Assessing Pastoral Value in Alpine Grazing Systems Using Remote Sensing

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Context: mountain grasslands

Multifunctional Ecosystems

Semi-natural mountain pastures provide key ecosystem services: forage production, water regulation, biodiversity, and landscape conservation

Land Abandonment

Declining stocking rates across the Alps often result in undergrazing:

- ↓ Plant diversity
- ↓ Forage quality
- ↑ Shrub encroachment and forest recolonisation

Pasture management: scalable tools for monitoring

Satellite remote sensing can provide a standardised, scalable tool to spatially monitor pasture quality at landscape scale (?)

Pastoral Value

$$PV = \Sigma_i (CS_i \times IS_i) \times 0.2 \rightarrow \textit{Index ranging 0–100}$$

CS_i	IS_i
Specific Contribution Percentage of presence of species *i* within the plot (simplified Braun-Blanquet method)	**Specific Index** Species quality score (0-5) reflecting productivity, nutritive value, palatability and digestibility

PV synthesizes botanical composition, forage quality and productivity into a single index and it allows the determination of pastures carrying capacity.

(Daget & Poissonet, 1972; Cavallero et al., 2007)

PV < 15 — Poor pasture
PV 15–25 — Medium pasture
PV > 25 — Good pasture

(Argenti et al., 2017)

Objectives

01

Develop a standardised RS methodology to spatially predict pastoral value

Predict PV from freely available satellite products (Sentinel-2 & Google Embeddings)

02

Assess temporal changes in pastoral value

Reconstruct past (2017-2018) and current (2023-2025) PV maps and quantify the change over time through RS

03

Link pastoral value trends to management proxies

Examine the spatial relationship between PV temporal trends and slope or distance from night barns

Study Area

Mt. Zoncolan - Eastern Italian Alps

46° 30’ N - 12° 55' E

Sites

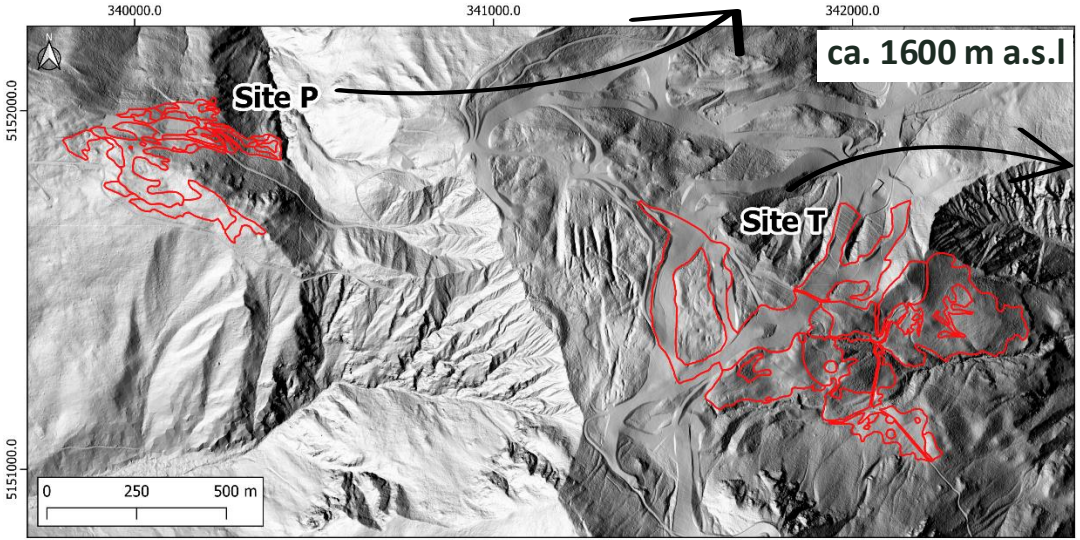
Site T (Tamai) - **29 ha**
Site P (Pozof) - **7.3 ha**

Characteristics

Summer semi-natural pastures composed of a **mosaic of open pastures, shrub-encroached areas and tree patches.** Mainly grazed by Bruna cattle.

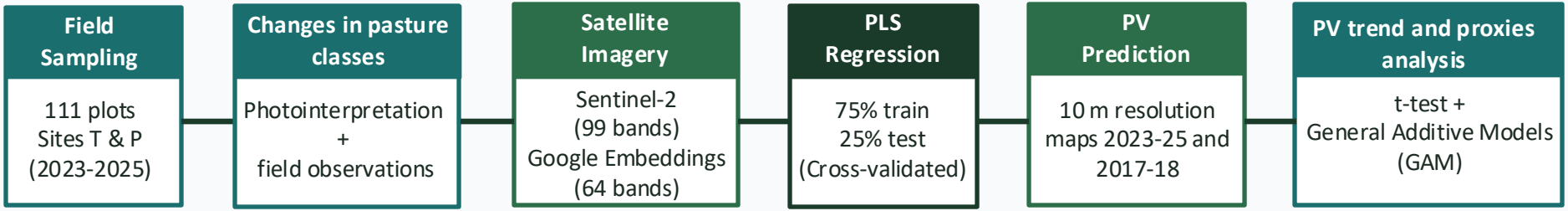
Study period

Grazing seasons 2023-2025



DTM hillshade map (source: FVG regional administration - own elaboration). Pictures taken by the authors.

Methods Overview



Sentinel-2 temporal compositing ('phenological approach')

Monthly composites (min, max, median) from May to November
Difference bands (May-June, June-July, July-Sept, Sept-Nov)
Total: 99 bands

Google Embeddings

Yearly rasters composed of **64 bands** (a combination of optical, radar, LiDAR and environmental data).
→ High level **analysis ready data**
Total: 64 bands

Sentinel-2 Vegetation Indices

- **NDVI** (NIR−RED) / (NIR+RED)
- **GNDVI** (NIR−Green) / (NIR+Green)
- **NARI** (1/Green−1/RedEdge) / (1/Green+1/RedEdge)

Results: Model Performance (Obj.1)

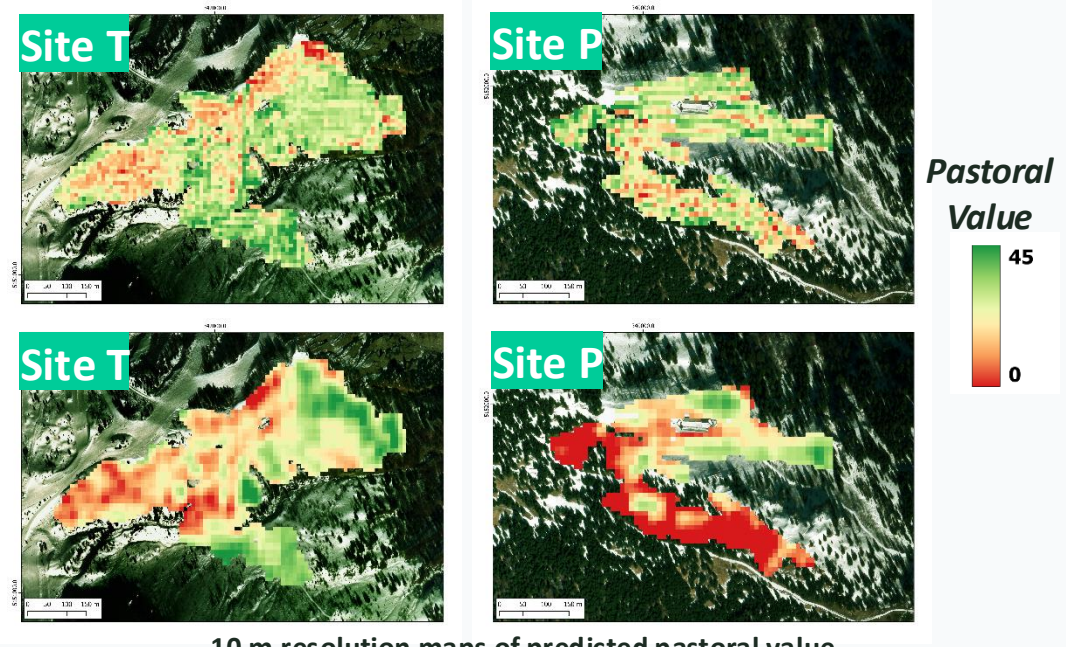
Imagery	R^2 (train)	RMSE (train)	R^2 (test)	RMSE (test)
Sentinel-2	**0.75**	9.11	**0.53**	11.03
Google Embeddings	**0.70**	9.27	**0.60**	12.08

Sentinel-2

Early season phenological differences (May-June) were the **most contributing** predictors.

Google Embeddings

High accuracy with minimal pre-processing. **Biological interpretation** of predictors is **not possible.**

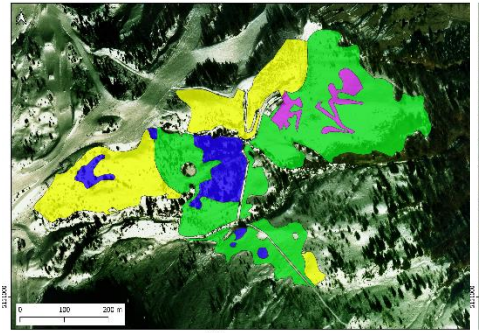


10 m resolution maps of predicted pastoral value

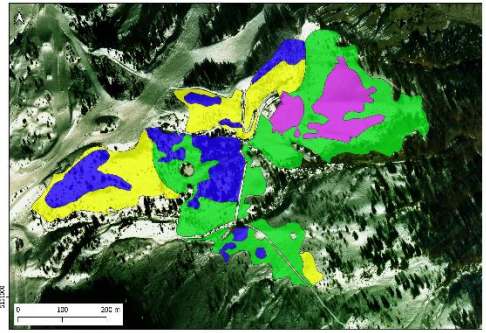
Results: Pasture classes change: 2013 vs. 2025 (Obj. 2 - baseline)

Site T

2013

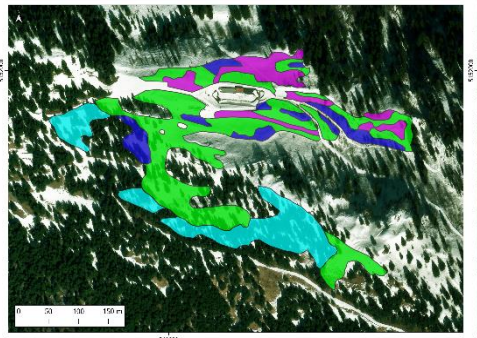


2025

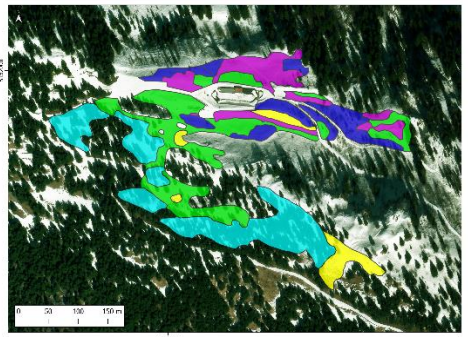


Site P

2013



2025

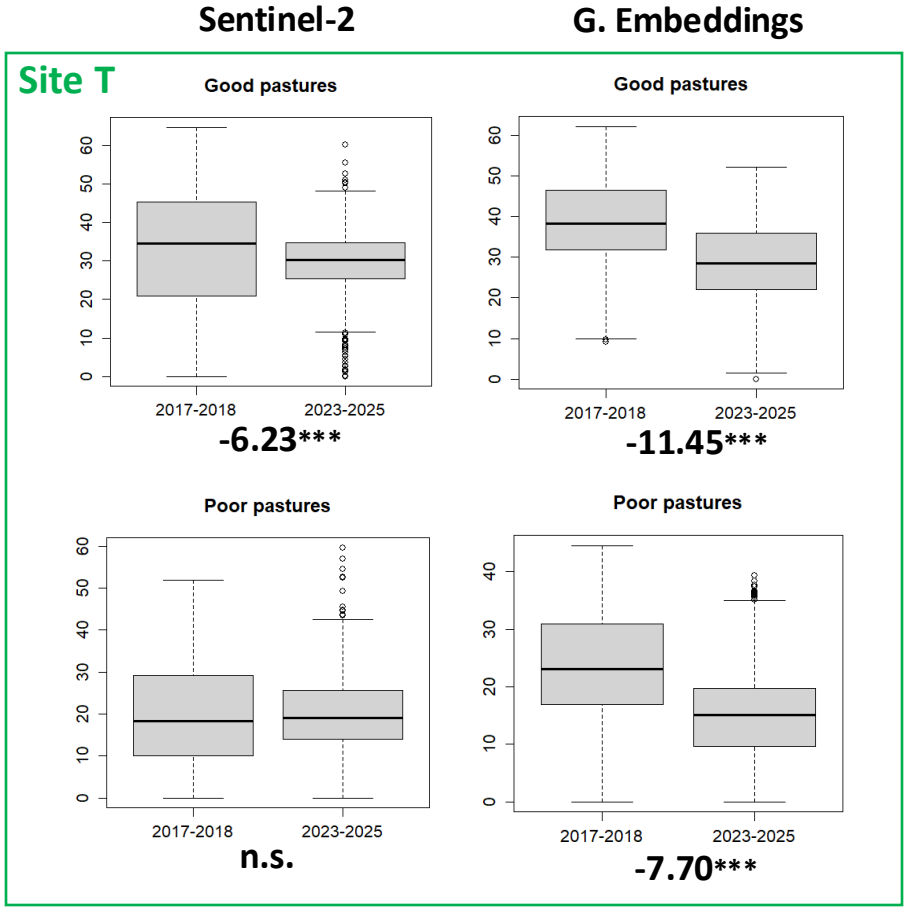


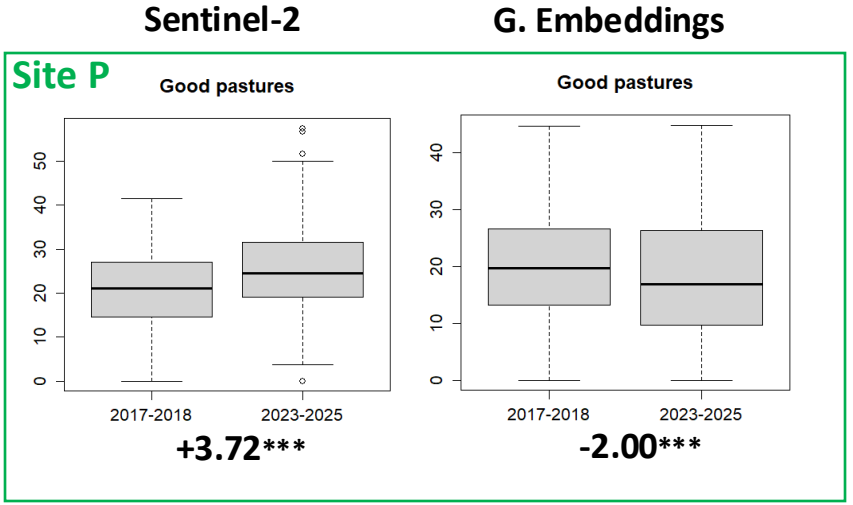
Classes
- Shrub encroached
- Nitrophilous flora
- Trees presence
- Poor pastures
- Good pastures

Class	Site T 2013 (ha)	Site T 2025 (ha)	Site T Δ	Site P 2013 (ha)	Site P 2025 (ha)	Site P Δ
Good pastures	20.6	18.8	–6%	3.7	2.2	–20%
Poor pastures	5.8	4.3	–5%	0	0.5	+6%
Shrub encroach.	1.8	3.72	+7%	0.8	1.1	+4%

Overall decline in pastures quality

Results: Temporal trends of pastoral value (Obj. 2)





Mostly decreasing pastoral value trend between 2017-2018 and 2023-2025 as detected by satellite imagery over 'good' and 'poor pasture' classes

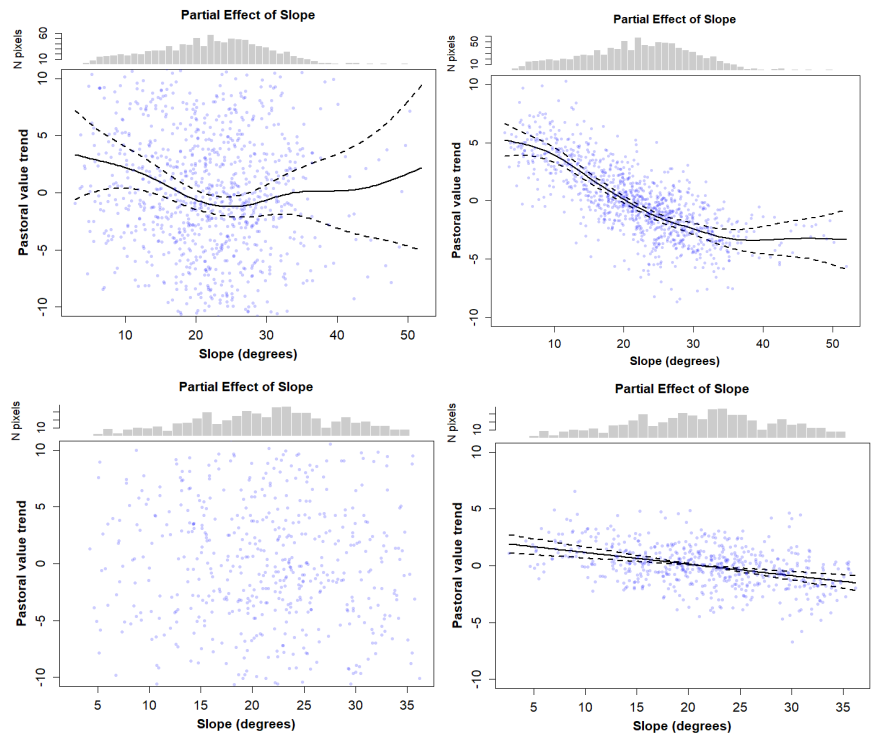
Results: Temporal trends and management proxies (Obj. 3)

Sentinel-2 | G. Embeddings

Good pastures

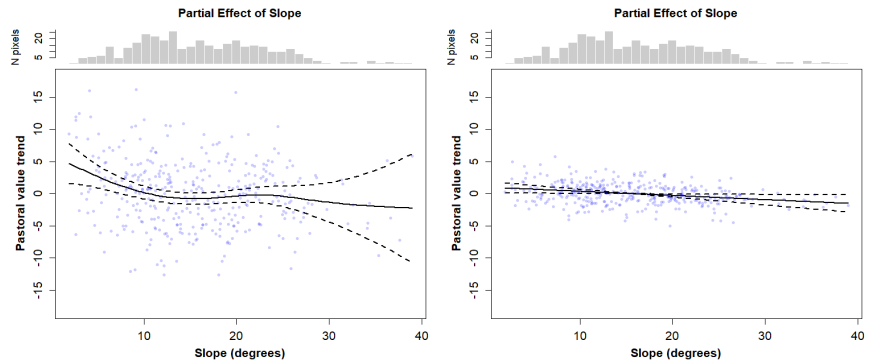
Poor pastures

Site T



Sentinel-2 | G. Embeddings

Site P



Negative relationship between slope and pastoral value trend over time after accounting for spatial autocorrelation

Distance from night barns had no significant relationship with pastoral value trend

Conclusions

RS-based PV modelling is feasible

PLS regression on Sentinel-2 and Google Embeddings achieved R^2 0.53-0.75, spatially distinguishing poor (PV ~15) from productive pastures (PV > 25).

PV declined over the last decade

Good pasture area decreased at both sites.
Remote sensing consistently captured the deterioration in forage quality between 2017-18 and 2023-25.

Slope is a key management proxy

Steeper areas showed a stronger PV decline, likely due to cattle avoidance causing undergrazing on steeper slopes.
Distance from barns had no effect (landscape fragmentation)

Future directions:

Higher-resolution imagery (PlanetScope, IRIDE constellation…) might help in fragmented landscapes.
Google embeddings dataset is promising but require interpretability assessment.

Thank you for your attention!

References

Argenti, G., Bianchetto, E., & Ferretti, F. (2017). Proposal of a simplified method for pastoral value assessment inside forest planning. *Annals of Silvicultural Research*, *41*(2), 67–73. https://doi.org/10.12899/asr-1377

Cavallero, A., Aceto, P., Gorlier, A., Lombardi, G., Lonati, M., Martinasso, B., Tagliatori, C. (2007). *I tipi pastorali degli areali alpini piemontesi*. (Pasture types of the Piedmontese Alps). Bologna (Italy): Alberto Perdisa Editore. p. 467;

Daget P., Poissonet J., 1972. *Un procédé d'estimation de la valeur pastorale des pâturages*. Fourrages 49: 31-39.