together around a common observation: the need for greater coordination between players and for more communication and popularisation of the forestry practices that our society needs.

Eurofornorm, a regional network of normandy's forest areas

Five signatory territories of a Forest Charter of Territory (CFT) of Normandy joined together around a common observation: the need for a greater coordination between actors and more communication and vulgarization of the silvicultural practices necessary to our society.

Created in 2018, the EUROFORNORM operational group is made up of the following players: the Centre National de la Propriété Forestière (Délégation Haut-de-France - Normandie); the Office National des Forêts; the Normandie Maine, Perche and Boucles de Seine Regional Natural Parks; the Métropole Rouen Normandie and Seine Eure Agglomération. Its coordinator is the 'Union Régionale des Collectivités Forestières de Normandie (URCOFOR'), an association of local authorities in Normandy that may or may not own forests. URCOFOR is a forum for exchanging and sharing experiences, offering services to promote and support forest areas with the aim of enhancing their value

and integrating the forest environment into the heart of local development. URCOFOR has been organised as a network serving elected representatives for over 80 years, with a national federation.

The overall aim of the EUROFORNORM operational group was to create and lead a regional network of forest areas in Normandy, focusing on a common priority theme: 'The future of Normandy's forests in the face of climate change'. A three-year action programme has therefore been drawn up to meet the following objectives: - to raise awareness and encourage reflection on possible future developments in the forest in order to adapt to climate change and mitigate its effects, - to explain today's forest, forestry operations and the methods used to try to anticipate changes, - to encourage exchanges between the various stakeholders in order to understand each party's expectations and seek compromises, in order to design the Normandy forests of tomorrow.

During the first two years of work, various actions (meeting sessions in the forest, colloquia - *see image 1*) and tools (forward-looking workshops based on the Foster Forest role-playing game) have enabled awareness-raising and exchanges with a large number of identified stakeholders, such as private owners, elected representatives and the general public.

Aim of the innovation

In 2020, the consortium members agreed to work on the development of a specific teaching tool on the subject of 'forests and climate change', with the aim of targeting primary school classes as a priority. This target group was chosen because municipal elected officials are responsible for primary schools, and the URCOFOR carry out missions aimed at these councillors.

Image 1 : Meeting session realized within the EUROFORNORM project.

It was decided to develop this tool in the form of a game, which could be used to complement other activities and tools available in the regions, but could also be incorporated into other formats offered by Regional Natural Parks or inter-municipal bodies.

Finally, the members of the consortium were keen to get this tool up and running by the start of the next school year.

At the time of the launch of this project, most of the games already available on the market dealt with « global » issues such as deforestation or carbon emissions on a global scale. No games on a regional scale in Normandy dealing with climate change issues emerged from the survey, which reinforced the consortium's desire to develop this tool.

Implementation of the project

On the basis of these deliberately vague criteria, in order to be able to explore a wide range of proposals, various companies specialising in educational publishing and the creation of play concepts were approached. One of the key selection criteria was the company's ability to provide support in designing the project. The service provider selected put forward proposals for game formats, and the consortium agreed on a 'board' format with questions in the form of cards. The game was chosen in a form similar to that of the game of the goose, because the rules of the game were already familiar to the target audience. From experience, games with innovative formats (such as 'Foster Forest', presented in this operational group) require a considerable amount of time to explain the rules, which could not be envisaged for a target audience in this age group. As the subject was already little known, it was important for the consortium that the rules could be easily integrated. A timetable was drawn up in agreement with the service provider, scheduling the production of the various plates and graphic proposals, with the aim of highlighting the Normandy context, climate change and the multifunctionality of forests.

The consortium was responsible for drafting the scientific and technical maps. Questions were submitted both in advance by mailing list and at the meetings, and the answers had to be agreed at the meetings. The consortium set itself the target of drafting a certain number of question and answer sheets per meeting, which were then submitted to the service provider who, given his experience in educational publishing, could then provide advice on reformulating the content if it did not seem intelligible to schoolchildren.

This collaborative approach generated a great deal of discussion within the consortium, which included a wide range of stakeholders. Some questions, for example, although relevant, had to be set aside, as no consensus could be reached by the members on the answers to be provided. In addition, the diversity of the profiles present in the consortium meant that a wide range of forestry issues could be addressed by experts across the entire value chain. This helped to enrich the knowledge of each of the players, but also to understand each other's points of view and working methods.

Presentation of the game

The « Foresters, it's your turn to play » game (see image 2) is based around ten main themes: old trees, the forest, young trees, cutting down trees, harvesting wood, woodworking professions, leisure activities in the forest, plants and animals, and finally the uses of wood. One important point to bear in mind was to maintain the link with climate change, which is dealt with in specific 'bonus' and 'pitfall' cards.

Image 2 : Presentation of the « 'Foresters, it's your turn to play » game.

The aim of the game, which can be played by between two and six players (or teams), is to reach the finishing square first. The player takes on the role of a forester, whose mission is to manage the Normandy forest in his or her care as best as possible in order to preserve it in the face of climate change. To do this, each team rolls the die and moves forward the corresponding number of squares, choosing their path to reach the finish.

The squares on the board are circled in colour, each corresponding to a different theme, and the team stopping on a square must answer a question on the associated theme (10 question cards per theme). Depending on the question, there may be one or more correct answers. If the team makes a mistake, it must move back one square; if it gives an incomplete answer, it does not move; and if it answers correctly, it is entitled to move forward one more square. A maximum of two teams can share a square; if a third team arrives on that square, it must stop at the previous square. When a team stops on a 'bonus' or 'pitfall' square, it draws a corresponding card, performs the action indicated on the card and ends its turn (20 bonus and pitfall cards in total). Some of these cards indicate an action that can affect all the teams.

The winning team is the one that reaches the 'finish' square first, using a fair count on the dice. If a team exceeds the number of squares to the finish, it must retrace its steps.

Variations can make the game easier or faster, for example by replaying a correct answer or reaching the finish square without a correct count. For an older or more experienced audience, the questions can be asked without a suggested

answer, or the game master can set a specific objective for each team at the start of the game, such as rejuvenating the forest, conserving biodiversity, or answering at least one question from each of the ten themes.

Difficulties and opportunities encountered in developing this innovation

No major difficulties were encountered by the consortium. First of all, the budget was respected. The planning and timing were tight, which was both a challenge and an opportunity for the development of this innovation. This enabled the group to work dynamically and maintain a steady pace, which prevented the participants from losing focus on the work at hand. This was made possible by the commitment and responsiveness of the partners in the consortium, who responded to the various requests in a very short space of time, with no member working full-time on the project.

Distribution, feedback and future developments for the game

The game was distributed to 350 primary schools and 50 copies were given to partners in the project and the regional forestry/wood industry. It can be used as part of an educational programme in schools, media libraries, associations, local authorities, or at special events such as trade fairs to raise awareness. The game is not currently on the market, but many users have expressed a desire to acquire it. It is also distributed and used to support other national initiatives, such as the national '1000 communes, la forêt fait école' programme, in which local authorities make plots of land available to a school to manage.

The game was presented and passed on to the other regional forest Communities units. Its relevance and the interest shown by the other delegations in the network have led to plans for a national version of the game (currently being studied). The plan is to keep the same game board, but for each regional delegation to adapt some of the 'forest' theme cards to its own specific needs. A national version featuring all the cards from the different regions could therefore be envisaged.

European application

It may be possible to spread this game throughout Europe, but a direct translation of the game does not seem appropriate, as the questions and answers depend on the legislation of each member country, which may have different regulations. In France, the forestry code simplified the work, as it provided a framework on which the consortium could work. Nevertheless, if some countries wish to develop a similar game, exchanges or partnerships could be discussed, if this would save the actors time and allow them to draw inspiration from the work already done.

Interview with the Eurofornorm operational group coordinator

Mrs Ferrier, what is your vision of operational groups and innovation in the forestry sector in general? What is the value of working in partnership to achieve these innovations?

For me, cooperation between different players has always been a way of creating a very interesting emulation between people and particularly effective for developing collective actions. As co-ordinator, our aim is to build up a habit of exchange between the members of the operational group; we establish a climate of trust that allows everyone to express themselves freely and to be a source of ideas. Working in partnership in this way encourages the stimulation and emergence of new ideas that enable us to innovate in our field. I'm a great believer in the African proverb: 'Alone we go faster, together we go further'.

So, beyond the creation of this game, it's the development of working relationships between the partners that I find particularly interesting. It allows them to get to know and understand the players involved, to learn from each other and to maintain a collaborative dynamic within the regions. And finally, it encourages the development of new partnership projects in the future: perhaps a future EIP?

3. **Innovation title:** UAV and multispectral camera to map stressed forest area (GO-SURF)

Nota tecnica Sherwood

L'importanza del Monitoraggio della Salute Forestale e il ruolo dei droni e delle camere multispettrali

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https://www.rivistasherwood.it/sherwood-digital/sherwood-digital-base-3.html

Introduzione

Il Forest Health Monitoring (FHM), o Monitoraggio della Salute Forestale, è un processo volto a valutare lo stato di salute degli ecosistemi forestali (Trumbore et al. 2015). Questo monitoraggio coinvolge l'osservazione e la registrazione di vari indicatori, come il grado di defoliazione, la presenza di malattie o parassiti, e altri segni di stress. L'obiettivo principale del FHM è rilevare tempestivamente eventuali cambiamenti nella salute delle foreste al fine di prendere provvedimenti per mitigare i danni e preservare la salute degli ecosistemi forestali (Ecke et al. 2022).

Instituire sistemi di FHM è particolarmente rilevante in un contesto di cambiamento climatico, dove la vegetazione subisce sempre più spesso effetti di stress con perdita di attività fotosintetica (Puletti et al. 2019), e dove eventi estremi come incendi e infestazioni di insetti (Kautz et al. 2024) e patogeni di altra natura sono sempre più impattanti. È diventato, quindi sempre più importante ed essenziale per ogni gestore forestale sia pubblico che privato istituire sistemi di monitoraggio FHM al fine di poter mitigare eventuali problematiche sui soprassuoli, cercando di intervenire prontamente.

Nel contesto italiano, ma anche europeo, il monitoraggio in situ della salute delle foreste è stato effettuato per diversi decenni sia a livello locale, che regionale e globale, attraverso l'utilizzo di indicatori standard basati su rilievi di campo effettuati da parte di personale addestrato che identificano per esempio il grado di defoliazione della chioma (Canullo et al. 2012). Queste reti di monitoraggio forniscono un quadro standardizzato per la valutazione dello stato di salute delle foreste, tuttavia in un limitato numero di punti, che consente di avere un monitoraggio a scala nazionale, ma che non è coerente con le esigenze dei gestori forestali. Infatti, i gestori forestali pubblici e privati si trovano sempre più spesso a dover affrontare l'impatto dei disturbi forestali sui propri soprassuoli e, come detto in precedenza, diventa fondamentale, implementare sistemi di monitoraggio FHM che identifichino prontamente eventuali problematiche, permettendo interventi tempestivi di mitigazione.

I rilievi classici in situ, condotti da operatori, però presentano un alto grado di incertezza poiché la qualità dipende dall'esperienza e dalla percezione soggettiva degli osservatori. Per questo, sono necessari corsi specifici per poter procedere ai rilievi in maniera standardizzata e ottimale. Inoltre, rilievi in situ risultano complessi logisticamente e costosi sia in termini di tempo che di manodopera. Ciò li rende fattibili solo a scala di plot o di singole particelle. Per questo motivo, il telerilevamento (RS) si è affermato come parte del FHM, consentendo l'acquisizione di indicatori di salute forestale in modo obiettivo, quantitativo e ripetitivo a diverse scale spaziali (Lambert et al. 2013; Ecke et al. 2024).

In questo contesto, il telerilevamento basato su satelliti domina ancora la ricerca e l'applicabilità nel settore del FHM. Infatti, i dati di immagini multispettrali pubblicamente accessibili come Landsat, MODIS e Sentinel-2, consentono di istituire su ampie aree sistemi di monitoraggio, grazie alla risoluzione temporale e spaziale che il più delle volte è

sufficiente ad identificare i disturbi (Francini and Chirici 2022). Tuttavia, come evidenziato da alcune ricerche, i satelliti possono presentare delle difficoltà nel monitoraggio dovuto per esempio alla copertura nuvolosa (Giannetti et al. 2021) che può impedire la vista di porzioni di foresta, e rendere l'istituzione di sistemi di allerta precoce in alcuni contesti come quelli montani delle alpi e dell'appennino. Una soluzione a queste problematiche, per esempio, sono gli aerei con equipaggio che possono volare sotto la copertura nuvolosa (Ecke et al. 2024). Tuttavia, nella pratica, visti gli alti costi e le limitazioni logistiche, questi supporti non vengono utilizzati, se non annualmente o con cadenza pluriennale su grandi superfici. Questo li rende di fatto, non congrui all'identificazione precoce degli stress (Ecke et al. 2024).

È in questa nicchia che gli UAV (Unmanned Aerial Vehicle) hanno trovano un crescente utilizzo, non come concorrenti ma come tecnologia complementare alle piattaforme tradizionali di osservazione della Terra (Ecke et al. 2024). Anche nell'ambito del Gruppo Operativo EIP-AGRI Go-SURF, in regione Toscana, droni dotati di camere multispettrali sono stati utilizzati per mappare gli stress ai soprassuoli forestali. Il GO-SURF SURF – "Sistema di SUppoRto decisionale alla pianificazione Forestale sostenibile" – infatti ha lavorato per sviluppare un Sistema di Supporto Decisionale (SSD) innovativo per la gestione forestale sostenibile, utilizzando anche varie tecnologie in alcune aree pilota in modo tale da fornire ai proprietari e tecnici forestali informazioni utili alla gestione con un approccio basato sulla "precision forestry" (Giannetti et al. 2023).

Gli UAV, rispetto ai satelliti e agli aerei, coprono aree più ristrette ma sono insuperabili per risoluzione spaziale che può arrivare a Ground Sampling Distance dell'ordine dei cm. Inoltre, sono molto efficienti in termini di costi, flessibilità e soprattutto tempi di rivisita che possono essere frequenti poiché dipendono soltanto dall'operatore.

L'area che può essere coperta con questi velivoli varia da un ettaro a diversi chilometri quadrati in un singolo volo. La copertura è influenzata soprattutto del tipo di UAV, dalla tecnologia di propulsione, dal tipo di fotocamera, dal tipo di terreno e dall'accessibilità dell'area. Anche le normative sul funzionamento degli UAV devono essere considerate come fattore limitante alla copertura. Tuttavia, il nuovo regolamento Europeo identifica la possibilità di volare ad una quota di 120 m sopra il livello del terreno con una distanza di buffer di 500 m che permette di coprire tranquillamente con i droni più performanti anche 10-20 ha con un unico volo.

Oltre alla tipologia di drone, ciò che fa la differenza nell'istituire un sistema di FHM è il sensore che il drone può trasportare a bordo. Negli ultimi tempi, sono diventate disponibili sul mercato numerose nuove camere multispettrali. Queste camere, grazie alla loro capacità di acquisire diverse lunghezze d'onda dello spettro elettromagnetico, possono essere utilizzate per mappare vari tipi di stress forestale (Barzagli et al. 2018; Zhang et al. 2019; Ecke et al. 2022).

Tuttavia, la varietà di camere disponibile sul mercato e i vari indici di vegetazione che si possono derivare da queste, rende difficile orientarsi in un panorama di ricerca e avanzamento tecnico costante. Per questo motivo, il presente articolo mira a fornire un quadro conoscitivo sugli indici di vegetazione utili a mappare gli stress della vegetazione forestale, fornire un quadro su alcune delle camere disponibili sul mercato e sulle tecniche di elaborazione più semplici o promettenti, basandosi sui risultati del progetto GO-SURF e ponendo attenziona anche alla letteratura internazionale, al fine di offrire informazioni utili ai tecnici impegnati nei monitoraggi forestali.

Le camere multispettrali e gli indici di vegetazione

Le camere multispettrali sono dispositivi di *imaging* avanzati che catturano informazioni visive su diverse bande dello spettro elettromagnetico. Queste bande possono includere il visibile (rosso, verde, blu) e il infrarosso (NIR), ed in alcuni casi il vicino infrarosso (Red-Edge). Utilizzando queste diverse lunghezze d'onda, le camere multispettrali forniscono dati dettagliati che possono essere utilizzati per analizzare vari aspetti della vegetazione, del suolo, forestale, in particolare, grazie alla possibilità di acquisire informazioni nell'Infrarosso è possibile indagare l'attività fotosintetica delle piante e quindi valutare la salute degli alberi, evidenziare la presenza di malattie o altri tipi di stress. Al pari delle camere RGB possono essere utilizzate per acquisizioni fotogrammetriche che consentono di derivare non solo dati 2D

(ortomosaico multispettrale), ma anche per derivare dati 3D come nuvole di punti e DSM utili per l'analisi della struttura forestale (Barzagli et al. 2018; Giannetti et al. 2020)

Tuttavia, il loro principale vantaggio, come già riportato in precedenza, è la possibilità che queste camere hanno di catturare immagini in diverse lunghezze d'onda dello spettro elettromagnetico, permettendo agli operatori di distinguere variazioni nel contenuto di clorofilla nella vegetazione che possono indicare prontamente la presenza di uno stress, di malattie o la presenza di patogeni. Infatti, grazie alla possibilità di acquisire informazioni a diversa lunghezza d'onda possono essere facilmente utilizzate per derivare diversi indici di vegetazione attraverso semplici operazioni matematiche tra le immagini delle diverse bande, tramite anche i normali applicativi GIS come QField attraverso le funzioni del calcolatore raster.

Tra gli indici di vegetazione che possono essere calcolati riportiamo quelli in tabella 1 che risultano essere i più promettenti per il monitoraggio degli stress in ambiente forestale e che possono essere calcolati con le camere attualmente in commercio.

Tabella 1 – Indici di vegetazione utili al monitoraggio forestale che possono essere calcolati con camere multispettrali

Indice di Vegetazione	**Formula**
NDVI (Normalized Difference Vegetation Index)	NDVI=(NIR−Rosso)/(NIR+Rosso)
NDRE (Normalized Difference Red Edge)	NDRE=(NIR−RedEdge)/(NIR+RedEdge)
GNDVI (Green Normalized Difference Vegetation Index)	GNDVI= (NIR−Verde)/(NIR+Verde)
LCI (Leaf Chlorophyll Index)	LCI=(RedEdge-Rosso)/(RedEdge+Rosso)
SAVI (Soil-Adjusted Vegetation Index)	SAVI=((1+L)(NIR−Rosso))/(NIR+Rosso+L) dove L è una costante che dipende dalle condizioni del suolo (tipicamente L= 0.5
OSAVI (Optimized Soil-Adjusted Vegetation Index)	OSAVI=(NIR-Rosso)/(NIR+Rosso+0.16)
MCARI (Modified Chlorophyll Absorption Ratio Index)	MCARI=((RedEdge-Rosso)-0.2*(RedEdge-Verde))/(RedEdge+Rosso)
CIRE (Chlorophyll Index Red Edge) EVI (Enhanced Vegetation Index)	CIRE=(NIR/RedEdge)-1
EVI (Enhanced Vegetation Index)	EVI=2.5*((NIR-Rosso)/(NIR+6*Rosso-7.5*Blu+1)

VARI (Visible Atmospherically Resistant Index)	VARI=(Verde-Rosso)/(Rosso+Verde-blu)

L'NDVI è, forse, l'indice più utilizzato per monitorare la salute delle piante, tuttavia la sua saturazione a volte non aiuta ad individuare gli stress precocemente in foresta. L'indice, si basa sul fatto che la clorofilla nelle piante vive riflette fortemente la luce nel vicino infrarosso (NIR) e assorbe la luce rossa, quindi valori alti di NDVI, vicino a 1, indicano vegetazione densa e sana, mentre valori bassi sotto 0.7 suggeriscono stress o, sotto 0.6, morte delle piante. Secondo però l'esperienza del GO-SURF e l'analisi della bibliografia anche nel contesto della pioppicoltura (Chianucci et al. 2021), l'NDVI risulta forse l'indice meno accurato per l'individuazione degli stress. In particolare, il GNDVI risulta molto più sensibile all'allerta precoce. Questo indice è molto simile all'NDVI, in quanto si tratta di un indice normalizzato, ciò che lo differenzia è il fatto di utilizzare nella normalizzazione con la banda del NIR la banda verde invece della rossa. Questo lo rende utile per monitorare piante con alta densità di foglie o per identificare stress idrico, rendendo possibile anche un'allerta precoce (Raddi et al. 2021). Per la valutazione del contenuto di clorofilla, invece, l'LCI è molto sensibile alla clorofilla presente nelle foglie (Gallardo-Salazar et al. 2023). La clorofilla assorbe fortemente la luce rossa e riflette la luce nel Red-Edge, questo rende questo indice utile alla stima anche diretta del contenuto di clorofilla, come indicatore della capacità fotosintetica della pianta . Allo stesso modo il CIRE (Chlorophyll Index Red Edge) che però risulta ancora più correlato anche allo stato nutrizionale delle piante (Kleinsmann et al. 2023).

Per l'identificazione dello stress delle piante anche in porzioni di chioma, l'NDRE è particolarmente utile. Infatti, il Red Edge è molto sensibile ai cambiamenti nella struttura della foglia e al contenuto di clorofilla e consente di individuare piccole variazioni (Minařík R and Langhammer 2016). Inoltre, è utile per identificare piante che potrebbero essere affette da malattie o carenze nutrizionali prima che questi problemi siano visibili ad occhio nudo. Il MCARI è invece progettato per essere meno sensibile alle variazioni del suolo, e migliora la capacità di rilevare lo stress delle piante in ambienti eterogenei, dove si hanno anche porzioni di suolo scoperto (Zou et al. 2019). Per la valutazione invece dell'attività della Fotosintesi e dell'Attività Vegetativa, l'EVI migliora la sensibilità nelle aree di alta densità vegetativa e riduce le interferenze atmosferiche e del suolo rispetto all'NDVI. Mentre, il VARI può essere utilizzato per monitorare la vegetazione utilizzando solo le bande visibili, rendendolo utile in condizioni in cui le bande NIR non sono disponibili come quello delle camere RGB.

Droni e camere multispettrali in commercio

Tra i droni che nascono con sensore multispettrale integrato, DJI Mavic 3M combina una fotocamera RGB da 20 MP e 4 fotocamere multispettrali da 5 MP che acquisiscono nelle bande del verde (560nm±16nm), rosso (650nm±16nm), Red-Edge (730±16nm), e NIR (860nm±26 nm) e sensore di luce integrato, che consente di catturare l'irradianza solare, utile in fase di post-processing per la compensazione di eventuali "sbalzi" di luce nelle immagini. L' autonomia di volo dichiarata dal produttore è di 43 minuti con una copertura per volo di 2km^2. Il drone è in commercio anche con modulo RTK che permette la georeferenziazione del rilievo con alta precisione.

Tra i droni DJI con sensore integrato anche il P4 Multispectral è dotato di 6 diverse camere da 2,08 MP: una fotocamere RGB e cinque fotocamere multispettrali che acquisiscono nelle bande del blu (450 ±16nm), verde (560 ±16nm), rosso (650±16nm), Red-Edge (730±16nm) e vicino-infrarosso (840±26nm). Anche questo drone è dotato di sensore di luce e di modulo RTK. Il produttore dichiara una autonomia di volo di 27 minuti ed una operatività massima per singolo volo di 0.63 km^2. In un recente studio in Germania (Ecke et al. 2024) questo drone è stato utilizzato per acquisire immagini multispettrali ad alta risoluzione di 235 diverse aree di monitoraggio forestale di larga scala (ICP Level-I plots) distribuite in Baviera per un tempo di monitoraggio di tre anni (2020-2022). Nonostante, sia stato utilizzato un dataset eterogeno poiché acquisito nel tempo, con diverse condizioni meteorologiche e di illuminazione, in foreste caratterizzate da una diversa composizione e distribuite in un ampia area di studio, l'articolo evidenzia come sia stato

possibile classificare cinque specie di alberi, a livello di genere, gli alberi morti e lo stato di salute delle principali specie di alberi presenti per un totale di 14 diverse classi, utilizzando l'architettura EfficientNet CNN. Questa metodologia di monitoraggio, inoltre, ha ridotto significativamente i costi e i tempi di acquisizione in campo, consentendo anche una standardizzazione del dato.

Tra le camere che invece si possono montare su diversi tipi di droni, tra cui per esempio DJI Matrice 300, Wingtra One Gen II, senseFly eBeeX, la MicaSense RedEdge-MX è tra le più efficienti ma anche tra le più costose. Questa camera può catturare immagini nelle bande Blu (475 nm ± 20 nm), verde (560 nm ± 20 nm), rosso (668 nm ± 10 nm), Red-Edge (717 nm ± 10 nm) e vicino-infrarosso (840 nm ± 40 nm) ed offre una precisione e una coerenza spettrale elevate, rendendola ideale per l'analisi della vegetazione forestale. La camera è dotata di un sensore di luce e di un pannello di riflettanza per la sua calibrazione che deve essere acquisito nel momento di decollo e atterraggio del drone.

Figura 1 - drone Wingra ONE GEN II con camera multispettrale

Figura 2 - Camera Micasense RedEdge-RX con pannello di riflettanza

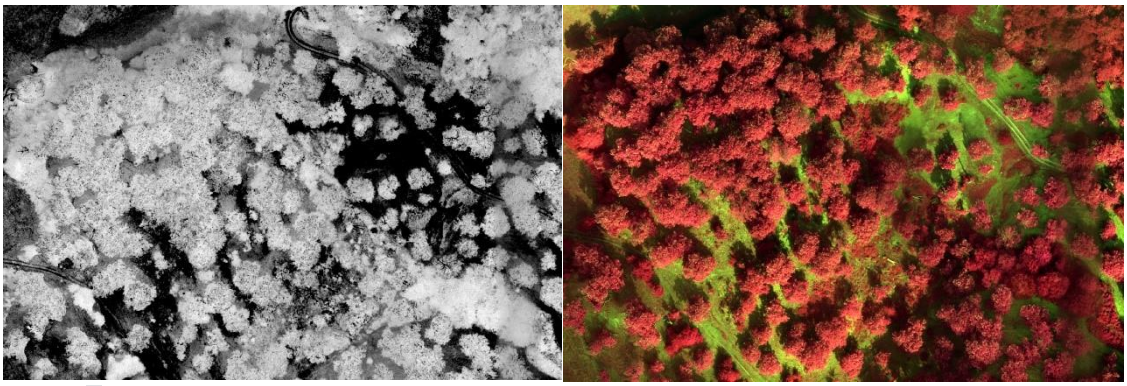

Figura 3 - Immagine multispettrale acquisita con drone camera Micasense RedEdge-Rx a sinistra visione nelle bande RedEdge-Rosso-Verde, a destra calcolo dell'indice NDVI sulla stessa immagine

Potenzialità dell'utilizzo dei superpixel per l'identificazione degli stress

Questa camera è stata testata anche nell'ambito del progetto GO-SURF in cui è stata impiegata per l'acquisizione di diverse aree in Toscana attraverso l'utilizzo del drone WINGTRA ONE GEN II. L'elaborazione delle immagini ha permesso attraverso tecniche di segmentazione basate sul "*Simple Linear Iterative Clustering* (SLIC)" (Achanta et al. 2012) di individuare le piante morte e deperimenti attraverso l'identificazione di soglie di stress. Lo SLIC è un algoritmo utilizzato per la segmentazione delle immagini, in particolare per creare i cosiddetti "superpixel". I superpixel sono gruppi di pixel contigui con caratteristiche simili, che semplificano l'analisi dell'immagine riducendo il numero di elementi da considerare, pur mantenendo la maggior parte delle informazioni rilevanti. Nello specifico, nell'ambito del progetto GO-SURF le immagini multispettrali acquisite sono state elaborate con software fotogrammetico Metashape Agisoft al fine di generare un ortomosaico a diverse [bande Blu (475 nm ± 20 nm), verde (560 nm ± 20 nm), rosso (668 nm ± 10 nm), Red-Edge (717 nm ± 10 nm), vicino-infrarosso (840 nm ± 40 nm)]. Le immagini importate nel software R-Cran utilizzando vari pacchetti di processamento, sono state utilizzate per inizializzare l'algoritmo. Durante l'inizializzazione l'algoritmo identifica con una distribuzione uniforme i centri di superpixel sull'immagine. Dopo questo processo, ogni pixel dell'immagine viene assegnato al superpixel il cui centro è più vicino in termini di distanza combinata (spazio e colore). La distanza combinata tiene conto sia delle coordinate spaziali dei pixel che dei valori di colore identificati nell'immagine (spazio CIELAB). L'algoritmo procede iterativamente fino ad individuare e segmentare le singole chiome. È possibile utilizzare questo algoritmo anche attraverso software Desktop come SAGA GIS. Dai

diversi test effettuati nell'ambito del progetto GO-SURF si è individuato che la segmentazione in ambiente forestale funziona molto bene anche utilizzando soltanto la banda del Red-Edge e non bande multiple. Infatti, questa banda sembra essere la più sensibile all'individuazione delle singole chiome, o porzioni di chioma caratterizzate da attività fotosintetica simile. Il metodo di segmentazione riduce i tempi rispetto a metodi complessi e rileva accuratamente le singole chiome, o porzioni di chioma con attività fotosintetica diversa, come ad esempio quelle morte o deperenti. Tuttavia, per arrivare al passaggio di classificazione in diverse classi di decadimento (porzione di chioma morta, porzione di chioma deperente, porzione di chioma viva) è necessario estrarre sui poligoni che vengono generati dallo SLIC gli indici di vegetazione sui quali calibrare le soglie di individuazione delle piante morte. In questo modo, per ogni superpixel, vengono applicate delle soglie agli indici di vegetazione per classificarli come rappresentanti piante sane, stressate o morte. Il vantaggio di questo metodo è che la segmentazione dei superpixel, riduce il numero di unità da analizzare, rendendo l'analisi più veloce ed efficiente, inoltre, i superpixel tendono a seguire i contorni naturali delle piante, migliorando l'accuratezza della classificazione rispetto ai metodi basati su pixel singoli.

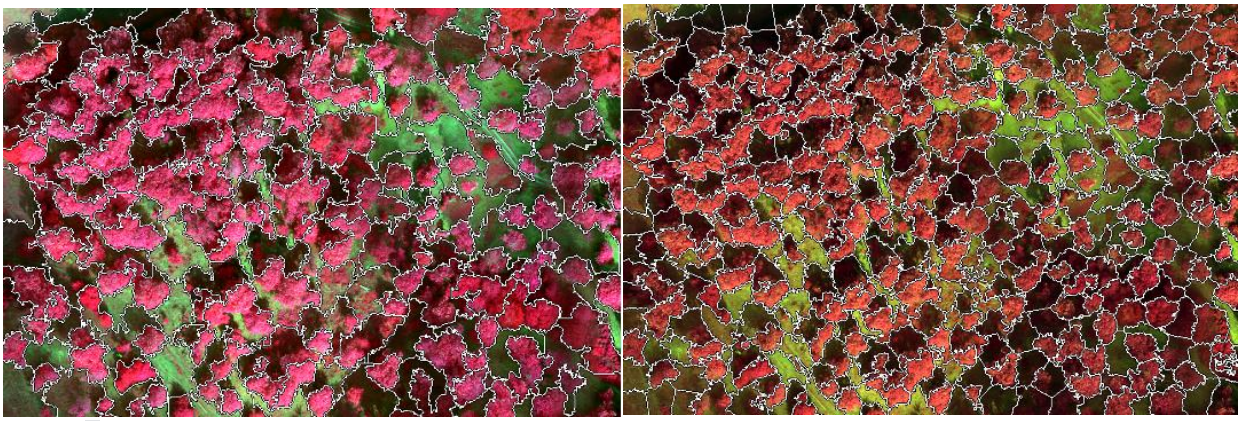

Figura 4 - identificazione dei superpixel contorni bianchi, a sinistra visione dell'immagine nella composizione Infrarosso (NIR), rosso e verde, a destra nella visione RedEdge, Rosso e Verde

L'uso dei SLIC Superpixels nelle immagini da drone rappresenta una tecnica avanzata per l'identificazione e il monitoraggio delle piante morte. Attraverso la segmentazione delle immagini in regioni omogenee e l'applicazione di soglie su indici di vegetazione, è possibile ottenere una mappa accurata delle aree problematiche, permettendo interventi tempestivi e mirati nella gestione delle colture.

Tra le altre camere in commercio multispettrali ad un costo minore rispetto a quanto evidenziato in precedenza, ci sono la Parrot Sequoia, la Sentera Double 4K, la Mapir Survay3, e la Mapir Survay2. Tutte queste camere al pari delle altre acquisiscono informazioni multispettrali nelle bande del rosso, blu, verde, e vicino infrarosso, ma non nel vicino infrarosso Red-Edge. Questo le rende meno performanti nel calcolo di alcuni indici riportati in precedenza.

Figura 5 - DJI Phantom 3 equipaggiato con MAPIR Survay 3 che acquisice nelle bande Rosso, Verde, Infrarosso

Conclusioni

Dato l'attuale fermento in termini di ricerca e produzione, è davvero complesso dare una piena visione di tutte le camere che sono in commercio in questo momento. Tuttavia, per la nostra esperienza, risulta fondamentale porre l'attenzione su quelle camere che permettono di calcolare un numero maggiore di indici di vegetazione, contribuendo così a mappare in maniera precisa eventuali danni, in quanto diventa sempre più di primaria importanza riuscire a intervenire prontamente. Infatti, nonostante alcune limitazioni, i droni equipaggiati con camere multispettrali rappresentano uno strumento potente e versatile per il monitoraggio forestale che può essere, come dimostrato dal progetto GO-SURF, già implementato a livello italiano. Si prevede che ulteriori sviluppi tecnologici e la crescente accessibilità ai droni renderanno questi strumenti sempre più fondamentali nella gestione sostenibile delle foreste.

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The Importance of Forest Health Monitoring and the Role of Drones and Multispectral Cameras

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Abstract

Forest Health Monitoring (FHM) is essential for assessing and maintaining the health of forest ecosystems, especially in the context of climate change. While traditional in situ surveys are limited by subjectivity, logistical complexity, and

high costs, remote sensing (RS) offers a more efficient alternative. Among RS technologies, Unmanned Aerial Vehicles (UAVs) equipped with multispectral cameras have proven particularly effective. These drones provide high-resolution, cost-effective, and flexible monitoring solutions, capturing detailed data across various wavelengths. This enables precise identification of vegetation stress and damage, facilitating timely and targeted interventions. As demonstrated by the GO-SURF project, UAVs with multispectral sensors are becoming indispensable tools for sustainable forest management.

Introduction

Forest Health Monitoring (FHM) is a process aimed at assessing the health status of forest ecosystems (Trumbore et al. 2015). This monitoring involves observing and recording various indicators, such as the degree of defoliation, the presence of diseases or pests, and other signs of stress. The main goal of FHM is to promptly detect any changes in forest health in order to take measures to mitigate damage and preserve the health of forest ecosystems (Ecke et al. 2022).

Establishing FHM systems is particularly relevant in the context of climate change, where vegetation increasingly experiences stress effects with a loss of photosynthetic activity (Puletti et al. 2019), and where extreme events such as fires and insect infestations (Kautz et al. 2024) and other pathogens are becoming more impactful. Therefore, it has become increasingly important and essential for every forest manager, both public and private, to establish FHM monitoring systems to mitigate potential problems in the forest stands and to intervene promptly.

In the Italian and European context, in situ forest health monitoring has been carried out for several decades at local, regional, and global levels, using standard indicators based on field surveys conducted by trained personnel who, for example, identify the degree of crown defoliation (Canullo et al. 2012). These monitoring networks provide a standardized framework for assessing forest health, though at a limited number of points, allowing for national-scale monitoring, but not aligning with the needs of forest managers. Public and private forest managers increasingly face the impact of forest disturbances on their stands and, as previously mentioned, it is crucial to implement FHM monitoring systems that promptly identify potential problems, enabling timely mitigation interventions.

However, classic in situ surveys conducted by operators present a high degree of uncertainty because the quality depends on the experience and subjective perception of the observers. Therefore, specific training courses are necessary to carry out surveys in a standardized and optimal manner. Moreover, in situ surveys are logistically complex and costly in terms of time and labor, making them feasible only at the plot or single parcel scale. For this reason, remote sensing (RS) has established itself as part of FHM, allowing the acquisition of forest health indicators in an objective, quantitative, and repetitive manner at various spatial scales (Lambert et al. 2013; Ecke et al. 2024).

In this context, satellite-based remote sensing still dominates research and applicability in the FHM sector. Indeed, publicly accessible multispectral image data such as Landsat, MODIS, and Sentinel-2, allow for monitoring systems over large areas, thanks to the temporal and spatial resolution that is often sufficient to identify disturbances (Francini and Chirici 2022). However, as highlighted by some research, satellites can present difficulties in monitoring, for example due to cloud cover (Giannetti et al. 2021) that can obscure portions of the forest, making it challenging in some contexts, such as the mountainous areas of the Alps and the Apennines, to establish early warning systems. These issues, for instance, are incompatible when biotic or abiotic factors cause rapid changes in forests. To overcome these problems, manned aircraft can meet these requirements because they can fly below the cloud cover (Ecke et al. 2024). However, in practice, due to high costs and logistical limitations, they are used only annually or biennially over large areas. This makes them, in fact, not suitable for early identification of stress (Ecke et al. 2024).

It is in this context that UAVs have found increasing use, not as competitors but as a complementary technology to traditional Earth observation platforms (Ecke et al. 2024). In the context of the Go-SURF Operational Group, drones equipped with multispectral cameras have been used to map stress in forest stands. UAVs, compared to satellites and aircraft, cover smaller areas but are unbeatable in spatial resolution, which can reach a Ground Sampling Distance on

the order of centimeters. They are also very efficient in terms of costs, flexibility, and especially revisit times, which can be frequent as they depend only on the operator.

The area that can be covered with these UAV ranges from one hectare to several square kilometers in a single flight. The coverage is mainly influenced by the type of UAV, propulsion technology, camera type, terrain type, and area accessibility. Also, UAV operation regulations must be considered as a limiting factor for coverage. However, the new European regulation allows flying at an altitude of 120 meters above ground level with a buffer distance of 500 meters, which allows even the most performant drones to comfortably cover 10-20 hectares in a single flight.

However, besides the drone, what makes the difference in establishing an FHM system is the sensor the drone can carry onboard. Recently, numerous new multispectral cameras have become available on the market. These cameras, thanks to their ability to capture different wavelengths of the electromagnetic spectrum, can be used to map various types of forest stress (Barzagli et al. 2018; Zhang et al. 2019; Ecke et al. 2022).

Nevertheless, the variety of cameras available on the market and the various vegetation indices that can be derived from them make it difficult to navigate a constantly evolving research and technical advancement landscape. For this reason, this article aims to provide an overview of vegetation indices useful for mapping forest stress, an overview of some of the cameras available on the market, and the most straightforward or promising processing techniques, based on the results of the EIP-AGRI GO-SURF and also considering international literature, to offer useful information to technicians involved in forest monitoring.

Multispectral Cameras and Vegetation Indices

Multispectral cameras are advanced imaging devices that capture visual information across different bands of the electromagnetic spectrum. These bands can include the visible spectrum (red, green, blue) and the near-infrared (NIR), and in some cases, the red-edge near-infrared. By using these various wavelengths, multispectral cameras provide detailed data that can be used to analyze various aspects of vegetation, soil, and forests. Specifically, thanks to the ability to acquire information in the infrared spectrum, it is possible to investigate the photosynthetic activity of plants, assess tree health, and highlight the presence of diseases or other types of stress. Like RGB cameras, they can be used for photogrammetric acquisitions that allow the derivation of not only 2D data (multispectral orthomosaic) but also 3D data such as point clouds and digital surface models (DSM) useful for analyzing forest structure (Barzagli et al. 2018; Giannetti et al. 2020).

However, their main advantage, as previously mentioned, is their ability to capture images in different wavelengths of the electromagnetic spectrum, allowing operators to distinguish variations in chlorophyll content in vegetation that can promptly indicate the presence of stress, diseases, or pathogens. Indeed, thanks to the ability to acquire information at different wavelengths, they can be easily used to derive various vegetation indices through simple mathematical operations between the images of different bands, also using common GIS applications like QField through the raster calculator functions.

Among the vegetation indices that can be calculated, we report those in Table 1, which are the most promising for monitoring stress in forest environments and can be calculated with currently available multispectral cameras.

Table 1 – Vegetation Indices Useful for Forest Monitoring That Can Be Calculated with Multispectral Cameras

Indice di Vegetazione	**Formula**
NDVI (Normalized Difference Vegetation Index)	$NDVI=(NIR-Red)/(NIR+Red)$
NDRE (Normalized Difference Red Edge)	$NDRE=(NIR-RedEdge)/(NIR+RedEdge)$

GNDVI (Green Normalized Difference Vegetation Index)	$GNDVI = (NIR - Green)/(NIR + Green)$
LCI (Leaf Chlorophyll Index)	$LCI = (RedEdge - Red)/(RedEdge + Red)$
SAVI (Soil-Adjusted Vegetation Index)	$SAVI = ((1+L)(NIR - Red))/(NIR + Red + L)$ dove L è una costante che dipende dalle condizioni del suolo (tipicamente $L = 0.5$
OSAVI (Optimized Soil-Adjusted Vegetation Index)	$OSAVI = (NIR - Red)/(NIR + Red + 0.16)$
MCARI (Modified Chlorophyll Absorption Ratio Index)	$MCARI = ((RedEdge - Red) - 0.2*(RedEdge - Verde))/(RedEdge + Red)$
CIRE (Chlorophyll Index Red Edge) EVI (Enhanced Vegetation Index)	$CIRE = (NIR/RedEdge) - 1$
EVI (Enhanced Vegetation Index)	$EVI = 2.5*((NIR - Red)/(NIR + 6*Red - 7.5*Blue + 1)$
VARI (Visible Atmospherically Resistant Index)	$VARI = (Green - Red)/(Green + Red - Blue)$

The NDVI (Normalized Difference Vegetation Index) is perhaps the most widely used index for monitoring plant health. However, its tendency to saturate can sometimes hinder the early detection of stress in forests. The index is based on the fact that chlorophyll in living plants strongly reflects near-infrared (NIR) light and absorbs red light. High NDVI values, close to 1, indicate dense and healthy vegetation, while lower values below 0.7 suggest stress, and values below 0.6 indicate plant death. However, according to the experience of the GO-SURF project and the literature review in the context of poplar cultivation (Chianucci et al. 2021), NDVI may be the least accurate index for detecting stress.

For instance, the GNDVI (Green Normalized Difference Vegetation Index) is more sensitive for early warning of stress. This index is similar to NDVI but uses the green band instead of the red band for normalization with the NIR band. This makes it useful for monitoring plants with high leaf density or identifying water stress, allowing for early warnings (Raddi et al. 2021). For assessing chlorophyll content, the LCI (Leaf Chlorophyll Index) is very sensitive to the chlorophyll present in leaves (Gallardo-Salazar et al. 2023). Chlorophyll absorbs red light and reflects red-edge light, making this index useful for directly estimating chlorophyll content, which is an indicator of the plant's photosynthetic capacity. Similarly, the CIRE (Chlorophyll Index Red Edge) is even more correlated with the nutritional status of plants (Kleinsmann et al. 2023).

The NDRE (Normalized Difference Red Edge) is particularly useful for identifying plant stress in canopy sections. The Red Edge is very sensitive to changes in leaf structure and chlorophyll content, allowing for the detection of small

variations (Minařík and Langhammer 2016). It is useful for identifying plants that may be affected by diseases or nutritional deficiencies before these issues are visible to the naked eye. The MCARI (Modified Chlorophyll Absorption Ratio Index) is designed to be less sensitive to soil variations, enhancing the ability to detect plant stress in heterogeneous environments with exposed soil (Zou et al. 2019). For evaluating photosynthetic activity and vegetative vigor, the EVI (Enhanced Vegetation Index) improves sensitivity in high-density vegetation areas and reduces atmospheric and soil interferences compared to NDVI. The VARI (Visible Atmospherically Resistant Index) can be used to monitor vegetation using only the visible bands, making it useful in conditions where NIR bands are unavailable, such as with RGB cameras.

Drones and Multispectral Cameras on the Market

Among drones with an integrated multispectral sensor, the DJI Mavic 3M combines a 20 MP RGB camera and four 5 MP multispectral cameras that capture in the green (560nm±16nm), red (650nm±16nm), red-edge (730±16nm), and NIR (860nm±26nm) bands, along with an integrated light sensor. This setup captures solar irradiance, allowing for post-processing compensation for any light fluctuations in the images. The manufacturer claims a flight autonomy of 43 minutes with a coverage per flight of 2 km². The drone is also available with an RTK module, providing precise georeferencing of the survey with high accuracy.

Another DJI drone with an integrated sensor is the P4 Multispectral, equipped with six different cameras of 2.08 MP—one RGB camera and five multispectral cameras capturing in the blue (450±16nm), green (560±16nm), red (650±16nm), red-edge (730±16nm), and near-infrared (840±26nm) bands. This drone also features a light sensor and RTK module for light correction in the image and precise georeferencing of the survey. The manufacturer claims a flight autonomy of 27 minutes and a maximum operational area per flight of 0.63 km². In a recent study in Germany (Ecke et al. 2024), this drone was used to acquire high-resolution multispectral images of 235 different large-scale forest monitoring areas (ICP Level-I plots) distributed in Bavaria over a three-year monitoring period (2020-2022). Despite the heterogeneous dataset acquired over time under various weather and lighting conditions, in forests with diverse compositions spread over a large study area, the article demonstrates how it was possible to classify five tree species, at the genus level, dead trees, and the health status of the main tree species into 14 different classes using the EfficientNet CNN architecture. The article highlights that this monitoring methodology can significantly reduce field acquisition costs and times, allowing for data standardization.

Among the cameras that can be mounted on various types of drones, such as the DJI Matrice 300, Wingtra One Gen II, and senseFly eBeeX, the MicaSense RedEdge-MX stands out as one of the most efficient but also one of the most expensive. This camera captures images in the blue (475nm±20nm), green (560nm±20nm), red (668nm±10nm), red-edge (717nm±10nm), and near-infrared (840nm±40nm) bands, offering high spectral precision and consistency, making it ideal for analyzing forest vegetation. The camera is equipped with a light sensor and a reflectance panel for calibration, which must be captured at the drone's takeoff and landing.

This camera was also tested in the GO-SURF project, where it was used to acquire images of various areas in the Tuscany region using the Wingtra One Gen II drone. Image processing through segmentation techniques based on the “Simple Linear Iterative Clustering (SLIC)” method (Achanta et al. 2012) allowed the identification of dead and declining plants by identifying stress thresholds. SLIC is an algorithm used for image segmentation, particularly for creating superpixels—groups of contiguous pixels with similar characteristics, which simplify image analysis by reducing the number of elements to consider while maintaining most of the relevant information. Specifically, in the GO-SURF project, multispectral images were processed using photogrammetric software Metashape Agisoft to generate an orthomosaic in different bands (blue, green, red, red-edge, near-infrared). The images were imported into R-Cran software, using various processing packages to initialize the algorithm. During initialization, the algorithm uniformly distributes superpixel centers across the image. These centers are chosen to cover the entire image uniformly. Each pixel in the image is then assigned to the nearest superpixel center based on combined distance (space and color). The combined distance considers both spatial coordinates and color values (CIELAB space). The algorithm

iterates until it segments the individual canopies. This algorithm can also be used through desktop software like SAGA GIS. Tests conducted in the GO-SURF project showed that forest environment segmentation works very well even using only the red-edge band, not multiple bands. This band seems most sensitive to identifying individual canopies or canopy portions with similar photosynthetic activity. The segmentation method reduces time compared to complex methods and accurately detects individual canopies or canopy portions with different photosynthetic activities, such as dead or declining canopy portions. However, to classify different decay classes (dead canopy portion, declining canopy portion, live canopy portion), vegetation indices need to be extracted from the polygons generated by SLIC, calibrating thresholds to identify dead plants. Thus, for each superpixel, thresholds are applied to vegetation indices to classify superpixels as representing healthy, stressed, or dead plants. The advantage of this method is that superpixel segmentation reduces the number of units to analyze, making the analysis faster and more efficient. Additionally, superpixels tend to follow the natural contours of plants, improving classification accuracy compared to single-pixel methods.

Figure 1 - Identification of Superpixels with White Contours, Detection of Declining Canopy in Yellow, and Dead Canopy Portions in Blue

The use of SLIC Superpixels in drone imagery represents an advanced technique for identifying and monitoring dead plants. By segmenting images into homogeneous regions and applying thresholds on vegetation indices, it is possible to obtain an accurate map of problematic areas, allowing for timely and targeted interventions in crop management.

mong other multispectral cameras on the market at a lower cost compared to those previously mentioned are the Parrot Sequoia, the Sentera Double 4K, the Mapir Survey3, and the Mapir Survey2. All these cameras, like the others, acquire multispectral information in the red, blue, green, and near-infrared bands, but not in the Red-Edge near-infrared. This makes them less effective in calculating some of the indices previously mentioned.

Conclusions

It is impossible to have a complete overview of all the cameras available on the market at this time. However, based on our experience, it is essential to focus on those cameras that allow for the calculation of different vegetation indices, which can contribute to accurately mapping potential damage. This is because it is increasingly important to be able to intervene promptly. Despite some limitations, drones equipped with multispectral cameras represent a powerful and versatile tool for forest monitoring, as demonstrated by the GO-SURF project already implemented at the Italian level. It is anticipated that further technological developments and increasing accessibility to drones will make these tools increasingly fundamental in sustainable forest management.

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La importancia de vigilar la salud de los bosques y el papel de los drones y las cámaras multiespectrales

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Resumen

El seguimiento de la salud de los bosques es esencial para evaluar y mantener la salud de los ecosistemas forestales, especialmente en el contexto del cambio climático. Mientras que los estudios in situ tradicionales se ven limitados por la subjetividad, la complejidad logística y los elevados costes, la teledetección ("Remote Sensing", RS) ofrece una alternativa más eficaz. Entre las tecnologías de RS, los vehículos aéreos no tripulados (UAV) equipados con cámaras multiespectrales han demostrado ser especialmente eficaces. Estos drones ofrecen soluciones de vigilancia de alta resolución, rentables y flexibles, y captan datos detallados en varias longitudes de onda. Esto permite identificar con precisión el estrés y los daños en la vegetación, facilitando intervenciones oportunas y específicas. Como demuestra el proyecto GO-SURF, los vehículos aéreos no tripulados con sensores multiespectrales se están convirtiendo en herramientas indispensables para la gestión forestal sostenible.

Introducción

El seguimiento de la salud forestal ("Forest Health Monitoring", FHM) es un proceso destinado a evaluar el estado de salud de los ecosistemas forestales (Trumbore et al. 2015). Este seguimiento implica la observación y el registro de diversos indicadores, como el grado de defoliación, la presencia de enfermedades o plagas y otros signos de estrés. El principal objetivo del FHM es detectar con prontitud cualquier cambio en la salud de los bosques con el fin de tomar medidas para mitigar los daños y preservar la salud de los ecosistemas forestales (Ecke et al. 2022).

El establecimiento de sistemas FHM es particularmente relevante en el contexto del cambio climático, donde la vegetación experimenta cada vez más efectos de estrés con una pérdida de actividad fotosintética (Puletti et al. 2019), y donde los eventos extremos como los incendios y las plagas de insectos (Kautz et al. 2024) y otros patógenos son cada vez más impactantes. Por ello, cada vez es más importante e imprescindible para todo gestor forestal, tanto público como privado, establecer sistemas de seguimiento de la FHM para mitigar posibles problemas en las masas forestales e intervenir con prontitud.

En el contexto italiano y europeo, el seguimiento in situ de la salud de los bosques se lleva a cabo desde hace varias décadas a nivel local, regional y global, utilizando indicadores estándar basados en estudios de campo realizados por personal formado que, por ejemplo, identifica el grado de defoliación de las copas (Canullo et al. 2012). Estas redes de seguimiento proporcionan un marco normalizado para evaluar la salud de los bosques, aunque en un número limitado de puntos, lo que permite un seguimiento a escala nacional, pero no se ajusta a las necesidades de los gestores forestales. Los gestores forestales públicos y privados se enfrentan cada vez más al impacto de las perturbaciones forestales en sus masas y, como se ha mencionado anteriormente, es crucial implementar sistemas de seguimiento de la FHM que identifiquen rápidamente los problemas potenciales, permitiendo intervenciones oportunas de mitigación.

Sin embargo, los muestreos clásicos in situ realizados por operadores presentan un alto grado de incertidumbre porque la calidad depende de la experiencia y la percepción subjetiva de los observadores. Por lo tanto, se necesitan cursos de formación específicos para realizar las encuestas estandarizada y óptimamente. Además, las encuestas in situ son logísticamente complejas y costosas en términos de tiempo y mano de obra, por lo que sólo son viables a escala de parcela o de parcela única. Por esta razón, la teledetección (RS) se ha establecido como parte de la FHM,

permitiendo la adquisición de indicadores de salud forestal de forma objetiva, cuantitativa y repetitiva a varias escalas espaciales (Lambert et al. 2013; Ecke et al. 2024).

En este contexto, la teledetección por satélite sigue dominando la investigación y la aplicabilidad en el sector de la FHM. De hecho, los datos de imágenes multiespectrales de acceso público, como Landsat, MODIS y Sentinel-2, permiten sistemas de seguimiento en grandes áreas, gracias a la resolución temporal y espacial que a menudo es suficiente para identificar perturbaciones (Francini y Chirici 2022). Sin embargo, como se destaca en algunas investigaciones, los satélites pueden presentar dificultades en el seguimiento, por ejemplo debido a la nubosidad (Giannetti et al. 2021) que puede oscurecer partes del bosque, lo que dificulta en algunos contextos, como las zonas montañosas de los Alpes y los Apeninos, el establecimiento de sistemas de alerta temprana. Estas cuestiones, por ejemplo, son incompatibles cuando los factores bióticos o abióticos provocan cambios rápidos en los bosques. Para superar estos problemas, los aviones tripulados pueden cumplir estos requisitos porque pueden volar por debajo de la capa de nubes (Ecke et al. 2024). En la práctica, por los elevados costes y las limitaciones logísticas, solo se usan anual o bianualmente en grandes áreas. Esto hace que, de hecho, no sean adecuados para la identificación temprana del estrés (Ecke et al. 2024).

En este contexto, los vehículos aéreos no tripulados se utilizan cada vez más, no como competidores, sino como tecnología complementaria de las plataformas tradicionales de observación de la Tierra (Ecke et al. 2024). En el contexto del Grupo Operativo Go-SURF, se han utilizado drones equipados con cámaras multiespectrales para cartografiar el estrés en las masas forestales. Los UAV, en comparación con los satélites y las aeronaves, cubren áreas más pequeñas, pero son imbatibles en resolución espacial, que puede alcanzar una distancia de muestreo del suelo del orden de centímetros. También son muy eficientes en cuanto a costes, flexibilidad y, sobre todo, tiempos de revisita, que pueden ser frecuentes al depender únicamente del operador.

El área que puede cubrirse con estos UAV oscila entre una hectárea y varios kilómetros cuadrados en un solo vuelo. En la cobertura influyen principalmente el tipo de UAV, la tecnología de propulsión, el tipo de cámara, el tipo de terreno y la accesibilidad de la zona. También hay que tener en cuenta la normativa sobre el funcionamiento de los UAV como factor limitante de la cobertura. Sin embargo, la nueva normativa europea permite volar a una altitud de 120 metros sobre el nivel del suelo con una distancia de seguridad de 500 metros, lo que permite incluso a los drones más potentes cubrir cómodamente entre 10 y 20 hectáreas en un solo vuelo.

Sin embargo, además del dron, lo que marca la diferencia a la hora de establecer un sistema FHM es el sensor que el dron puede llevar a bordo. Recientemente han aparecido en el mercado numerosas cámaras multiespectrales nuevas. Estas cámaras, gracias a su capacidad para captar diferentes longitudes de onda del espectro electromagnético, pueden utilizarse para cartografiar diversos tipos de estrés forestal (Barzagli et al. 2018; Zhang et al. 2019; Ecke et al. 2022).

Sin embargo, la variedad de cámaras disponibles en el mercado y los distintos índices de vegetación que pueden derivarse de ellas dificultan la navegación por un panorama de investigación y avances técnicos en constante evolución. Por esta razón, este artículo pretende ofrecer una visión general de los índices de vegetación útiles para cartografiar el estrés forestal, una visión general de algunas de las cámaras disponibles en el mercado y las técnicas de procesado más sencillas o prometedoras, basándose en los resultados del GO-SURF del EIP-AGRI y considerando también la bibliografía internacional, para ofrecer información útil a los técnicos implicados en la monitorización forestal.

Cámaras multiespectrales e índices de vegetación

Las cámaras multiespectrales son dispositivos avanzados de captura de imágenes que captan información visual en diferentes bandas del espectro electromagnético. Estas bandas pueden incluir el espectro visible (rojo, verde, azul) y el infrarrojo cercano (NIR) y, en algunos casos, el infrarrojo cercano de borde rojo. Al utilizar estas distintas longitudes de onda, las cámaras multiespectrales proporcionan datos detallados que pueden utilizarse para analizar diversos

aspectos de la vegetación, el suelo y los bosques. En concreto, gracias a la capacidad de adquirir información en el espectro infrarrojo, es posible investigar la actividad fotosintética de las plantas, evaluar la salud de los árboles y poner de relieve la presencia de enfermedades u otros tipos de estrés. Al igual que las cámaras RGB, pueden utilizarse para adquisiciones fotogramétricas que permiten derivar no solo datos 2D (ortomosaico multiespectral), sino también datos 3D como nubes de puntos y modelos digitales de superficie (DSM) útiles para analizar la estructura de los bosques (Barzagli et al. 2018; Giannetti et al. 2020).

Sin embargo, su principal ventaja, como ya se ha mencionado, es su capacidad para captar imágenes en diferentes longitudes de onda del espectro electromagnético, lo que permite a los operadores distinguir variaciones en el contenido de clorofila de la vegetación que pueden indicar rápidamente la presencia de estrés, enfermedades o patógenos. De hecho, gracias a la capacidad de adquirir información a diferentes longitudes de onda, pueden utilizarse fácilmente para derivar diversos índices de vegetación mediante sencillas operaciones matemáticas entre las imágenes de diferentes bandas, utilizando también aplicaciones SIG comunes como QField a través de las funciones de calculadora raster.

Entre los índices de vegetación que pueden calcularse, presentamos en la Tabla 1 los más prometedores para monitorizar el estrés en entornos forestales y que pueden calcularse con las cámaras multiespectrales disponibles actualmente.

Tabla 1 - Índices de vegetación útiles para la vigilancia forestal que pueden calcularse con cámaras multiespectrales

Índice de vegetación	**Fórmula**
NDVI (Índice de vegetación de diferencia normalizada)	$NDVI=(NIR- rojo)/(NIR+ rojo)$
NDRE (Borde rojo de diferencia normalizada)	$NDRE=(NIR-RedEdge)/(NIR+RedEdge)$
GNDVI (Índice de vegetación de diferencia normalizada verde)	$GNDVI= (NIR-Verde)/(NIR+Verde)$
LCI (Índice de clorofila foliar)	$LCI=(RedEdge- rojo)/(RedEdge+ rojo)$
SAVI (Índice de vegetación ajustado al suelo)	$SAVI=((1+L)(NIR- rojo))/(NIR+ rojo+L)$ dove L è una costante che dipende dalle condizioni del suolo (tipicamente L= 0.5
OSAVI (Índice de vegetación optimizado ajustado al suelo)	$OSAVI=(NIR- rojo)/(NIR+ rojo+0.16)$
MCARI (Índice de absorción de clorofila modificado)	$MCARI=((RedEdge- rojo)-0.2*(RedEdge-Verde))/(RedEdge+ rojo)$
CIRE (Índice clorofílico de borde rojo)	$CIRE=(NIR/RedEdge)-1$

EVI (Índice de vegetación mejorado)	EVI=2.5*((NIR- rojo)/(NIR+6* rojo-7.5* azul+1)
VARI (Índice de resistencia atmosférica visible)	VARI=(Verde- rojo)/(rojo+Verde- azul)

El NDVI ("Normalized Difference Vegetation Index", Índice de vegetación de diferencia normalizada) es quizá el índice más utilizado para controlar la salud de las plantas. Sin embargo, su tendencia a saturarse puede dificultar a veces la detección precoz del estrés en los bosques. El índice se basa en el hecho de que la clorofila de las plantas vivas refleja intensamente la luz infrarroja cercana (NIR) y absorbe la luz roja. Los valores altos de NDVI, cercanos a 1, indican una vegetación densa y sana, mientras que los valores más bajos, inferiores a 0,7, sugieren estrés, y los inferiores a 0,6 indican la muerte de las plantas. Sin embargo, según la experiencia del proyecto GO-SURF y la revisión bibliográfica en el contexto del cultivo del álamo (Chianucci et al. 2021), el NDVI puede ser el índice menos preciso para detectar el estrés.

Por ejemplo, el GNDVI ("Green Normalized Difference Vegetation Index", índice de vegetación de diferencia verde normalizada) es más sensible para la alerta temprana del estrés. Este índice es similar al NDVI, pero utiliza la banda verde en lugar de la roja para la normalización con la banda NIR. Esto lo hace útil para monitorizar plantas con alta densidad foliar o identificar estrés hídrico, permitiendo alertas tempranas (Raddi et al. 2021). Para evaluar el contenido de clorofila, el LCI (Leaf Chlorophyll Index) es muy sensible a la clorofila presente en las hojas (Gallardo-Salazar et al. 2023). La clorofila absorbe la luz roja y refleja la luz de borde rojo, por lo que este índice es útil para estimar directamente el contenido de clorofila, que es un indicador de la capacidad fotosintética de la planta. Del mismo modo, el CIRE (Chlorophyll Index Red Edge) está aún más correlacionado con el estado nutricional de las plantas (Kleinsmann et al. 2023).

El NDRE ("Normalized Difference Red Edge" o borde rojo de diferencia normalizada) es especialmente útil para identificar el estrés de las plantas en secciones de la cubierta. El borde rojo es muy sensible a los cambios en la estructura de la hoja y el contenido de clorofila, lo que permite detectar pequeñas variaciones (Minařík y Langhammer 2016). Es útil para identificar plantas que puedan estar afectadas por enfermedades o deficiencias nutricionales antes de que estos problemas sean visibles a simple vista. El MCARI (Modified Chlorophyll Absorption Ratio Index) está diseñado para ser menos sensible a las variaciones del suelo, lo que mejora la capacidad de detectar el estrés de las plantas en entornos heterogéneos con suelo expuesto (Zou et al. 2019). Para evaluar la actividad fotosintética y el vigor vegetativo, el EVI (Enhanced Vegetation Index) mejora la sensibilidad en zonas de vegetación de alta densidad y reduce las interferencias atmosféricas y del suelo en comparación con el NDVI. El VARI (Visible Atmospherically Resistant Index) se puede utilizar para supervisar la vegetación utilizando solo las bandas visibles, lo que lo hace útil en condiciones en las que las bandas NIR no están disponibles, como con las cámaras RGB.

Drones y cámaras multiespectrales en el mercado

Entre los drones con sensor multiespectral integrado, el DJI Mavic 3M combina una cámara RGB de 20 MP y cuatro cámaras multiespectrales de 5 MP que capturan en las bandas verde (560nm±16nm), roja (650nm±16nm), de borde rojo (730±16nm) y NIR (860nm±26nm), junto con un sensor de luz integrado. Esta configuración capta la irradiancia solar, lo que permite compensar a posteriori cualquier fluctuación de luz en las imágenes. El fabricante asegura una autonomía de vuelo de 43 minutos con una cobertura por vuelo de 2 km². El dron también está disponible con un módulo RTK, que proporciona una georreferenciación precisa del estudio con gran exactitud.

Otro dron de DJI con sensor integrado es el P4 Multiespectral, equipado con seis cámaras diferentes de 2,08 MP: una cámara RGB y cinco cámaras multiespectrales que capturan en las bandas azul (450±16nm), verde (560±16nm), roja (650±16nm), de borde rojo (730±16nm) e infrarroja cercana (840±26nm). Este dron también cuenta con un sensor de luz y un módulo RTK para la corrección de la luz en la imagen y la georreferenciación precisa del levantamiento. El fabricante afirma una autonomía de vuelo de 27 minutos y una superficie operativa máxima por vuelo de 0,63 km². En un estudio reciente realizado en Alemania (Ecke et al. 2024), este dron se utilizó para adquirir imágenes multiespectrales de alta resolución de 235 zonas diferentes de seguimiento forestal a gran escala (parcelas de nivel I del PCI) distribuidas en Baviera durante un periodo de seguimiento de tres años (2020-2022). A pesar de la heterogeneidad del conjunto de datos adquiridos a lo largo del tiempo bajo diversas condiciones meteorológicas y de iluminación, en bosques con composiciones diversas repartidos por una amplia zona de estudio, el artículo demuestra cómo fue posible clasificar cinco especies arbóreas, a nivel de género, árboles muertos y el estado de salud de las principales especies arbóreas en 14 clases diferentes utilizando la arquitectura EfficientNet CNN. El artículo destaca que esta metodología de seguimiento puede reducir significativamente los costes y tiempos de adquisición sobre el terreno, permitiendo la estandarización de los datos.

Entre las cámaras que pueden montarse en varios tipos de drones, como el DJI Matrice 300, el Wingtra One Gen II y el senseFly eBeeX, la MicaSense RedEdge-MX destaca como una de las más eficientes, pero también una de las más caras. Esta cámara captura imágenes en las bandas azul (475nm±20nm), verde (560nm±20nm), rojo (668nm±10nm), borde rojo (717nm±10nm) e infrarrojo cercano (840nm±40nm), ofreciendo una alta precisión y consistencia espectral, lo que la hace ideal para analizar la vegetación forestal. La cámara está equipada con un sensor de luz y un panel de reflectancia para la calibración, que debe capturarse en el despegue y el aterrizaje del dron.

Esta cámara también se probó en el proyecto GO-SURF, en el que se utilizó para adquirir imágenes de diversas zonas de la región de la Toscana mediante el dron Wingtra One Gen II. El procesamiento de imágenes mediante técnicas de segmentación basadas en el método "Simple Linear Iterative Clustering (SLIC)" (Achanta et al. 2012) permitió identificar plantas muertas y en declive mediante la identificación de umbrales de estrés. SLIC es un algoritmo utilizado para la segmentación de imágenes, en particular para la creación de superpíxeles -grupos de píxeles contiguos con características similares, que simplifican el análisis de imágenes reduciendo el número de elementos a considerar y manteniendo al mismo tiempo la mayor parte de la información relevante. Concretamente, en el proyecto GO-SURF se procesaron imágenes multiespectrales utilizando el software fotogramétrico Metashape Agisoft para generar un ortomosaico en diferentes bandas (azul, verde, rojo, borde rojo, infrarrojo cercano). Las imágenes se importaron en el software R-Cran, utilizando varios paquetes de procesamiento para inicializar el algoritmo. Durante la inicialización, el algoritmo distribuye uniformemente los centros de los superpíxeles por la imagen. Estos centros se eligen para cubrir toda la imagen de manera uniforme. A continuación, cada píxel de la imagen se asigna al centro de superpíxel más cercano en función de la distancia combinada (espacio y color). La distancia combinada tiene en cuenta tanto las coordenadas espaciales como los valores de color (espacio CIELAB). El algoritmo itera hasta segmentar las copas de los árboles individuales. Este algoritmo también se puede utilizar mediante software de escritorio como SAGA GIS. Las pruebas realizadas en el proyecto GO-SURF mostraron que la segmentación del entorno forestal funciona muy bien incluso utilizando sólo la banda del borde rojo, no múltiples bandas. Esta banda parece ser la más sensible a la hora de identificar copas individuales o porciones de copas con una actividad fotosintética similar. El método de segmentación reduce el tiempo en comparación con métodos complejos y detecta con precisión copas individuales o porciones de copas con diferentes actividades fotosintéticas, como porciones de copas muertas o en declive. Sin embargo, para clasificar las distintas clases de decaimiento (porción de cubierta muerta, porción de cubierta en declive, porción de cubierta viva), es necesario extraer índices de vegetación de los polígonos generados por SLIC, calibrando umbrales para identificar plantas muertas. Así, para cada superpíxel, se aplican umbrales a los índices de vegetación para clasificar los superpíxeles como representativos de plantas sanas, estresadas o muertas. La ventaja de este método es que la segmentación de superpíxeles reduce el número de unidades que hay que analizar, lo que

hace que el análisis sea más rápido y eficaz. Además, los superpíxeles tienden a seguir los contornos naturales de las plantas, lo que mejora la precisión de la clasificación en comparación con los métodos de píxel único.

Figura 1 - Identificación de superpíxeles con contornos blancos, detección de cubierta decreciente en amarillo y partes de cubierta muerta en azul

El uso de superpíxeles SLIC en imágenes de drones representa una técnica avanzada para la identificación y el seguimiento de plantas muertas. Al segmentar las imágenes en regiones homogéneas y aplicar umbrales a los índices de vegetación, es posible obtener un mapa preciso de las zonas problemáticas, lo que permite realizar intervenciones oportunas y específicas en la gestión de los cultivos.

Entre otras cámaras multiespectrales del mercado con un coste inferior a las anteriormente mencionadas se encuentran la Parrot Sequoia, la Sentera Double 4K, la Mapir Survey3 y la Mapir Survey2. Todas estas cámaras, al igual que las demás, adquieren información multiespectral en las bandas roja, azul, verde e infrarroja cercana, pero no en la infrarroja cercana de borde rojo. Esto las hace menos eficaces para calcular algunos de los índices mencionados anteriormente.

Conclusiones

Es imposible tener una visión completa de todas las cámaras disponibles en el mercado en este momento. Sin embargo, basándonos en nuestra experiencia, es esencial centrarse en aquellas cámaras que permiten calcular diferentes índices de vegetación, lo que puede contribuir a cartografiar con precisión los daños potenciales. Esto se debe a que cada vez es más importante poder intervenir con prontitud. A pesar de algunas limitaciones, los drones equipados con cámaras multiespectrales representan una herramienta potente y versátil para la vigilancia forestal, como demuestra el proyecto GO-SURF ya ejecutado a nivel italiano. Se prevé que los nuevos avances tecnológicos y la creciente accesibilidad a los drones harán que estas herramientas sean cada vez más fundamentales en la gestión forestal sostenible.

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4. Innovation name: Establishing new business models with NWFP

Kathrin Böhling and Helena Eisele, LWF

29.05.2025

Geschäftsentwicklung für Honig aus dem Bienenwald

Honig zählt neben Pilzen, Beeren, Nüssen und Harz zu den sogenannten Nicht-Holz Waldprodukten. Laut Definition der Internationalen Welternährungsorganisation (FAO) handelt es sich bei Nicht-Holzwaldprodukten um Güter bzw. Produkte aus dem Wald mit biologischem Ursprung: "… goods derived from forests that are tangible and physical objects of biological origin other that wood." Hierzulande gilt für Wälder das freie Betretungsrecht. Hobbysammler dürfen für den eigenen Gebrauch und in begrenzten Mengen Pilze und Beeren sammeln. Auch trifft man bei Waldbesuchen gelegentlich auf Bienenstöcke, die Imkerinnen und Imker nach Abstimmung der betreffenden Waldbesitzenden dort aufstellen.

Die Erwirtschaftung von Erträgen aus diesen Nicht-Holz Waldprodukten ist in Deutschland jedoch unüblich. Private Forstbetriebe mit über 200 ha Wald erwirtschaften nahezu 100% ihrer Einnahmen aus dem Verkauf von Holz, für

kommunale Forstbetriebe sind es über 90% (Wühr 2019). Kleinprivatwaldbesitzende mit weniger als 50 ha verkaufen zumindest einen Teil ihrer Holzernte als Stammholz. Insbesondere Kleinstprivatwaldbesitzende mit weniger als 5 ha Wald nutzen ihr Holz jedoch überwiegend für energetische Zwecke (Hastreiter 2023). Für die Vermarktung von Nicht-Holz Waldprodukte gibt es kaum Vertriebswege.

Potenziale von Nicht-Holz Waldprodukten als Geschäftsfeld

Das innovative Praxisprojekt „Zukunftsfähiger Bienenwald Hessen“, das für die Dauer von 3 Jahren aus Mitteln der Gemeinsam Agrarpolitik finanziert wird (2022-2025), tritt den Beweis an, dass sich die Geschäftsentwicklung für Honig und Nüsse lohnen könnte. Dies legt eine im Februar 2024 abgerundete Masterarbeit der Uni Göttingen nahe, die „die Rentabilität einer auf Nebennutzung ausgerichteten naturnahen Waldwirtschaft“ untersucht hat. Mithilfe der sogenannten Kapitalwertmethode – eine in der Forstökonomie verbreiteten Methode, die den Einsatz von Kapital für forstliche Produktionssysteme vergleichend analysiert – hat Marcus Ziegler die Ertragsmöglichkeiten für eine Biodiversitäts-fördernde Wiederbewaldung mit dem Schwerpunkt auf Nicht-Holz Waldprodukte für einen angenommenen Nutzungszeitraum von 60 Jahren untersucht.

Bienenwald Hessen

Das Projekt „Zukunftsfähiger Bienenwald“ in Hessen

Hessen gehört zu den waldreichsten Bundesländern in Deutschland. Die mit Fichten dominierten Wälder sind in den letzten Jahren jedoch von den Auswirkungen des Klimawandels wie Wetterextreme, Stürme und sich daran anschließendem Borkenkäferbefall stark beeinträchtigt. Abgestorbene und kahle Waldflächen prägen in weiten Teilen das Landschaftsbild in Mitteldeutschland. Zwei landwirtschaftliche Betriebe haben sich deshalb mit Imkern und Bienenspezialisten zusammengetan, um eine Alternative zur Aufforstung mit Fichten und anderen Nadelbaumarten zu entwickeln. Sie gründeten die Operationelle Gruppe "Zukunftsfähiger Bienenwald Hessen", der vielfältiger Lebensraum für Insekten und andere bestäubende Insekten ist, viel CO2 speichert und Holzproduktion ermöglicht. Das Konzept verbindet den Naturschutz und den Schutz von Bienen und anderen Bestäubern mit der Forstwirtschaft und der Produktion von Nichtholzprodukten aus dem Wald.

"Wir wollten einen Wald gestalten, der für Honigbienen und andere bestäubende Insekten Lebensräume mit klimaresistenten Baumarten bietet. Auch die Erhöhung der Artenvielfalt im Ökosystem Wald war uns wichtig. Gleichzeitig muss der Wald für die Waldbesitzenden finanziell rentabel sein, und so war ein weiteres wichtiges Element des Entwurfs, dass sich Ökonomie und Ökologie nicht gegenseitig ausschließen müssen." (Judith Treis, Koordinatorin des Projekts „Zukunftsfähiger Bienenwald")

Nicht-Holz Waldprodukte bieten veritable Einkommensmöglichkeiten

Eine Möglichkeit, die Rentabilität von forstlichen Investitionen einzuschätzen ist die Kapitalwertmethode. Bei dieser Methode wird die Aufforstung einer Fläche mit einem bestimmten forstlichen Produktionssystem als Investition betrachtet. Insgesamt wurden 5 Varianten solcher Produktionssysteme untersucht. Dem Fichtenreinbestand mit dem Ziel einer reinen Holzproduktion wurden zwei Varianten von Buchen-Douglasien-Mischbeständen (mit und ohne Honigproduktion) sowie zwei Varianten mit unterschiedlichen Edellaubgehölzen, die sich in der Bandbreite der Nicht-Holz-Waldprodukte (Honig, Nüsse, Himbeeren) voneinander unterscheiden, gegenübergestellt.

Marcus Ziegler zeigt, dass sich mit Nicht-Holz Waldprodukten neue Einkommensmöglichkeiten für Waldbesitzende erschließen lassen. „Eindeutig ist" – so das zentrale Ergebnis seiner Masterarbeit – „dass zusätzliche Flächennutzung [mit Gehölzen für Honig und Nüsse] den Kapitalwert weit über ein Niveau von Flächen mit reiner Holzproduktion anheben kann." Mit Honig kann die nach einer Aufforstung noch offene Waldgesellschaft eines Buchen-Douglasien Mischbestandes relativ schnell ökonomisch genutzt werden. Eine höhere Rentabilität verspricht der Anbau eines Kirschen-Wertholzbestandes mit Maronennutzung und Honigproduktion. Die höchsten Erlöse würde aber die Variante eines Laubbaumbestandes mit Nuss-Beerenplantage und Honig erzielen. Auf diesem sehr plantagenähnlichen Bestand, welcher nur unter bestimmten Voraussetzungen Anwendung findet, stabilisieren sich die verschiedenen Nebennutzungsformen gegenseitig. Insgesamt ergibt sich daher: Je mehr Nicht-Holz Waldprodukte auf einer Fläche genutzt werden, desto höher ist die Annuität.

Die Untersuchung hat außerdem die staatliche Förderung von einzelnen Baumarten und Maßnahmen wie die Einzäunung von aufgeforsteten Flächen als „signifikanten Einflussfaktor auf die Vorteilhaftigkeit und Amortisationszeiträume der Investitionen" aufgezeigt. Die Fördervorgaben von Forstverwaltungen können somit nicht nur Anreize für die Anpflanzung und Pflege von insektenfreundlichen Wäldern, sondern auch für die Etablierung neuer Einkommensmöglichkeiten für Waldbesitzende schaffen.

Geschäftsentwicklung für Waldhonig braucht gute Rahmenbedingungen

Das Europäische Forstinstitut (EFI) und die FAO haben zuletzt verstärkt auf das Potenzial von Nicht-Holz Waldprodukten hingewiesen (Martinez de Arano et al. 2021). In dem kürzlich erschienen Bericht „Non-wood forest products for people, nature and the green economy. Recommendations for policy priorities in Europe" kommt das Autoren-team zu dem Schluss, dass vier Faktoren erfüllt sein sollten. Das Projekt „Zukunftsfähiger Bienenwald" zeigt wie der erste (1) Faktor – Sicherung und Schutz eines nachhaltigen Angebots von Nicht-Holzprodukten – realisiert werden kann. Hinzu kommen drei weitere Faktoren: (2) Aufbau von wettbewerbsfähigen und fairen Wertschöpfungsketten; (3) Transparenz und Rückverfolgbarkeit von Nicht-Holz Waldprodukten; und (4) Koordinierung relevanter Politikfelder (Forstwirtschaft, Naturschutz, Ernährung, Ländliche Entwicklung) und Investitionsförderung.

Im Projekt „Zukunftsfähiger Bienenwald" arbeiten Landwirte und Imker regional zusammen. Bestehende Vermarktungswege für Honig werden genutzt, um neue Produkte zu etablieren. Damit ist ein wichtiger Schritt für ein neues Geschäftsfeld gesetzt. Für den flächigen Ausbau braucht es jedoch weitere Unterstützung von Entscheidungsträgern in der Forstwirtschaft und Politik.

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29.05.2025

Title of innovation: Business development for honey from the bee forest

Alongside mushrooms, berries, nuts and resin, honey is one of the so-called non-wood forest products. According to the definition of the International Food and Agriculture Organisation (FAO), non-wood forest products are goods or products from forests of biological origin: ".. goods derived from forests that are tangible and physical objects of biological origin other than that wood." Gemany, the right of free access applies to forests. Hobby collectors are allowed to pick mushrooms and berries for their own use and in limited quantities. When visiting forests, one occasionally comes across beehives that beekeepers have set up there with the agreement of the forest owners concerned.

However, it is unusual in Germany to generate income from these non-wood forest products. Private forest enterprises with more than 200 hectares of forest generate almost 100% of their income from the sale of timber, for municipal forest enterprises it is over 90% (Wühr 2019). Small private forest owners with less than 50 ha sell at least part of their timber harvest as logs. However, small private forest owners with less than 5 ha of forest in particular use their wood primarily for energy purposes (Hastreiter 2023). Channels for the marketing of non-timber forest products are hard to find.

The potential of non-wood forest products for business development

The innovative practical project 'Sustainable Bee Forest Hesse', which is being funded by the Joint Agricultural Policy for a period of three years (2022-2025), proves that business development for honey and nuts could be worthwhile.

This is suggested by a master's thesis completed in February 2024 at the University of Göttingen, which examined 'the profitability of near-natural forestry geared towards secondary use'. Using the net present value method - a method widely used in forestry economics that analyses the use of capital for forestry production systems on a comparative basis - Marcus Ziegler examined the earnings potential for biodiversity-promoting reforestation with a focus on non-wood forest products for an assumed rotation period of 60 years.

The project "Sustainable bee forest" in Hesse

Hesse is one of the most densely forested federal states in Germany. However, the spruce-dominated forests have been severely affected by the effects of climate change in recent years, such as extreme weather events, storms and subsequent bark beetle infestations. Dead and bare forest areas characterize large parts of the landscape in central Germany. Two agricultural businesses have therefore joined forces with beekeepers and bee specialists to develop an alternative to reforestation with spruce and other coniferous tree species. They founded the Operational Group "Sustainable Bee Forest Hesse", which provides a diverse habitat for insects and other pollinating insects, stores a lot of CO2 and enables wood production. The concept combines nature conservation and the protection of bees and other pollinators with forestry and the production of non-timber forest products.

> *"We wanted to design a forest that provides habitats for honey bees and other pollinating insects with climate-resilient tree species. The increasing biodiversity in the forest ecosystem was also important to us. At the same time, the forest needs to be financially viable for the forest owners, and so another important element of the design was that economy and ecology do not have to be mutually exclusive." (Judith Treis, project coordinator)*

Non-wood forest products offer new sources of income

One way to estimate the profitability of forestry investments is the net present value method. In this method, the afforestation of an area with a specific forestry production system is regarded as an investment. A total of 5 variants of such production systems were analyzed. Two variants of mixed beech-Douglas fir stands (with and without honey production) and two variants with different deciduous trees, which differ in the range of non-timber forest products (honey, nuts, raspberries), were compared to the pure spruce stand, aiming at pure timber production.

Marcus Ziegler shows that non-wood forest products can open up new income opportunities for forest owners. He concludes: "It is clear that additional land utilization [with woody plants for honey and nuts] can raise the capital value far above the level of land with pure wood production." With honey, the forest land that is still open after reforestation as a mixed beech-douglas fir stand can be utilized economically relatively quickly. The variant of the cherry timber stand with chestnut utilization and honey production might generate an even higher profitability. However, the highest revenues may be achieved by the variant of a deciduous tree stand with nut-berry plantation and honey. On

this very plantation-like stand, which is only used under certain conditions, the various secondary uses stabilize each other. Overall, this means that the more non-timber forest products are utilized on an area, the higher the annuity.

The study also showed that state subsidies for individual tree species and measures such as fencing afforested areas are a ‘significant factor influencing the profitability and amortization periods of investments’. The funding requirements of forest administrations can therefore not only incentivize the planting and maintenance of insect-friendly forests, but also the establishment of new income opportunities for forest owners.

Business development for honey from forests requires supportive framework conditions

The European Forest Institute (EFI) and the FAO have recently emphasised the potential of non-wood forest products (Martinez de Arano et al. 2021). In the recently published report “Non-wood forest products for people, nature and the green economy. Recommendations for policy priorities in Europe", the team of authors concludes that four factors should be fulfilled. The “Sustainable Bee Forest” shows how the first (1) factor - Securing the conservation and sustainable supply of NWFP - can be realized. In addition, there are three further factors: (2) Building competitive and equitable value chains; (3) Providing transparency, data, and information flow on NWFP; and (4) Creating enabling conditions.

Farmers and beekeepers work together regionally in the “Sustainable Bee Forest” project. Existing marketing channels for honey will be utilized to establish the new products. This is an important step for business development. However,

further support from decision-makers in forestry and politics is needed to encourage other forest owners to manage their land for non-wood forest products.

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5. **Innovation title:** Course on GIS and Remote Sensing Data to monitor forest ecosystem (GO-SURF)

Uporaba GIS-a i podataka daljinskog istraživanja za praćenje šumskih ekosustava (GO SURF)

Održivo upravljanje šumama ključno je za održavanje ekološke ravnoteže, osiguranje bioraznolikosti i borbu protiv klimatskih promjena. Prisutnost geoprostornih tehnologija, posebice geo-informacijskih sustava (GIS) i daljinskog istraživanja, revolucionirala je praćenje i upravljanje šumama. Operativna grupa GO SURF (OG) predstavlja značajan korak naprijed u ovom području, pružajući strukturirani tečaj osmišljen za unapređenje sposobnosti stručnjaka uključenih u praćenje šumskih ekosustava.

GO SURF nije razvio samo napredni sustav za podršku odlučivanju, već i obrazovni program s ciljem osposobljavanja dionika osnovnim vještinama u GIS-u i daljinskom istraživanju. Ovaj članak pruža uvid u ciljeve, strukturu i utjecaj tečaja, naglašavajući njegovu važnost za održivo upravljanje šumama.

Primarni cilj GO SURF tečaja je pružiti sveobuhvatnu obuku u GIS-u i daljinskom istraživanju, s naglaskom na njihovu primjenu u praćenju šumskih ekosustava. Specifični ciljevi obuhvaćaju:

- Razumijevanje osnova: Sudionici stječu temeljito razumijevanje principa GIS-a i daljinskog istraživanja.
- Prikupljanje i obrada podataka: Obuka u prikupljanju, obradi i upravljanju geoprostornim podacima.
- Primjena u praćenju šuma: Praktične vještine u korištenju ovih tehnologija za praćenje zdravlja šuma, praćenje promjena i podršku održivom upravljanju.
- Podrška odlučivanju: Poboljšanje sposobnosti donošenja informiranih odluka na temelju analize prostornih podataka.

GO SURF tečaj pažljivo je dizajniran kako bi pokrio sve ključne aspekte GIS-a i daljinskog istraživanja. Podijeljen je u nekoliko modula, od kojih se svaki fokusira na različite aspekte ovih tehnologija i njihove primjene u praćenju šuma.

Modul 1: Uvod u GIS i daljinsko istraživanje - Ovaj temeljni modul uvodi sudionike u osnovne pojmove i principe GIS-a i daljinskog istraživanja. Ključne teme uključuju:

- Osnove GIS-a: Razumijevanje vrsta prostornih podataka, koordinatnih sustava i kartografskih projekcija.

- Osnove daljinskog istraživanja: Pregled satelitskih snimaka, zračnih fotografija i elektromagnetskog spektra.
- Softverski alati: Uvod u popularne GIS i softvere za daljinsko istraživanje kao što su QGIS, ArcGIS i Google Earth Engine.

Modul 2: Prikupljanje i obrada podataka Visokokvalitetni podaci ključni su za učinkovitu analizu. Ovaj modul pokriva:

- Izvori podataka: Tehnike za prikupljanje satelitskih snimaka, zračnih fotografija i podataka s terena.
- Tehnike obrade: Koraci poput geometrijske i radiometrijske korekcije, kalibracije i poboljšanja.
- Integracija podataka: Metode za integraciju podataka iz različitih izvora kako bi se stvorili sveobuhvatni skupovi podataka.

Modul 3: Primjene u šumskim ekosustavima - Sudionici uče kako primijeniti GIS i tehnologije daljinskog istraživanja za praćenje šumskih ekosustava:

- Kartiranje šumskog pokrova: Tehnike za stvaranje točnih karata šumskog pokrova i otkrivanje promjena tijekom vremena.
- Procjena zdravlja šuma: Korištenje daljinskog istraživanja za identifikaciju bolesti, napada štetnika i ekoloških stresora.
- Praćenje krčenja i pošumljavanja: Praćenje promjena šumskog pokrova i procjena napora pošumljavanja.
- Procjena zaliha ugljika i biomase: Procjena šumske biomase i zaliha ugljika za ublažavanje klimatskih promjena.

Modul 4: Napredne analitičke tehnike - Ovaj modul fokusira se na napredne analitičke metode:

- Prostorna analiza: Tehnike za analizu prostornih obrazaca i odnosa unutar šumskih ekosustava.
- Analiza vremenskih serija: Praćenje promjena u šumskom pokrovu i zdravlju pomoću podataka vremenskih serija.
- Strojno učenje: Primjena algoritama strojnog učenja za klasifikaciju pokrova zemljišta i predviđanje promjena u šumama.

Modul 5: Praktične sesije i studije slučaja - Praktična obuka ključni je dio tečaja. Ovaj modul uključuje:

- Praktične vježbe: Rad s stvarnim skupovima podataka za primjenu naučenih pojmova.
- Studije slučaja: Dubinske analize uspješnih primjena GIS-a i daljinskog istraživanja u praćenju šuma.
- Projektni rad: Sudionici provode projekte kako bi primijenili svoje vještine na specifične probleme praćenja šuma.

Modul 6: Politike i donošenje odluka - Razumijevanje uloge GIS-a i daljinskog istraživanja u politici i donošenju odluka ključno je za učinkovito upravljanje šumama:

- Ekološke politike: Uloga geoprostornih tehnologija u formuliranju i provođenju ekoloških politika.
- Studije slučaja utjecaja: Primjeri kako su podaci GIS-a i daljinskog istraživanja informirali odluke i strategije očuvanja.

Sudionici GO SURF tečaja dobivaju brojne pogodnosti, unapređujući svoje sposobnosti u praćenju i upravljanju šumama.

Tehnička stručnost - Tečaj pruža detaljnu obuku o softverima za GIS i daljinsko istraživanje, omogućujući sudionicima da postanu stručni u tim alatima. Ova tehnička stručnost ključna je za provođenje točnih analiza i izradu pouzdanih rezultata.

Analitičke vještine - Sudionici razvijaju jake analitičke vještine, omogućujući im da učinkovito interpretiraju geoprostorne podatke i donose informirane odluke na temelju svojih analiza. Ove vještine ključne su za prepoznavanje trendova, obrazaca i odnosa unutar šumskih ekosustava.

Praktično iskustvo - Praktična obuka sa stvarnim skupovima podataka i studijama slučaja osigurava da sudionici mogu primijeniti svoje vještine u praktičnim situacijama. Ovo praktično iskustvo neprocjenjivo je za profesionalce koji rade u upravljanju šumama i očuvanju.

Mogućnosti umrežavanja - GO SURF tečaj pruža mogućnosti za sudionike da se povežu s profesionalcima i stručnjacima u području praćenja šuma i upravljanja okolišem. Ove veze mogu dovesti do suradnji, partnerstava i profesionalnog rasta.

Primjene GIS-a i daljinskog istraživanja u praćenju šuma - Primjena GIS-a i daljinskog istraživanja u praćenju šuma je široka i raznolika. Neke ključne primjene uključuju:

1. Kartiranje šumskog pokrova - Točne karte šumskog pokrova ključne su za razumijevanje opsega i raspodjele šuma. GIS i tehnologije daljinskog istraživanja omogućuju stvaranje detaljnih i ažuriranih karata šumskog pokrova. Ove karte koriste se u razne svrhe, uključujući planiranje korištenja zemljišta, očuvanje bioraznolikosti i ublažavanje klimatskih promjena.

2. Praćenje krčenja i pošumljavanja - Praćenje trendova krčenja i pošumljavanja ključno je za procjenu utjecaja ljudskih aktivnosti i prirodnih poremećaja na šumske ekosustave. Podaci daljinskog istraživanja mogu se koristiti za otkrivanje promjena u šumskom pokrovu tijekom vremena, identifikaciju žarišta krčenja šuma i procjenu uspjeha napora pošumljavanja.

3. Procjena zdravlja šuma - Zdravlje šuma pod utjecajem je niza čimbenika, uključujući bolesti, štetnike i ekološke stresore. Tehnologije daljinskog istraživanja mogu se koristiti za praćenje zdravlja šuma otkrivanjem promjena u vegetacijskom pokrovu, identifikacijom znakova bolesti ili napada štetnika i procjenom utjecaja ekoloških stresora kao što su suša ili zagađenje.

4. Procjena biomase i zaliha ugljika - Šume igraju ključnu ulogu u sekvestraciji ugljika i ublažavanju klimatskih promjena. Procjena šumske biomase i zaliha ugljika ključna je za razumijevanje ugljične dinamike šumskih ekosustava i razvijanje strategija za upravljanje ugljikom. Podaci daljinskog istraživanja, kombinirani s terenskim mjerenjima i GIS analizom, mogu se koristiti za precizno procjenjivanje šumske biomase i zaliha ugljika.

5. Praćenje staništa i bioraznolikosti - Šume su dom velikom broju biljnih i životinjskih vrsta. Praćenje staništa i bioraznolikosti ključno je za napore očuvanja. GIS i tehnologije daljinskog istraživanja mogu se koristiti za mapiranje tipova staništa, procjenu kvalitete staništa i praćenje promjena u bioraznolikosti tijekom vremena.

Kako bismo ilustrirali utjecaj GO SURF-a, u nastavku ćemo prikazati slučaj gdje su tečaj i njegove primjene napravile značajnu razliku u praćenju i upravljanju šumama.

GO SURF je implementiran u regiji Toskana u Italiji, području poznatom po svojim raznolikim šumskim ekosustavima. Projekt je imao za cilj unaprijediti prakse upravljanja šumama korištenjem GIS-a i tehnologija daljinskog istraživanja.

Specifični ciljevi projekta uključivali su:

- Unapređenje praćenja šuma: Poboljšanje točnosti i učinkovitosti kartiranja šumskog pokrova i procjene zdravlja šuma.
- Podrška održivom upravljanju: Pružanje uvida temeljenih na podacima za podršku održivim praksama upravljanja šumama.
- Angažiranje dionika: Uključivanje lokalnih zajednica, donositelja politika i upravitelja šuma u proces praćenja.

Projekt je proveden u nekoliko faza:

- Obuka i izgradnja kapaciteta: GO SURF tečaj je proveden kako bi se lokalni dionici obučili za korištenje GIS-a i tehnologija daljinskog istraživanja. Sudionici su uključivali upravitelje šuma, donositelje politika i istraživače.
- Prikupljanje i analiza podataka: Prikupljeni su satelitski snimci visoke rezolucije i terenski podaci te obrađeni korištenjem GIS-a i softvera za daljinsko istraživanje. Primijenjene su napredne analitičke tehnike za generiranje karata šumskog pokrova, procjene zdravlja i procjene biomase.
- Podrška odlučivanju: Obrađeni podaci i analize integrirani su u sustav za podršku odlučivanju, pružajući dionicima praktične uvide za upravljanje šumama.

Projekt je postigao nekoliko pozitivnih rezultata:

- Poboljšano praćenje: Točnost i učinkovitost praćenja šuma značajno su poboljšani, omogućujući pravovremeno otkrivanje promjena u šumskom pokrovu i zdravlju.
- Informirano odlučivanje: Uvidi temeljeni na podacima podržali su informiranije donošenje odluka, što je dovelo do boljih praksi upravljanja i politika.
- Angažman dionika: Uključenje lokalnih dionika u proces praćenja potaknulo je veću suradnju i posvećenost održivom upravljanju šumama.

Iako tehnologije GIS-a i daljinskog istraživanja nude moćne alate za praćenje šuma, nekoliko izazova ostaje:

Dostupnost i kvaliteta podataka - Pristup visokokvalitetnim i ažuriranim podacima daljinskog istraživanja može biti izazov, posebno u regijama s ograničenim resursima. Napori za povećanje dostupnosti besplatnih i otvorenih podataka, kao i poboljšanja u kvaliteti podataka, ključni su za učinkovito praćenje šuma.

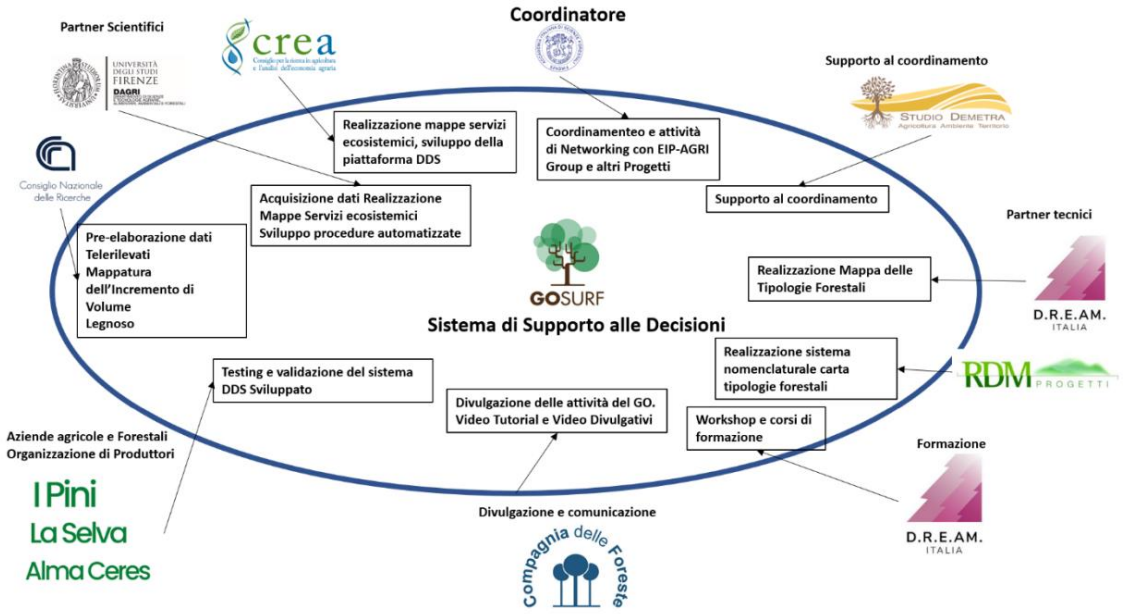
Tehnička stručnost - Učinkovita upotreba GIS-a i tehnologija daljinskog istraživanja zahtijeva određenu razinu tehničke stručnosti. Programi obuke poput GO SURF tečaja ključni su za izgradnju kapaciteta i osiguravanje da profesionalci imaju vještine potrebne za učinkovito korištenje ovih tehnologija.

Integracija izvora podataka - Integracija podataka iz više izvora, uključujući satelitske snimke, zračne fotografije i terenska mjerenja, može biti složena. Razvijanje metoda za besprijekornu integraciju podataka ključno je za pružanje sveobuhvatnog razumijevanja šumskih ekosustava.

Napredak tehnologije - Brzi napredak u tehnologijama daljinskog istraživanja, kao što je razvoj novih senzora i sve veća upotreba bespilotnih letjelica (UAV-ova), nudi nove prilike za praćenje šuma. Držanje koraka s ovim napretkom i njihova integracija u programe praćenja ključno je za ostanak na čelu upravljanja šumama.

GO SURF i njegov sveobuhvatni tečaj o GIS-u i podacima daljinskog istraživanja predstavljaju značajan napredak u području praćenja šumskih ekosustava. Osposobljavajući dionike potrebnim vještinama i znanjem, tečaj doprinosi održivom upravljanju i očuvanju šumskih ekosustava. Kako šume nastavljaju biti pod pritiskom ljudskih aktivnosti i klimatskih promjena, inicijative poput GO SURF-a ključne su za osiguravanje njihovog zdravlja i otpornosti za buduće

generacije. Kroz tehničku stručnost, analitičke vještine, praktično iskustvo i mogućnosti umrežavanja, sudionici su osnaženi da donose odluke temeljene na podacima koje podržavaju održivo upravljanje šumama i napore očuvanja.



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GO SURF: A Course on GIS and Remote Sensing Data for Monitoring Forest Ecosystems

Sustainable forest management is vital for maintaining ecological balance, ensuring biodiversity, and combating climate change. The presence of geospatial technologies, particularly Geographic Information Systems (GIS) and remote sensing, has revolutionized forest monitoring and management. The GO SURF operational group (OG) represents a significant step forward in this field, providing a structured course designed to enhance the capabilities of professionals involved in forest ecosystem monitoring.

GO SURF did not developed only an advanced decision support system but also an educational program aimed at equipping stakeholders with essential skills in GIS and remote sensing. This article provides insight into the course's objectives, structure, and impact, emphasizing its importance in sustainable forest management.

The primary goal of the GO SURF course is to provide comprehensive training in GIS and remote sensing, focusing on their applications in forest ecosystem monitoring. The specific objectives include:

- Understanding the Fundamentals: Participants gain a thorough understanding of GIS and remote sensing principles.
- Data Acquisition and Processing: Training in acquiring, preprocessing, and managing geospatial data.
- Application in Forest Monitoring: Practical skills in using these technologies to monitor forest health, track changes, and support sustainable management.
- Decision-Making Support: Enhancing the ability to make informed decisions based on spatial data analysis.

The GO SURF course is meticulously designed to cover all critical aspects of GIS and remote sensing. It is divided into several modules, each focusing on different facets of these technologies and their applications in forest monitoring.

Module 1: Introduction to GIS and Remote Sensing

This foundational module introduces participants to the basic concepts and principles of GIS and remote sensing. Key topics include:

- GIS Fundamentals: Understanding spatial data types, coordinate systems, and map projections.
- Remote Sensing Basics: Overview of satellite imagery, aerial photography, and the electromagnetic spectrum.
- Software Tools: Introduction to popular GIS and remote sensing software such as QGIS, ArcGIS, and Google Earth Engine.

Module 2: Data Acquisition and Preprocessing

High-quality data is crucial for effective analysis. This module covers:

- Data Sources: Techniques for acquiring satellite imagery, aerial photographs, and field data.
- Preprocessing Techniques: Steps like geometric and radiometric correction, calibration, and enhancement.

- Data Integration: Methods for integrating data from various sources to create comprehensive datasets.

Module 3: Forest Ecosystem Applications

Participants learn how to apply GIS and remote sensing technologies to monitor forest ecosystems:

- Forest Cover Mapping: Techniques for creating accurate forest cover maps and detecting changes over time.
- Forest Health Assessment: Using remote sensing to identify diseases, pest infestations, and environmental stressors.
- Deforestation and Reforestation Monitoring: Tracking changes in forest cover and assessing reforestation efforts.
- Carbon Stock and Biomass Estimation: Estimating forest biomass and carbon stocks for climate change mitigation.

Module 4: Advanced Analytical Techniques

This module focuses on advanced analytical methods:

- Spatial Analysis: Techniques for analysing spatial patterns and relationships within forest ecosystems.
- Time Series Analysis: Monitoring changes in forest cover and health using time series data.
- Machine Learning: Applying machine learning algorithms to classify land cover and predict forest changes.

Module 5: Practical Sessions and Case Studies

Hands-on training is a critical component of the course. This module includes:

- Practical Exercises: Working with real-world datasets to apply the concepts learned.
- Case Studies: In-depth analyses of successful applications of GIS and remote sensing in forest monitoring.
- Project Work: Participants undertake projects to apply their skills to specific forest monitoring problems.

Module 6: Policy and Decision-Making

Understanding the role of GIS and remote sensing in policy and decision-making is crucial for effective forest management:

- Environmental Policy: The role of geospatial technologies in formulating and implementing environmental policies.
- Impact Case Studies: Examples of how GIS and remote sensing data have informed policy decisions and conservation strategies.

Participants of the GO SURF course gain numerous benefits, enhancing their capabilities in forest monitoring and management.

Technical Proficiency - The course provides in-depth training on GIS and remote sensing software, enabling participants to become proficient in these tools. This technical proficiency is essential for conducting accurate analyses and producing reliable results.

Analytical Skills - Participants develop strong analytical skills, allowing them to interpret geospatial data effectively and make informed decisions based on their analyses. These skills are critical for identifying trends, patterns, and relationships within forest ecosystems.

Practical Experience - Hands-on training with real-world datasets and case studies ensures that participants can apply their skills in practical situations. This practical experience is invaluable for professionals working in forest management and conservation.

Networking Opportunities - The GO SURF course provides opportunities for participants to connect with professionals and experts in the field of forest monitoring and environmental management. These connections can lead to collaborations, partnerships, and professional growth.

Applications of GIS and Remote Sensing in Forest Monitoring - The application of GIS and remote sensing in forest monitoring is vast and varied. Some key applications include:

1. Forest Cover Mapping - Accurate forest cover maps are essential for understanding the extent and distribution of forests. GIS and remote sensing technologies enable the creation of detailed and up-to-date forest cover maps. These maps are used for a variety of purposes, including land use planning, biodiversity conservation, and climate change mitigation.

2. Deforestation and Reforestation Monitoring - Monitoring deforestation and reforestation trends is crucial for assessing the impacts of human activities and natural disturbances on forest ecosystems. Remote sensing data can be used to detect changes in forest cover over time, identify hotspots of deforestation, and evaluate the success of reforestation efforts.

3. Forest Health Assessment - Forest health is influenced by a range of factors, including diseases, pests, and environmental stressors. Remote sensing technologies can be used to monitor forest health by detecting changes in vegetation cover, identifying signs of disease or pest infestations, and assessing the impacts of environmental stressors such as drought or pollution.

4. Biomass and Carbon Stock Estimation - Forests play a critical role in sequestering carbon and mitigating climate change. Estimating forest biomass and carbon stocks is essential for understanding the carbon dynamics of forest ecosystems and developing strategies for carbon management. Remote sensing data, combined with field measurements and GIS analysis, can be used to estimate forest biomass and carbon stocks accurately.

5. Habitat and Biodiversity Monitoring - Forests are home to a vast array of plant and animal species. Monitoring habitat and biodiversity is essential for conservation efforts. GIS and remote sensing technologies can be used to map habitat types, assess habitat quality, and monitor changes in biodiversity over time.

To illustrate the impact of the GO SURF, let's examine a case study where the course and its applications have made a significant difference in forest monitoring and management.

The GO SURF was implemented in the Tuscany region of Italy, an area known for its diverse forest ecosystems. The project aimed to improve forest management practices by leveraging GIS and remote sensing technologies.

The specific objectives of the project included:

- Enhancing Forest Monitoring: Improving the accuracy and efficiency of forest cover mapping and health assessment.

- Supporting Sustainable Management: Providing data-driven insights to support sustainable forest management practices.
- Engaging Stakeholders: Involving local communities, policymakers, and forest managers in the monitoring process.

The project was carried out in several phases:

- Training and Capacity Building: The GO SURF course was conducted to train local stakeholders in the use of GIS and remote sensing technologies. Participants included forest managers, policymakers, and researchers.
- Data Collection and Analysis: High-resolution satellite imagery and field data were collected and processed using GIS and remote sensing software. Advanced analytical techniques were applied to generate forest cover maps, health assessments, and biomass estimates.
- Decision Support: The processed data and analyses were integrated into a decision support system, providing stakeholders with actionable insights for forest management.

The project achieved several positive outcomes:

- Improved Monitoring: The accuracy and efficiency of forest monitoring were significantly improved, enabling the timely detection of changes in forest cover and health.
- Informed Decision-Making: Data-driven insights supported more informed decision-making, leading to better management practices and policies.
- Stakeholder Engagement: The involvement of local stakeholders in the monitoring process fostered greater collaboration and commitment to sustainable forest management.

While GIS and remote sensing technologies offer powerful tools for forest monitoring, several challenges remain:

Data Availability and Quality - Access to high-quality and up-to-date remote sensing data can be a challenge, particularly in regions with limited resources. Efforts to increase the availability of free and open-access data, as well as improvements in data quality, are essential for effective forest monitoring.

Technical Expertise - The effective use of GIS and remote sensing technologies requires a certain level of technical expertise. Training programs like the GO SURF course are crucial for building capacity and ensuring that professionals have the skills needed to utilize these technologies effectively.

Integration of Data Sources - Integrating data from multiple sources, including satellite imagery, aerial photographs, and field measurements, can be complex. Developing methods for seamless data integration is essential for providing a comprehensive understanding of forest ecosystems.

Advancements in Technology - Rapid advancements in remote sensing technologies, such as the development of new sensors and the increasing use of unmanned aerial vehicles (UAVs), offer new opportunities for forest monitoring. Keeping up with these advancements and incorporating them into monitoring programs is crucial for staying at the forefront of forest management.

The GO SURF and its comprehensive course on GIS and remote sensing data, represents a significant advancement in the field of forest ecosystem monitoring. By equipping stakeholders with the necessary skills and knowledge, the course contributes to the sustainable management and conservation of forest ecosystems. As forests continue to face pressures from human activities and climate change, initiatives like GO SURF are essential for ensuring their health and resilience for future generations. Through technical proficiency, analytical skills, practical experience, and networking opportunities, participants are empowered to make data-driven decisions that support sustainable forest management and conservation efforts.


PSR
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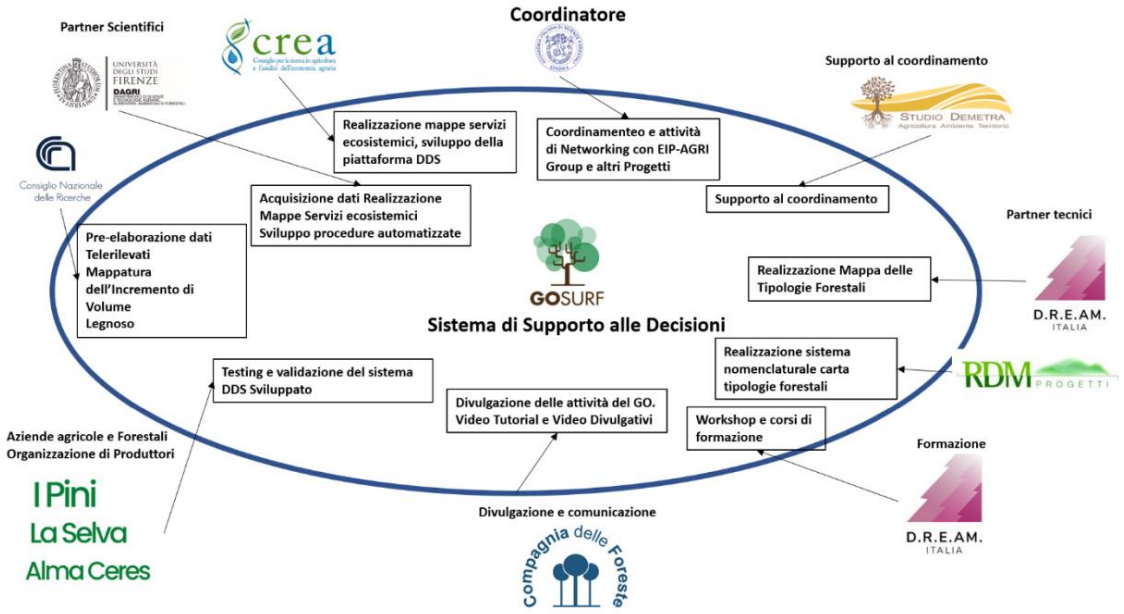
GOSURF


UNA PIATTAFORMA INNOVATIVA
PER PIANIFICARE LA GESTIONE SOSTENIBILE
DELLE FORESTE TOSCANE



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6. **Innovation title:** Developing a Novel Martelloscope for Assessing Biodiversity and Growing Stock Volume with the aid of a Digital Twin

OG: BIOSEIFORTE BIOdiversity and Ecosystem Services in Forests and Territory

Jauna marteleskopa attīstīšana bioloģiskās daudzveidības un augošās koksnes krājumu novērtēšanai ar digitālā dvīņa palīdzību

Operacionālās grupas mežasaimniecības un agromežsaimniecības sektorā spēlē īpašu lomu inovāciju virzībai ES līmenī. Šīs grupas izplata to aktivitāšu un inovāciju rezultātus citās ES valstīs projekta FOREST4EU (https://www.forest4eu.eu/) ietvaros, ko finansē Horizon Europe programma.

Operacionālā grupa no Itālijas BIOSEIFORTE dalās ar tās inovāciju - jauna marteleskopa attīstīšanu bioloģiskās daudzveidības un augošās koksnes krājumu novērtēšanai ar digitālā dvīņa palīdzību.

Eksperimentāls marteleskops tika lietots tur, kur koki tika apsekoti, iegādājoties Geoslam ZEB portatīvo lāzerskeneru sistēmu, kas ļāva no jauna izveidot 3D digitālo dvīni. Tad, katram no apsekotajiem kokiem, kas veido daļu no marteloskopa, pēc tam tika iegūti dendromikrobiotopi, izmantojot tradicionālo uzmērīšanu, kas ļāva katram kokam iegūt potenciālās bioloģiskās daudzveidības indeksu (IBP), lai varētu ieviest bioloģiskās daudzveidības kvantitatīvo noteikšanu meža apsaimniekošanas plānos un sniegtu lietotājiem iznākumu ne tikai attiecībā uz produktīvām intervencēm (augošas koksnes krājumi), bet arī mežkopības intervencēm, kurās ņemti vērā bioloģiskās daudzveidības parametri. Praktiski 1 hektāra pārejas dižskābarža audzes teritorijā katrs atsevišķais koks (koks vai zīdējs) tika numurēts, izmērīts (vainaga ievietošanas augstums un kopējais augstums) un ģeoreference, un tā aprēķinātie tilpuma un atrašanās vietas dati ierakstīti speciālā programmatūrā. Turklāt katrā atsevišķā kokā vai celmā tika pārbaudīta dendrotēlija klātbūtne (izmaiņas, dobumi, plaisas stumbrā un zaros), kas var veidot mikrobiotopus dažādām augu un/vai dzīvnieku sugām un palielināt audzes ekosistēmas vērtību bioloģiskās daudzveidības aspektā.

Faktiski marteleskops ir daļa no meža ar zināmu virsmu, kurā katram kokam noteikti dažādi parametri: novietojums (ģeoreference), biometriskie raksturlielumi (stumbra diametrs, augstums, tilpums u.c.), veģetatīvais stāvoklis, loma sabiedrībā, ekoloģiskā nozīme utt. Tāpēc marteloskops ir pastāvīga vieta, kurā tiek uzskaitīti visi koki, un tā ir patiesa "vingrošanas zāle brīvā dabā", ko var izmantot studentu un mežsaimniecības tehniķu apmācībai, lai modelētu konkrētus mežkopības pasākumus.Tas ir potenciāls instruments, lai izplatītu informāciju, kas saistīta ar dažādiem mežsaimniecības veidiem, kā arī meža bioloģiskās daudzveidības saglabāšanu un klimata pārmaiņu mazināšanu.

Pirmie Eiropas marteloskopi, kuru izcelsme ir Francijā kopš 1990. gadiem, tagad ir pieejami Dienvidtirolē, Lombardijā, Toskānā un Apūlijā un tiek izmantoti dažādos Eiropas projektos, piemēram, LIFE projektos (GoProFor un SelPiBioLife) un Erasmus+ (Hammer), kā arī BIOSEIFORETE OG Itālijā.Pateicoties šo “brīvdabas trenažieru zāļu” izmantošanai, apmācāmie var nekavējoties iegūt, arī izmantojot ar marteloskopu saistītu programmatūru, kvantitatīvos datus par simulēto iejaukšanos, tostarp grafikus, lai nekavējoties pārbaudītu savas izvēles rezultātus, gan vadības un ekonomikas jomā.

Parasti marteloskopam jābūt ar labu pieejamību, stenda reprezentativitāti, ilgtermiņa novērošanas iespējām un informācijas pieejamību par pagātnes intervenci. Visiem kokiem jābūt marķētiem ar numurētu etiķeti, savukārt dabiskā reģenerācija tiek sasniegta redzamās iekšējās zonās. Lai izveidotu marteleskopu, ļoti svarīgi ir veikt pagātnes intervences vēsturisko izpēti, kuras mērķis ir noskaidrot, vai iepriekš ir bijuši traucējumi, piemēram, vēja gāzes, meža ganības, ugunsgrēki utt.

Operators, neatkarīgi no tā, vai tas ir students vai mežsaimniecības tehniķis, pamatojoties uz no lauka savāktajiem datiem, var simulēt "virtuālu āmura sitienu",t.i., piedāvāto intervences pasākumu praktiska simulāciju un pēc tam

grafiski atveidot audzi pirms un pēc intervences, aprēķinot ražas intensitāti, audzes struktūras izmaiņas, izņemto apjomu utt.

Galvenais marteloskopa mērķis ir "mācīt" dažādu veidu mežkopības intervenci, izmantojot:

- Meža struktūras analīzi (specifiskais sastāvs, blīvums, pamatlaukums, apjoms, koku seguma pakāpe utt);
- Koku atlase mežkopības intervencē un iespējamo eksperimentālo metožu apgūšana;
- Apziņa par to, kā bioloģiskā daudzveidība un ekoloģiskās vērtības ietekmē mežkopības izvēles.

Izmantojot marteleskopus, ir iespējams ne tikai demonstrēt praktiskus mežkopības intervences pasākumus, bet arī veikt dažādu intervenču salīdzinājumus, novērot šo izvēļu ilgtermiņa ietekmi, uzraudzīt atjaunošanos, identificēt iespējamos samazināšanās cēloņus, noteikt ar konkurences parādībām saistīto bilanču evolūciju un aprēķināt mežaudzes vērtību saistībā ar izmaksu un ieguvumu attiecību

Pateicoties tehnoloģiju attīstībai un digitalizācijas metodēm, kuru mērķis ir ģenerēt 3D modeļus no lauka mērījumiem, ir kļuvis iespējams rekonstruēt interesējošās zonas trīsdimensiju modeļus un tādējādi izveidot digitālo marteloskopu. Jo īpaši virszemes LiDAR sistēmas savāc lielu datu apjomu, sākot no desmitiem tūkstošu līdz miljardiem 3D punktu, lai noteiktu izpētes zonas telpu.

Detalizētāk paskaidrojot, lāzerskenēšana, kas pazīstama arī kā LiDAR (Light Detection and Ranging), ir tehnoloģija, ko izmanto attālinātai uzrādei, lai mērītu attālumus līdz objektiem vai virsmām, izmantojot lāzera impulsus. To plaši izmanto dažādās jomās, piemēram, mežsaimniecībā, pilsētplānošanā, arheoloģijā un vides monitoringā.

Mežsaimniecībā lāzerskenēšanai ir izšķiroša nozīme meža inventarizēšanā un apsaimniekošanā. Virszemes lāzerskeneri (TLS) tiek izmantoti, lai savāktu detalizētus datus par mežu struktūru, tostarp koku izmēru un formu, meža blīvumu un zemes reljefu. Pēc tam šie dati tiek izmantoti, lai izveidotu precīzus meža platību 3D modeļus, kas var palīdzēt mežsaimniekiem pieņemt pārdomātus lēmumus par meža apsaimniekošanu, piemēram, mežizstrādi, saglabāšanas pasākumiem un meža veselības novērtēšanu.

TLS sistēmas spēj ātri un precīzi savākt lielu datu apjomu, nodrošinot precīzus koka diametra, augstuma un lapotnes struktūras mērījumus. Šī informācija ir būtiska, lai novērtētu meža oglekļa krājumus, bioloģisko daudzveidību un ekosistēmu veselību.

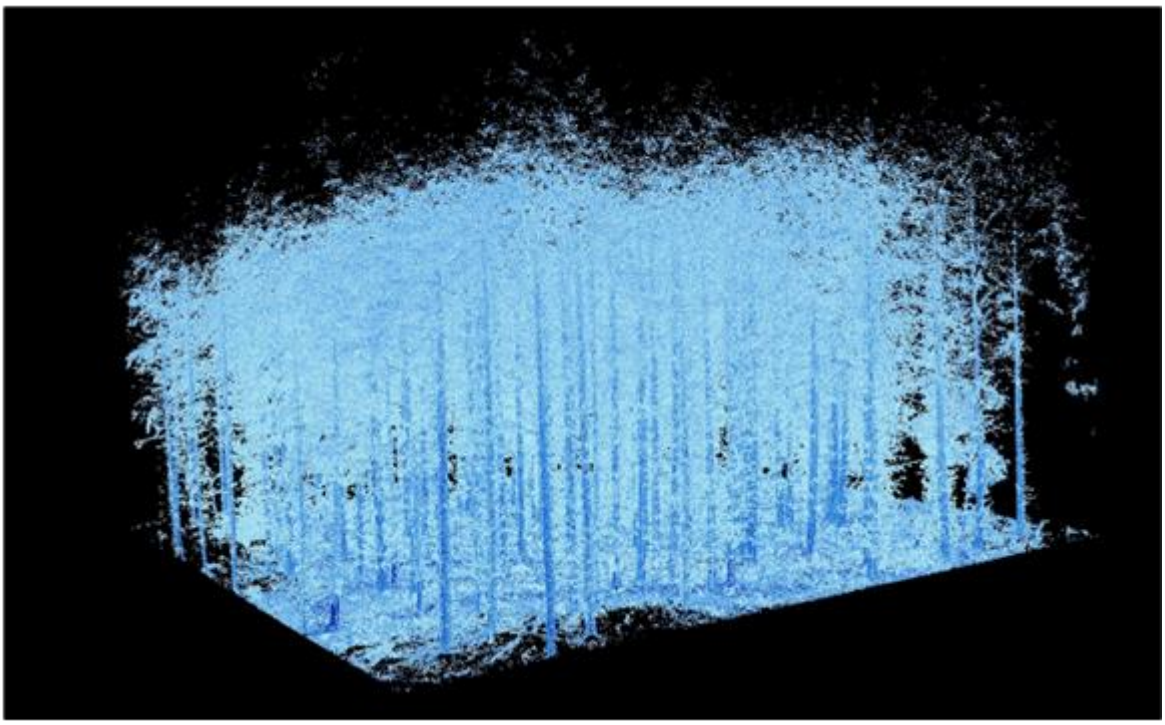
Kopumā lāzerskenēšanas tehnoloģija ir mainījusi mežsaimniecības praksi, nodrošinot detalizētus un precīzus datus, kuru iegūšana iepriekš bija sarežģīta vai laikietilpīga. Tas ir ievērojami uzlabojis mūsu spēju izprast un ilgtspējīgi pārvaldīt meža ekosistēmas.

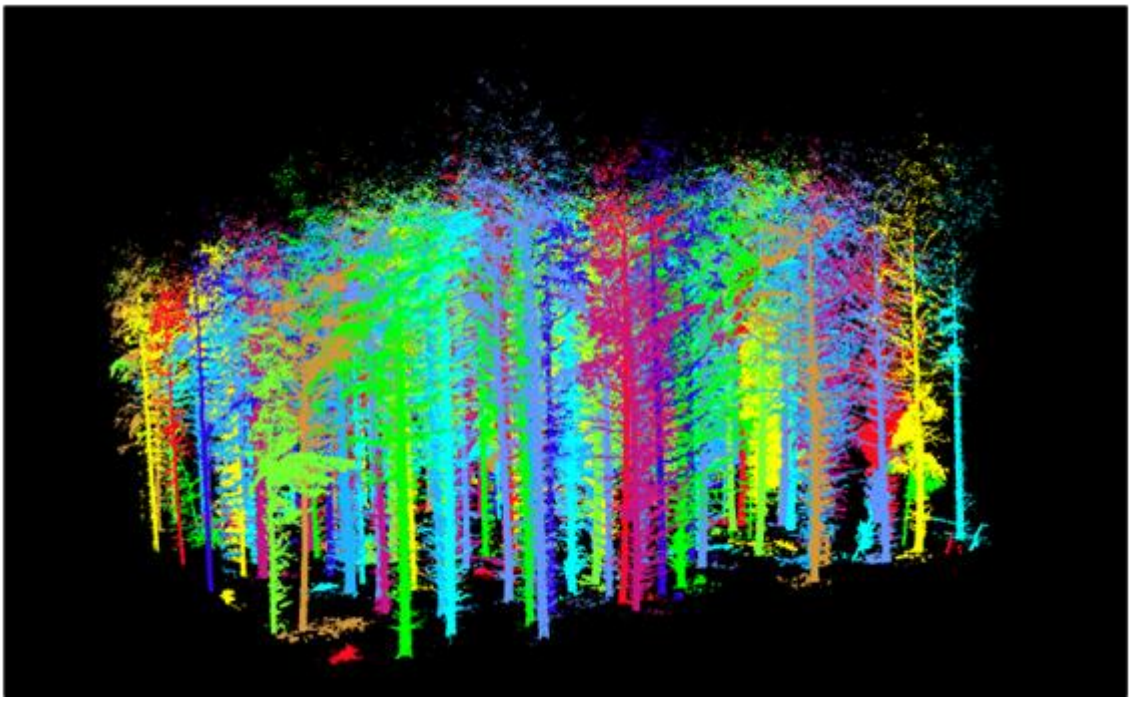
Meža apsekošanas darbībās virszemes lāzerskeneris (TLS) var ātri, automātiski ar centimetru izšķirtspēju savākt ievērojamus datu apjomus. TLS izmantošanas mērķis ir uzlabot datu vākšanas efektivitāti, aizstājot dārgos manuālos mērījumus; līdz ar to virszemes lāzerskeneri tiek izmantoti, lai savāktu dendrometriskos mainīgos lielumus, piemēram, DBH (augu diametrs 1,30 m augstumā virs zemes), koku augstumu un gandrīz precīzu auga atrašanās vietu. Pētījumi, ko veica Berger u.c. 2014.gadā, demonstrē, ka koku diametrs un augstums tiek raksturots ar kļūdu vismaz 5,6% apmērā, un manuālo mērījumu izkropļojumi ietekmē novērtējumu par 26,4%. Tāpēc, izmantojot klasiskās metodes tilpuma un biomasas novērtēšanai, rodas nenozīmīgas nejaušības kļūdas.

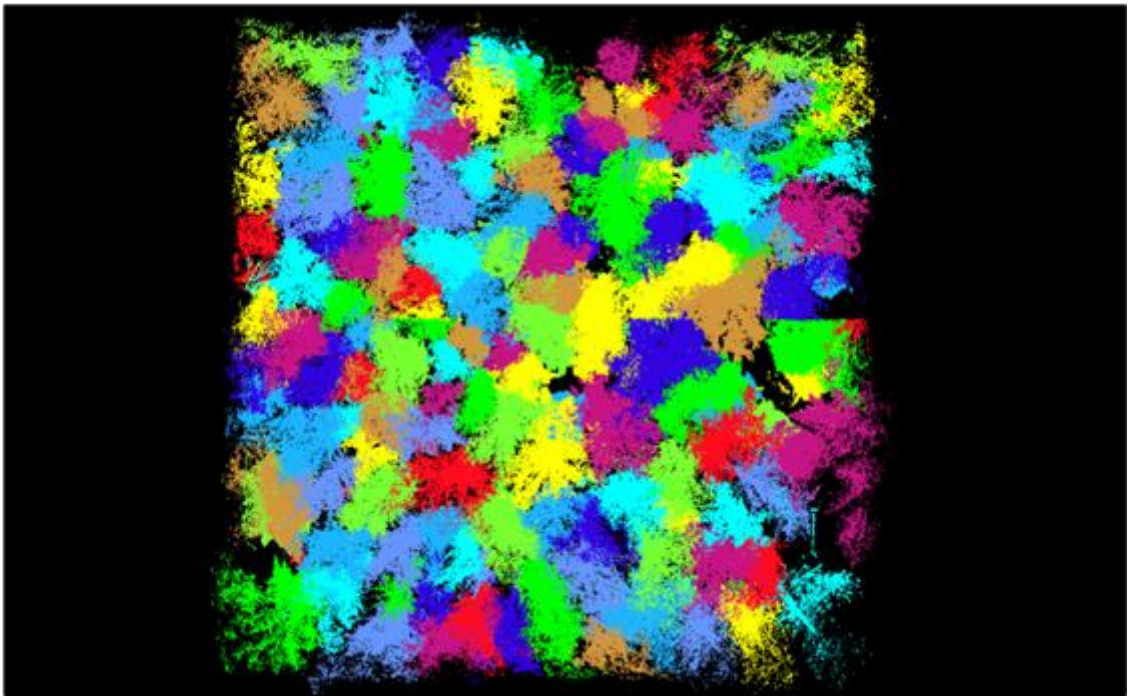
Rezultāts, ko rada lāzera skeneru izmantošana, ir punktu mākonis, kas ir atbilstoši jāapstrādā, lai atsevišķus augus, kas atrodas punktu mākonī, varētu identificēt, izmantojot segmentācijas procesu.Segmentācija attiecas uz katra atsevišķā koka profila izņemšanu no punktu mākoņa, pamatojoties uz kuru tiek iegūti dendrometriskie mainīgie. Papildus atsevišķu koku segmentēšanai, vēl viens process, kas optimizē punktu mākoņu apstrādi, ir zemes virsmas klasifikācija, kas ir būtisks aspekts visā meža digitālā dvīņa apstrādes procesā.Kā uzsvērts Zhong u.c. 2017. gada pētījumā, modeļi bieži neizdodas koku slīpās orientācijas, krūmu klātbūtnes un citu reizēm sastopamu objektu dēļ.

Jaunu tehnoloģiju izmantošana kļūst arvien izplatītāka mežaudžu analīzē un monitoringā un jo īpaši mobilā LiDAR izmantošana mežsaimniecībā kļūst arvien izplatītāka, jo tā ļauj ievērojami samazināt apsekošanas laiku un izmaksas un nodrošina labu datu precizitāti, kamēr līdz šim to galvenokārt izmantoja būvniecības un infrastruktūras nozarēs.

Turklāt bioloģiskās daudzveidības izmaiņu uzraudzība un kvantitatīva noteikšana, pamatojoties uz mežkopībā izdarītajām izvēlēm, izmantojot marteloskopu, ir noderīga pievienotā vērtība meža ilgtspējīgai apsaimniekošanai, ekosistēmu pakalpojumu uzlabošanai, kā arī ražošanas aspektiem.







Informācija no Operacionālās Grupas datu bāzes:

https://www.innovarurale.it/it/pei-agri/gruppi-operativi/bancadati-go-pei/biodiversita-e-servizi-ecosistemici-foreste-e-territorio

OG: BIOSEIFORTE BIOdiversity and Ecosystem Services in Forests and Territory

Developing a Novel Martelloscope for Assessing Biodiversity and Growing Stock Volume with the aid of a Digital Twin

Operational Groups in forestry and agroforestry sector play a key role in driving innovations at the EU level. These Groups disseminate results of OG's activities and innovations to other EU countries within the project FOREST4EU (https://www.forest4eu.eu/) that is funded by the Horizon Europe programme.

Operational group from Italy BIOSEIFORTE shared its innovation – devlopment of novel martelloscope for assessing biodiversity and growing stock volume with the aid of a digital trwin.

An experimental marteloscope was used, where trees were surveyed through acquisition with the Geoslam ZEB Portable Laser Scanner system, which made it possible to recreate a 3D digital twin. Then, for each of the trees surveyed and forming part of the marteloscope, dendromicrohabitats were then obtained by means of traditional surveying, which made it possible to derive the Index of Potential Biodiversity (IBP) for each tree, in order to be able to introduce the quantification of biodiversity into the forest management plans and provide the users of the "gymnasium" an output in relation not only to productive interventions (wood growing stock) but also silvicultural interventions that take into account the biodivesity parameters. Operationally, in a 1-hectare area of transitional beech stand, each individual tree (tree or sucker) was numbered, measured (crown insertion height and total height) and georeferenced, and its calculated volume and position data recorded in special software. In addition, each

individual tree or stump was checked for the presence of dendrothelia (alterations, cavities, cracks in the stem and branches) that may constitute microhabitats for various plant and/or animal species and increase the ecosystem value of the stand in terms of biodiversity

Actually, the "martelloscope" is a portion of forest, of known surface area, in which for each tree present, various parameters have been defined: position (georeferencing), biometric characteristics (trunk diameter, height, volume, etc.), vegetative state, role within the community, ecological significance, etc. The martelloscope is therefore a permanent area where all trees are inventoried and constitutes a true "open-air gym" that can be used for the training of students and forestry technicians to simulate specific silvicultural interventions. It represents a potential tool for promoting dissemination on issues related to different types of forestry, as well as forest biodiversity conservation and climate change mitigation.

The first European martelloscopes, originated in France since the 1990s, are now present in South Tyrol, Lombardy, Tuscany, and Apulia and used in various European projects, such as LIFE projects (GoProFor and SelPiBioLife) and Erasmus+ (Hammer) and also the BIOSEIFORETE OG in Italy. Thanks to the use of these open-air gyms, trainees can immediately obtain, also through the use of martelloscope-related software, data regarding the simulated intervention in quantitative terms, including graphs, in order to verify immediately the outcome of their choices, both in terms of management and economics.

Generally, a martelloscope must have good accessibility, representativeness of the stand, long-term observation possibilities, and information availability on past interventions. All trees present must be marked with a numbered tag, while natural regeneration is assessed in visible internal areas. For the establishment of a martelloscope, it is very important to conduct a historical investigation on past interventions, aimed at establishing whether there have been previous disturbances such as windthrows, forest grazing, fires, etc.

The operator, whether a student or forestry technician, based on field-collected data, can simulate a "virtual hammer blow," i.e., a practical simulation of the proposed interventions, and subsequently graphically reproduce the stand before and after the intervention, calculating harvest intensity, structural changes in the stand, volume removed, etc.

The main objective of the martelloscope is to "teach" various types of silvicultural interventions through:

- Analysis of forest structure (specific composition, density, basal area, volume, degree of tree cover, etc.);
- Selection of trees in a silvicultural intervention and learning of possible experimental methods;
- Awareness of how biodiversity and ecological values influence silvicultural choices.

Through martelloscopes, it is possible not only to demonstrate practical silvicultural interventions but also to make comparisons between different interventions, observe the long-term effects of these choices, monitor regeneration, identify possible causes of decline, determine the evolution of balances related to competition phenomena, and calculate the value of the forest stand in relation to the cost-benefit ratio.

Thanks to the development of technologies and digitization techniques aimed at generating 3D models from field measurements, it has been possible to reconstruct three-dimensional models of the area of interest, and so create digital martelloscope. In particular, terrestrial lidar systems collect large amounts of data ranging from tens of thousands to billions of 3D points to determine the space of a study area.

In details, laser scanning, also known as lidar (Light Detection and Ranging), is a technology used for remote sensing to measure distances to objects or surfaces using laser pulses. It's widely used in various fields such as forestry, urban planning, archaeology, and environmental monitoring.

In forestry, laser scanning plays a crucial role in forest inventory and management. Terrestrial laser scanners (TLS) are used to collect detailed data about the structure of forests, including the size and shape of trees, forest density, and

ground terrain. This data is then used to create accurate 3D models of forested areas, which can help foresters make informed decisions about forest management, such as harvesting, conservation efforts, and assessing forest health.

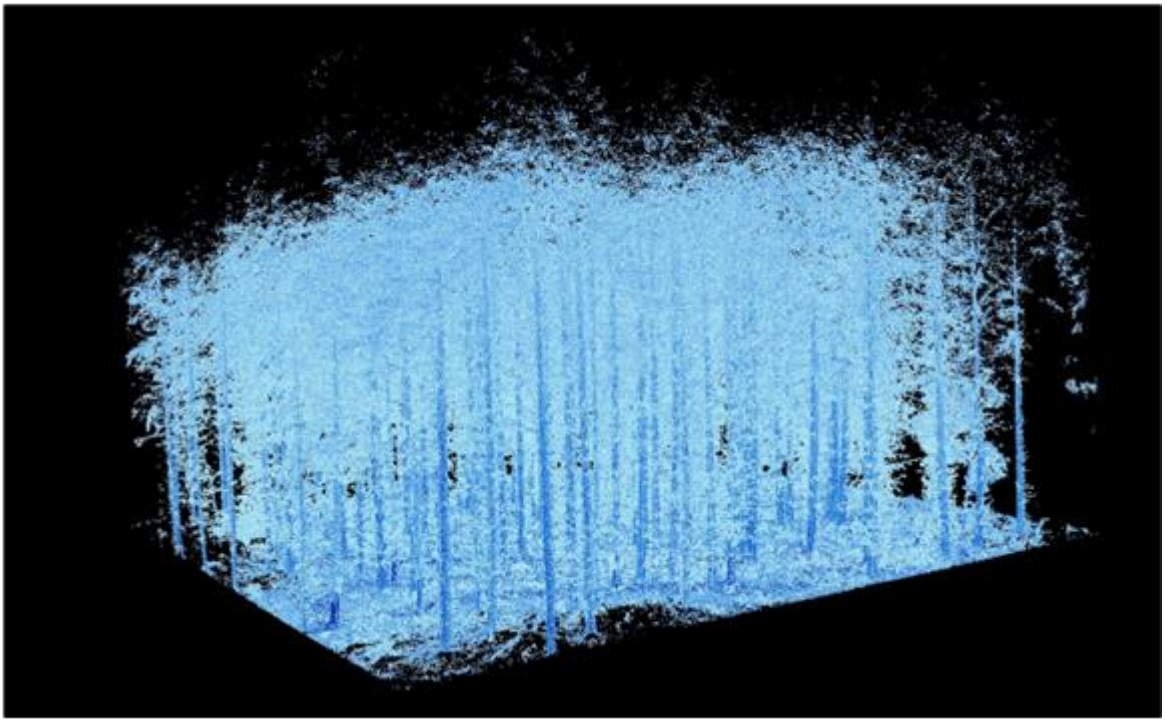
TLS systems are capable of collecting large amounts of data quickly and accurately, providing precise measurements of tree diameter, height, and canopy structure. This information is essential for assessing forest carbon stocks, biodiversity, and ecosystem health.

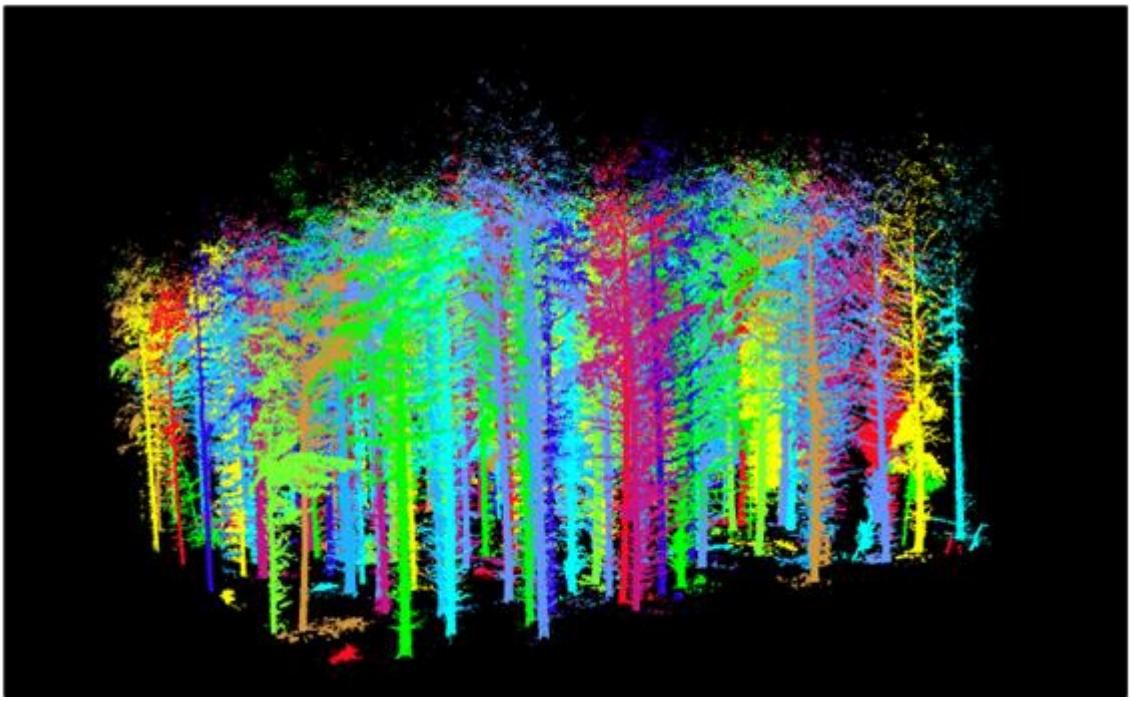
Overall, laser scanning technology has revolutionized forestry practices by providing detailed and accurate data that was previously difficult or time-consuming to obtain. It has greatly improved our ability to understand and manage forest ecosystems sustainably.

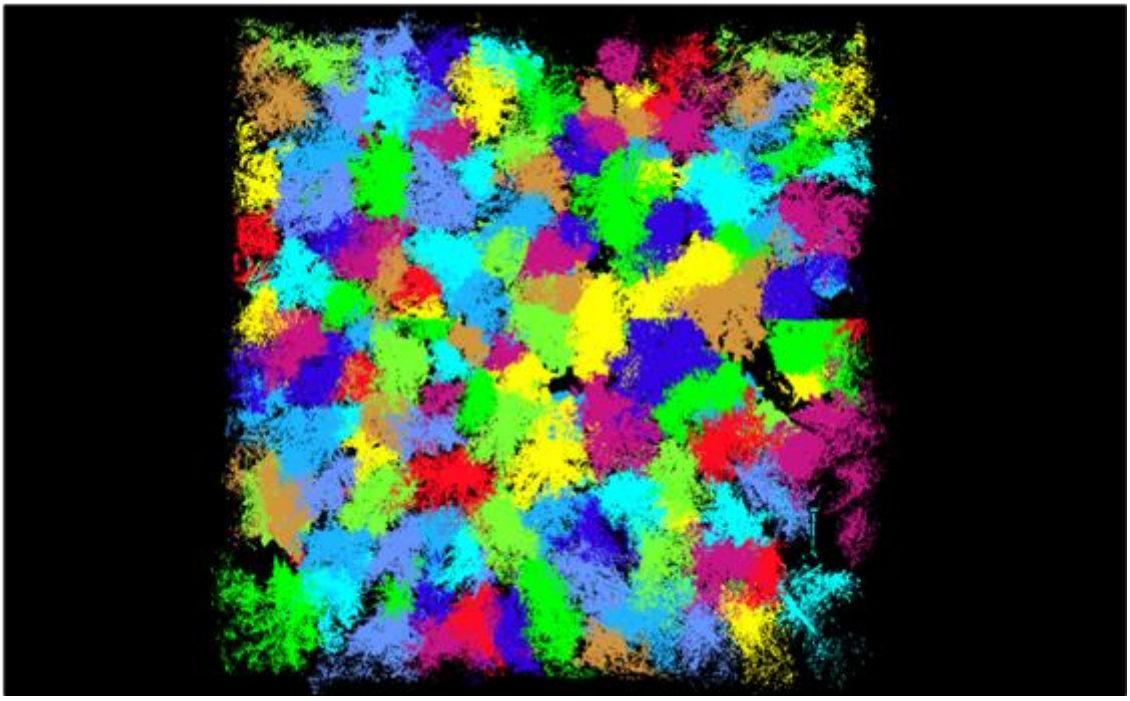
In forest survey activities, the Terrestrial Laser Scanner (TLS) can collect significant amounts of data rapidly, automatically, with centimetric resolutions. The purpose of using TLS is to improve the efficiency of data collection by replacing costly manual measurements; consequently, terrestrial laser scanners have been used to collect dendrometric variables such as DBH (diameter of plants at 1.30 m height above ground), tree height, and nearly exact plant position. Studies conducted by Berger et al. in 2014 demonstrate that tree diameter and height are characterized by an error of at least 5.6%, and manual measurement distortion affects the estimate by 26.4%. Therefore, using classical methods for volume and biomass estimation entails non-negligible random errors.

The result generated by the use of laser scanners is a point cloud, which must be appropriately processed so that individual plants present in the point cloud can be identified through a process called segmentation. Segmentation refers to the extraction from a point cloud of the profile of each individual tree, based on which dendrometric variables are extracted. In addition to segmenting individual trees, another process to optimize in point cloud processing is the classification of the ground surface, a crucial aspect for the entire process of forest digital twin processing. As highlighted in Zhong et al.'s 2017 study, models often fail due to the tilted orientation of trees, the presence of shrubs, and other occasionally present subjects.

The use of new technologies is becoming more and more widespread in the analysis and monitoring of forest stands, and in particular forestry application of mobile LiDAR is becoming more widespread as it allows a considerable reduction in survey time and costs and returns good data accuracy, whereas up to now it has been used mainly in the building and infrastructure sector. Furthermore, the monitoring and quantification of biodiversity variation based on silvicultural choices made with the marteloscope is a useful added value for forest sustainable management, ecosystem services enhancement, as well as production aspects.







Information from Operational Group's database:

https://www.innovarurale.it/it/pei-agri/gruppi-operativi/bancadati-go-pei/biodiversita-e-servizi-ecosistemici-foreste-e-territorio

7. **Innovation title:** Criteria and indicators for the certification of the sustainable management of an agroforestry system PEFC (NEWTON)

NEWTON – Mreža Operativnih skupina za agrošumarstvo u Toskani: Kriteriji i pokazatelji za certifikaciju održivog upravljanja agrošumarskim sustavom PEFC

NEWTON – Mreža Operativnih skupina za agrošumarstvo u Toskani predstavlja inovativnu operativnu skupinu (OS). Glavni cilj rada OS bio je promovirati inovativni sustav za "održivu poljoprivrednu intenzifikaciju" agrošumarstva i njegovih praksi putem participativnog širenja inovativnih tehničkih i znanstvenih znanja među svim dionicima, kako bi se unaprijedili tradicionalni agrošumarski sustavi (ASC) (miješano uzgajanje maslina; Mantino i dr., 2016.) i promovirali inovativni agrošumarski sustavi (srebrni sustavi s policikličkim redovima; Mantino i dr., 2017.). Ovaj cilj postignut je aktivnostima usmjerenim na prijenos znanja te aktivnostima usmjerenim na demonstraciju i širenje inovacija.

Specifični ciljevi OS-e bili su:

- stvaranje regionalne mreže znanja za ASC agrošumarske sustave,
- razvoj mreže inovacija temeljenih na studijama slučaja u privatnim i javnim poduzećima,
- širenje znanja i inovacija putem web portala posvećenog ASC agrošumarskim sustavima u Toskani (www.gonewton.it) i
- identifikacija inovativnih strategija za valorizaciju agrošumarske i agro-silvikulturalne proizvodnje.

Prijenos znanja proveden je kroz mrežu poljoprivrednika i dionika, temeljenu na participativnom pristupu i korištenju interaktivnih informacijskih alata kao što su web-GIS portal i gamifikacijski alati/tehnike za učenje. Nadalje, prijenos znanja podržan je implementacijom alata za obuku kao što su seminari, sastanci, tečajevi i studijska putovanja te konačno uspostavom prve Agrošumarske škole.

Aktivnosti u poljoprivrednim i šumarskim poduzećima koje je provodila PEFC Italia (partner OG Newton projekta), igrale su važnu ulogu u priznavanju napora NEWTON-a. Inovacije koje je predložila PEFC Italia odnosile su se na ekonomske, ekološke i društvene sfere agrošumarskih poduzeća. Ovi segmenti mogu se postići implementacijom sustava s nižim emisijama stakleničkih plinova, očuvanjem bioraznolikosti i plodnosti tla, većom stabilnošću i većom dodanom vrijednošću na tržištu, istovremeno imajući proizvode s certifikatom održivosti; sve su to pitanja koja spadaju u članstvo certifikacijskih shema. Prijenos ovih inovacija odvijao se kroz izravnu komunikaciju s partnerskim poduzećima projekta o kvaliteti i količini proizvoda proizašlih iz njihovog upravljanja koji su potencijalno predmet certifikacije. Za poduzeća koja ne sudjeluju u projektu, inovacije koje proizlaze iz projekta pretočit će se u Standard "Održivo upravljanje agrošumarskim sustavom" prilagođen i usavršen u poduzećima projekta GO-NEWTON te ponovljiv u drugim regionalnim i nacionalnim kontekstima.

PEFC Italia analizirala je podatke o sljedivosti i održivosti agro-silvikulturalne proizvodnje i povezanih transformacija provedenih od strane partnerskih poduzeća (CIRAA Pisa). Vrijeme je posvećeno analizi podataka koje su dostavila poduzeća, a paralelno, provedena je identifikacija vrste certifikabilnih proizvoda proizašlih iz poljoprivredne, stočarske, šumarske i agrošumarske komponente, kao i identifikacija certifikacijskih shema koje se potencijalno mogu implementirati kako bi se osigurala održivost i sljedivost identificiranih proizvoda.

Za provedbu ovih aktivnosti bilo je ključno identificirati procesne ili produktne certifikacijske standarde koji imaju nacionalnu vrijednost, znajući da su neki prepoznati i na globalnoj razini (kao što su ISO standardi ili PEFC-FSC standardi, Global Gap, BRC itd.). U studiji provedenoj u partnerskim poduzećima identificirano je 48 proizvoda ili kategorija proizvoda i 13 transformiranih i obrađenih proizvoda. Ovi 61 proizvod potencijalno je predmet certifikacije (i kvalitete i proizvoda, ali i etike i održivosti) koja ima prepoznatljivost certifikata na talijanskoj, europskoj ili globalnoj razini.

Konačni rezultat je 35 certifikacijskih shema primjenjivih na međunarodnoj razini za 61 proizvod i prerađene proizvode partnerskih poduzeća projekta NEWTON.

Tijekom provedbe projekta, kao dopunska i u početku nepredviđena aktivnost, razna referentna certifikacijska tijela u nacionalnom sektoru bila su uključena za validaciju podataka i tipa certifikacije koji je prvotno identificirala PEFC Italia. Uključivanje je bilo posljedica dobivanja pozitivnih povratnih informacija od stručnjaka konzultiranih u vezi s metodologijom i tržišnom konzistentnošću certifikacija koje je prvotno identificirala PEFC Italia. Za ovo istraživanje, PEFC Italia je inicijalno koristila online platformu (https://sustainabilitymap.org) sposobnu za simultano analiziranje različitih procesa i zahtjeva raznih identificiranih certifikacijskih standarda prikladnih za globalno izvještavanje za svaki proizvod/kategoriju proizvoda.

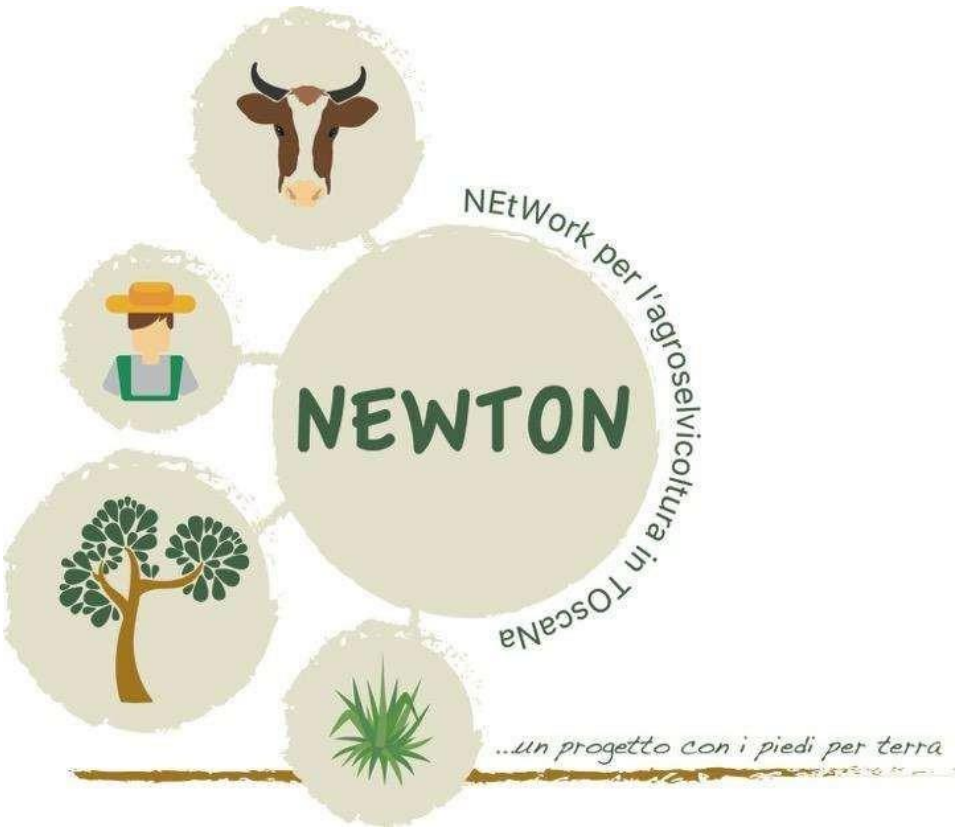
Za aktivnost "Primjena unutarnjih provjera (audita) za integraciju različitih certifikacijskih standarda u OG poduzećima" PEFC Italia, unutar procesa izrade standarda certifikacije "Održivo upravljanje agrošumarstvom" usko povezanog s projektom NEWTON, organizirala je i provela sedam službenih online sastanaka tijekom cijelog procesa pisanja standarda, uključujući dvadeset i dvije institucije i organizacije koje predstavljaju agrošumarski sektor u Italiji kroz 38 aktivnih sudionika u procesu, uključujući istraživače i partnerske tvrtke projekta NEWTON. Ovi sastanci posvećeni temi agrošumarstva u Italiji vidjeli su primjenu zahtjeva koje je izdalo međunarodno PEFC, prevedene i diskutirane s stručnjacima koji su sudjelovali u Forumu, te nacionalnog zakonodavstva, obrađujući kao studije slučaja posebno sustave upravljanja partnerskih poduzeća projekta NEWTON.

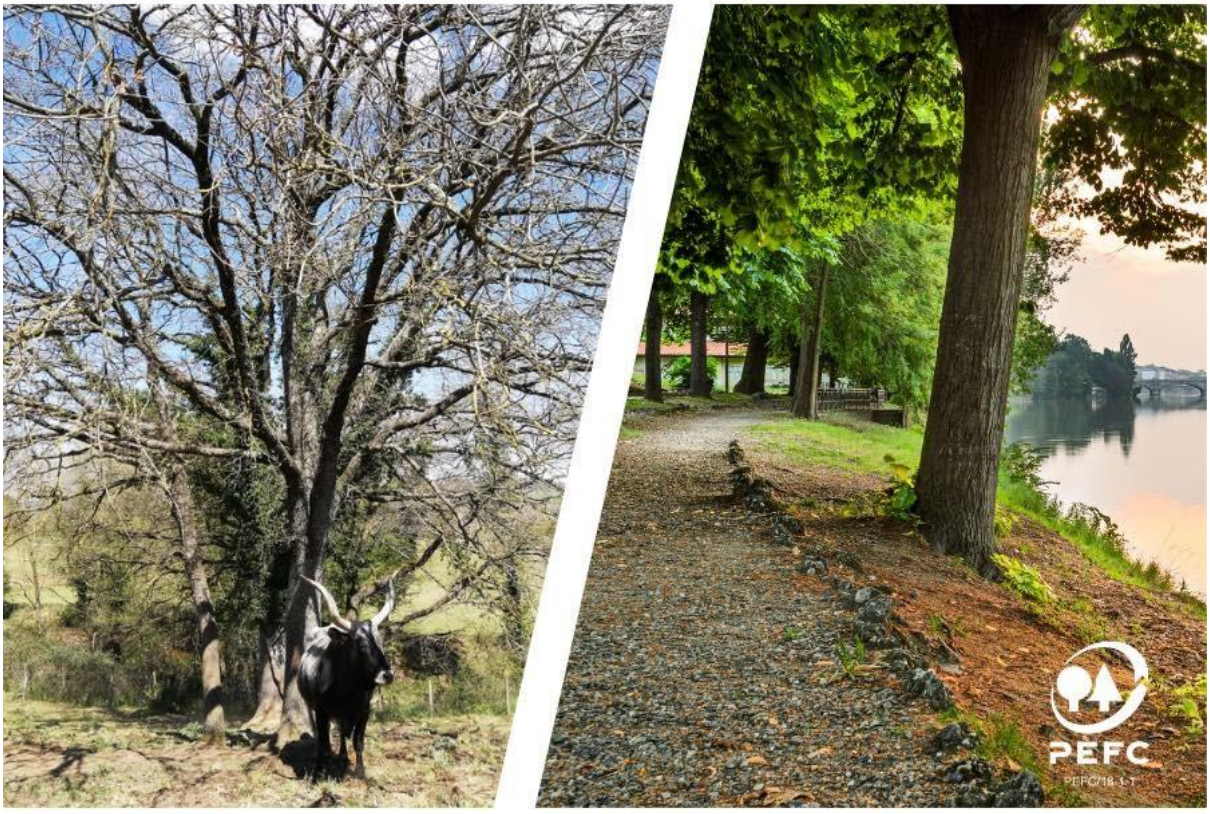
PEFC Italia provela je pilot testove za standard održivog upravljanja agrošumarskim sustavom (PEFC ITA 1001-5) u jesen 2022. koji su omogućili tehničarima poduzeća analizu smjernica i pokazatelja uspostavljenih tijekom procesa izrade standarda, ističući teškoće primjene nekih i poboljšanje drugih. Iskustvo i znanje stečeno tijekom projekta bit će regionalno i nacionalno preneseno kroz dokument lako primjenjiv u bilo kojem poduzeću za certifikaciju proizvoda koji proizlaze iz održivog agrošumarskog upravljanja.

Ekonomski učinci bit će vidljivi u poduzećima spremnim ulagati u certifikaciju proizvoda koji potječu iz agro-šumsko-pastoralnih sustava ili kroz certifikaciju održivog upravljanja agrošumarskim sustavom prema PEFC Italia shemi, što bi u oba slučaja omogućilo pristup tržištu s certifikacijama sljedivosti proizvoda i sustava, dajući krajnjem potrošaču jamstvo ispravnog upravljanja sustavom poduzeća. Kao posljedica ekonomskih reperkusija, certifikacije proizvoda i sustava imat će utjecaj na poduzeća koja su opreznija i koja poštuju obvezne ekološke zahtjeve koje zahtijevaju certifikacijske sheme, implementirajući korporativnu održivost u društvenim i ekološkim terminima i otvarajući se novim tržišnim kanalima.

Projekt GO-NEWTON doprinio je temeljnim pitanjima prvog sustava certificiranja agrošumarstva u Europi, i jednog od prvih u svijetu, dostupnog već od ožujka 2023. i primjenjivog na akreditiran način u prvim mjesecima 2024.

Obzor Europa projekt FOREST4EU (https://www.forest4eu.eu/) ima za cilj povezivanje postojećih operativnih skupina iz različitih zemalja diljem Europe (Španjolska, Portugal, Italija, Francuska, Austrija, Slovenija, Latvija, Švedska, Nizozemska, Njemačka) kako bi se potaknula razmjena znanja i iskustava u inovativnim pristupima provedenim u šumarstvu i agrošumarstvu. NEWTON - Operativna mrežna skupina za agrošumarstvo u Toskani jedan je od tih primjernih inovativnih OG-ova.





Izvori:

https://ec.europa.eu/eip/agriculture/en/find-connect/projects/network-l%E2%80%99agroselvicoltura-toscana-newton.html

https://gonewton.it/

https://www.facebook.com/people/Newton-Agroforestry-Network-in-Tuscany/100045126715220/

https://eu-cap-network.ec.europa.eu/projects/agroforestry-network-tuscany-newton_de

Relazione tecnica finale del Gruppo Operativo NEWTON - NEtWork per l'agroselvicoltura in TOscaNa

https://www.innovarurale.it/it/pei-agri/gruppi-operativi/bancadati-go-pei/network-lagroselvicoltura-toscana

NEWTON - NEtWork Operational Group for agroforestry in Tuscany: Criteria and indicators for the certification of the sustainable management of an agroforestry system PEFC

The NEWTON - NEtWork Operational Group for agroforestry in Tuscany is one innovative operational group (OG). The main objective was the promotion of an innovative system for "sustainable agricultural intensification" of agroforestry and its practices through participatory dissemination of innovative technical and scientific knowledge among all stakeholders, in order to enhance traditional Agroforestry (ASC) agroforestry systems (mixed olive growing; Mantino et al., 2016) and to promote innovative ASC agroforestry systems (silverable systems with polycyclic rows; Mantino et al., 2017). This objective was achieved through activities focused on the transfer of knowledge and the activities focused on demonstration and dissemination of innovations.

The specific objectives of the OG were:

- the creation of the regional knowledge network for ASC agroforestry systems,
- the development of the innovation network based on case studies in private and public companies,
- the dissemination of knowledge and innovations through a web portal dedicated to ASC agroforestry systems in Tuscany (www.gonewton.it) and
- the identification of innovative strategies for the valorisation of agro-forestry and agro-silvicultural production.

The knowledge transfer has been implemented through the network of farmers and stakeholders, based on the participatory approach and the use of interactive information tools such as the web-GIS portal and gamification tools/techniques for learning. Furthermore, knowledge transfer was supported by the implementation of the training tools such as seminars, meetings, courses and study visits and finally the establishment of the first Agroforestry School.

The activities in agriculture and forestry companies carried out by the PEFC Italia (OG Newton project partner), played an important role in the recognition of NEWTON efforts. The innovations proposed by PEFC Italia concerned economic, environmental and social spheres of agro-forestry companies. These segments can be pursued by implementing systems with lower emissions of greenhouse gases, conserving the biodiversity and fertility of the soil, having greater stability and giving greater added value in the market and at the same time having products with sustainability certification; all issues that fall within the membership of certification schemes. The transfer of these innovations occurred through direct communication with the project's partner companies on the quality and quantity of the products deriving from their management potentially subject of the certification. For companies not participating in the project, the innovations deriving from the project will flow into the Standard of "Sustainable management of an agroforestry system" adapted and refined in the companies of the GO-NEWTON project and replicable in other regional and national contexts.

The PEFC Italia analysed the data on traceability and sustainability of agro-silvicultural production and related transformations implemented by the project partner companies (CIRAA Pisa). Time was devoted to the analysis of the data provided by the companies, and in parallel, identification of the type of certifiable products deriving from the agricultural, livestock, forestry and agroforestry component was conducted, plus the identification of certification schemes potentially implementable to provide guarantee of the sustainability and traceability of the identified products.

For the purpose of implementing these activities was essential to identify the process or product certification standards that have a national value, knowing that some are also recognized on a global scale (such as the ISO standards or the PEFC-FSC standards, Global Gap, BRC, etc.).

In the study carried out in the partner companies, 48 products or product categories and 13 transformed and processed products were identified. These 61 products are potentially the subject of a certification (both of quality and product, but also ethics and sustainability) that has recognition of the certification on an Italian, European or global scale.

The final result is 35 certification schemes applicable on an international scale for the 61 products and products processed by the partner companies of the NEWTON project.

During the project implementation, as a supplementary and initially unforeseen activity, various reference Certification Bodies in the national sector were involved for the validation of the data and the certification type initially identified by PEFC Italia. Involvement was as consequence of receiving positive feedback from experts consulted regarding the methodology and market consistency of the certifications initially identified by PEFC Italia. For this

research, PEFC Italy initially used an online platform (https://sustainabilitymap.org) capable of simultaneously analysing the different processes and requirements of the various certification standards identified and suitable to be reported on a global scale for each product/product categories.

For action "Application of internal checks (audits) for the integration of the different certification standards in OG companies" PEFC Italy, within the process of drafting the certification standard of "Sustainable management of Agroforestry" closely connected to the NEWTON project, organized and conducted seven official online meetings throughout the entire process of writing the standard, involving twenty-two bodies and institutions representing the agroforestry sector in Italy through 38 active participants in the process, including researchers and the partner companies of the NEWTON Project. These meetings dedicated to the topic of Agroforestry in Italy saw the application of the requirements issued by the International PEFC, translated and discussed with the experts participating in the Forum, and of the national legislation, treating as case studies in particular the management systems of partner companies of the NEWTON project.

The PEFC Italia conducted the pilot tests for the Sustainable Management standard of an Agroforestry system (PEFC ITA 1001-5) in autumn 2022 which enabled the company's technicians to analyse the guidelines and indicators established during the process of drafting the standard, highlighting the difficult application of some and improving others. The experience and the knowledge acquired during the project will be regionally and nationally taken through a document easily implementable in any company for the certification of products deriving from sustainable agroforestry management.

The economic repercussions will be visible in companies willing to invest in the certification of products coming from agro-forestry-pastoral systems or through the certification of the sustainable management of an agroforestry system according to the PEFC Italia scheme, which in both cases would allow access to the market with product and system traceability certifications, to give the end consumer a guarantee of the correct management of the company system. As a consequence of the economic repercussions, product and system certifications will have an impact on companies more prudent and respectful of the mandatory environmental requirements required by the certification schemes, implementing corporate sustainability in social and environmental terms and opening up to new market channels.

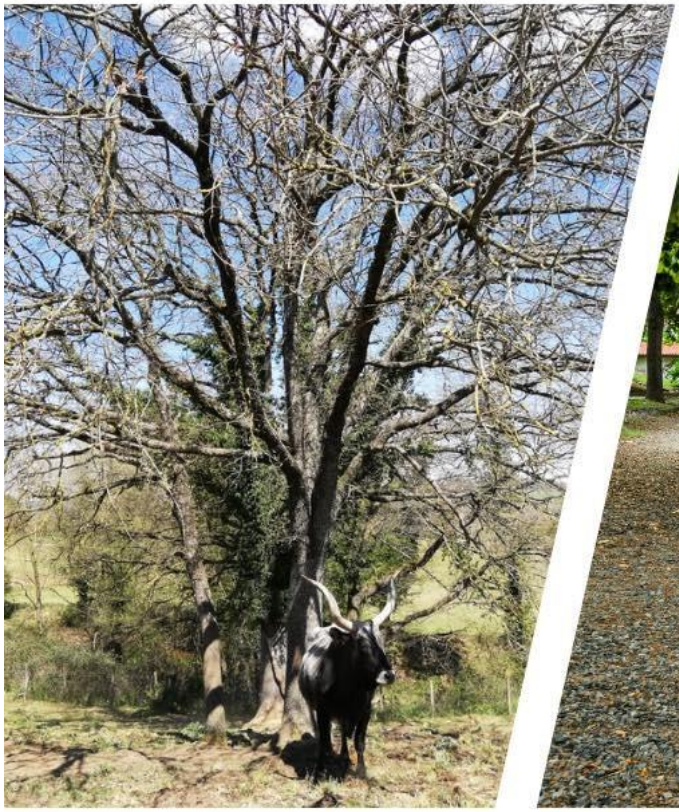
The GO-NEWTON project contributed in fundamental matters to the first Agroforestry certification system in Europe, and one of the first worldwide, available as early as March 2023 and applicable in an accredited manner in the first months of 2024.

Horizon Europe funded project **FOREST4EU** (https://www.forest4eu.eu/) aims at connecting existing operational groups from different countries across Europe (Spain, Portugal, Italy, France, Austria, Slovenia, Latvia, Sweeden, Netherlands, Germany) in order to encourage the transfer of knowledge and experience in innovative approaches implemented in forestry and agroforestry. The NEWTON - NEtWork Operational Group for agroforestry in Tuscany is one of those exemplar innovative OGs.

NEtWork per l'agroselvicoltura in TOscaNa

NEWTON

...un progetto con i piedi per terra



Sources:

https://ec.europa.eu/eip/agriculture/en/find-connect/projects/network-l%E2%80%99agroselvicoltura-toscana-newton.html

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8. **Innovation title:** Biological Treatment of cancer chestnut (Cryphonectria parasitica) in Portugal

Inovação e Transferência de Tecnologia no Tratamento do Cancro do Castanheiro em Portugal.

Forest4Eu é um Projeto europeu financiado pelo programa Horizonte Europa. Centra-se na procura e seleção de informação relevante que ilustre o manancial de conhecimento e de inovação advindo do trabalho dos Grupos Operacionais, na Europa, focados nas temáticas Florestais e Agroflorestais. A apresentação desta informação será feita em formato escrito ou audiovisual, procurando chegar a um público vasto, nos vários países participantes naquele projeto. Este trabalho enaltece o valioso contributo de muitos Grupos Operacionais para a resolução de problemas ligados aos setores referidos, o qual, por vezes, fica confinado regionalmente ou no país de origem.

O presente artigo aborda o tratamento biológico do cancro do castanheiro (*Cryphonectria parasitica*) em Portugal, baseado no Relatório emanado do Grupo Operacional BioChestnut-IPM, tendo como base geográfica principal a região de Trás-os-Montes, onde se situa mais de 85 % da área de castanheiro em Portugal. No âmbito do Forest4Eu este trabalho foi considerado de grande importância para outros produtores e consultores noutros países produtores de castanha, em especial na orla mediterrânica.

A relevância deste trabalho sobre o cancro do castanheiro advém da ligação efetiva que demonstra entre a ciência e a prática, com resultados importantes para quem labora nesta cultura. Este tipo de conexão é, aliás, um dos contributos comuns e importantes dos Grupos Operacionais, em vários países europeus. Este facto leva a que se procurem fazer, em devido tempo e no âmbito do Forest4Eu, recomendações no sentido de aqueles serem devidamente apoiados, ressaltando até a possibilidade de serem plurinacionais.

As espécies Florestais tradicionais, como é o caso do castanheiro (em todas as suas variantes), desempenham um importante papel produtivo, económico, social e ambiental nas regiões onde estão instaladas. Assim, há a necessidade de lhes dar a devida atenção e análise, melhorando o seu estado fitossanitário (como é o caso aqui apresentado) e o seu caráter atrativo, enquanto base de explorações florestais ou agroflorestais.

Materiais e métodos

Este artigo tem como base o relatório "Manual de boas práticas para o tratamento biológico do cancro do castanheiro (*Cryphonectria parasitica*) em Portugal", com edição do Centro Nacional de Competências para os Frutos Secos, dada a riqueza da sua informação. Tentamos realçar os aspetos fulcrais relativos à doença do castanheiro aqui em apreço, bem como as pistas apontadas para futuros trabalhos.

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Revisão: Profª. Maria Eugénia Gouveia – Instituto Politécnico de Bragança

Innovation and Technology Transfer in the Treatment of Chestnut Cancer in Portugal.

Forest4Eu is a European project funded by the Horizon Europe program. It focuses on searching and selecting relevant information that illustrates the knowledge and innovation arising from the work of Operational Groups in Europe focused on the Forestry and Agroforestry fields. This information will be presented in written or audiovisual format to reach a wide audience in the various countries participating in that project. This work highlights the valuable contribution of many Operational Groups to solving problems linked to the aforementioned sectors, sometimes confined regionally or in the country of origin.

This article addresses the biological treatment of chestnut canker (*Cryphonectria parasitica*) in Portugal, based on the Report issued by the BioChestnut-IPM Operational Group, having as its main geographic base the region of Trás-os-Montes, where more than 85% of the chestnut area in Portugal is located. Within the scope of Forest4Eu, this work was important for other producers and consultants in other chestnut-producing countries, especially on the Mediterranean coast.

The relevance of this work on chestnut canker comes from the effective link it demonstrates between science and practice, with important results for those who work in this crop. This type of connection is, in fact, one of the common and important contributions of Operational Groups in several European countries. This fact leads to efforts being made, in due time and within the scope of Forest4Eu, to ensure that they are properly supported, even highlighting the possibility of them being developed in more than one country.

Traditional forest species, such as chestnut trees (in all their variants), play an important productive, economic, social, and environmental role in the regions where they are located. Therefore, they need to be given due attention and analysis, improving their phytosanitary status (as presented here) and their attractiveness as a basis for forestry or agroforestry farms.

Materials and methods

This article is based on the report “Manual of Good Practices for the Biological Treatment of Chestnut Canker (*Cryphonectria parasitica*) in Portugal,” published by the National Competence Centre for Dried Fruits, given its richness of information. We highlighted the key aspects of the chestnut disease under consideration here and the clues for future work.

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Revision: Profª. Maria Eugénia Gouveia – Instituto Politécnico de Bragança

9. **Innovation title:** New and innovative cultivation methods of highly productive apples adapted to northern climates.

Tanja Kähkönen, Euroopan metsäinstituutti

Pohjoinen ilmasto ja omenalajikkeet innovaatioiden lähteenä: maatalouden tuottavuus ja kestävyys pohjoisessa omenantuotannossa jääsiideriä, makeaa jälkiruokaviiniä, varten Uumajassa, Ruotsissa

Halu asua Pohjois-Ruotsissa, kunnianhimoinen asenne korkealaatuisten tuotteiden tuottamiseen ja uteliaisuus viinejä kohtaan ovat olleet johtavia syitä maaseudun innovaatioryhmän "Kaupallinen tuottava omenankasvatus pohjoisessa ilmastossa – innovaatio uudelle ilmastokestävälle maataloudelle Pohjois-Euroopassa (Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in Northern Europe)" perustamiselle Uumajaan, Pohjois-Ruotsiin.

KUVA (Brännland Ciderin valokuvavarastosta tai julkisesti saatavilla oleva valokuva jääsiideriyrityksestä).

Euroopan pohjoisilla maaseutualueilla on ollut haasteita saada elantonsa perinteisestä maataloudesta, kaupallisesti viljeltyjen lajien rajallisesta määrästä ja yleisesti ankarista ilmasto-olosuhteista. Maaseudun innovaatioryhmän "Kaupallinen tuottava omenankasvatus pohjoisessa ilmastossa – innovaatio uuteen ilmastokestävään maatalouteen Pohjois-Euroopassa" Uumajassa, Västerbottenin alueella, tarina alkoi jo kauan ennen sen perustamista yhden miehen, joka halusi asua Pohjois-Ruotsissa, visiosta. Yrittäjä Andreas Sundgren halusi asua alueella ja perusti Brännland Ciderin Uumajan lähelle Vännäsbyn kylään vuonna 2010 ja alkoi valmistaa jääsiideriä kellarissa Uumajan Brännlandissa vuonna 2011. Brännland Ciderin alusta lähtien tavoitteena on ollut tuottaa juoma, joka tunnetaan kaikkialla maailmassa, visio luoda maailman paras makea viini. Yrityksen kaksi ensimmäistä vuotta olivat täynnä kokeilujen kautta oppimista. Siinä missä ensimmäinen tavoite oli tuottaa siideriä, joka on yksinkertaisempi tuote kuin jääsiideri, kahden ensimmäisen vuoden aikana tehdyissä kokeissa tehtyjen uusien löytöjen avulla kävi selväksi, että pohjoisruotsalaiset omenat soveltuivat parhaiten jääsiiderin tuotantoon. Havainto kahdesta paikallisesta voimavarasta - sekä kylmän sään että ruotsalaisten korkean happamuuden jälkiruokaomenoiden saatavuudesta, jotka soveltuvat luonnollisesti makean siiderin tuotantoon - tasoitti tietä menestyksekkään jääsiiderin tuotannon aloittamiselle alueella. Yhdistämällä nämä kaksi paikallista vahvuutta Brännland Cideristä tuli viininvalmistaja siiderinvalmistajan sijaan. Brännland Ciderin kansainväliset verkostot, joihin kuuluu viininvalmistuksen asiantuntijoita, jääsiiderin tuotannon asiantuntijoita ja omenanviljelyn asiantuntijoita, ovat tasoittaneet tietä ainutlaatuisen omenoista valmistetun viinin luomiselle. Nyt Pohjois-Ruotsin omenoista valmistettu jääsiideri, makea jälkiruokaviini, on maailman parhaiden joukossa ja se on myös ensimmäinen ruotsalainen viini, jota tarjoiltiin Nobel-juhlassa vuonna 2022. Maaseudun innovaatioryhmässä on nostettu tulevaisuuden visiota siten, että siihen osallistuu laajempi sidosryhmäjoukko, erityisesti viljelijöitä, aluehallinto, yliopistomaailma ja yritykset – sekä Ruotsissa että kansainvälisellä tasolla.

Maaseudun innovaatioryhmien tavoitteena on ratkaista maataloudessa ja alkutuotannossa havaittuja ongelmia. Ne pyrkivät myös jakamaan keksittyjä innovaatioita yleiseen käyttöön muille sidosryhmille. Ryhmissä on vähintään kaksi kumppania: maa- ja metsätalous, maataloustuotteiden jalostus ja näihin liittyvät muut biotalousyritykset sekä ongelman ratkaisemisen kannalta merkitykselliset asiantuntijat/organisaatiot, kuten tutkijat, neuvonantajat, muut yritykset, yhdistykset. Maaseudun innovaatioryhmien rahoitusta haetaan kunkin Euroopan unionin maan toimivaltaisilta kansallisilta viranomaisilta.

Ilmastokestävän maatalouden uuden haaran perustaminen

Koeomenatarhoja perustettiin ennen maaseudun innovaatioryhmän perustamista. Ennen maaseudun innovaatioryhmän perustamista Brännland Cider oli perustanut koeomenantuotantoalueita Uumajan lähelle Pohjois-Ruotsiin. Ensimmäinen kokeellinen omenatarha, jossa on 250 puuta, perustettiin sata kilometriä Uumajasta pohjoiseen vuonna 2014. Toinen kokeellinen hedelmätarha istutettiin vuonna 2016 ja se koostui 1200 omenapuusta,

jotka sijaitsevat Röbäcksdalenissa lähellä Uumajaa. Kokeellisissa hedelmätarhoissa käytettiin kaikkia saatavilla olevia kylmäkestäviä omenalajikkeita.

Vuonna 2019 maaseudun innovaatioryhmä "Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in Northern Europe" sai rahoitusta hankkeen toteuttamiseen vuosina 2020–2023. Covid-19: n aiheuttamien viivästysten vuoksi omenapuiden saamisessa hankkeen kestoa jatketaan ja se kestää elokuuhun 2024 asti. Hankkeen 10,7 miljoonan Ruotsin kruunun kokonaisbudjetista 85 prosenttia rahoitettiin EIP-Agri-varoilla. Toimintaryhmän käynnistyttyä vuonna 2020 useiden viljelijöiden omistamille kiinteistöille on istutettu yhteensä yli 12000 omenapuuta 10 hehtaarille tavoitteena kaupallinen kannattavuus yhteistyössä paikallisten viljelijöiden, sekä nykyisten viljelijöiden että viljelijöiksi haluavien kanssa. Ruotsin pohjoisimpia alueita – Jämtlantia, Norrbottenia, Västerbottenia ja Västernorrlandia – on käytetty näihin omenanistutusalueisiin. Etelä-Ruotsin Skåneen on istutettu vertailuomenanviljelyalue, jossa käytetään pohjoisia omenalajikkeita. Näiden omenanviljelyalueiden perustamisessa on käytetty yhteensä kymmeniä eri omenalajiketta.

Maaseudun innovaatioryhmän tavoitteiden saavuttamiseksi ryhmässä oli mukana eri organisaatioita – yrityksiä, maakuntahallinto, viljelijöiden yhdistys ja yksittäisiä asiantuntijoita. Maaseudun innovaatioryhmään kuuluvat ruotsalaiset yritykset ovat jääsiiderin tuottaja Brännland Cider, teknologian kehitysyhtiö Boreal Orchards sekä hedelmien ja vihannesten tukkukauppias ja yksi Ruotsin suurimmista omenanviljelijöistä Elsanta. Ryhmässä on mukana myös yksi kansainvälinen yritys, eurooppalainen pohjoisten omenalajikkeiden asiantuntija Blomqvist Plantskola Oy Lepplaxista, Suomesta. Yritysten lisäksi ryhmässä on mukana Norrbottenin aluehallinto, kansallinen viljelijäyhdistys LRF Västerbotten ja yksi yksittäinen puutarhuri, jolla on pitkä kokemus pohjoisen omenoista. Kutakin osallistuvaa organisaatiota edustaa ryhmässä yksi henkilö. Kaikki mukana olevat henkilöt tuovat ryhmään monipuolista agronomista, puutarhanhoidollista, kaupallista, teknologista, tutkimuksen ja viljelyn osaamista. Maaseudun innovaatioryhmän tuloksena viljelijät ovat saaneet mahdollisuuden monipuolistaa tuotantoaan alueella taloudellisesti ja ympäristön kannalta. Kaiken kaikkiaan hanke edistää ilmastonmuutoksen kestävää elintarviketurvaa, uuselintarvikkeiden kehittämistä kuluttajille sekä viljelijöiden, alueiden ja paikallisyhteisöjen taloudellista ja ympäristöön liittyvää kestävyyttä.

Skannaa QR-koodi tai katso video klikkaamalla linkkiä maaseudun innovaatioryhmän, Brännland Isciderin, tarinasta. 2023. Tämä on tarinan alku.):

Maanviljely hyötyy paikallisista pohjoisista vahvuuksista

Koska omenanviljely ei sinänsä ole kannattavaa Pohjois-Ruotsissa, omenanviljelijät saavat voittoa myymällä omenoita Brännland Ciderille, joka tuottaa omenoista premium-tuotetta, jääsiideriä. Omenanviljelyn kannattavuutta haetaan myös esimerkiksi keskittämällä viljelypanostuksia paikallisiin vahvuuksiin, kuten olemassa olevaan paikalliseen tietoon omenoiden kasvattamisesta pohjoisessa ilmastossa, suotuisiin pienilmastotaskuihin ja kylmiin ankariin talviin.

Koska omenanviljelyolosuhteet Pohjois-Ruotsissa ovat erilaiset kuin Etelä-Ruotsissa, myös viljelyratkaisuja on mukautettava paikallisesti. Koska kaupallisen tason omenanviljely on uutta pohjoisessa ilmastossa, omenanviljelyn mukauttaminen pohjoisiin olosuhteisiin on sisältänyt omenatarhojen hoitokäytäntöjen kokeilua ja oppimista omenoiden käytännön kasvattamisen kautta. Samalla kun on kokeiltu perinteisten viljelymenetelmien yhdistämistä uusiin menetelmiin, on käytetty laajaa valikoimaa omenalajikkeita, optimoitu maankäyttöä, erilaisia istutusjärjestelyjä, erilaisia hoitovaihtoehtoja, vähennetty kuljetuksia ja vähennetty vedenkäyttöä. Kokeilujen avulla on saatu selville taimien optimaalinen istutussyvyys ja ikä. On huomattu, että omenan taimien on oltava kaksivuotiaita selviytyäkseen

hyvin ensimmäisinä kasvukausina ja ne tuottavat omenoita myös aikaisemmin kuin pienemmät taimet. Yksi kokeellisista käytännöistä on kuivaviljely, eli ilman kastelua, ulkoisia ravinnepanoksia tai torjunta-aineita testataan omenatarhojen hoitoa suotuisissa mikroilmastotaskuissa. Hanke innostaa viljelijöitä menemään tavallisen liiketoiminnan ja alueen perinteisen maatalouden käytäntöjen yli. Jokainen viljelijä löytää myös oman tapansa hoitaa omenatarhaansa – koko ideana on oppia uutta tulevaisuutta varten ja tehdä havaintoja, jotta asioita voi tehdä paremmin jääsiiderin tuotantoon soveltuvien sokeripitoisten omenoiden kasvattamisessa Pohjois-Euroopassa.

Koska sokerilla on ratkaiseva merkitys omesta tehtävän siiderin tuotannossa, tavoitteena on tuottaa runsaasti sokeria sisältäviä omenoita sen sijaan, että keskityttäisiin vain tonnimääriin. Korkean sokeripitoisuuden lisäksi pyritään tuottamaan maukkaita omenoita sen sijaan, että tuotettaisiin omenoita, joiden väri, koko ja muoto ovat samanlaisia. Jotkut varhaisimmista omenalajikkeista, joiden kanssa Brännland Cider työskenteli, olivat Austere, Cox Orange ja Mutsu. Nyt käytetyt lajikkeet ovat paljon monipuolisempia ja vielä monipuolisempia tulevaisuudessa, kun kaikkien valittujen kylmäkestävien lajikkeiden istutetut omenapuut alkavat kantaa enemmän hedelmää.

KUVA (Brännland Ciderin valokuvavarastosta tai julkisesti saatavilla oleva valokuva omenoista).

Jääsiiderin tuotantoprosessi Brännland Ciderissä

Kryokonsentraatio

Kylmä ilmasto on avain jääsiiderin tuotantoon. Jääsiiderin kryokonsentraatio tehdään käyttämällä Uumajan luonnollista kylmää vuodenaikaa. Kun omenat on poimittu syksyllä, niitä säilytetään kylmävarastossa sään kylmenemiseen asti, tyypillisesti marraskuun loppuun asti. Omenat puristetaan ja mehu jäädytetään viinitilan ulkopuolella olevissa säiliöissä. Sen lisäksi, että luonnollinen kylmä on avain jääsiiderin valmistukseen, se helpottaa myös omenoiden perusteellisempaa ja kestävämpää käyttöä raaka-aineena. Kun omenamehu jäätyy, vesi jäätyy ensin ja jäljellä olevasta nesteestä tulee suhteellisesti makeampaa luonnollisesti tiivistettyä omenamehua. Tässä kryokonsentraatioprosessissa sokeri toimii jäätymisenestoaineena. Koska tiivistetty omenamehu on vettä raskaampaa, se putoaa säiliön pohjalle. Kun yrittäjät pitävät pitoisuutta riittävänä, he tuovat säiliön sisälle sulamaan hieman ennen mehun valuttamista toiseen säiliöön säiliön pohjassa olevan venttiilin kautta. Valuttamisen jälkeen uusi säiliö, joka on täynnä kylmällä tiivistettyä omenamehua, viedään ulos jäätymään ja tiivistymään uudelleen. Tämä prosessi tehdään niin monta kertaa kuin tarvitaan, mikä voi vaihdella vuosittain. Brännland Ciderin vuotuinen raakarypälemehukapasiteetti on noin 110000 litraa.

Käyminen

Brännland Ciderin aloitusjääsiiderin sokeripitoisuus on 35–40° Brix. Kryokonsentroinnin jälkeen tiivistetty omenamehu asetetaan käymissäiliöihin yhdessä hiivan kanssa. Jääsiiderit eivät ole muotoutuneet ennen kuin niiden luonne eri lajikkeiden ja eri sokeripitoisuuksien edustajina nähdään. Jokaisen jääsiiderisäiliön annetaan käydä itsestään yrittäjien viininviljelijäkokemuksen määrittelemien ohjeiden mukaisesti. Kun käymisen katsotaan olevan parhaimmillaan, käymissäiliön pohjalle kertynyt sakka pumpataan pois.

Suodatus, sekoitus ja pullotus

Sakan poistamisen jälkeen viini suodatetaan. Osa suodatetusta viinistä jätetään terässäiliöihin pullotettavaksi tulevien kuukausien aikana, ja osa syvimmistä ja tummimmista viineistä kypsytetään tammityynnyreissä. Sekoitusprosessi tapahtuu haistelemalla, maistamalla ja keskustelemalla viinien ominaisuuksista. Viimeisenä vaiheena viini pullotetaan käsityötä pullotusprosessissa tarvitsevilla koneilla. Kukin 0,5 litraa Brännlandin jääsiideriä valmistetaan neljästä kilosta omenoita. Brännland Ciderillä on kolme pääpullotusta jääsiideriä, joista jokaisella on ainutlaatuiset ominaisuudet ja jotka on suunnattu eri kuluttajille.

Tällä hetkellä Brännland Cider ostaa 140 tonnia omenoita Skånen omenanviljelijöiltä, ja pohjoisia omenalajikkeita on istutettu myös Skånen Österleniin yhteistyössä alueen paikallisen kumppanin kanssa. Eteläisistä omenoista valmistettujen viinien luonne eroaa pohjoisista omenalajikkeista valmistettujen viinien luonteesta, mutta molemmilla on ainutlaatuisia ominaisuuksia, jotka voivat täydentää toisiaan. Vaikka vain pieniä määriä jääsiideriä on tuotettu omenoista yrityksen omilla pohjoisilla omenaviljelmillä, tämän pohjoisen jääsiiderin luonteen on todettu olevan pohjimmiltaan ainutlaatuinen verrattuna eteläisistä omenalajikkeista tuotettuihin.

Skannaa QR-koodi katsoaksesi video jääsiiderin tuotantoprosessista tai napsauta linkkiä: Brännland Cider. 2023. Jääsiiderivuosi – Viininvalmistus kaukana pohjoisessa):

Edelläkävijä eurooppalaisissa jääsiideristandardeissa

Omenoista valmistetun jääsiiderin innovaatio, *cidre de glace*, juontaa juurensa 1900-luvun lopun Kanadaan ja jääsiiderin laadun nimitys perustettiin vuonna 2005 Kanadan Quebecissä. Jääsiiderin valmistus aloitettiin kuitenkin Kanadassa, varsinainen jääviinin valmistus aloitettiin Saksassa 1700-luvun lopulla ja 1800-luvun alussa. 1970-luvulla jääviinin valmistusmenetelmä vietiin Pohjois-Amerikkaan ja erityisesti Kanadaan lämpimien kesien ja kylmien talvien ilmasto-olosuhteiden vuoksi. Vuonna 1978 Kanadassa valmistettiin ensimmäinen rypäleistä valmistettu jääviini. 1990-luvun alussa otettiin ensimmäiset kehitysaskeleet kohti jääsiiderin tuotantoa, kun ensimmäiset havainnot osoittivat, että jääviinin valmistusta voidaan toteuttaa onnistuneesti omenoilla. Vuonna 1999 ensimmäinen pullo jääsiideriä myytiin Kanadassa jääsiiderin virallisella nimityksellä. Jääsiiderin tuotannon kehitys on ollut siitä lähtien nopeaa useiden tuottajien erikoistuessa jääsiideriin Kanadassa ja Yhdysvalloissa. Vain muutama vuosi sitten, vuonna 2018, Euroopassa oli 10-15 jääsiiderin tuottajaa.

Jääsiiderin tuotannon edelläkävijänä Euroopassa Brännland Cider on ollut aktiivinen jääsiideristandardin kehittämisessä Eurooppaan yrityksen alkuvuosista lähtien. Vuodesta 2013 lähtien Brännland Ciderillä on ollut oma laatumääritelmänsä jääsiiderille, joka noudattaa pääosin kansainvälistä jääsiideristandardia. Koska jääsiiderille ei ollut yhteistä eurooppalaista standardia ja he olivat ainoa jääsiiderin tuottaja Euroopassa vuonna 2013, Brännland Cider teki oman jääsiiderin määritelmän sen perusteella, mitä he pitivät oikeana jääsiiderin tuotantomenetelmänä. Määritelmä seuraa muutamia poikkeuksia lukuunottamatta, kuten alhaisempi jäännössokerin tarve g/l, jääsiiderin määritelmää, jonka ovat kehittäneet jääsiiderin tuottajat ja siihen liittyvät viranomaiset Kanadan Quebecissä, joka on maailman alkuperäinen jääsiiderin kehitysalue. Vaikka määritelmä helpotti kuluttajille tiedottamista jääsiiderin laadusta, se ilmaisi myös näkemyksen yhteisen jääsiiderin tuotantostandardin kehittämisestä Euroopalle. Brännlandin Ciderin käyttämä määritelmä ei kuitenkaan ole vielä virallinen, vaan se antaa kuluttajille ja muille jääsiiderin tuottajille signaalin säännöistä, joita Brännland Cider noudattaa tuotannossaan ja mitä he pitävät perustana Euroopan yhteiselle jääsiideristandardille.

Brännlandin jääsiiderin laadun nimityksen mukaan "*Jääsiideri on makea viini, joka on valmistettu käymällä omenamehua ja jonka sokeripitoisuus on vähintään 30 ° Brixin ennen käymistä. Sokerin konsentrointi on tehtävä käyttämällä luonnossa esiintyvää kylmää. Lopputuotteen alkoholipitoisuuden on oltava 7–13 tilavuusprosenttia ja jäännössokerin vähintään 130 g/l.*" (Brännland Cider 2018b). Määritelmässä todetaan myös, että jääsiiderin lähtömehun on oltava "*100-prosenttinen tiivistämätön luonnollinen omenamehu Ruotsissa kasvatetuista omenoista*" ilman lisättyjä säilöntä-, maku- tai väriaineita, alkoholia tai sokeria.

Jääsiiderin määritelmässä luonollinen kylmä on yhteinen nimittäjä jääsiiderin tuotannolle. Jääsiiderin tuotannon kansainvälisessä nimityksessä esitetään kaksi menetelmää sokerin tiivistämiseksi omenamehuun: kryouutto ja kryokonsentraatio. Brännland Ciderissä omenamehun kryokonsentraatio jääsiideriä varten tehdään omenamehun omenamehun jäätämisen ja valutuksen toistojen kautta. Kryouutossa omenoiden annetaan pysyä puissa, kunnes niissä oleva mehu on riittävän väkevää jääsiiderin tuotantoon. Brännland Cider ei tee kryouuttoa.

KUVA (Brännland Ciderin valokuvavarastosta tai julkisesti saatavilla oleva kuva omenoiden kukinnasta).

Mitä tulevaisuus tuo tullessaan?

Brännland Cider on kasvattanut tuotantokapasiteettiaan tasaisesti vuosien varrella. Jääsiiderin lisäksi Brännland Cider on valmistanut omenaglögiä vuodesta 2017 lähtien. Kaiken kaikkiaan heidän tuotteitaan tuotetaan 80000-90000 pulloa vuodessa, josta lähes puolet menee vientiin, tärkeimpinä vientimarkkinoina Norja, Yhdistynyt kuningaskunta, Espanja ja Sveitsi. Jääsiiderin tuotannon lisäksi Brännland Cider on myös tehnyt yhteistyötä ruotsalaisen maailmanlaajuisesti tunnustetun lasisuunnittelijan kanssa suunnitellakseen jääsiiderilasin erityisesti heidän tuotteelleen, mikä on yksi askel matkalla jääsiiderikokemuksen laajentamiseksi kokonaisuudeksi.

Mitä tulee omenoiden hankintaan tulevaisuudessa, Brännland Cider jatkaa yhteistyötä omenanviljelijöiden kanssa sekä Etelä- että Pohjois-Ruotsissa. Samalla yhtiö suunnittelee omistavansa suuremman osan omenanviljelyalueistaan. Jääsiiderin luonteen ja laadun osalta tavoitteena on tulevaisuudessa siirtyä viininvalmistajan mausta*, vin d'effort*, houkuttelevan kuluttajaystävällisen viinin tuottamiseen, *vin d'terroir*, paikan tunteeseen, joka ilmentää eri omenantuotantoalueiden omenoista valmistetun jääsiiderin ainutlaatuista makua, joka johtuu erityisistä paikallisista kasvuolosuhteista, kuten ilmastosta, maaperästä ja topografiasta. Ainutlaatuiset paikalliset ominaispiirteet toteutuvat tulevaisuudessa entistä paikkakohtaisemmalla pullotuksella. Muuttuvassa ilmastossa omenalajikkeiden valinta sopimaan myös tuleviin ilmasto-olosuhteisiin on tärkeä jatkuva tehtävä valittaessa omenalajikkeita tulevaisuutta varten.

Vaikkakin Brännland Cider ja sen toiminta ovat olleet maaseudun innovaatioryhmän "Kaupallinen tuottava omenanviljely pohjoisessa ilmastossa – innovaatio uutta ilmastokestävää maataloutta varten Pohjois-Euroopassa" painopisteenä, maaseudun innovaatioryhmän pitkän aikavälin tavoitteena on edistää ilmastokestävää maataloutta ja luoda suotuisia kumppanuuksia viljelijöiden ja elintarvikkeiden jalostusyritysten välille uusien tuotteiden kehittämiseksi paikallisesti, alueelliset ja maailmanlaajuisille markkioille. Hanke ja sen spinoffit etsivät jatkuvasti lisää yhteistyötä akateemisen maailman ja muiden kumppaneiden kanssa. Jos olet kiinnostunut oppimaan lisää toimijaryhmästä "Kaupallinen tuottava omenanviljely pohjoisessa ilmastossa – innovaatio uuteen ilmastokestävään maatalouteen Pohjois-Euroopassa", löydät hankkeen yhteystiedot EIP-AGRI-hanketietokannasta: https://eu-cap-network.ec.europa.eu/projects/commercial-productive-apple-growing-northern-climate-innovation-new-climate-resilient_en

Tietoja FOREST4EU projektista

Artikkeli on tuotettu FOREST4EU hankkeessa osana capacity building -materiaaleja, jotka on suunnattu sidosryhmille ympäri Eurooppaa. Koska maaseudun innovaatioryhmissä kehitetyt innovaatiot ovat yleensä saatavilla paikallisesti, FOREST4EU-hankkeen tavoitteena on siirtää metsätaloutta ja agrometsätaloutta koskevaa tietoa ja parhaita käytäntöjä sidosryhmille ja toimijaryhmille kaikkialla Euroopassa. Hanke on saanut rahoitusta Euroopan unionin Horisontti Eurooppa -tutkimus- ja innovaatio-ohjelmasta hankesopimuksen N° 101086216 mukaisesti.

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FOREST4EU extended summary on the operational group "Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in northern Europe" & interview with Daniel Pacurar, 22.8.2023.

Tanja Kähkönen, European Forest Institute

Northern climate and apple varieties as a source for innovation: agricultural productivity and sustainability in northern apple production for ice cider, a sweet dessert wine in Umeå, Sweden

A desire to live in Northern Sweden, ambitious attitudes towards producing high quality products, and curiosity of wines has been some of the leading causes to the establishment of EIP-AGRI Operational Group "Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in northern Europe" in Umeå, Northern Sweden.

PHOTO (from the photo repository of Brännland Cider or a publicly available photo of a cidery).

Northern rural areas of Europe have been featured by challenges in making living from traditional agriculture, limited number of commercially cultivated species, and generally harsh climate conditions. The story of the EIP-AGRI Operational group "Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in northern Europe" in Umeå, region of Västerbotten, Sweden, started well before its establishment from a vision of a man who desired to live in Northern Sweden. With the desire to live in the region, an entrepreneur Andreas Sundgren, established Brännland Cider in the village of Vännäsby near Umeå in 2010 and started to make ice cider in a basement in Brännland, Umeå in 2011. Since the beginning of Brännland Cider, the aim has been to produce a drink that would be known all over the world, a vision to create the best sweet wine in the world. The first two years of the company were full of learning through trials. Whereas the first aim was to produce cider, a simpler product than

ice cider, through new discoveries in trials during the first two years it became clear that northern Swedish apples were best suited for ice cider production. An observation of having two local assets - access to both cold weather and Swedish high acidity dessert apples suitable for production of naturally sweet cider – paved the way for starting successful ice cider production in the region. Through combining these two local assets, Brännland Cider became winemakers instead of cider makers. The international networks of Brännland Cider including winemaking experts, ice cider production experts and apple growing experts have paved the way to create a unique wine made from apples. Now the ice cider, a sweet dessert wine, made from apples in Northern Sweden is among the best ones in the world and it is also the first Swedish wine ever served at Nobel banquet in 2022. The future vision has been levelled up in the EIP-AGRI operational group to involve wider stakeholder population especially farmers, regional governments, academia, and business – both in Sweden and at international level.

EIP-AGRI Operational Groups aim to solve identified problems in agriculture and primary production. They also aim to share the invented innovations to general use for other stakeholders. The groups consist of at least of two partners: enterprises in agriculture, forestry, processing of agricultural products and other bioeconomy enterprises related to these, and experts / organisations relevant to solving the problem such as researchers, advisors, other enterprises, associations. The funding for EIP-AGRI operational groups is applied from responsible national authorities in each country in European Union.

Establishing a new branch of climate resilient sustainable agriculture

Trial apple orchards preceded the establishment of the EIP-AGRI Operational Group. Before the establishment of the EIP-AGRI Operational Group, Brännland Cider had established trial apple production areas near Umeå, Northern Sweden. The first experimental apple orchard was established with 250 trees in one hundred kilometers north of Umeå in 2014. The second experimental orchard was planted in 2016 and it consisted of 1200 apple trees located in Röbäcksdalen near Umeå. In the experimental orchards, all the cold-hardy apple varieties that were available were used.

In 2019, EIP-AGRI Operational Group “Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in northern Europe” received funding to run the project between years 2020 and 2023. Due to delays caused by covid-19 in getting apple trees, the project duration is extended and it will run until August 2024. Out of the total project budget 10.7 million SEK, 85% was funded with EIP-Agri funds. After the start of the operational group in 2020, more than 12000 apple trees have been planted in total in 10 hectares in plots owned by several farmers with an aim of commercial viability in collaboration with local growers, both farmers and those aspiring to become farmers. The northernmost regions of Sweden – Jämtland, Norrbotten, Västerbotten and Västernorrland – have been used for these apple planting areas. A comparison apple cultivation area has been planted in Skåne, southern Sweden, using northern apple varieties. In total tens of different apple varieties have been used in establishment of these apple cultivation areas.

To reach the aims of the operational group, different organizations – enterprises, regional government, farmers’ association, and individual experts – were involved in the group. The Swedish enterprises included in the operational group are the ice cider producer Brännland Cider, technology development company Boreal Orchards, and fruit and vegetable wholesaler and one of Sweden’s biggest apple growers Elsanta. Also one international company, European expert in northern apple varieties Blomqvist Plantskola Oy from Lepplax, Finland, is involved in the operational group. Besides enterprises, the regional government of Norrbotten, the national farmers’ association LRF Västerbotten, and one individual gardener with long experience in northern apples are involved in the group. Each involved organisation is represented by an individual person in the operational group. All the involved individuals bring diverse agronomical, horticultural, commercial, technological, research and farming expertise in the operational group. As a result of the operational group, farmers have received an opportunity to diversify economically and environmentally their production in the region. Overall, the project contributes to climate resilient food security, developing novel foods for consumers, economic and environmental resilience of farmers, region and local communities.

Scan the QR code or click the link to watch a video to learn about the story of the operational group: Brännland Iscider. 2023. This is the beginning of the story.):

Farming practices benefit from local northern strengths

As apple cultivation as such is not profitable in northern Sweden, apple growers receive profit through selling apples to Brännland Cider which produces a premium product, ice cider from the apples. Profitability of apple cultivation is also sought for instance through leaning the cultivation efforts with benefiting from local strengths such as existing local knowledge on growing apples in northern climates, favourable microclimate pockets, and cold harsh winters.

As the conditions for apple growing in northern Sweden are different from those in southern Sweden, cultivation solutions also need to be locally adapted. As commercial level apple cultivation is new in northern climates, adapting apple cultivation to northern conditions has included experimenting with apple orchard management practices and learning by growing apples in practice. While experimenting with combining traditional cultivation methods with new ones, a wide range of apple varieties has been used, optimising land use, different planting arrangements, different management options, decreasing transportation, and decreasing water use has taken place. Through experimenting, the optimal plantation depth and age of seedlings has been established. It has been noticed that apple seedlings need to be two-year-old to cope well during the first growing seasons and they also produce apples earlier than smaller seedlings. One of the experimental practices is dry farming, i.e. applying no irrigation, external nutrient inputs or pesticides, is tested in the management of apple orchards in favourable microclimate pockets. The project inspires farmers to go beyond business as usual and traditional agriculture in the area. Each farmer also finds their own way of managing their apple orchard – the whole idea is to learn new things for future and do observations to do things better in terms of growing apples with high sugar content suitable for ice cider production in the Northern Europe.

As sugar is crucial in producing apple cider, the aim is to produce apples with high sugar content instead of focusing on tonnage only. Besides the high sugar content, apples full of flavour are aimed at to be produced instead of producing apples with similar qualities in colour, size and shape. Some of the earliest apple varieties that Brännland Cider worked with were Austere, Cox Orange and Mutsu. Now the used varieties are much more varied and will be more varied in future as the planted apple trees of all the chosen cold hardy varieties will start to bear more fruit.

PHOTO (from the photo repository of Brännland Cider or a publicly available photo of apples).

Ice cider production process at Brännland Cider

Cryoconcentration

Cold climate is the key for ice cider production. Cryoconcentration of ice cider is done with using the natural cold season present in Umeå. After the apples have been picked in autumn, they are stored in a cold storage until weather gets cold, typically until the end of November. The apples are pressed and the juice is frozen in tanks outside the winery. Besides natural cold being the key for producing ice cider, it also facilitates more thorough and sustainable use of apples as the raw material. When the apple juice gets frozen, water gets frozen first and remaining liquid becomes relatively sweeter naturally concentrated apple juice. In this cryoconcentration process sugar acts as an antifreeze agent. As the concentrated apple juice is heavier than water, it drops at the bottom of the tank. Once the entrepreneurs consider the concentration being sufficient, they brink a tank inside to thaw a bit before tapping the juice in another tank through a valve at the bottom of the tank. After tapping the new tank, full of cryoconcentrated

apple juice, is taken outside to refreeze and reconcentrate. This process is done as many times as needed which may vary from year to year. At Brännland Cider, annual raw must capacity is about 110000 liters.

Fermentation

At Brännland Cider, the starting ice cider must has a sugar content between 35° and 40° brix. After cryoconcentration, the concentrated apple juice is placed in fermentation tanks together with yeast. Ice ciders are not shaped before their nature as representations of different varieties and different sugar concentrations is seen. Each ice cider tank is let to ferment on their own based on the guidelines defined by the entrepreneurs' experience as winemakers. After fermentation is deemed to be at its best, racking, pumping the wine of the solid matter accumulated at the bottom of the fermentation tank takes place.

Filtering, blending and bottling

After racking, wine is filtered. A part of the filtered wine is left in the steel tanks to be bottled within the coming months, and a part, the most deepest and darkest wines are aged in oak barrels. Blending process is done through smelling, tasting and discussing the qualities of the wines. As the final step, the wine is bottled with machinery requiring manual labour in the bottling process. Each 0.5 liters of Brännland Ice Cider is made of four kilos of apples. Brännland Cider has three main bottlings of ice wine, each with unique characteristics and aimed at different consumers.

Currently Brännland Cider purchases 140 tonnes of apples from apple growers in Skåne and northern apple varieties have been planted also in Österlen in Skåne in collaboration with a local partner in the region. Whereas the expression of wines made from southern apples is different from the wines made from the northern apple varieties, both have their unique qualities which can complement each other. Although only small quantities of ice cider has been produced from apples in their own northern apple plantations, the expression of this northern ice cider has been noted to be fundamentally unique compared to those produced from southern apple varieties.

Scan the QR code to watch a video on the ice cider production process or click the link: Brännland Cider. 2023. The Ice Cider Year – Wine making in the far North):

Trailblazing in European ice cider standards

Innovation of ice cider, *cidre de glace*, made from apples has its roots in Canada in late 1900s and the denomination of ice cider quality was established in 2005 in Quebec, Canada. Yet, production of ice cider was started in Canada, actual ice wine making was started in Germany in late 1700s and early 1800s. In 1970s the ice wine making method was taken to North America, and especially to Canada due to climatic conditions of warm summers and cold winters. In 1978 the first ice wine made out of grapes was produced in Canada. In early 1990s the first developments towards producing ice cider were taken with first observations that ice wine making can be successfully implemented with apples. In 1999 the first bottle of ice cider was sold in Canada under the official designation of ice cider. The development of ice cider production has been rapid ever since with several producers specialising in ice cider in Canada and the US. Just a few years ago, in 2018, there were 10-15 ice cider producers in Europe.

As a trailblazer for ice cider production in Europe, Brännland Cider has been active in developing an ice cider standard for Europe since the company's early years. Since 2013, Brännland Cider has had its own definition of quality for ice cider which mainly follows the international ice cider standard. As there was no common European standard for ice

cider and they were the only ice cider producer in Europe in year 2013, Brännland Cider made its own ice cider definition based on what they considered being the correct ice cider production procedure. The definition follows with a few exceptions, such as lower residual sugar requirement g/L, the ice cider definition developed by ice cider producers and related authorities in Quebec, Canada, the original ice cider development area in the world. Whereas the definition made it easier to communicate with the consumers about the quality of the ice cider, it also signalled a view on developing common ice cider production standard for Europe. Yet the definition that Brännland cider uses is not official yet, it gives consumers and other ice cider producers a signal of rules which are followed by Brännland Cider in their production and what they consider as a ground for joint ice cider standard for Europe.

According to the Brännland denomination for ice cider quality, "*Ice Cider is a sweet wine produced through the fermentation of apple juice that holds a sugar content of at least 30° brix before fermentation. Concentration of sugar is to be done using naturally occurring cold. Alcohol content in the finished product must be between 7 and 13 percent by volume and residual sugar must be at least 130gr/L.*" (Brännland Cider 2018b). The definition also states that the starting juice for ice cider has to be "*100%, unconcentrated natural apple juice from Swedish grown apples*" with no added preservatives, flavors or coloring, alcohol or sugar (chaptalization).

In the ice cider definition, naturally occurring cold is the common denominator for ice cider production. In the international appellation for the production of ice cider, two methods of concentration of sugar in the apple juice are outlined: cryoextraction and cryoconcentration. In Brännland Cider cryoconcentration of apple juice is done by repeated cycle of freezing and tapping of the apple juice. In cryoextraction apples are let to stay in trees until the juice in them is concentrated enough for ice cider production. Cryoextraction is not done by Brännland Cider.

PHOTO (from the photo repository of Brännland Cider or a publicly available photo of apples flowering).

What may the future hold?

Brännland Cider has been steadily increasing its production capacity over the years. Besides ice cider, Brännland Cider has produced an apple mulled wine since 2017. Overall, 80000-90000 bottles of their products per year are produced with nearly half of them being exported with main export markets being Norway, the United Kingdom, Spain and Switzerland. Besides ice cider production, Brännland Cider has also partnered with a Swedish world renowed glass designer to design an ice cider glass specifically for their product which is one step in a journey to extend the ice cider experience into a whole.

What comes to sourcing apples in future, Brännland Cider will continue collaborating with apple growers both in southern and northern Sweden. At the same time, the company plants to own a larger proportion of its apple cultivation areas. In terms of expression and quality in future, the aim is to move from *vin d'effort*, taste of the winemaker to produce an attractive consumer-friendly wine, to *vin d'terroir*, sense of place expressing unique flavour of ice cider made from apples from different apple production areas stemming from specific local growing conditions such as climate, soil and topography. The unique local characteristics will be realised through more site-specific bottling in future. Under changing climate, choosing apple varieties to fit also in future climatic conditions is an important ongoing task while selecting apple varieties for future.

Whereas Brännland Cider and its operations have been the focal point of the operational group "Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in northern Europe", the long-term goal of the operational group is to contribute to climate resilient sustainable agriculture and to create favourable partnerships between farmers and food processing companies to develop further products in local, regional and global markets. The project and its spinoffs continuously search for further collaboration with academia and other partners. If you are interested to learn more about the operational group "Commercial productive apple growing in a northern climate – innovation for new climate resilient agriculture in northern Europe", you can find the

project's contact details on the EIP-AGRI Project Database: https://eu-cap-network.ec.europa.eu/projects/commercial-productive-apple-growing-northern-climate-innovation-new-climate-resilient_en

About FOREST4EU project

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