

Introduction

The Alta Segarra plateau (550–800 m a.s.l., central Catalonia) represents a historical high-altitude viticultural landscape deeply transformed after the 1895 phylloxera crisis. Formerly characterised by the *Vinya Campa* agroecosystem and renowned for high-acidity wines, the region experienced an almost complete loss of autochthonous grapevine diversity following vineyard abandonment and conversion to cereal monoculture. In the context of current global warming, the recovery of locally adapted grapevine germplasm emerges as both a biocultural and climatic resilience strategy.

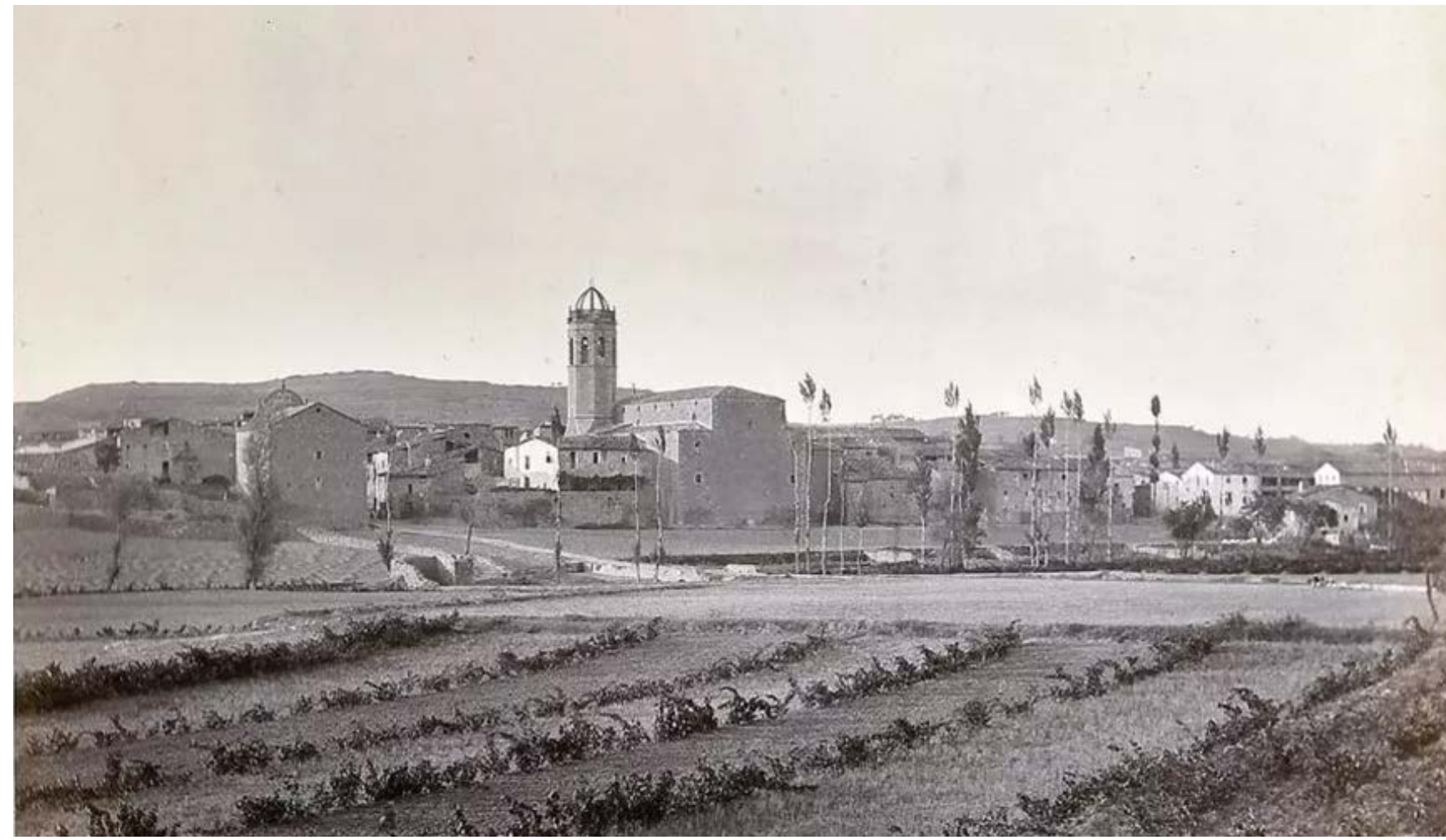
Objectives: 1) Identify and recover relict grapevine germplasm surviving in Alta Segarra. 2) Characterise recovered accessions using molecular (SSR) and phytosanitary tools. 3) Evaluate the role of high-altitude viticulture as a thermal refuge under climate change. 4) Establish an ex-situ conservation and valorisation platform.

Materials and Methods

Field Propection

Figure 1. Historical viticultural landscape and vineyard retreat (Alta Segarra)

Historical photograph (Calaf military manoeuvres, 1890) illustrating the *Vinya Campa* agroecosystem, combined with mid-20th-century aerial imagery showing the progressive conversion to cereal monoculture.



Conservation Platform

Figure 2. Spatial layout of the Vinya-Museu del Padró (ex-situ conservation vineyard).

Block-based organisation of the conservation vineyard (Pujalt, 750 m a.s.l.), showing 27 genetic islands arranged to ensure varietal traceability, phytosanitary control and long-term preservation of relict grapevine germplasm.



Systematic surveys across ~100 locations integrating historical cartography, aerial imagery and georeferenced fieldwork ("green archaeology").

ANALYSES Genetic Characterisation

Twenty nuclear SSR markers analysed by capillary electrophoresis; profiles compared with INCAVI and VIVC databases.

Phytosanitary Screening

ELISA diagnostics for major grapevine viruses (GFLV, ArMV, GLRaV-1, -2, -3, -4, -9).

Establishment of the *Vinya-Museu del Padró* (Pujalt) as an ex-situ living collection, with accessions grafted mainly on 1103 Paulsen rootstock for limestone and drought tolerance.

Results and Discussion

Figure 3. Long-term temperature evolution in Alta Segarra (1984–2025).

Mean annual temperature series from the Pujalt and Veciana observatories. Continuous lines represent annual means; dashed lines indicate linear trends (+0.85 °C and +0.60 °C per decade), evidencing sustained regional warming and the role of altitude as a thermal moderator.

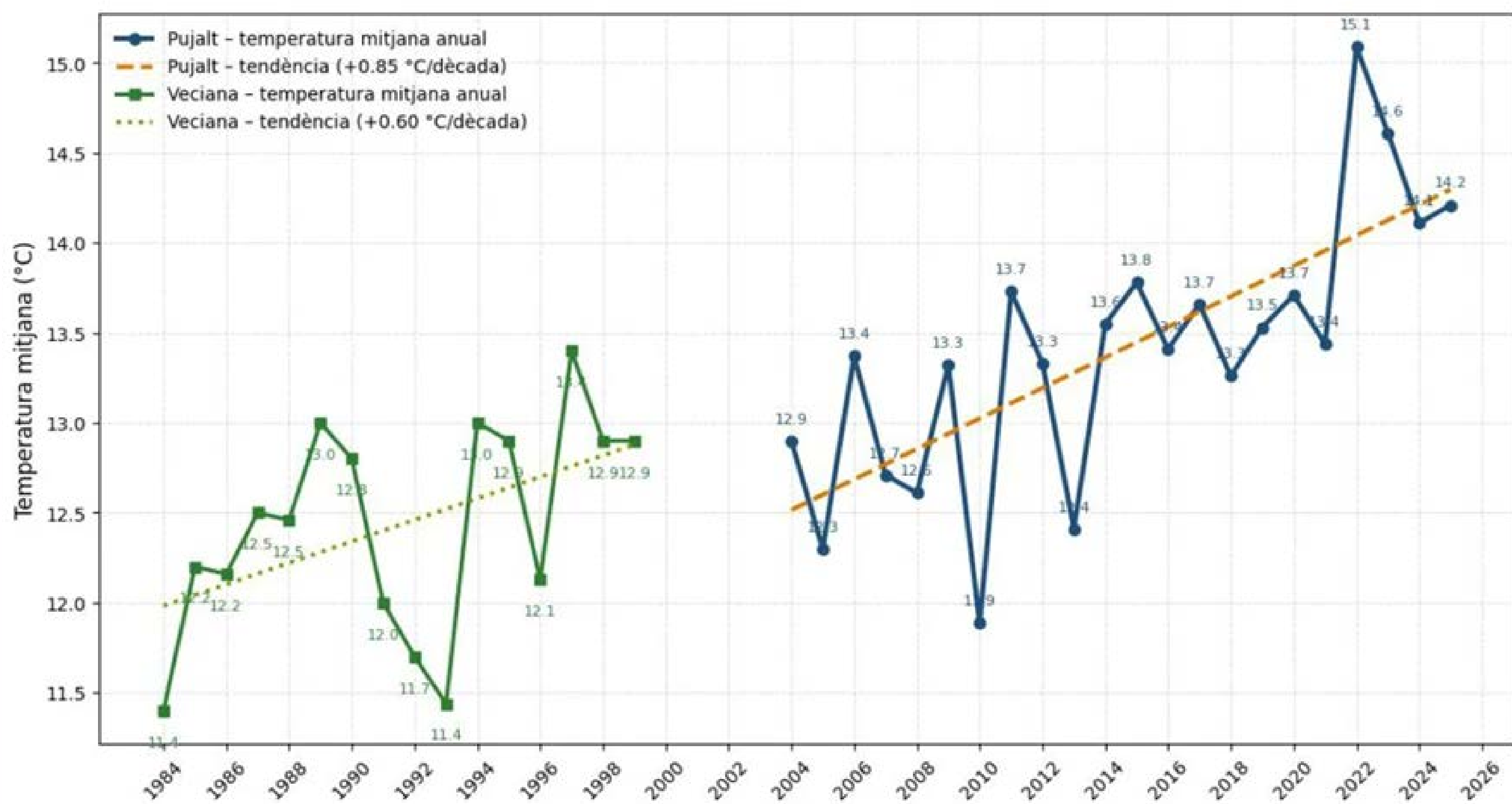


Figure 4. Examples of recovered relict vines in situ.

Isolated grapevine specimens surviving along forest margins, dry-stone walls and abandoned terraces, illustrating long-term natural selection under marginal edaphoclimatic conditions.



- ❖ 205 accessions recovered, representing 30 identified varieties.
- ❖ Detection of 13 previously undocumented genotypes, unique to Alta Segarra.
- ❖ Key recovered cultivars include Sumoll Negre, Morastell (Graciano), Cuatendre, Trobat and Picapoll.
- ❖ 75–80 % of accessions free of major viral pathogens, suitable for direct conservation.
- ❖ Climatic series (1984–2025) show a +0.85 °C per decade warming trend, while altitude provides significant thermal moderation.

The Alta Segarra plateau functions as a strategic altitudinal thermal refuge, allowing extended and balanced grape ripening compared with low-elevation Mediterranean regions. The persistence of relict vines after more than a century of abandonment indicates strong local adaptation, combining drought tolerance, cold resistance and resilience to calcareous soils. Recovered germplasm constitutes a critical genetic reservoir for climate-resilient mountain viticulture and reinforces the region's biocultural heritage.

Conclusions

Alta Segarra preserves a unique pool of autochthonous grapevine biodiversity shaped by long-term natural selection.

Germplasm recovery integrates climate adaptation, conservation genetics and heritage valorisation.

High-altitude Mediterranean viticulture offers viable pathways to mitigate climate-change impacts.

The *Vinya-Museu del Padró* provides a replicable model for sustainable conservation and territorial identity building.

Acknowledgments

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References

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