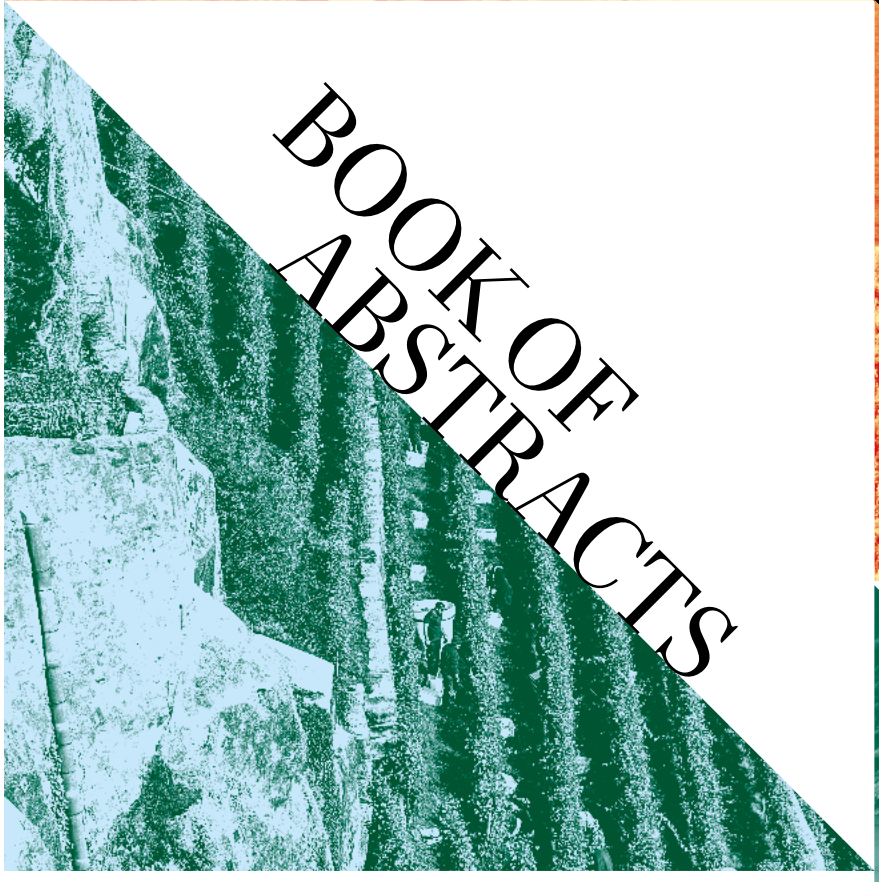
HEROIC VINEYARD

BOOK OF ABSTRACTS



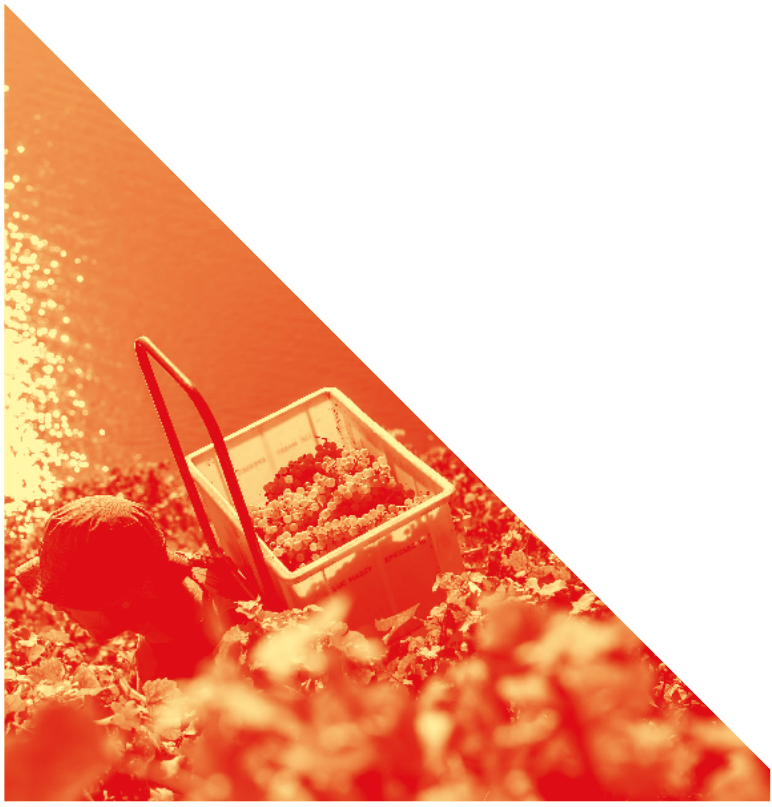
8th International Congress on Mountain and Steep Slopes Viticulture, Montreux
6–8 May 2026

OIV
Under the patronage of the International Organisation of Vine and Wine

6 MAY 2026
PRESENTATIONS

6 MAY 2026

WEDNESDAY MORNING



08:30 AM OPEN SESSION

08:30 AM Salutations by the authorities
Valérie Dittli, *State council of canton of Vaud in charge of Agriculture, Viticulture, Sustainability and Numeric*

08:40 AM CERVIM president
Nicola Abbrescia

08:50 AM President of the technical commission of CERVIM
Dr. Diego Tomasi: presentation of the congress

09:00 AM Keynote: Statistical and economic data on global and heroic viticulture
Dr. A. Mondoux, *president of the expert group on economic statistics and conjuncture OIV*

09:20 AM COFFEE BREAK

09:45 AM Keynote: Importance and role of heroic vineyards in Alsace, France
F. Schwaerzler, *agricultural chamber of Alsace*

10:05 AM Keynote: Situation and perspectives of heroic viticulture in Douro
Prof. Dr. J. Queiroz *university of Porto and vineyard owner*

10:25 AM Keynote: Italians heroic vineyards
Dr. D. Tomasi, *Director of the interprofessional organization Prococco Valdobbiadene and president of the technical commission of CERVIM and Uniqueness and futurability of Conegliano valdobbiadene Prosecco DOCG: a value model between vocation and innovation*
U. Marchiori, *Consorzio Tutela del Vino Conegliano Valdobbiadene Prosecco*

10:45 AM Keynote: The challenges of heroic viticulture in Switzerland
Dr. O. Viret, *responsible for viticulture State of Vaud, previously in charge of research and development at Agroscope*

11:05 AM Round table discussion on the future of heroic viticulture in Switzerland and in Europe, the role of CERVIM, labels and trade marks, OIV, and European Union
brief allocution by H. Dorfmann, *euro-deputy for viticulture* moderated by Anick Goumaz, *redactor of the Swiss French edition of the journal VINUM*

12:00 AM LUNCH

6 MAY 2026

WEDNESDAY AFTERNOON

ORAL PRESENTATIONS SESSION I

UNIQUE LANDSCAPES TO PRESERVE

Chairman D. Tomasi

1:15 PM Historical and heroic landscape to preserve through certification programs
Pomatto, Devecchi

1:30 PM Unique landscapes: how online reviews reveal the Lavaux visitor experience
Mele et al.

1:45 PM Functional biodiversity in heroic terraced viticulture: a heritage-based conservation approach across Italian national Parks
Gagnarli et al.

2:00 PM Landscape services, a tool to help managing the landscape value of vineyards
Reynard

SHORT COMMUNICATIONS SESSION I

2:15 PM The multifunctional value of historical viticulture as living heritage
Santoro et al.

2:25 PM A standardized GIS-based methodology for assessing water erosion risk in sloping vineyards: a case study in the UNESCO vineyard region of Monferrato
Bidoccu et al.

2:35 PM Heroic heritage: a case study of systemic vineyard regeneration in Santa Maria
Coutinho

6 MAY 2026

WEDNESDAY AFTERNOON TRIP

TRIP IN LAVAUX

A MILLENNIUM OF KNOW-HOW

3:00 PM Transfer by Lavaux Panoramic tourist train

Refer to the trip booklet for the full programme.

10:00 PM END OF THE EVENING

KEYNOTE: STATISTICAL AND ECONOMIC DATA ON GLOBAL AND HEROIC VITICULTURE

Global viticulture is undergoing profound structural transformation under the combined pressures of climate change, evolving consumption patterns, market concentration, and regulatory shifts. At the same time, so-called «heroic viticulture», characterized by extreme slopes, high altitudes, terraced landscapes, and strong manual labor intensity, represents both a cultural heritage asset and an economic challenge.

This keynote proposes a statistical and economic assessment of global and heroic viticulture, integrating production data, trade flows, price dynamics, and cost structures. Using international datasets combined with regional case studies, we examine three core dimensions: (1) the global redistribution of vineyard areas and production, (2) the economic sustainability and cost competitiveness of heroic viticulture systems, and (3) the market positioning strategies (premiumization, origin labeling, sustainability claims) that enable value capture despite structural deterrents.

Preliminary results highlight a dual trend: while global vineyard area is stabilizing or declining in several traditional producing countries, value creation is increasingly driven by premium segments and strong geographical identities. Heroic viticulture, despite higher production costs and lower mechanization potential, often benefits from price premiums linked to landscape value, tourism attractiveness, and perceived authenticity. However, its long-term resilience remains highly sensitive to labor availability, climate exposure, and public policy support.

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IMPORTANCE AND ROLE OF HEROIC VINEYARDS IN ALSACE

The Alsatian vineyard stretches for more than 120 km from south to north along the Vosges mountain range. It is located between the Vosges fault and the Rhine fault, and several fracture zones also cross the vineyard from west to east. As a result, many steep slopes are found within a mosaic of highly diverse terroirs.

For several centuries, Alsatian winegrowers have cultivated these steep hillsides, where a range of terroirs can be found, from limestone to granite and Vosges sandstone. Historically, these slopes were farmed in small plots bordered by stone walls known in Alsatian as *Kammerla*, literally meaning «little chambers.»

Since the 1970s, these hillsides have been restructured to improve mechanization. The Riesling grape variety has developed strongly on these steep slopes, particularly following the classification of many terroirs as Grand Cru. The improvement in the quality of Alsace wines, together with the growing reputation of terroir-driven Riesling, has contributed to enhancing the value of these steep-slope terroirs.

These slopes are often located close to historic villages and contribute significantly to the landscape and hiking attractiveness of the region, helping to stimulate local wine sales in winery tasting rooms and restaurants. Currently, the economic and environmental context is making the management of these heroic vineyards more challenging, particularly in finding alternatives to chemical weed control and techniques that can help limit labor costs for manual vineyard operations.

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CURRENT SITUATION AND PERSPECTIVES FOR HEROIC VINEYARDS IN THE DOURO REGION

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The Douro region in northern Portugal is the oldest demarcated and regulated wine region in the world and one of the most emblematic examples of heroic viticulture. Viticulture in the Douro is characterized by steep slopes, terraced landscapes, shallow soils, and extreme climatic conditions typical of a Mediterranean mountain environment. A large proportion of vineyards are located on slopes exceeding 30%, with very limited mechanization possibilities, fitting the criteria defined by CERVIM for heroic viticulture.

Beyond its physical constraints, the Douro presents unique orographic conditions—combining location, altitude, and exposure—that generate significant climatic gradients over short distances. These gradients represent an important asset in the context of climate change, offering natural opportunities for adaptation through site selection and vineyard management. In addition, the region benefits from an exceptional genetic heritage, with a remarkable diversity of grapevine varieties that enhances resilience. Douro vineyards also constitute a unique cultural landscape recognized as a UNESCO World Heritage Site.

Currently, heroic viticulture in the Douro faces several structural challenges, including climate change, with increasing heat and water stress; demographic decline and shortage of skilled labor; and the economic sustainability of small and medium-sized farms. Despite these challenges, the Douro also presents significant opportunities through advances in viticulture, improved soil and water management, and the valorization of the region's landscape, heritage, and high-quality wines—together with the growing importance of enotourism.

UNICITÀ E FUTURIBILITÀ DEL CONEGLIANO VALDOBBIADENE PROSECCO DOCG: UN MODELLO DI VALORE TRA VOCAZIONE E INNOVAZIONE

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Conegliano Valdobbiadene Prosecco Superiore DOCG, Italie

In un mercato vitivinicolo globale caratterizzato da una crescente complessità, l'unicità del Conegliano Valdobbiadene Prosecco DOCG continua ad evolversi grazie al concetto dinamico di Vocazione, definita come la sintesi sinergica di tre pilastri: Ambiente, Viti e Persone. Il presente contributo analizza come la rinnovata combinazione tra questi macro-fattori sia determinante per la resilienza futura e l'adeguamento nell'offerta e nel posizionamento nel segmento globale dei fine wines.

Ambiente (Paesaggio formale e sostanziale):
L'orografia collinare di transizione, caratterizzata da pendenze che favoriscono il drenaggio idrico e l'esposizione solare, garantisce condizioni eliotermiche e sanitarie d'eccellenza. Il riconoscimento UNESCO ne sancisce il valore paesaggistico e identitario, fondamentale per la distintività dell'offerta.

Viti (Fisiologia e Genetica):
La centralità del vitigno Glera, storicamente adattato a questo habitat, permette un'espressione territoriale autentica. Le sfide attuali impongono un'evoluzione verso il concetto di «vigore efficiente», ottimizzando gli input agronomici e preservando la salute del vigneto di fronte al cambiamento climatico attraverso innovazione tecnica e tecnologica.

Persone (Metodo e Visione):
Il fattore umano integra la scienza enologica con l'arte della spumantizzazione. Per evitare i rischi di omologazione del mercato di massa, è necessario un rinnovamento tecnico che valorizzi le differenze sensoriali originali e la capacità evolutiva dei vini, garantendo un modello di business concentrato sul valore anziché sul volume.

In conclusione, la futuribilità della Denominazione dipende dalla capacità di presidiare ed adeguare questi tre pilastri, trasformando i crescenti costi di una viticoltura eroica in un vantaggio competitivo etico e sostenibile. L'adozione di una strategia condivisa e di un impianto normativo flessibile sarà la chiave per consolidare il Conegliano Valdobbiadene come riferimento imprescindibile nel panorama internazionale dei vini effervescenti di pregio.

THE CHALLENGES OF HEROIC VITICULTURE IN SWITZERLAND

Viticulture in Switzerland dates to the 11th century and has been established in steep areas facing south, particularly along lakes to benefit from favorable conditions of a cool, alpine climate. The country in the middle of Europe (41,000 km^2) has one third of the territory inhabitable, offering limited possibilities of extension except at the expense of agriculture. About 30% of the wine growing area (14,484 ha in 2024) is located in steep slopes over 30% and belongs to heroic viticulture according to CERVIM.

The unicity of the landscapes, the quality of the produced wines, and the ecosystemic role of those areas imply their economic sustainability. On the other hand, production costs are worldwide among the highest, justifying more expensive prices for Swiss wines. Today's wine de-consumption and the strong competition from foreign wines questioned the future of those heroic vineyards, being negatively considered by certain citizens as a monoculture impacting the environment.

Today's most important challenge of heroic viticulture in Switzerland is its economic sustainability in a globalized market, facing the dilemma between traditional wines and novel products adapted to the dynamic of consumer's taste. The massive development of cultivars resistant to fungal diseases offers new marketing opportunities but raises the question of the varietal choice. Polygenic resistance against downy, powdery mildews, grey mold and black rot should be prioritized, considering wine and consumer tastes.

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HISTORICAL AND HEROIC VITICULTURAL LANDSCAPES TO PRESERVE THROUGH CERTIFICATION PROGRAMS: THE CASE OF THE «VINEYARD AND AGRICULTURAL TERRACED LANDSCAPES OF MOMBARONE» (PIEDMONT, ITALY)

Heroic viticulture landscapes are characterized by multiple values: historical, biocultural, and social. They preserve traditional practices, ancient grape varieties, and identity elements. However, in many European contexts, their integrity is threatened by abandonment due to management efforts, low remuneration, and social changes. Certification programs can help to promote the awareness of terraced landscapes, and a sustainable tourism that recognizes the added value of the landscape in vine bottles.

In Italy the Minister of Agriculture in 2012 promoted the «National Register of Historical Rural Landscapes, Agricultural Practices, and Traditional Knowledge». The aim of the research was to analyse the historical values, and assess the integrity of the «Vineyard and Agricultural Terraced landscapes of Mombarone» in order to promote their adhesion to the National Register.

The landscape integrity was assessed through cartographical analyses using QGIS 3.16 Hannover. The results showed that the historical organization of the landscape mosaic is well preserved. The vine breeding technique is the pergola caremiese, built with local chestnut poles and supported by stone columns. In the area (608.3 ha) the 67.8% of the surface preserves the historical landscape, showing a good integrity. From the end of 2024 the landscape is certified as national heritage, and inscribed in the National Register. The process of certification and development could evolve in future through the adhesion of Mombarone vineyard terraced landscape to the GIAHS Program promoted by FAO.

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UNIQUE LANDSCAPES: HOW ONLINE REVIEWS REVEAL THE LAVAUX VISITOR EXPERIENCE

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Research objectives

This study aims to explore how online user-generated content can inform our understanding of wine tourism experiences in the Lavaux region. Specifically, drawing from past research about wine tourism (Meneses et al., 2025), we investigate how visitors describe their encounters with the landscape, wineries, and overall destination by analyzing online reviews posted on TripAdvisor and Google about key points of interest. The research mainly seeks to determine the thematic prominence of landscapes in these reviews and assess visitors' emotional evaluations through sentiment analysis.

Description of methods

The study relies on a dataset of publicly accessible reviews referring to Lavaux wine experiences. After data cleaning and preprocessing, topic extraction is conducted using natural language processing techniques to identify recurrent themes, with particular attention to landscape-related vocabulary. Sentiment analysis is then applied to quantify positive, neutral, and negative perceptions. Additional metadata – such as temporal patterns, user origin, or review length – is analyzed to complement textual findings and enrich the interpretation.

Envisaged results

The analysis is expected to show that landscape appreciation constitutes an important theme in visitors' descriptions of their wine-tourism experiences. Topic extraction will likely highlight frequent mentions of scenic views, cultural value, and the uniqueness of the terraced vineyards. Sentiment analysis is anticipated to reveal predominantly positive emotional tones. On the one hand, the study aims to provide insights that can inform the sustainable management of wine tourism. On the other hand, this exploratory research wants to underline the potential of online reviews as a rich, low-cost source of strategic information for stakeholders of the region.

FUNCTIONAL BIODIVERSITY IN HEROIC TERRACED VITICULTURE: A HERITAGE-BASED CONSERVATION APPROACH ACROSS ITALIAN NATIONAL PARKS

Terraced agro-ecosystems represent an agro-cultural heritage of outstanding importance in Italian protected areas. Built and managed without mechanization, these traditional systems support ecosystem services: hydrogeological stability, sustainable food production, and functional biodiversity. The 5-RESTE project investigated the relationship between traditional agronomic practices and soil biological quality across five Italian National Parks (Cinque Terre, Maiella, Vesuvio, Arcipelago Toscano, Isola di Pantelleria).

Edafic microarthropod communities were dominated by Acari (74–95%). Vineyards with conservative inter-row management showed QBSar >140 with high richness of euedaphic groups (i.e. Diplura, Symphyla, Protura, Pseudoscopiones), while naturalized terraces exceeded 200. At Cinque Terre, 17 predatory mite species confirmed the role of low-input viticulture in sustaining biological control. At Vesuvio, drought stress caused a 21–46% decline in microarthropod abundance, highlighting soil vulnerability to climate change.

Traditional practices – native cultivar selection, dry-stone wall maintenance, minimum tillage and permanent ground cover – act as cultural biodiversity, preserving soil resilience. Results support shared indicators for terraced landscape management aligned with EU Nature Restoration Law objectives.

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LANDSCAPE SERVICES, A TOOL TO HELP MANAGING THE LANDSCAPE VALUE OF VINEYARDS

In line with the concept of nature's contributions to society, it can be argued that landscapes also provide goods and services to society. Landscape services describe the benefits that landscapes provide to different stakeholders. The fundamental resources that make up a landscape (water, forests, agricultural land, etc.) generate economic goods. This is the case with wine-growing landscapes, which provide the setting to produce grapes and wine.

A study has shown that the main benefits of a landscape can be grouped into four broad categories: aesthetic pleasure, identification and sense of place, recreation and health, and attractiveness of the location. The landscape services approach has been applied to the Lavaux vineyard, designated a UNESCO World Heritage Site in 2007. At the management level, landscape services provide three types of opportunities: (1) to communicate and encourage the public to engage with landscapes; (2) to improve cooperation between landscape stakeholders and to constructively manage conflicts; (3) to support public authorities at strategic and operational levels. Landscape services were therefore included in the revision of the management plan of the Lavaux World Heritage Site.

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THE MULTIFUNCTIONAL VALUE OF HISTORICAL VITICULTURE AS LIVING HERITAGE

Historic viticulture represents a highly multifunctional cultural landscape and living heritage (cultural, touristic, economic, social, and environmental). Maintaining these landscapes allows for a wide range of ecosystem services to be provided to rural communities. The historic landscapes of the Soave Vineyards represent an example of how maintaining historic landscape features contributes to the preservation of a widespread ecological network. This landscape, whose importance is recognized internationally (the Soave Vineyards are part of the FAO GIAHS Programme), is characterized by the widespread presence of minor forest formations, which play a key role in landscape perception, culture, ecology, and biodiversity.

A high-resolution spatial analysis demonstrated that linear tree formations in the Soave Vineyards area show particularly high-density values, equal to 57 m/ha, while small woods show an average density equal to 8.7 woods/100 ha of agricultural areas. These minor forest formations have a key landscape and ecological role, acting as connecting features between large forest patches, and also an important role for hydrological protection as they can be found also in steep slopes.

Preserving these landscapes through the application of traditional and biodiversity-friendly farming, similarly to the maintenance of drystone walls in terraced landscapes, also means strengthening a system of connections and exchanges between habitats, thus counteracting fragmentation and its negative impacts on biodiversity.

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A STANDARDIZED GIS-BASED METHODOLOGY FOR ASSESSING WATER EROSION RISK IN SLOPING VINEYARDS: A CASE STUDY IN THE UNESCO VINEYARD REGION OF MONFERRATO (PIEDMONT, NW ITALY)

Vineyards in steep Mediterranean and subAlpine terrains represent highly sensitive agroecosystems, where vineyard practices influence multiple soil functions, including water and soil conservation, biodiversity, slope stability, and flood protection. This concern is especially relevant in UNESCO-designated vineyard areas, where long-term soil sustainability supports both agricultural productivity and the preservation of cultural heritage.

We propose a standardized and reliable methodology, relying on open-source GIS and datasets, to evaluate water-driven soil erosion risk in vineyard soil systems by integrating climatic, soil, topographic and remote-sensing information. The workflow consists of an implementation of the Revised Universal Soil Loss Equation (RUSLE) in a QGIS framework using the ORUSCAL tool. The method was applied to a study site in the UNESCO vineyard landscape of Monferrato (Piedmont, NW Italy), using exclusively freely accessible data or tools, and including an uncertainty appraisal. A first regional assessment assuming temporary cover-crop adoption shows that most vineyards undergo low to moderate mean erosion rates, despite the generally steep slopes.

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HEROIC HERITAGE: A CASE STUDY OF SYSTEMIC VINEYARD REGENERATION IN SANTA MARIA

Santa Maria's heroic vineyards can be seen around the island's steep shorelines. These singular terraces rise up the mountainous slopes in dry-stone walls that are true medieval engineering achievements. Famous over the centuries for producing quality wines, the vineyards were progressively abandoned due to several factors. By the turn of the millennium they were severely degraded and laid dormant underneath lush vegetation.

Through collaborative action-research by a strong partnership, a rural regeneration project was brought to life by multiple local stakeholders from public, private and non-profit sectors. Using a systems-thinking approach and mixed methodologies, project partners have been involved in holistic efforts to recover the significant economic, social and environmental functions. Widespread recognition of the intrinsic value of the cultural landscape was a first step to seeing its economic potential, its importance for the local social fabric and the ecosystem services it provides.

These tangible and intangible assets have made a very strong case for investing in the rehabilitation of the landscape: by adapting legislation, providing public financing for human resources and optimizing institutional processes and communication flows. Sourcing funding for infrastructure development as well as training and knowledge transfer among local producers has led to a sharp increase in productive vineyard areas, stakeholder buy-in and the coming into being of a range of commercial wines and wine products, including three certified GI wines. This project makes a strong case for collaborative, systemic intervention in the rehabilitation of fringe environments such as cultural landscapes in heroic viticulture.

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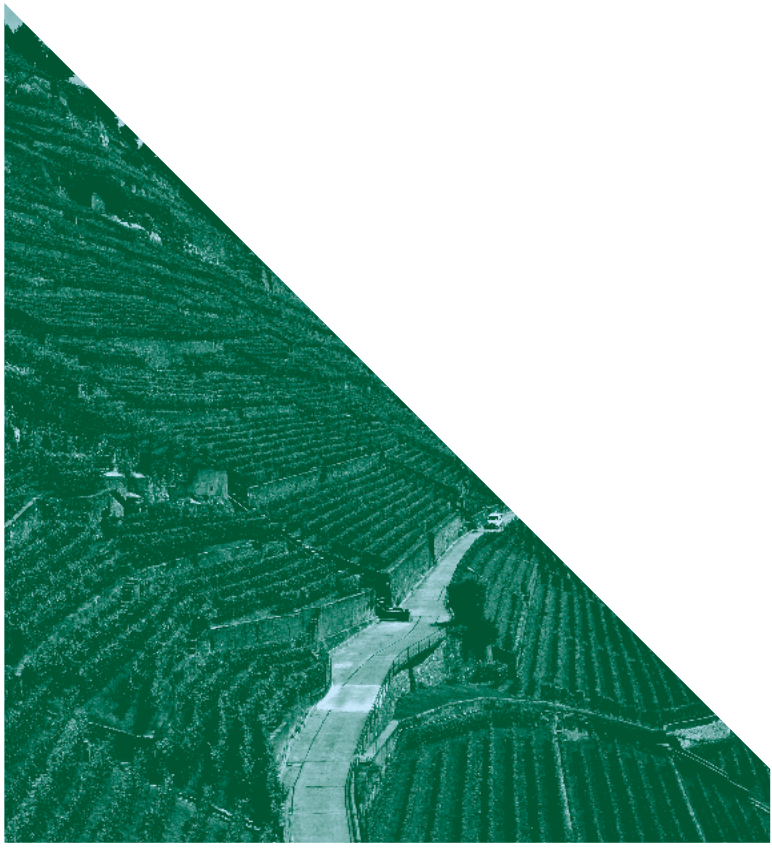
7 MAY 2026
PRESENTATIONS

7 MAY 2026

THURSDAY MORNING



ORAL PRESENTATIONS SESSION II
ECONOMICAL SUSTAINABILITY OF HEROIC VITICULTURE
chairman A. Mondoux

8:30 AM Heroic viticulture in Conegliano Valdobbiadene area and economic sustainability
Mayr

8:45 AM Recovery strategy of the Collioure-Banyuls heroic vineyards: terroir zoning, product-area adequacy and collective positioning
Akhiridinov and Gautreau

9:00 AM A post-growth paradigm for wine law: learning from heroic viticulture
Reinhardt, Noufaily and Monaco

9:15 AM Understanding the expression of time in Chasselas wines
Blackford et al.

SHORT COMMUNICATIONS SESSION III

9:30 AM Turning environmental commitment into economic value: a viticulture case study from the Yvorne region (Switzerland)
Heger et al.

9:40 AM Climate-adaptive viticulture and territorial fragility
Perucchini et al.

9:50 AM Soil water availability in steep slope vineyards, A case study of different systematizations in the Douro Region
Valente and Alves

10:00 AM COFFEE BREAK

ORAL PRESENTATIONS SESSION III
TECHNICS AND AGRONOMY
chairman V. Zufferey, *Agroscope*

10:30 AM Overview of non-herbicide soil management solutions in non- or poorly mechanized terraced vineyards
Marchand and Sonnard

10:45 AM Water balance modeling for terroir characterization and adaptative management in extreme viticulture
Tarditi et al.

11:00 AM Physiological and management-based adaptation of mountain vineyards to increase water stress under Mediterranean climate
Malheiro and Moutinho-Pereira

11:15 AM From soil to grape: multi-scale monitoring and precision irrigation in Madeira vineyards
Ragonezi et al.

7 MAY 2026

THURSDAY MORNING

SHORT COMMUNICATIONS SESSION III

11:30 AM Unmanned aerial system for crop protection in heroic viticulture: an eight-year field assessment
Pagliai et al.

11:40 AM Elevation-driven microclimates shape physiological, metabolomic, and microbial terroir in a steep-slope vineyard network in Lavaux (Switzerland)
Rienth et al.

11:50 AM Influence of slope and topography on aroma composition and sensory profile of Glera grapes in the Conegliano Valdobbiadene PDO
Marcuzzo et al.

12:00 AM Climatic and morphological variability in alpine viticulture: effects on Nebbiolo production in Valtellina
Bianchi et al.

12:10 AM Sustainable management of invasive plants in a steep slope vineyard
Delavallade et al.

12:20 AM Slope of the terrace embankment matters ? A case study reviewing geometry terraces in Douro Region
Alves, Valente, Pereira

12:30 AM Conclusion and perspectives
O. Viret

12:45 AM – 1:45 PM LUNCH

7 MAY 2026

THURSDAY AFTERNOON TRIP

TRIP IN CHABLAIS

IMMERSION IN THE HEART OF A MOUNTAIN VINEYARD

2:00 PM TRANSFER BY COACH TO YVORNE

Refer to the trip booklet for the full programme.

8:00 PM END OF THE DAY AND RETURN TO MONTREUX

HEROIC VITICULTURE IN CONEGLIANO VALDOBBIADENE AND ECONOMIC SUSTAINABILITY

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General Manager Ruggeri – Conegliano Valdobbiadene Prosecco Superiore DOCG, Italie

Heroic viticulture in the Conegliano Valdobbiadene Prosecco Superiore DOCG area is characterised by slopes exceeding 30%, where mechanisation is impossible and all vineyard operations must be performed manually. These steep areas cover 1,403 ha, representing 18% of the DOCG. The landscape is recognised as a UNESCO World Heritage Site, contributing unique cultural and branding value but also involving substantially higher labour costs compared to accessible or gently sloping vineyards.

Ruggeri manages 147 ha of vineyards in the Valdobbiadene and Cartizze zones, including 79 ha on very steep slopes requiring intensive labour. With 4 million bottles produced annually, 37 employees, and exports to 55 markets (66% of turnover), the winery plays a leading role in the region. It is the largest harvester and vinifier of Cartizze grapes, accounting for about 12% of the total Cartizze yield.

Production costs rise sharply with increasing slope. Annual grape production costs range from €9,883/ha in flat or gently sloping Sylvoz-trained vineyards to €21,539/ha in heroic conditions. Labour hours double or triple, reaching 769 hours/ha in heroic areas versus 200 hours/ha on flat terrain. As a result, grape costs can reach €119.66 per quintal in heroic zones. Only owner-operated farms maintain a competitive cost of production in heroic viticulture areas.

The strategic way forward is based on four pillars: establishing a certified premium classification for vineyards with slopes ≥30%; advocating for targeted CAP and regional subsidies; investing in innovative technologies to reduce labour intensity; enhancing tourism and storytelling linked to the UNESCO landscape to generate value beyond agricultural production.

RECOVERY STRATEGY OF THE COLLIOURE-BANYULS HEROIC VINEYARD: TERROIR ZONING, PRODUCT-AREA ADEQUACY AND COLLECTIVE POSITIONING

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Context

The Collioure-Banyuls vineyard is a Mediterranean heroic viticulture system marked by steep slopes, manual practices and strong climatic exposure. In response to economic decline and environmental pressures, a collective recovery strategy was developed to strengthen resilience, territorial identity and value creation.

Objectives

The strategy combines production and market aims: improving parcel productivity through vineyard renewal and terrace rehabilitation, while enhancing price positioning, wine tourism potential and access to high-value niche markets. It also seeks to structure a shared narrative to reinforce visibility and credibility.

Methods

Climatic and soil analyses were coupled with participatory communication work. A network of sensors across 35 homogeneous units monitored temperature, rainfall, wind and solar radiation. Spatial modelling enabled microclimatic zoning. Interviews with winegrowers helped clarify identity and define communication guidelines.

Results

Findings confirm strong agricultural potential shaped by relief and exposure. Zoning identifies cooler, more humid sectors suited to dry wines (AOP Collioure) and warmer, drier areas adapted to fortified sweet wines (AOP Banyuls). This product–area coherence, combined with collective communication, reinforces territorial image and market recognition.

Conclusions

Linking terroir zoning, appellation identity and collective positioning strengthens resilience and economic viability in heroic viticulture, providing a transferable model for mountainous and coastal wine regions.

A POST-GROWTH PARADIGM FOR WINE LAW: LEARNING FROM HEROIC VITICULTURE

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European wine law is confronted with a structural decline in wine consumption, driven by demographic change and shifting lifestyles. Regulatory frameworks historically designed for growth are progressively losing their steering capacity in this situation. Crisis instruments proposed in the new «wine package» (distillation, grubbing-up schemes, promotional support) address symptoms but fail to address the underlying mismatch between production structures and shrinking markets.

This paper conceptualizes a post-growth paradigm for wine law. It examines existing legal rules using post-growth principles of sufficiency, regeneration, distribution, commons governance and care as an analytical benchmark. It shows how the entire legal framework, even recent sustainability-oriented instruments, are embedded in a growth-oriented logic that combines detailed micromanagement of practices with latent support for structural expansion. In regions experiencing degrowth, this combination risks accelerating exit, consolidation and landscape abandonment rather than sustainability.

The paper explores how «heroic viticulture» could inspire a redesign of wine law. Practiced on steep slopes or islands, heroic viticulture has persevered in conditions where growth is not the main motivation. Geographical Indications constitute the key institutional lever for a post-growth transition, not through additional detailed rules, but through a shift in institutional design. Collective production corridors for the use of the collective name could stabilize value, reduce overinvestment and internalize scarcity while preserving producer autonomy.

UNDERSTANDING THE EXPRESSION OF TIME IN CHASSELAS WINES

Chasselas is a refined grape variety renowned for its subtlety and its remarkable ability to reflect the characteristics of its terroir. Typically consumed when young, it is valued for its low acidity and its subtle fruity and floral aromas. However, in specific terroirs such as the steep Dézaley slope, Chasselas can develop a complex qualitative aromatic profile with age.

This study investigates the ageing potential of Chasselas wines from the Dézaley appellation by comparing the 2009 and 2022 vintages from four different estates. Gas chromatography-mass spectrometry (GC-MS), olfactometric analysis, standard wine analysis and sensory evaluations were employed.

Key compounds were identified as markers of ageing: furfural (a bready note) in older wines and isoamyl acetate (a fruity, banana note) in younger wines. Meanwhile, 3-ethoxy-1-propanol decreased over time. Analysis of the chemical compounds revealed the complexity of the composition of aged Chasselas wines, emphasising the importance of integrating sensory, chemical, and standard analyses to better understand their quality and ageing potential.

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TURNING ENVIRONMENTAL COMMITMENT INTO ECONOMIC VALUE: A VITICULTURE CASE STUDY FROM THE YVORNE REGION (SWITZERLAND)

Growing consumer awareness of environmental issues is pushing the wine industry toward more sustainable practices. Yet efforts remain mostly individual, limiting their cumulative ecological impact. To address these challenges, researchers and nearly all winegrowers of the Yvorne region (Swiss Alps) are developing an appellation-wide model of sustainable viticulture. In 2022 a catalogue of best practices was established and winegrowers began deploying a network of semi-natural habitats across the vineyards.

Encouraging early results include reduced herbicide use, and rising abundance of several vulnerable plant, butterfly and orthopteran species. More recently, economic and marketing measures were introduced to strengthen producer margins by promoting short supply chains, increasing direct sales, and raising bottle prices. Furthermore, a sustainability label will enhance the appellation's reputation. Taken together, these ecological and economic measures position Yvorne as a leading example of integrated sustainability in viticulture, offering a transferable model for other winegrowing regions.

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CLIMATE-ADAPTIVE VITICULTURE AND TERRITORIAL FRAGILITY

Scope of the research

The objective is to verify whether municipalities affected by socio-economic vulnerability also possess environmental conditions suitable for vineyard establishment, thus identifying development opportunities for rural revitalization and diversification.

Methods

A composite fragility index was constructed for 92 municipalities by aggregating socio-economic, agricultural, and tourism variables using equal weighting. Climatic suitability was assessed through GIS analysis of long-term data (1994–2023) on heat stress, evapotranspiration deficit, late frost events, and the Winkler Index. The climatic layers were integrated to produce a suitability map for sparkling wine base production.

Results

The fragility index reveals clusters of high and very high vulnerability in the northeastern Apennine belt and southern Umbria. The climatic assessment identifies about 5,000 hectares of pasture with high or very high suitability for sparkling viticulture, mainly in mountainous zones. The results support the conclusion that climate-adaptive sparkling viticulture may represent a strategic lever for rural resilience, land reactivation, and sustainable development in marginal mountain areas.

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SOIL WATER AVAILABILITY IN STEEP SLOPE VINEYARDS: A CASE STUDY OF DIFFERENT SYSTEMATISATIONS IN THE DOURO REGION

The mountain viticulture regions are characterised by highly diverse topographies, which present a multitude of challenges, beginning with vineyard layout. This study aimed to assess the variability of water retention in three vineyard management systems on steep slopes: vertical rows, terraces with two rows of vines, and narrow terraces with one row of vines. A portable capacitive probe (Diviner 2000, Sentek) was used to assess soil moisture with the ability to take readings at depths of up to 100 cm, at 10 cm intervals. Monitoring has been carried out weekly since 2017. Since the 2020 season, water stress has been monitored through pre-dawn leaf water potential on a weekly basis, from berry set to harvest, using a Scholander chamber.

The results revealed differences in water availability when comparing narrow terraces with vertical vineyards and the inner and outer rows within the same vineyard. In the case of vertical rows, differences in soil moisture were observed, ranging from -40% in winter to -20% to -8% in spring and summer. Significant differences were noted between the top and bottom of the vineyard plots, impacting leaf water potential values and vine vigour.

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OVERVIEW OF NON-HERBICIDE SOIL MANAGEMENT SOLUTIONS IN NON- OR POORLY MECHANIZABLE TERRACED VINEYARDS

Objectives

In non- or poorly mechanizable terraced vineyards, soil management historically relied on tillage practices. The widespread use of herbicides developed from the 1950s onwards to reduce technical constraints and labor hardship. However, herbicide use affects the environment and soil fertility, while the number of approved active substances is steadily decreasing. Many winegrowers are therefore seeking to manage their soils without herbicides. This contribution provides an overview of non-herbicide soil management solutions in terraced vineyards.

Methods

This overview combines long-term advisory experience in organic viticulture with practice observations, surveys among winegrowers and applied research in different Swiss wine regions. It draws on the CV-VigneSol project, VaudCouvertViti on temporary low-competitive cover crops in terraces, Kukuvine assessing the potential of Kunekune pigs for weed control, and the EU Horizon project Agroboost, starting in 2026, aiming to develop a lightweight autonomous robot in Lavaux in partnership with EPFL.

Results

Implemented solutions include adapted manual and motorized tools for terraces, rational management of temporary and permanent vegetation covers, mulching, fertilization management, eco-grazing and emerging robotic technologies. Results show that a wide range of solutions exists, which must be combined and adapted to local pedoclimatic, topographical and socio-economic conditions.

Conclusions

Herbicide-free soil management represents a challenge in non- or poorly mechanizable terraced vineyards. Labor hardship and working hours can be optimized while limiting invasive plant development through different techniques, particularly vegetation cover management and tillage practices. Direct production costs generally remain higher than herbicide-based systems, but long-term effects on soil, environment and system sustainability should be considered.

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WATER BALANCE MODELING FOR TERROIR CHARACTERIZATION AND ADAPTIVE MANAGEMENT IN EXTREME VITICULTURE

Extreme viticulture systems are increasingly exposed to water deficits driven by climate variability and site-specific pedoclimatic constraints. In these environments, soils are often heterogeneous, frequently characterized by terraces and high skeleton content, which complicate the assessment of plant-available water. This study employs a water balance model to estimate the available soil water reserve under such conditions. Predawn leaf water potential data collected over a 30-year period (1995–2024) in adult vines of *Vitis vinifera* cv. Chasselas (clone 14/33-4, grafted onto 5BB) grown in a vineyard located in Leytron (Valais, Switzerland) were integrated with corresponding meteorological records to reconstruct long-term water balance dynamics.

The model considers several vineyard characteristics as input variables, including canopy geometry and density, exposed leaf area, phenological stages, planting layout, and the maximum crop coefficient (Kmax). A sub-model calculates Kmax from intercepted light radiation data and vineyard characteristics. By identifying critical stress thresholds and their seasonal dynamics, the model could provide a decision-support tool for targeted agronomic management including soil and canopy management, irrigation scheduling, and biostimulant application.

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PHYSIOLOGICAL AND MANAGEMENT-BASED ADAPTATION OF MOUNTAIN VINEYARDS TO INCREASING WATER STRESS UNDER MEDITERRANEAN CLIMATE

Mountain and steep-slope vineyards in Mediterranean regions are increasingly exposed to severe water stress. In the Douro Demarcated Region (NE Portugal), atmospheric water demand largely exceeds precipitation, generating seasonal water deficits that often surpass 700 mm. This work synthesizes results from several field studies conducted in commercial vineyards under predominantly rainfed conditions, complemented by deficit irrigation trials, aiming to identify key mechanisms supporting grapevine resilience to water scarcity.

Results show that grapevines activate coordinated physiological responses to prolonged drought, including stomatal control, adjustment of total leaf area and nocturnal rehydration. Training system emerged as a key structural adaptation measure influencing whole-vine water dynamics. Complementary deficit irrigation, applied selectively during critical phenological stages, effectively mitigated extreme water stress. Adaptation of mountain viticulture to climate change should rely primarily on optimized rainfed systems combined with appropriate training systems, while using deficit irrigation as a targeted and flexible support tool.

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FROM SOIL TO GRAPE: MULTI-SCALE MONITORING AND PRECISION IRRIGATION IN MADEIRA VINEYARDS

This work reports on the research component deployed in Madeira under the twinning project isUP-AgrO, which aims to transfer and implement advanced methods and tools for characterizing viticultural agrosystems and supporting the transition toward precision and sensor-based viticulture. During the first implementation cycle, two vineyards were surveyed and instrumented to compare farmer-managed irrigation with scheduled precision irrigation. Soil samples were collected for physicochemical analysis. Throughout the cycle, climate data were monitored using weather stations located near the vineyards. Drone imagery was performed, and soil moisture and temperature and photosynthetic traits were measured on a weekly basis. Additional soil samples were collected for microbiome analysis.

System-wide data will be systematically organized and analyzed using statistical and AI-based approaches to integrate climate, irrigation, microbiome, phenotype, and quality into a single, holistic model. The results may reveal multiple opportunities to enhance sustainability and establish a terroir-based methodological framework for Madeira viticulture.

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UNMANNED AERIAL SYSTEMS FOR CROP PROTECTION IN HEROIC VITICULTURE: AN EIGHT-YEAR FIELD ASSESSMENT

In recent years, the use of drones for crop protection (UASS) has grown rapidly, offering new opportunities, especially in complex scenarios such as heroic viticulture. Since 2017, the Agrismart Lab research group has been testing three UASS models (Bly-c-agri, DJI Agras T10 and T25) in terraced vineyards. Coverage and deposition on the canopy, ground losses, drift and operator contamination were examined.

The Bly-c-agri UAS (2017) showed insufficient coverage, especially within the canopy, due to problems related to maintaining a constant flight altitude above irregular terrain. With technological advances (DJI Agras T10 - 2022), performance improved significantly: coverage was similar (22.13%) to that of the backpack sprayer. However, ground losses were three times higher than with traditional methods.

A significant advantage of UASS is operator safety, with contamination levels approximately 300-fold lower than in manual spraying. The Agras T25 (2025) confirmed good coverage. In conclusion, UAS technology has achieved levels comparable to conventional techniques in terms of canopy deposition, but the issue of excessive ground losses remains unresolved.

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ELEVATION-DRIVEN MICROCLIMATES SHAPE PHYSIOLOGICAL, METABOLOMIC, AND MICROBIAL TERROIR IN A STEEP-SLOPE VINEYARD NETWORK IN LAVAUX (SWITZERLAND)

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Background and Aims

Understanding how vineyard-scale spatial variability («terroir») shapes vine physiology, fruit chemistry and associated microbiomes remains a major challenge. Using a network of 12 closely located steep-slope vineyard plots in Switzerland, monitored over three years, we investigated how micro-site variation influences vine ecophysiology, grape metabolomics and the composition of bacterial and fungal communities.

Materials and Methods

Across the 12 plots, we recorded climate, phenology, vigor, yield components, leaf water potential, gas exchange and $\delta^{13}C$. Berry and soil samples were subjected to bacterial and fungal marker-gene sequencing (680 samples across the broader survey). Grapes at maturity underwent untargeted GC-MS and LC-MS/MS metabolomic profiling. Multi-omics datasets were integrated with environmental variables, including topography and microclimate.

Results

Vine vigor, yield and water status showed significant spatial variation among plots. Topography and microclimate jointly structured microbial communities, with berry-associated fungi exhibiting the strongest site-specific imprint. Metabolomic profiling revealed distinct chemical signatures across plots, including variation in polyphenols, aroma precursors and stress-related metabolites. Microclimate and berry chemistry displayed inverse relationships shaping fungal dominance (*Hanseniaspora* vs. *Saccharomyces*), each associated with distinct metabolite and aroma profiles.

Conclusions

Fine-scale environmental heterogeneity drives coordinated variation in vine physiology, microbial communities and grape metabolomes, revealing clear «micro-terroirs» within a single vineyard. The integration of ecophysiology, microbiomes and metabolomics highlights mechanistic links among climate, plant stress, microbial assembly and wine-relevant chemistry.

INFLUENCE OF SLOPE AND TOPOGRAPHY ON AROMA COMPOSITION AND SENSORY PROFILE OF GLERA GRAPES IN THE CONEGLIANO VALDOBBIADENE PDO

The term «Terroir» refers to a geographic area whose environmental conditions contribute to the production of wines with distinctive characteristics. Local factors—such as slope, aspect, and elevation of the vineyard—could further influence the accumulation of aroma precursors and shape the wine's sensory profile. Six vineyards of *Vitis vinifera* L. cv. Glera, located in three distinct areas (Premaor, Bigolino and Manzana), were selected. Each area included a hilly and a flat sub-area characterized by different microclimatic conditions. Vineyards were monitored over two consecutive vintages (2021–2022).

A gas chromatography–mass spectrometry (GC-MS) analytical approach was applied to characterize the aromatic profiles of grapes. Terpenes were identified as the most sensitive compound class to slope and altitude, particularly linalool and trans-8-hydroxylinalool. Benzenoids and norisoprenoids were less influenced by both geographic location and topography. The results confirmed that slope can play a role in determining the aromatic profile of grapes, with especially relevant implications for heroic viticulture.

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CLIMATIC AND MORPHOLOGICAL VARIABILITY IN ALPINE VITICULTURE: EFFECTS ON NEBBIOLO PRODUCTION IN VALTELLINA

Valtellina, the East–West oriented Alpine valley, exhibits marked radiative and thermal asymmetry between the south-facing terraced slope, where most vineyards are located, and the cooler north-facing slope. In the context of increasing climatic variability and the progressive abandonment of higher-altitude vineyards, this study aimed to clarify the role of altitude in shaping Nebbiolo ripening dynamics and grape quality. A 20-year dataset (2001–2021) was analyzed, including ripening curves from 15 vineyards located between 300 and 700 m a.s.l. In 2023–2024, nine vineyards grouped into three elevation zones (<400 m, 400–500 m, >500 m) were further investigated. A multivariate approach based on Linear Discriminant Analysis (LDA) was applied to technological and phenolic maturity parameters.

Sugar accumulation showed a clear altitudinal delay: 20°Brix was reached in early September at 300 m and more than 10 days later at 700 m. Higher elevations consistently preserved greater acidity (about 12.5 g/L vs 10 g/L at equivalent sugar levels). The LDA model correctly classified 76% of vineyards according to elevation. Overall, the results demonstrate that altitude strongly modulates Nebbiolo ripening through its interaction with local climatic conditions, with topographic variability acting both as a source of differentiation and as a buffering factor against warming trends.

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SUSTAINABLE MANAGEMENT OF INVASIVE PLANTS IN A STEEP SLOPE VINEYARD

Weed management is essential to preserve grape yield and quality by reducing competition for resources. In steep slope vineyards, herbicides are still widely used due to mechanization constraints. However, growing concerns about herbicide resistance, environmental and health risks, biodiversity loss, stricter regulations and the expansion of organic farming are driving the search for more sustainable alternatives. In Switzerland, invasive *Conyza* species have rapidly spread in vineyards, thriving on disturbed soils and competing strongly with grapevines, with some populations developing herbicide resistance.

A three-year study was initiated in 2024 in a 40% slope vineyard, planted with *Vitis vinifera* L. cv. Chasselas at Yvorne (Vaud Alps, Switzerland). Six weed management strategies were compared: herbicide application (glyphosate), manual removal, frequent mowing, sowing low-competitive species, mulching, and a combination of techniques reflecting regional practices. Each treatment was randomly repeated four times.

Results from the first two years showed that plant species richness was highest under sowing and manual removal and lowest under mowing. Manual removal and mulching were the most costly strategies because of high labor requirements. Sowing appears to be a promising approach as it limits workload and has only a slight negative impact on yield.

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SLOPE OF THE TERRACE'S EMBANKMENT MATTERS? A CASE STUDY REVIEWING TERRACE GEOMETRY IN THE DOURO REGION

supporting two rows of vines and the currently advocated narrower single row dominates the vineyards' planting layout. The slope of these terraces, in other words, the supporting earth ramp, is a key element in these vineyards' construction. Existing bibliography on the subject is relatively scarce and there is little consensus in the definition of the ideal slope gradient for these embankments.

A study was carried out to assess the method of calculation of the slope gradient (n=900), including the use of GIS supported data, and high-precision digital models that allowed continuous measurements of slope gradients. The results showed that the earth ramps' gradients range from 80% to 110%. The resultant geometry translates into a different land usage coefficient, i.e., lower plant densities, which means less efficient land usage and, inevitably, some financial sacrifice borne by the growers. However, these numbers are in accordance with established parameters in regions with hillside vineyards, including aspects such as terrace stability.

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CONTENT POSTERS

Heroic Vineyard
8th International Congress on Mountain and Steep Slopes Viticulture, Montreux
6–8 May 2026

Vignobles héroïques
8ème Congrès International sur la Viticulture de Montagne et en Forte Pente Montreux
6 - 8 mai 2026

SESSION III

TECHNICS AND AGRONOMY

A. POSTERS AND ORAL PRESENTATION DURING FIELD VISITS

B. POSTERS

SESSION I

UNIQUE LANDSCAPES TO PRESERVE

NATIVE PLANT SPECIES AND THEIR PHYTOREMEDIATION POTENTIAL IN VINEYARDS WITH HIGH LEVELS OF ARSENIC AND COPPER

In Europe, vineyards are the land use with the highest concentration of Copper (Cu) in soil. The case study of this work is set in a vineyard in the Douro Demarcated Region, where levels of Cu and As in soils reach 132.62 and 1957.45 mg kg^{-1}, respectively. Results obtained for leaves indicate that they are accumulating As up to 14.40 mg kg^{-1}.

In order to improve soil health in this vineyard, phytoremediation can be a viable way to reduce the total or available contents of these contaminants in soils. Preliminary results for one of the tested plants show its potential to be used as a phytostabilisation strategy, with levels of Cu in roots reaching 67.23 mg kg^{-1} and As levels as high as 941.69 mg kg^{-1}. Overall, results point to a possible phytostabilisation strategy of both Cu and As, which can be concomitantly applied with grapevine crops.

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VINE WALLS IN LAVAUX: PRELIMINARY STUDY ON LAND IMPROVEMENTS

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In recent years, the wine-growing industry has experienced considerable changes. In Lavaux, more intense rainfall and periods of drought increase the deterioration on vine walls and sharpen the financial burden on winemakers. Given that the vine walls in Lavaux are primarily a tool for production and almost exclusively the responsibility of vineyard owners, the maintenance and restoration of these structures is becoming a major challenge for the preservation of the vineyard's integrity and authenticity.

To alleviate this pressure, the Lavaux section of the Fédération Vaudoise des Vignerons has decided to launch a land improvement initiative. These subsidies are granted in the form of non-repayable contributions aiming to promote the implementation of land improvement measures. They are jointly financed by the Confederation and the canton.

The preliminary study should provide a comprehensive overview of the issue by: informing winemakers and coordinating the collection of basic data; establishing a diagnosis and static inventory of walls (position, measurements); establishing a dynamic inventory of walls (state of health) through sampling and surveying; and ultimately an estimation of overall repair costs and planning of the work to be undertaken. The study started in June 2025 and should carry on until Spring 2027.

TERRACED VINEYARDS: ASSESSMENT OF THE CURRENT SITUATION IN RELATION TO CLIMATE CHANGE IN THE PRIMORSKA REGION, SLOVENIA

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Primorska winegrowing region in Slovenia is well known for its distinctive topography, landscape and wine production. Primorska with 6,250 ha of vineyards is divided into four winegrowing districts with distinct climatic and soil conditions. Terraced vineyards dominate the landscape, nearly 80% in Goriska Brda and 60% in Vipavska Dolina district. Currently, two key issues define viticulture on terraces: (1) abandonment due to high production costs, and (2) increasing problems caused by climate change (drought, sunburn, heavy rainfall).

The parent rock is Eocene flysch, which has formed eutric brown soils suitable for grapevines, but is highly susceptible to erosion. The area has a sub-Mediterranean climate with very high summer temperatures and a high annual rainfall, unevenly distributed and often occurring as heavy downpours. Steep slopes, flysch parent material, and intense rainfall are the main causes of soil erosion, organic matter loss, and frequent landslides. Severe damage already occurred in Goriska Brda in November 2025, when over 200 mm of rain in a few hours triggered numerous landslides.

In the future, terraced vineyards will require expanded interventions, especially improved drainage. The article is based on data from the Environmental Agency of the Republic of Slovenia, the University of Ljubljana, the Pedological Society of Slovenia, and others, forming a basis for future decisions on terrace construction.

BUILDING RESILIENT WINE LANDSCAPES: ECOSYSTEM-BASED ADAPTATION FOR ALPINE WINE ORCHARDS (PROJET RESPOND)

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Alpine Wine Orchards (AWO) are traditional vineyard systems located on steep Alpine slopes, often maintained through terracing and small-scale, low-mechanization practices. Beyond wine production, these landscapes provide multiple benefits to people and nature: they support biodiversity, stabilize slopes and prevent erosion, preserve cultural heritage, sustain rural livelihoods, and contribute to regional tourism. However, AWO systems are increasingly under pressure from high management costs, intensifying competition in global wine markets, rural depopulation and land abandonment, and the growing impacts of climate change.

The RESPOnD project addresses these challenges by promoting and testing Ecosystem-based Adaptation (EbA) strategies to strengthen the climate resilience of Alpine wine systems. Working closely with winegrowers, cooperatives, sector professionals, wine consortia, and public authorities, the project identifies key AWO typologies and the ecosystem services they provide, assesses climate-related risks and vulnerabilities, and co-develops locally relevant adaptation measures.

Through a living lab approach, EbA solutions are implemented and evaluated in pilot sites across the Alpine region to assess their effectiveness, feasibility, and potential for upscaling. By combining stakeholder engagement, ecosystem service assessment, and practical field experimentation, RESPOnD aims to support the transition toward a more resilient, climate-adapted, and sustainable Alpine wine sector.

RECOGNIZING THE IMPORTANCE OF HYDRAULIC HERITAGE TO FIGHT AGAINST SLOPE IN LAVAUX, SWITZERLAND

The Lavaux vineyard was inscribed on the UNESCO World Heritage List as an evolving cultural landscape in 2007. Geomorphological processes have shaped the Lavaux hillside: (1) geology explains the broad outlines of the landscape and the difference between the eastern part, which is very steep (Dézaley), and the western part with its undulating topography (Grandvaux); (2) erosion by Quaternary glaciers shaped the slope; (3) slope movements continue to shape the vineyard to this day. Among the measures undertaken by winegrowers to fight slope processes, the drainage system (*cunettes, coulisses*) in the vineyard terraces constitutes a valuable heritage that is often overlooked. Understanding and maintaining this system is crucial to ensuring the long-term preservation of the terraces on the steepest slopes.

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MAINTAINING AND DEVELOPING THE VITICULTURE AND OENOLOGICAL HERITAGE OF THE MOMBARONE TERRACES

The study, sponsored by the Unione Montana Mombarone, is a collection of information describing the viticulture and oenological potential of the terraced territory of Mombarone (North-West Italy) which includes the municipalities of Carema, Nomaglio and Settimo Vittone. The soils have significant limitations to cultivation due to their poor evolution, richness in skeleton, and vulnerability to erosion and landslides. The great slopes (5 to 40°) make traditional terraces indispensable.

Higher-altitude areas with huge slopes are difficult to access or mechanize and are at serious risk of abandonment; there are still about 40 hectares left today out of the 140 registered in the 1950s. However, the area maintains a good production potential and 5 to 7 hectares could be recovered to cultivation, even with public support, since they can also represent an important protection from hydro geological instability.

Carema has the largest vineyard area and the lowest average slopes. The «Carema» denomination of origin prevails, but it is also possible using the «Canavese Nebbiolo» one. The terraced vineyard landscape of Mombarone represents an example of mountain agriculture with a high identity value, in which viticulture plays a productive role, but also contributes significantly to the preservation of the historic landscape and local rural memory.

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CHARACTERIZATION OF MOUNTAIN AND HIGH-HILL VITICULTURAL AREAS IN THE MANDROLISAI DISTRICT IN SARDINIA

Research Objectives

This study examines the viticultural characteristics of two municipalities entitled to produce Mandrolisai DOC, a blend of Cannonau, Monica, and Bovale Sardo. The research aimed to characterize two areas with different altitudinal and pedoclimatic conditions: Meana Sardo (500–700 m a.s.l.), representative of mountain viticulture, and Ortueri (300–500 m a.s.l.), classified as a high-hill system.

Methods

The study analyzed vineyard management systems and their spatial distribution, focusing on key suitability factors such as altitude, exposure, slope, and soil characteristics. Ampelographic composition, yield performance, and the main qualitative parameters of musts were also evaluated. Territorial and productive variables were processed through thematic mapping to describe and interpret intra- and inter-area variability.

Main Results

Phenological trends, yields, and qualitative parameters differ significantly due to local environmental conditions. Mapping analysis highlighted compositional and qualitative differences in musts between Meana Sardo and Ortueri, as well as among vineyards within the same municipality, confirming the influence of altitude, soil, and exposure.

Conclusions

The findings confirm the viticultural complexity of the Mandrolisai area and the key role of environmental factors in shaping production and quality. Territorial heterogeneity emerges as a distinctive feature and a potential asset for zoning strategies and for strengthening the enological identity of the area.

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SESSION II

ECONOMICAL SUSTAINABILITY OF HEROIC VITICULTURE

TORILLE VINEYARD RECOVERY

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The Vi.A. TOUR Project – Tour of the Alpine Vineyard Route, co-financed by the European Union under the Interreg V-A Italy-France ALCOTRA 2014-2020 Cooperation Programme, aimed primarily at creating a cross-border experiential tourism offer that would enable the rediscovery of the wine-growing sector and the territory of the Alpine valleys of Savoy in France, and of Piedmont and the Aosta Valley in Italy.

As part of this project, a technical and economic feasibility study was carried out for the restoration of the ancient vineyard terraces of Torille, in the municipality of Verrès (Aosta Valley). The study included the restoration of the existing dry-stone walls, of the vineyard, and the construction of access paths to serve the agricultural plots, justified by a predictive profitability analysis. The Torille district is located in NW Alps of Italy in a south-facing natural amphitheater with a centuries-old winemaking tradition. Despite this heritage, the terraces have faced abandonment since the late 1980s due to lack of access and low profitability.

The project covers 17,330 m^2 of terraced land, requiring new access tracks, 930 m of wall restoration, and a 5,400 m drip irrigation system. Nebbiolo will be planted using the Pergola Valdostana Alta method. With a €2 M investment, profitability comes from premium wine («Clos de Torille») and wine tourism along the Via Francigena. The plan forecasts a 15-year payback and positive Net Present Value. In conclusion, the recovery of Torille appears a complex but feasible endeavour that transforms a high-risk abandoned area into a driver of sustainable wine tourism.

SANTA MARIA WINE LAB

This R&D project aimed to evaluate the viticultural and oenological potential of Santa Maria Island (Azores) by developing wines eligible for Azores Geographical Indication (GI) certification. It addressed gaps in technical knowledge, infrastructure and quality control in a context dominated by low-quality hybrid varieties, while promoting sector professionalization. The project also contributed to the valorisation of the island's cultural vineyard landscape.

An experimental micro-vinification winery was installed, enabling grape processing, wine production and laboratory control. A producer program provided training in vineyard management and study visits to other Azorean islands. The project generated data on vineyard and wine production, including increases in homologated (+1.91%) and non-homologated (+1.50%) vineyard areas. Noble grape production increased (273.6%), while hybrid varieties decreased (-63.15%). Wine was produced in both years (2022–2023), despite climatic constraints and young vineyards. Three wines obtained certification, confirming compliance with quality standards. The results demonstrate that Santa Maria can produce quality wines with appropriate infrastructure, protocols and training.

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SESSION III

TECHNICS AND AGRONOMY

A. POSTERS AND ORAL PRESENTATION DURING FIELD VISITS

STEEP VINEYARDS AS RESERVOIRS OF BIODIVERSITY: TWO CASE STUDIES

Two studies conducted between 2019 and 2025 systematically examined biodiversity in the vineyards of Yvorne and Lavaux. The aim of this work was to assess the biological richness of these sites, identify species of particular interest, and study measures likely to promote their presence and conservation. The study focused on 13 areas in Yvorne and 21 areas in Lavaux. Particular attention was paid to certain indicator groups, such as reptiles, birds, orthoptera, mollusks, and vascular plants.

The surveys confirmed the presence of most of the species that had been reported, attesting to the biological richness of the two vineyards. Rare and emblematic species, such as the emerald lizard and the wild marigold, were observed. However, the populations of these species of interest remain generally small and their situation remains precarious. Most rare and endangered species depend on small interstitial biotopes scattered throughout the vineyard: rocky outcrops, bushy areas, and uncultivated patches, which provide refuge during work carried out in the vineyard plots.

Comparison of the 34 areas surveyed reveals that the peripheral areas of the vineyards are richer in species than the central sectors. Furthermore, it has been observed that the average slope of the areas is positively correlated with their floristic diversity. Steep vineyards seem therefore to promote greater plant variety, highlighting their importance as biodiversity refuges.

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SIMULATING FUTURE DROUGHT SCENARIOS TO ASSESS CLIMATE CHANGE IMPACTS ON VINEYARD ECOSYSTEMS IN SWITZERLAND

Drought can strongly impact grapevine physiology, yield, berry composition and wine quality, as extensively demonstrated in controlled experiments. To address the gap in knowledge about field conditions in cooler viticultural regions, we set up a drought simulation experiment in a vineyard in Yvorne, Switzerland, planted with cv. Chasselas L. Four rainout shelters were installed in April 2024 to exclude natural rainfall. Within each shelter, three water supply regimes are applied via centralized irrigation: 1) a control regime reproducing the past 20-year average local rainfall; 2) a moderate to severe water deficit based on RCP 8.5 projections for 2085; 3) a severe water deficit corresponding to 50% of the 2085 projections.

Both moderate and severe water stress treatments differed significantly from the control. Leaf temperature was on average 2°C higher for the two stressed treatments compared to the control, indicating lower transpiration rates. Water stress treatments advanced all phenological stages, reduced leaf exposed surface, bud fertility, vigour, leaves nutritive elements, berry weight, yield, sugar per berry and malic acid in the musts. Yeast assimilable nitrogen in the musts was higher in stressed treatments. Wines produced from stressed treatments in 2024 were characterized by higher perceived volume and lower freshness, with honey and cooked fruits aromas. This experiment provides an integrative, field-scale platform to disentangle coupled responses of grapevine, soil and associated vegetation.

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COMBINING SOIL MANAGEMENT AND NITROGEN FERTILISATION TO OPTIMIZE VINE NUTRITION IN SWISS VINEYARDS

Scope

In the pursuit of more sustainable viticulture, many winegrowers have drastically reduced nitrogen (N) fertilisation and abandoned chemical weed control in favour of permanent grass cover. While these practices benefit soil health and biodiversity, they often increase competition for water and nutrients, characterized by reduced vigour, lower yields, and a decline in wine quality. To address these challenges, Agroscope launched the «Azote Vaud» project (2024–2026).

Method

The project aims to evaluate the combined effects of soil management and N fertilisation on vine N status, yield, and wine composition. A network of eight experimental plots was established in the canton of Vaud, Switzerland, planted with *Vitis vinifera* Chasselas and with a common split-plot design. The treatments compare full grass cover versus weeded under-vine, and localized soil N fertilisation (50 kg N/ha) versus no fertilisation.

Results

Preliminary results reveal substantial differences in the yeast assimilable N (YAN) content of musts across the network, with most plots falling below the critical deficiency threshold (< 140 mg N/L). Simple weed removal under the vine row significantly increased YAN concentration by an average of +28 mg N/L compared to fully grassed plots. The combination of weed control and localized N application successfully restored YAN levels above the deficiency threshold, confirming the strong influence of soil management on vine N nutrition. The project will continue through 2026.

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PHYSIOLOGICAL BEHAVIOR OF THE CHASSELAS GRAPE VARIETY UNDER WATER DEFICIT: 30 YEARS OF EXPERIMENTS IN SWITZERLAND

At Agroscope's experimental vineyard in Valais (Switzerland), a 30-year experiment was carried out on the physiological behavior of the Chasselas grape variety (clone 14/33-4, grafted onto 5 BB) under water deficit conditions. Physiological indicators were used to study the plant water status: predawn leaf (Ψ^{PD}) and stem (Ψ^{STEM}) water potentials, carbon isotope composition ($\delta^{13}C$) in must sugars. The impact of water deficit on stomatal (gs) and mesophyll conductance (gm), leaf gas exchange (photosynthesis A, dark respiration Rd and transpiration E), vessels morphology and hydraulic conductivity in petioles and stems ($K^{petioles/stems}$), vulnerability to cavitation (PLC, percentage loss of conductivity), yield components and berry composition at harvest were analyzed.

In non-irrigated vines, the progressively increasing water deficit reduced leaf gas exchange (A, Rd and E) and gs. The intrinsic water use efficiency (WUEi, A/gs) increased over the season. The rise in WUEi was correlated with an increase in $\delta^{13}C$ in the must sugars at harvest. Petioles were highly vulnerable to cavitation, with a 50% loss of hydraulic conductivity at a Ψ^{STEM} of -1.2 MPa, and up to 90% loss at a Ψ^{STEM} of -1.8 MPa. The Chasselas cultivar appears to develop hydraulic segmentation, in which petiole cavitation plays an important role as a 'hydraulic fuse'.

Moderate water stress during fruit ripening was favorable for sugar accumulation in berries and lowered the contents of total and malic acidity, and available nitrogen (YAN) in the must. Overall, the organoleptic characteristics and quality of Chasselas wines were influenced by the vine water regimes, particularly in the hot and dry seasons in 1998, 2000, 2003, 2009, 2011, 2015, 2018, 2020, 2022 and 2023.

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ON-FARM MONITORING OF GRAPEVINE WATER AND NITROGEN STATUS IN RELATION TO DIFFERENT SOIL MANAGEMENT PRACTICES IN VALAIS, SWITZERLAND

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In response to increasing societal demands for environmentally-friendly viticulture, winegrowers are adapting their cultivation techniques, particularly by reducing the use of herbicides. However, in the Valais region of Switzerland—where vineyards are often located on steep slopes and face dry pedoclimatic conditions with an average annual rainfall of 580 mm—this practice can be challenging to implement.

To investigate the impact of grass cover in vineyards, an on-farm network was established in Valais. This network includes over 90 vineyard plots planted with cv. Pinot noir and cv. Chasselas. Various soil management techniques are employed across the network, including spontaneous grass cover vs sown cover crops, inter-row cover cropping vs total cover cropping, and bare soil management. Over three vintages (2022-2025), several physiological and agronomical parameters were assessed, including vine vigor, yield components, mineral nutrition, and must composition. The water status of the vines was monitored using two indicators: predawn leaf water potential and *delta C13* in must sugars.

Our results indicate that, depending on the specific conditions (including vintages and terroirs), the competition between plant cover and vines for access to water and nutrients can be significant. This competition may lead to negative impacts on both the quantity and quality of the harvest. Therefore, the use and intensity of grass cover must be carefully adapted to the soil conditions of each plot to prevent excessive competition.

USE OF UAVS FOR PHYTOSANITARY TREATMENTS IN SWISS VINEYARDS

Switzerland is characterized by steep and sloped landscapes. Viticulture in mountainous regions is particularly demanding and requires substantial manpower. Consequently, the use of unmanned aerial vehicles (UAVs) for plant protection sprays has long attracted interest in Switzerland. A dedicated regulatory framework was established and entered into force in 2019.

Between 2018 and 2024, several Swiss public agencies conducted research projects on UAV-based pesticide application. Spray drift experiments conducted in accordance with ISO 22866:2005 were performed in grapevine, apple orchards, and arable crops. Overall, spray drift from UAV sprayers was generally lower than the reference values for air-assisted sprayers in vineyards and orchards, but higher than those of tractor-mounted boom sprayers.

A further project focused on spray deposition and biological efficacy of UAV-applied fungicides in grapevine. Deposition was found to be satisfactory in the upper canopy, but limited on leaves in the bunch zone and on the grape clusters themselves, indicating a potential risk of insufficient protection under high disease pressure. However, when UAV applications were combined with one or two supplementary ground-based treatments, disease control efficacy was comparable to that achieved with ground applications alone. Overall, UAV sprayers have become an established application technique in Switzerland, addressing a clear operational need in viticulture.

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CONTROLLING *SCAPHOIDEUS TITANUS* USING DRONES: A REVIEW OF THREE YEARS OF TRIALS

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Flavescence dorée is a grapevine yellowing disease transmitted by the leafhopper *Scaphoideus titanus* and causing a huge burden to the grape production. In Switzerland, the control of the vector of this quarantine disease relies on pyrethrins. One to two treatments are carried out in mandatory control areas whereupon numerous plots are difficult to access and the operation of drones could consequently be a major relief.

Trials were set up from 2023 to 2025 in Charrat (VS). In the Pinot noir plot of Charrat the following three treatments were tested: (1) Untreated control, (2) Atomizer (2 applications of Pyrethrum FS® at 0.8 l/ha) and (3) Drone (2 applications of Pyrethrum FS® at 0.8 l/ha). The efficacy was assessed by visual counting of *S. titanus* nymphs 6 to 7 days after spraying.

In Charrat, drone treatments with the T30 model showed an average effectiveness of 48.7%, compared to 69.5% for the T50 and 85.3% for the atomizer. In Villeneuve, the average number of captured *S. titanus* adults in plots treated on the ground (0.55) and by drone (0.35) did not differ significantly (p-value: 0.569). The tests show that drones do control S. titanus and could play an interesting role in heroic vineyards difficult to access, although they are less effective than ground treatments.

SESSION III

TECHNICS AND AGRONOMY

B. POSTERS

COPPER (BIO)AVAILABILITY, SOIL AMENDMENTS AND STRESS RESPONSES *IN VITIS VINIFERA*

Copper-based fungicides, used to control diseases such as downy mildew, are responsible for copper (Cu) accumulation in vineyard soils. Although Cu is an essential nutrient, in excess it can cause several metabolic disturbances in grapevines, impairing plant health. This study intended to evaluate how Cu availability, altered by soil amendments, affects molecular and physiological responses in grapevines. Vines were grown in Cu-contaminated soil from one Portuguese demarcated wine region, with or without a mixture of amendments comprising pine bark and mussel shell. Vine plants samples were collected after six months (T1) and one year (T2). Cu concentrations were measured by ICP-MS in leaves, roots, and soil samples at T2 and oxidative stress and antioxidant markers were assessed in leaves at both timepoints. RNA-seq was performed in leaves at both timepoints and in roots at T2.

In line with a decrease in Cu bioavailability, roots transcriptional profile at T2 indicated that several terms enriched under Cu268 were no longer enriched in the presence of the amendment, as for example the «metabolic pathways» category, along most membrane-remodelling and cell wall-remodelling-related terms, suggesting that their metabolic state may be closer to that of control roots.

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EVALUATING THE CORRELATION BETWEEN REGIONAL SOIL ALKALINITY AND PLANT NUTRITION: A DIAGNOSTIC STRATEGY FOR PRECISION FERTILIZATION IN HIGH-ALTITUDE SEMI-ARID VINEYARDS (GUANAJUATO, MEXICO)

A decadal assessment (2014-2025) of vineyards in Guanajuato reveals persistent soil alkalinity (pH 7.4-7.8) and high-bicarbonate irrigation water. This study utilizes Cell Tissue Extract (CTE) via LAQUA twin technology to monitor nutrient dynamics in *Vitis vinifera* early shoots. Unlike traditional bleeding sap, CTE provides a concentrated profile of current mineral status. Preliminary results show K^+ at 9600 ppm and Na^+ at 680 ppm. High Na^+ levels correlate with historical salinity stress, while the K^+ peak reflects starch mobilization.

Compared to international benchmarks, these CTE values indicate luxury consumption of K^+ and ionic imbalance. The transition to organic agriculture is expected to stabilize NO^{3-} flux and mitigate salinity, as organic amendments improve soil structure and counteract high pH effects. CTE diagnostics allow for real-time adjustment of fertilization programs in semi-arid terroirs.

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DEFICIT IRRIGATION, BASED ON ETº, IN TEMPRANILLO VINEYARDS CULTIVATED WITH ALTERNATE COVER CROP AT HIGH ALTITUDE: PRODUCTIVE AND QUALITATIVE EFFECTS IN THE DUERO VALLEY

Throughout the 2024 growing season, a study was conducted on the agronomic and qualitative response of the vineyard to weekly deficit irrigation (30% ETo) from pea size stage until harvest (99 mm), using drip irrigation, in the Duero valley, over 800 m.a.s.l. of altitude. The vineyard, of cv. Tempranillo, grafted onto Fercal rootstock, with vine distances of 2.5 x 1.2 m, trained on a vertical trellis system and pruned using the Guyot Poussard method, was cultivated using cover crops in alternate rows until June. Four randomized blocks were established, with elementary plots of 40 vines (in 4 rows of 10 vines).

Deficit irrigation resulted in differences in vegetative development and grape production compared to non-irrigation crop, increasing pruning wood weight by 7% and grape yield by 14%. This irrigation also clearly affected grape composition, reducing sugars, total acidity, tartaric acid, and polyphenols, but increasing pH and malic acid. Further research is recommended in subsequent years, given the annual climatic influence on vineyard performance.

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TECHNOLOGICAL INNOVATIONS FOR PLANT AND SOIL PROTECTION IN SLOPING VITICULTURE

In the framework of Agriculture 4.0, high-tech solutions can contribute to improve sustainability in viticulture. Researchers of CNR-STEMS have been involved in last years to different projects where autonomous vehicles and decision support systems (DSS) have been developed and tested in sloping vineyards.

CNR-STEMS was part of the H2020 SCORPION project, for development of a safe autonomous modular robot for precision spraying and UV treatments in steep-slope vineyards, raising advances in navigation, VRT spraying, safety, interoperability and modularity. Two different prototypes were realized, powered by a diesel engine and by full electrical source. In the H2020 ATLAS project, the PoliBOT prototype was tested to move and operate autonomously on different field conditions, including sloping condition in vineyards, thanks to proprioceptive sensors.

In the IN-GEST SOIL and MeRAViP projects, monitored data has been used to give information on soil degradation processes in vineyards, namely soil compaction and erosion, and suggest best management practices to preserve soil quality and water availability. Such advances in research on technological solutions can help next farmer's generation to increase their awareness about the possibilities offered by technologies, also in extreme conditions.

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THE SELECTION OF NEW GENOTYPES WITH RESISTANCE TRAITS, ORIGINATING FROM CHARDONNAY AND SCHIAVA

The aim of this study was to develop new grapevine genotypes combining high-quality oenological traits with resistance to major fungal pathogens, specifically downy mildew (*Plasmopara viticola*) and powdery mildew (*Erysiphe necator*). The breeding program focused on generating progeny from Chardonnay and Schiava to facilitate vineyard management in challenging orographic conditions and to select for diverse vegetative cycles adaptable to various altitudes and latitudes.

In 2011, a crossbreeding plan was initiated using *V. vinifera* cvs. Chardonnay and Schiava as parents, crossed with a resistant genotype (F12P161). The donor parent carries multiple resistance loci: RPV1, RPV3-1, and RPV12 (downy mildew) and RUN1, REN3, and REN9 (powdery mildew). The resulting seeds (707 from Chardonnay and 491 from Schiava) were germinated and the seedlings underwent controlled phenotypic screening via artificial inoculation with *P. viticola* and *E. necator*, and Marker-Assisted Selection (MAS) to confirm the pyramiding of resistance genes.

Initial screening identified 60 promising Chardonnay-derived genotypes and 50 Schiava-derived genotypes. Following field establishment in 2018, further agronomic and qualitative characterization narrowed the selection to 5 Chardonnay and 3 Schiava genotypes. After multi-year micro-vinification trials, three elite genotypes (2 Chardonnay-type and 1 Schiava-type) were selected for official registration in the National Register of Grape Varieties. These new resistant varieties represent a significant advancement for mountain viticulture.

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FROM TRADITIONAL SHORT TERRACES TO MECHANIZED LONG TERRACES: IMPACTS ON RUNOFF AND SLOPE STABILITY IN GORIŠKA BRDA VINEYARDS

In the Goriska Brda winegrowing district of Primorska region in Slovenia, the terraced landscape represents a fundamental spatial, agricultural, and cultural feature shaped over centuries of adaptation to steep terrain and local hydrological conditions. Traditional terraces were typically short (approximately 50–80 m) and sinuously aligned with the natural contours of slopes. This morphology enabled diffuse drainage, enhanced water retention, reduced surface runoff, and contributed to the long-term stability of soils and slopes.

In recent decades, the intensification of viticulture and the widespread use of heavy machinery have led to a systematic reconfiguration of terraces into longer, straighter, and wider units—often exceeding 100 m in length—designed primarily for mechanized cultivation. This structural transformation has significantly altered slope hydrodynamics. Linearized terraces promote concentrated surface runoff, reduce infiltration capacity, and disrupt microrelief patterns that previously functioned as natural hydraulic buffers.

These changes are occurring in the context of accelerating climate change, characterized by more frequent and intense rainfall events. Such extreme downpours increasingly cause flooding in lowland areas, while on steep vineyard slopes they exacerbate soil erosion, nutrient loss, terrace collapses, and landslides. Addressing these issues requires an integrated approach that combines engineering solutions, soil science, hydrology, and landscape planning to reconcile modern production needs with long-term environmental resilience and slope stability.

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CROSS-BREEDING VARIETIES «PIWI» AUTHORIZED IN TRENTINO: 3 YEARS OF OBSERVATIONS (2023–2025)

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Purpose

This study evaluated the phenological, agronomic, phytosanitary, and productive aspects of the 11 varieties included in the list of «under observation» for the autonomous province of Trento, resulting from interspecific crosses.

Materials and methods

The varieties evaluated were Bronner, Helios, Johanitter, Muscaris, Solaris, Souvignier Gris (from the Institute of Viticulture in Fribourg), Pinot Regina (University of Pecs), and Charvir, Valnosia, Nermantis, Termantis (FEM). The data collected were compared with those of an international reference variety: Chardonnay. The measurements were carried out in two different sites: one in a medium-early zone (Rovereto, 170 m asl) and one in a late zone (Telve, 470 m asl). Phytosanitary treatments were kept to a minimum to assess tolerance to the main cryptogams. Two to three treatments were carried out per season, concurrently with the insecticides against *Scaphoideus titanus* required by the mandatory Flavescence dorée control measures.

Results

The phenological measurements showed that these varieties are well-suited to cultivation in mountain viticulture contexts: their production cycle was shorter than Chardonnay by an average of 16 days, thanks to a later budbreak and earlier grape ripening. From a phytosanitary perspective, even in years with medium to high levels of the main cryptogams, the limited number of treatments ensured very good to excellent results in Rovereto. However, some critical issues emerged at the Telve vineyard with blackrot and anthracnose symptoms on the bunches. The ripening curves show a general advance in both the red and white varieties compared to Chardonnay, while must analyses have generally determined the high oenological potential of these varieties.

PROTECTIVE EFFECT OF KAOLIN IN PREVENTING GRAPE SUNBURN ON PETIT ROUGE: FIRST RESULTS

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Petit rouge, the most widespread native grape variety in the Aosta Valley (northwestern Italy), is particularly sensitive to grape sunburn, which causes partial or complete desiccation of exposed bunches. The Petit rouge shows an almost unique sensitivity starting from the «pea-size» phenological stage until veraison. Kaolin, sprayed over the whole canopy, is often used to protect vines from damage caused by hot weather, notably water stress and grape sunburn.

Within the RESPOnD project, co-funded by the European Union under the Interreg Alpine Space programme, an experiment was conducted to assess the direct effect of kaolin on Petit rouge bunches. Four experimental sites at high sunburn risk were selected; at each site, a randomized complete block design consisting of 3 replicates and 2 treatments («Untreated» and «Kaolin») was established. To maximise bunch sunburn, fruit-zone leaves were removed at the pea-size stage. Immediately thereafter, bunches of the «Kaolin» plots were sprayed with a 5% kaolin solution until fully covered and kept covered until veraison, with reapplications after significant rainfall.

Despite the defoliation, the sunburn damage observed in the first trial season (2025) was very limited, ranging from 1.6% to 4.9% for untreated plants (mean: 2.8%). The effect of kaolin was variable, with estimated burnt surfaces ranging from 0.9% to 3.8% (mean: 1.9%). In 3 out of 4 sites, the effect was statistically significant ($P < 0.001$). The overall odds ratio (OT) for kaolin was 0.57 (95% confidence intervals: 0.54–0.61), indicating a 43% reduction in the chance of burning for the treated plants compared to the untreated ones.

UAV-BASED VEGETATION INDICES FOR PREDICTING GRAPEVINE YIELD AND FRUIT QUALITY

The integration of unmanned aerial vehicles (UAVs) with vegetation indices has significantly advanced precision viticulture, enabling the spatial and temporal assessment of vine vigor, yield, and fruit quality. This study aimed to examine the correlations between UAV-derived vegetation indices and grapevine yield and quality parameters during the 2024 growing season. Five UAV flights were conducted from May to September 2024 to compute the NDVI, NDRE, GNDVI, NGRDI, and GLI. Field and laboratory measurements included total yield (kg per parcel and per plant) and fruit quality attributes, such as pH, titratable acidity (tartaric acid), ash content, electrical conductivity, and berry diameter.

The results indicated that NDRE was the most consistent index, showing a strong correlation with yield (ρ = 0.78 – 0.88) and fruit maturity indicators, being positively associated with pH and negatively associated with tartaric acid content. GNDVI exhibited a similar performance, serving as a reliable predictor of both yield and grape maturity. NDVI showed moderate correlations, particularly with mineral composition (ash content). Averaging the five flights confirmed NDRE and GNDVI as the most robust indices for monitoring vineyards.

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ENROBEZ VOS VIGNES, DORMEZ MIEUX

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Les biostimulants sont traditionnellement conçus pour améliorer les performances des plantes en favorisant l'absorption des nutriments et l'activité métabolique, le plus souvent grâce à des formulations à base d'extraits d'algues, de consortiums microbiens ou de substances humiques. Ces approches visent principalement à nourrir la plante et à stimuler ses processus physiologiques.

Aujourd'hui, nous présentons un concept de biostimulant innovant reposant sur un mode d'action fondamentalement différent. Plutôt que d'agir par stimulation nutritionnelle ou biochimique, ce biostimulant forme une couche protectrice sur les tissus végétaux, renforçant significativement la résistance aux stress abiotiques, en particulier à la sécheresse et à la salinité.

Des essais en plein champ ont montré une réduction du niveau des hormones de stress de la vigne pouvant atteindre 68%, entraînant une augmentation du rendement allant jusqu'à 2 t/ha. Par ailleurs, l'amélioration de l'équilibre physiologique des vignes traitées a permis de réduire jusqu'à 50% les traitements de pré-récolte, contribuant ainsi à des pratiques de gestion des cultures plus durables.

Fait essentiel, malgré une exposition à des conditions de sécheresse sévères, les vignes traitées avec ce biostimulant ont maintenu une qualité de vinification élevée, soulignant la capacité du produit à préserver la composition du raisin et son potentiel œnologique. Cet effet est attribué aux propriétés physiques et protectrices uniques de la formulation, qui limitent les pertes en eau et le stress osmotique tout en stabilisant le métabolisme de la plante.

Ces résultats suggèrent que les biostimulants à action protectrice représentent une nouvelle génération d'outils pour la viticulture, offrant une stratégie innovante et efficace pour améliorer la résilience de la vigne, la productivité et la qualité du raisin dans un contexte de contraintes climatiques croissantes.

CLIMATE CHANGE AND MOUNTAIN VITICULTURE IN TUSCANY (ITALY)

Tuscany is one of the world's leading wine-growing regions, with 60,000 hectares of vineyards. In recent years, climate change has progressively driven viticulture towards higher elevations, expanding into areas that were previously limited to small-scale, family-owned production. Currently, the vineyard area above 500 m a.s.l. amounts to approximately 1,300 hectares, largely consisting of recent plantings extending up to 1,000 m.

The shift to higher elevations presents several agronomic challenges, particularly regarding varietal choice and vineyard management. To support the development of high-altitude viticulture (above 800 m a.s.l.), ongoing research activities focus on both agronomic practices, such as the use of anti-hail nets, and varietal suitability. Several Pinot Noir clones are currently under evaluation. Trials also include newly introduced cultivars, such as Petit Rouge, Müller Thurgau, and Chenin Blanc, together with disease-resistant varieties derived from breeding programs, including Cabernet Eidos, Sauvignon Rytos, Sauvignon Kretos, and Solaris.

In high-altitude conditions, marked diurnal temperature fluctuations promote gradual ripening, enhanced aromatic expression, and acidity preservation, contributing to freshness and structural complexity in the resulting wines. Moreover, the adoption of resistant varieties may strategically reduce plant protection inputs and lower production costs, fostering more sustainable vineyard management in extreme mountain environments.

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HOW DO DEEP SOIL MOBILIZATION AND VEGETATION COVER INFLUENCE SOIL BIOLOGICAL FUNCTIONING IN VINEYARDS OF THE DOURO REGION?

In the Douro Demarcated Region, deep soil mobilization for vines plantation and inter-row vegetation management are common practices, yet their effects on soil biological functioning remain poorly characterized. This study was conducted at Quinta do Casal da Granja (Real Companhia Velha, Alijó, Portugal). Two factors were assessed independently: inter-row vegetation cover type (spontaneous vs. sown) and period since last deep mobilization, directly related to vineyard age (older vs. younger). Soil biological functioning was evaluated through enzyme activities (dehydrogenase, urease, CM-cellulase, arylsulfatase, acid phosphatase), earthworm biomass and density, invertebrates feeding activity (bait lamina test), and nematode community structure.

Vineyards with longer periods since mobilization supported higher earthworm biomass and density, greater nematode abundance and a higher relative abundance of predatory nematodes. Spontaneous cover supported higher microbial metabolic activity, particularly carbon mineralization and organic phosphorus and sulfur mineralization. Sown cover enhanced nitrogen cycling. These findings demonstrate that mobilization history and vegetation cover independently regulate soil biological functioning in Douro vineyards, highlighting the importance of integrating multiple biological indicators to support sustainable vineyard management.

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RÉCUPÉRATION DU GERMOPLASME VITICOLE EN ALTA SEGARRA (CATALOGNE): BIODIVERSITÉ, RÉSILIENCE CLIMATIQUE ET VALORISATION PATRIMONIALE

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Objectifs

L'Alta Segarra, région historiquement viticole du centre de la Catalogne, a subi une forte perte de diversité variétale après la crise du phylloxéra. Le projet vise à identifier les ceps survivants, à récupérer des génotypes adaptés aux conditions extrêmes et à valoriser ce patrimoine dans une perspective de résilience climatique et d'identité territoriale.

Méthodes

Une recherche documentaire (XI^{e}–XIX^{e} siècles) et des entretiens avec des viticulteurs locaux ont été combinés à une prospection systématique de vieux vignobles. Chaque cep a été géoréférencé, photographié et échantillonné. Une caractérisation ampélographique et une analyse SSR (20 marqueurs) ont été réalisées et comparées à des bases de données nationales et internationales.

Résultats

105 échantillons correspondant à 30 variétés ont été identifiés, dont *Sumoll Negre*, *Morastell*, *Trobat*, *Cuatendre* et *Picapoll*, ainsi que 13 génotypes inconnus. Plusieurs accessions présentent une forte tolérance à la sécheresse et une bonne adaptation aux sols pauvres. L'Alta Segarra apparaît comme un réservoir génétique unique, avec un potentiel pour des vins distinctifs et un œnotourisme fondé sur le patrimoine. Un vignoble-musée a été créé pour préserver et diffuser ce matériel.

Conclusions

La récupération de variétés locales renforce la diversité génétique, soutient les stratégies d'adaptation au climat et consolide l'identité territoriale. Ces résultats constituent la base de programmes de conservation, de réintroduction et de valorisation pour une viticulture de montagne durable.

MICROBIOLOGICAL MANAGEMENT OF NITROGEN DEFICIENT CHASSELAS MUST

Modern viticulture is facing the challenge of climate change, which is resulting in increasingly warmer vintages that affect not only agronomic parameters, but also the chemical composition of grapes. In particular, a reduction of yeast assimilable nitrogen (YAN) concentration in the must at harvest impacts the yeast metabolism and potentially lead to slow or even stuck fermentation. Consequently, these phenomena can negatively affect the development of the wine's aroma.

The aim of this study was to develop a microbiological strategy involving active dried yeast (ADY) strains by defining their nitrogen requirements that could be easily implemented in wineries to ensure the optimal fermentation of musts with YAN deficiencies.

Various commercial ADY strains were screened using a scaled-up fermentation design from bench-scale (250 µL to 500 mL) to cellar-scale (40 L), using Chasselas grape musts from the Canton of Vaud with different YAN content.

The results of the bench-scale assays showed that less than 10 % of the screened yeasts fermented sugars efficiently in YAN-deficient musts and were therefore categorized as low nitrogen requirement (LNR) strains. Cellar-scale experiments showed that LNR yeasts exhibited faster and more efficient fermentation kinetics than high nitrogen requirement (HNR) yeasts in nitrogen-deficient musts.

Our results suggest that choosing an LNR yeast strain could help the producers to efficiently manage the fermentation of nitrogen deficient musts (below 140 mg/L of YAN), while producing wines that maintain the typical Chasselas profile.

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GROWTH REGULATORS AND BIOSTIMULANTS AS TOOLS TO MITIGATE WARM WINTER EFFECTS ON GRAPEVINE DORMANCY IN MADEIRA ISLAND

Climate change is increasingly disrupting grapevine phenology in mild-winter regions by reducing winter chill accumulation, leading to delayed and uneven budburst and yield instability. Madeira Island, marked by strong microclimatic variability, already shows clear evidence of these effects. Field trials were conducted in Câmara de Lobos on *Vitis vinifera* L. cv. Sercial grown on a south-facing slope. Treatments included abscisic acid, 6-benzyladenine, their combination, a nitrogen-based biostimulant (Erger 7% + ActivErger 16%), and an untreated control. Budburst dynamics were evaluated alongside winter chill accumulation.

Growth regulators did not significantly improve budburst relative to the control. In contrast, the biostimulant markedly enhanced dormancy release, with 38% of vines exhibiting more than 50% of evolved buds, while budburst remained minimal in all other treatments. These results demonstrate that nitrogen-based biostimulants are more effective than hormonal regulators in compensating for insufficient winter chilling, representing a promising adaptation strategy to improve budburst uniformity and grapevine resilience under future climate change scenarios in mild-winter viticultural regions.

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MAPPING RUNOFF RISK FOR PLANT PROTECTION PRODUCTS IN A STEEP ALPINE VINEYARD: A PARCEL-SCALE GIS APPROACH IN YVORNE (SWITZERLAND)

In response to environmental pressures and economic constraints, the transition toward sustainable viticulture has become a necessity for winegrowing regions. The Yvorne Grandeur Nature association aims to make Yvorne the first Swiss appellation fully committed to sustainability along the entire value chain. The Yvorne vineyards are located on south-facing slopes of the Vaud Alps, established on an alluvial fan formed after a major landslide. Slope gradients range from 10° in lower parcels up to 58° in upper areas. The village is crossed by a river, which subsequently flows into the Rhône, increasing the risk of plant protection products (PPPs) being transported to surface waters.

In 2024, a parcel-scale assessment was conducted to identify areas vulnerable to PPPs transfer by runoff. Field surveys were combined with spatial analyses in a GIS covering the entire vineyard area (150 ha). The analysis considered: gradient and length of the slope, distance to the hydrographic network, landscape elements influencing runoff, soil texture, land use and tillage orientation relative to slope. The seven factors were classified into risk levels (0–4) and combined in a transfer risk assessment matrix to define an overall risk index. The aim is to develop a practical decision-support tool enabling winegrowers to identify the overall risk of PPPs transfer for each parcel.

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