Odessa centre | Pastoralism Research, Policy and Practice

TYPE Brief Research Report
PUBLISHED 08 August 2025
DOI 10.3389/past.2025.15222

Check for updates

OPEN ACCESS

EDITED BY
Carol Kerven,
University College London,
United Kingdom

*CORRESPONDENCE
Oguz Kemal Basar,
obasar@unibz.it

RECEIVED 04 July 2025
ACCEPTED 24 July 2025
PUBLISHED 08 August 2025

CITATION
Basar OK, Ugurlu E and Wellstein C (2025) Eco-cultural perspectives on plant diversity and NDVI in mountain pastures: a comparative study of Finail Valley (Italy) and Vercenik Valley (Turkey).
Pastoralism 15:15222.
doi: 10.3389/past.2025.15222

Eco-cultural perspectives on plant diversity and NDVI in mountain pastures: a comparative study of Finail Valley (Italy) and Vercenik Valley (Turkey)

Oguz Kemal Basar[1]*, Emin Ugurlu[2] and Camilla Wellstein[1]

[1]Department of Mountain Environment and Agriculture, Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen-Bolzano, Bolzano, Italy, [2]Department of Forest Engineering, Faculty of Forestry, Bursa Technical University, Bursa, Türkiye

Transhumance is one of the oldest traditional agricultural practices in Val Senales (Italy) and the Western Pontic Mountains (Turkey), playing a crucial role in shaping alpine ecosystems. This study examines the impact of traditional pastoral management on the distribution of dominant plant species and phytomass levels in summer grazing areas. Grazing routes were analyzed using NDVI values derived from drone-based orthophotos captured at an altitude of 35 m during the peak of the transhumance season in June, allowing for the quantification of vegetation cover and dominant species composition. Ethnographic fieldwork with local shepherds in Finailhof and the Vercenik Valley provided insights into traditional ecological knowledge related to pasture management and seasonal flock movements. Additionally, herbarium methods were employed to identify grazed plant species along the grazing routes. Although both regions share similar alpine climatic conditions, their distinct socio-cultural contexts and land-use histories result in different patterns of grazing impact and phytomass distribution. This bi-disciplinary research examines the relationship between NDVI values, phytomass variation, and dominant plant species in both study sites. The findings highlight the significance of integrating traditional ecological knowledge with remote sensing and ecological field methods to support sustainable pasture management and inform alpine policy frameworks. By combining ecological and ethnographic perspectives, the study contributes to a deeper understanding of the interdependent dynamics between cultural practices and environmental processes in pasture management of high-mountain landscapes.

KEYWORDS

transhumance, alpine farming, NDVI, ethnography, grazing

Introduction

Alpine pastures have evolved into distinct economic and cultural landscapes, shaped by animal husbandry practices since the earliest phases of domestication and human settlement. This study focuses on sheep flocks in two high-mountain regions, Finail Valley in Val Senales (Italy) and the high-pasture settlement of Vercenik Valley in the Western Pontic Mountains (Turkey). It examines dominant grazing species and phytomass distribution along daily grazing routes in June. According to common definitions of alpine farming, livestock graze on mountain pastures during the summer and are held in stables in the lowlands during winter (Mandl, 2009). Besides alpine farming and transhumance, the nomadic lifestyle differs from alpine farming in that herders travel from pasture to pasture with all their belongings and without permanent settlements (Reitmaier, 2010). By integrating ethnographic methods with vegetation analysis derived from the Normalized Difference Vegetation Index (NDVI), this study offers a comparative assessment of grazing patterns and pasture management. While both regions share similar alpine climatic conditions, their distinct cultural histories and pastoral traditions provide valuable insights into the relationship between ecological dynamics and traditional ecological knowledge in high-mountain grazing systems.

In Val Senales, the first indication of human impact, also in terms of grazing and pasture development, is documented in the pollen record of the Val Senales since 1400 cal BC (Festi et al., 2014). Today, 24 farms surround Lake Vernago, with a total of 60 farms distributed across the Val Senales region. The Finail Valley, situated to the north and adjacent to Val Senales, has fully embraced alpine farming practices throughout its landscape. Finailhof, located at an elevation of 1,953 m above sea level on the upper slopes above Lake Vernago and at the entrance of the Finail Valley, is managed by Shepherd Manni, the principal landowner and lead shepherd of his family, who employs a continuous free-grazing system for his flock.

The Vercenik Plateau lies at 2,650 m above sea level within the Vercenik Valley, part of the Eastern Pontic Mountains. Transhumance practices in this area extend to the highest elevations of Mount Vercenik (3,711 m a.s.l.). In this context, Shepherd Kadir, the head shepherd of his family, follows a four-stage annual transhumance system that reflects long-standing local traditions. The grazing strategy in the Vercenik Valley is characterized by intensive guided rotational grazing, in contrast to the continuous free-grazing system practiced in the Finail Valley.

Satellite platforms provide high-resolution, multi-temporal data, allowing for the generation of dense time series of reflectance spectral bands and vegetation indices, which are essential for capturing vegetation dynamics over seasonal and interannual scales (Schmidt et al., 2014). Among traditional vegetation indices, the Normalized Difference Vegetation Index (NDVI) (Rouse et al., 1973). Has emerged as a key metric for tracking phenological changes due to its high sensitivity to biomass stress (Pettorelli et al., 2011). For this reason, NDVI values of both study sites were scanned by drone to reach the fresh vegetation indexes after the grazing in June. Pasture growth rates and the amount of green pasture have a good correlation to satellite vegetation indices such as the NDVI (Donald et al., 2010). The use of remote sensing may provide an alternative method for estimating grass biomass and vegetation community structure over large areas at a reasonable cost (Clark et al., 2001). Previous estimates of green phytomass made using spectral data have used near infrared and red wave bands in ratio (Colwell, 1974) or linear combinations to form vegetation indices (Tucker et al., 1981).

The sheep are selective and, e.g., prefer both flowers and leaves (Austrheim et al., 2008). Several grazing experiments have been conducted where sheep grazing pressure is controlled, but only a few publications have focused on the effects of grazing on plants and ecosystems (Magnússon and Magnússon, 1992). Generally, grazing plays a key role in shaping plant communities. However, there are also further environmental factors, which are usually more important and decisive than grazing for species composition, i.e., altitude, being most relevant at the highest elevations (Brinkmann et al., 2009). Depending on the study area and system, grazing has a high, little, or hardly any effect on species richness or plant community composition (Stohlgren et al., 1999). Alpine farming and transhumance have historically induced observable transformations in the ecosystem. Ungulate grazing is the most common land use in the world (Diaz et al., 2007), and one of the most impacting disturbances on species composition (Huntly, 1991), together with habitat destruction (Pimentel Gomes and Garcia, 2002), invasion of exotic species (Pauchard et al., 2009) and fire. Despite the widespread use of this land, the understanding of the dynamics of plant communities under grazing management remains unachieved, as far as the results obtained are contradictory in many areas (Olff and Ritchie, 1998). In this study, the following research questions were examined to understand the post-grazing NDVI values and vegetation indices of Val Senales and Vercenik Valley.

- What are the post-grazing vegetation index (NDVI) values and corresponding phytomass levels in grazing sectors?
- What are the cover-abundance values of plant species identified along the mapped grazing routes, and how do these reflect grazing intensity?
- What is the spatial extent of the daily grazing area utilized by sheep flocks, and what is the total plant species richness within these areas?
- Which plant species are most frequently and preferentially grazed by flocks along their average daily grazing routes?

Methods

Study sites

The study was conducted in two alpine regions: the Finail Valley, Val Senales, Italy (46.7484°N, 10.8294°E), and the

Vercenik Valley, located in Çamlıhemşin, Rize, Turkey (40.7413°N, 40.9164°E). Adopting a bi-disciplinary research framework, the study integrates ecological analysis with ethnographic inquiry. To complement scientific data, traditional ecological knowledge (TEK) was gathered from local shepherds through ethnographic methods, including semi-structured interviews.

Ethnographic method and Shepherd's knowledge

Ethnography, emerging from anthropology, and adopted by sociologists, is a qualitative methodology that lends itself to the study of the beliefs, social interactions, and behaviours of small societies, involving participation and observation over a period of time, and the interpretation of the data collected (Reeves, 2008). The goal of ethnography, then, was to give an analytical description of other cultures (Barbour, 2007). These qualitative data were systematized to allow for comparative and quantifiable analysis for mapping the grazing routes and pastures. In collaboration with the shepherds, daily grazing routes, as well as pasture sectors in both valleys, were identified and spatially mapped in June 2022-24. This participatory approach also guided the selection of sampling sites for herbarium specimens and NDVI scanning areas, ensuring ecological data were grounded in local knowledge and pastoral practices. Furthermore, ethnographic data prepared the right basis for this study to be carried out and to obtain NDVI and post-grazing phytomass data.

Herbarium technique and Braun-Blanquet scale

Herbarium is a storehouse of botanical specimens, which are arranged in the sequence of an accepted classification system, and available for reference or other scientific study (Maden, 2006). For vegetation sampling, herbarium specimens were collected from designated grazing sectors along the daily routes of the flocks, focusing on areas actively used for foraging. Sampling followed the Braun-Blanquet cover-abundance scale within standardized 10 m^2 plots. Specimens were collected exclusively from locations where direct grazing activity was observed immediately after the flocks had passed. Within these grazing sectors, species density and cover were recorded based on observations by shepherds Manni and Kadir during daily grazing in June 2022–2024. Plant specimens were collected across the full spectrum of cover-abundance categories, ranging from dominant species (75%–100% cover) to rare individuals (approximately 1% cover) (Braun-Blanquet, 1964).

In total, 61 plant species were identified from the Finailhof site and 73 species from the Vercenik Plateau. Species identification was carried out using *Flora d'Italia* (Pignatti, 1982), *Flora of Turkey* (Günes and Ozhatay, 2000), and the *Turkish Plant List* (Güner A, et al., 2012). In addition to the herbarium collections, 23 plant species were identified *in situ* during field observations in the Finail Valley. The spatial distribution of these species, along with the corresponding movement patterns of the flocks, was recorded using georeferenced point data, including precise geographical coordinates and elevation. Following the completion of initial fieldwork, the grazing landscapes in both valleys were subdivided into distinct grazing sectors based on input and recommendations provided by shepherd Manni and Kadir. Furthermore, through observational data collected in cooperation with shepherds, the grazed species were classified into three categories: most grazed, secondary grazed, and sparsely grazed species.

NDVI drone scanning and orthophotography

Following the ethnographic phase, daily grazing routes and high-pasture areas were mapped and divided into grazing sectors. These divisions were determined through active participation in pasture activities with shepherds Manni and Kadir. Due to the monthly variation in flock grazing routes, this study specifically focused on spatial grazing patterns observed in July. Aerial surveys were conducted using a DJI Mavic Mini 2 drone between 10–16 July 2024 in the Finail Valley and between 23–29 July 2024 in the Vercenik Valley (Figure 1). To ensure the reliability of NDVI measurements, flock movements were first monitored in collaboration with the shepherds during July 2022 and 2023. This preliminary work allowed the identification of consistent grazing routes, which then served as a baseline for data collection in July 2024. Drone imagery was acquired at a flight altitude of 35 m above ground level, yielding a spatial resolution of 5 cm per pixel.

The resulting high-resolution orthophotographs were processed using Pix4D software to generate seamless mosaic images of the grazing areas. These mosaics were subsequently imported into QGIS for spatial analysis and NDVI extraction, providing a detailed representation of vegetation cover and phytomass distribution within the active grazing sectors. The value of the NDVI ranges from −1 to +1, the latter being the maximum level of greenness. NDVI graphics of Val Senales and Vercenik Valley were represented using the formula of NDVI = (Band 4 – Band 3)/(Band 4 + Band 3). It represents the total area and the reflectance of the sectors from the orthophotos. The vegetation index values are: 0-0.1 = Snow or cloud, 0.1–0.2 = Lake or stream, 0.2–0.3 = Streams, 0.3–0.4 = Rocky areas or cultural elements, 0.4–0.5 = Intensive grazing area, 0.5–0.6 = Grazing area, 0.6–0.7 = Lightly grazed area, 0.7–0.8 = Sparsely vegetated area, 0.8–0.9 = Dense vegetated area, 0.9–1.0 = Wetland area.

For spatial analysis, georeferenced flock movement points were imported into QGIS and systematically labeled to map the

10.3389/past.2025.15222

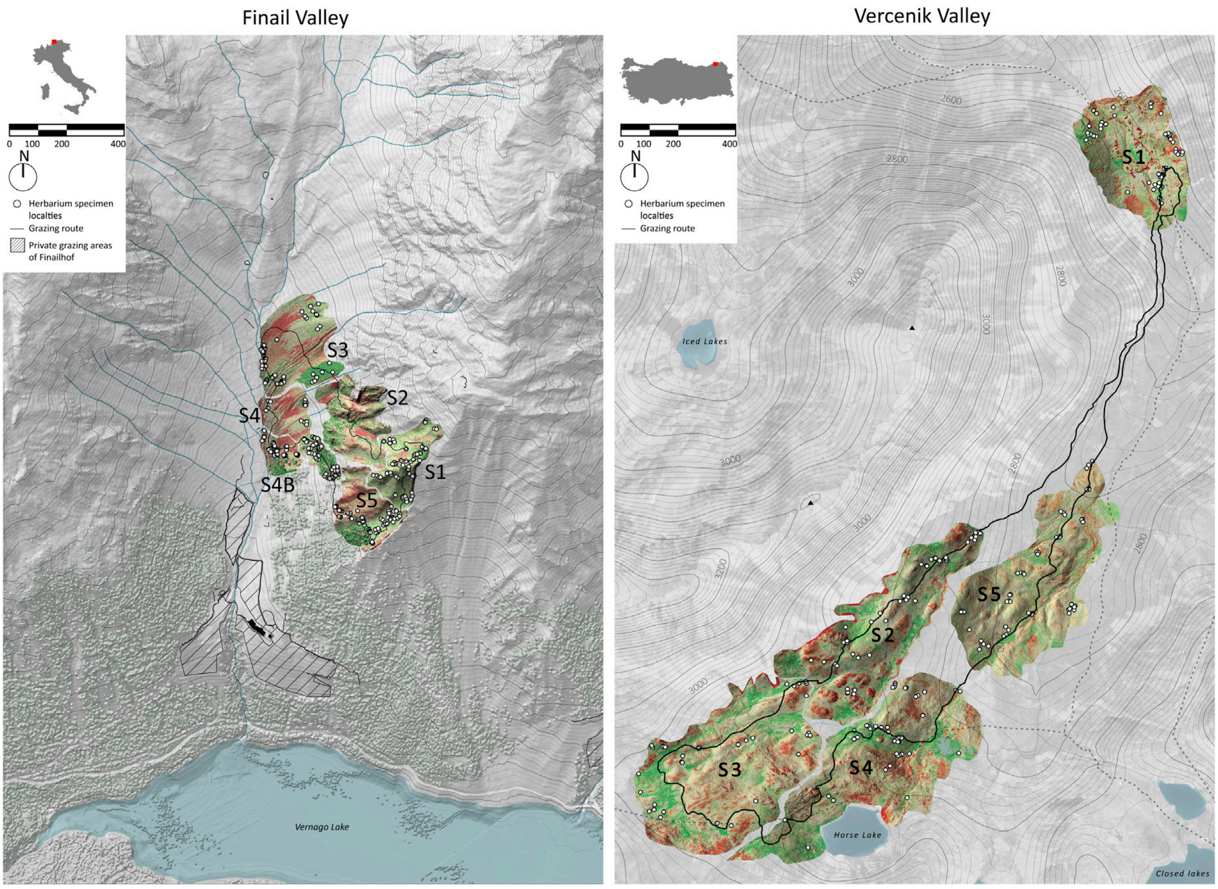

FIGURE 1
Grazing routes (black line), sectors (S), and herbarium sites (white dots) with NDVI (ranging from hardly vegetated areas in red to densely vegetated areas in dark green) in Finail Valley, Italy, and Vercenik Valley, Turkey.

flock movements. These routes were overlaid onto NDVI reflectance layers to assess spatial correlations between grazing paths and vegetation patterns. This integration enabled detailed evaluation of vegetation cover, habitat use, and grazing impact. Based on ethnographic and ecological data, and in collaboration with shepherds, grazing routes were subdivided into distinct grazing sectors. To assess grazing intensity and identify species contributing to phytomass reduction, GPS points were used to record grazing areas along the routes of two herds, allowing post-grazing phytomass monitoring.

Results

Herbarium specimen and grazing species

In both study areas, the distribution of species represented the flock movements. Not all species are grazed by flocks, but the most abundant grazed species (Figure 2) are: In Finail Valley, *Festuca ovina, Festuca rupicola, Poa alpina, Anthoxanthum alpinum, Festuca rubra, Poa supina,* and *Alopecurus pratensis*. Depending on the flowering season, secondary grazed species are: *Achillea moscata*, *Achillea millefolium agg.*, *Cerastium fontanum, Helianthemum nummularium, Carex sempervirens, Carex caryophyllea, Trifolium pratense, Trifolium alpinum, Trifolium badum, Luzula campestris agg., Thymus praecox, Deschampsia cespitosa, and Nardus stricta.* Sheep are very selective in finding fresh vegetation. As we observed in the field, sheep are mainly interested in white flower species in Asteraceae.

The flock grazes in Vercenik Valley mostly in the grasslands selected by shepherd Kadir. *Festuca woronovii, Festuca pratensis, Poa pratensis, Dactylis glomerata, Briza marcowiczii, Poa bulbosa, Calamagrostis epigejos, Poa annua, Veronica gentianoides, Pilosella hoppeana, Achillea latiloba, Carum meifolium, Taraxacum stevenii DC., and Bupleurum falcatum* are primary grazed species in Vercenik Valley. Semi-grazed species are *Carex nigra, Carex atrata, Thymus praecox, Trifolium canescens, and Alchemilla pseudaocartalinica.*

10.3389/past.2025.15222

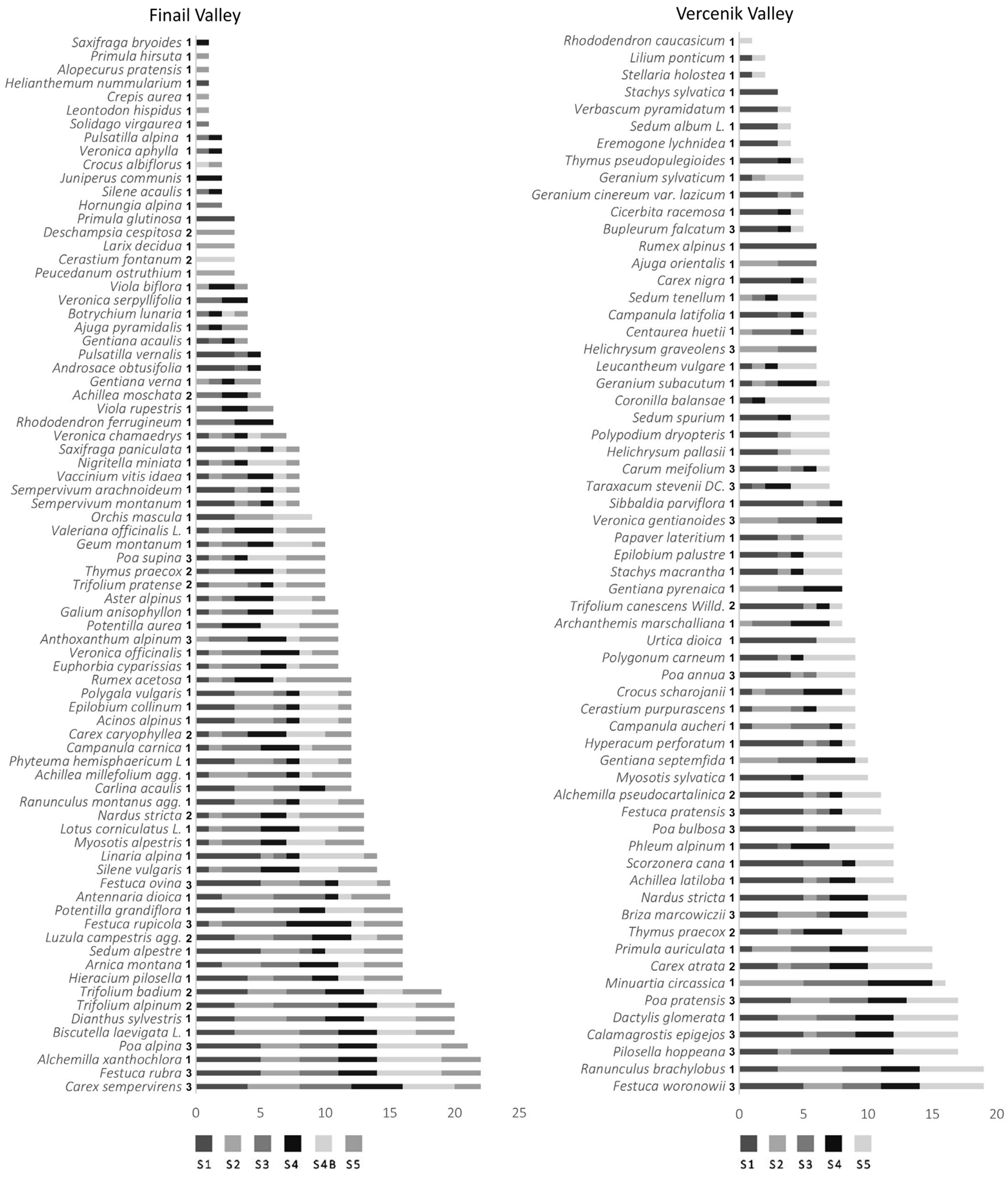

FIGURE 2
Herbarium specimens and cover abundance values of grazing sectors in Finail Valley and Vercenik Valley with the Braun-Blanquet Scale and Grazing priority. (3: most grazed, 2: secondary grazed, 3: sparsely grazed).

Distance of grazing routes

The present study examines the grazing routes of sheep flocks in two high-pasture regions: Vercenik Valley and Finail Valley. The grazing routes were recorded with the guidance of shepherd Kadir in Vercenik Valley and shepherd Manni in Finail Valley, and subsequently divided into grazing sectors in consultation with the shepherds. In Finail Valley, the total grazing route of the flock measures 3.2 km, whereas in Vercenik Valley, the daily grazing route extends to 8.1 km. Consequently, the travel time in Vercenik Valley is approximately twice that of Finail Valley. The distinct habitat and landscape characteristics of these valleys strongly influence the grazing patterns of the flocks. In Finail Valley, the flock follows an instinctive grazing path, resulting in a continuous free-grazing system that promotes an even distribution of phytomass. In contrast, the grazing method in Vercenik Valley is characterized by intensive, guided rotational grazing, which allows for controlled distribution and composition of plant species within the valley. This difference in grazing strategies leads to sharper fluctuations in phytomass ratios in Finail Valley, while in Vercenik Valley, phytomass distribution remains relatively uniform.

Relations between NDVI and phytomass

The relationship between NDVI and phytomass in the two study areas is negatively correlated (Figure 3). This is primarily

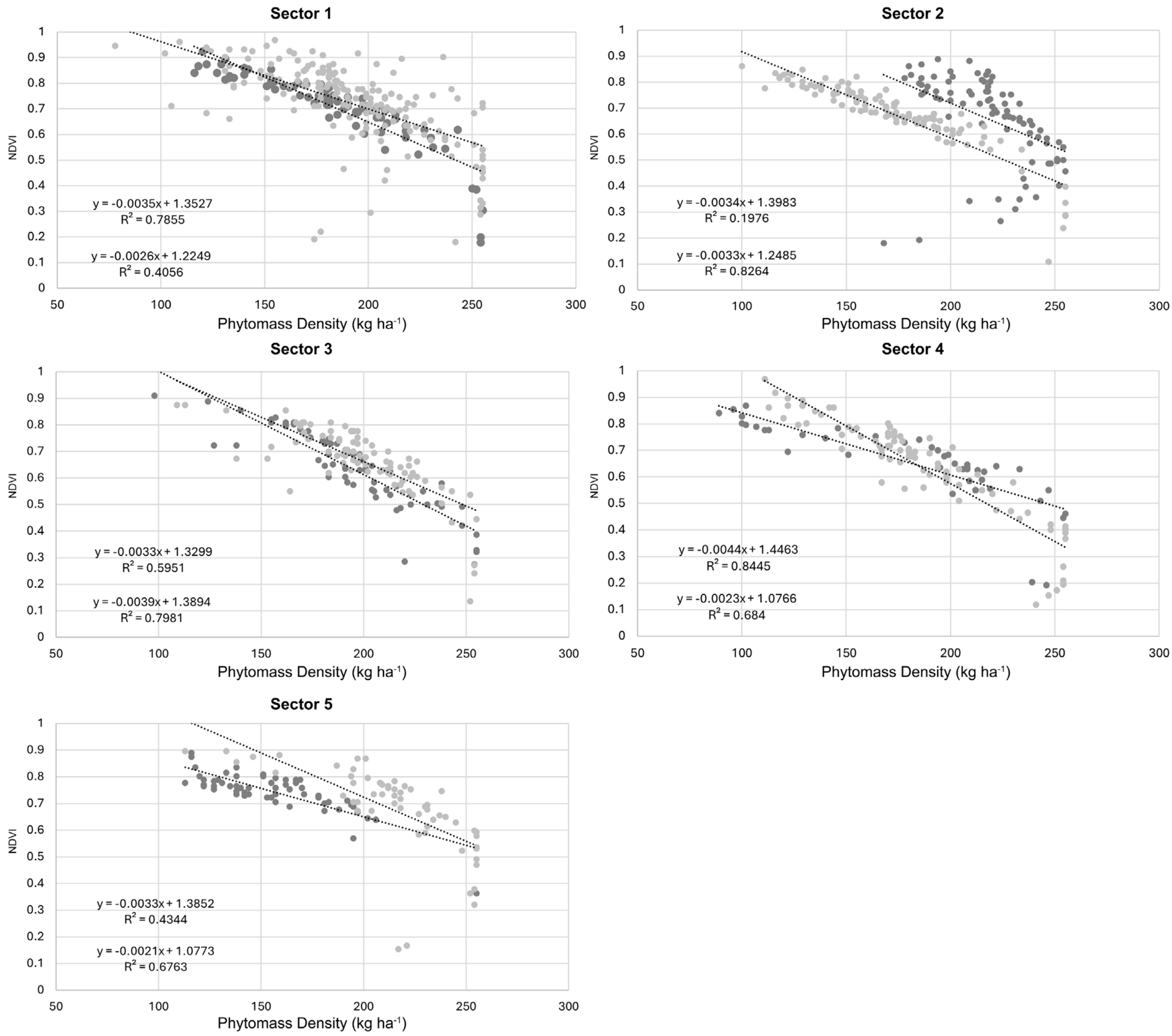

FIGURE 3
Phytomass (kg ha^{-1}) and NDVI density on grazing sectors in the post-grazing period (Dark grey: Finail Valley, Light grey: Vercenik Valley).

due to the absence of woody species at grazing altitudes and the dominance of herbaceous species. Moreover, the data were collected after the herds had grazed the land. As a result, NDVI values remain high, but the plants have recently been grazed and have not yet produced sufficient biomass. The combination of high NDVI values and low phytomass ratios in both study areas reflects the dominance of herbaceous species and the effects of recent grazing.

This study evaluates the relationship between Normalized Difference Vegetation Index (NDVI) and phytomass density (kg ha^{-1}) measured in different grazing sectors in Finail and Vercenik valleys. At the same time, species compositions of each valley were compared, and the effect of these structural differences on the NDVI–phytomass relationship was analyzed. Post-grazing data reveal the effect of different vegetation structures and species diversity on the spectral reflectance and phytomass relationship.

The relationship between NDVI and phytomass density was evaluated across five sectors in both the Finail and Vercenik valleys, based on post-grazing field measurements. Linear regression models revealed distinct spatial patterns of vegetation response to grazing pressure in each valley. In Sector 1, a strong negative linear relationship was observed in Finail Valley (R^2 = 0.7855), indicating that NDVI values declined substantially as phytomass decreased.

This suggests a high level of grazing pressure, which reduced vegetative cover significantly. Conversely, in Verçenik Valley, the data exhibited greater scatter (R^2 = 0.4056), indicating a weaker correlation and possibly more heterogeneous vegetation structure and less intensive grazing. In Sector 2, the pattern was reversed. A very strong negative correlation was found in Verçenik Valley (R^2 = 0.8264), whereas the relationship in Finail Valley was notably weaker (R^2 = 0.1976). The grazing areas are narrow in Finail Valley. This shift is attributed to increased grazing intensity and differences in species composition in Vercenik Valley.

In Sector 3, both valleys showed moderate to high negative correlations. The relationship was stronger in Verçenik Valley (R^2 = 0.7981) compared to Finail Valley (R^2 = 0.5951), suggesting that grazing influenced vegetation structure in both areas, although Vercenik exhibited more consistent spectral and phytomass responses.

In Sector 4, the Finail Valley displayed the steepest regression slope ($y = -0.0044x + 1.4463$, R^2 = 0.8445), reflecting a rapid decline in NDVI with decreasing phytomass because this sector has common grazing areas of cattle, goat, and sheep flock. This suggests an abrupt reduction in vegetative health or cover under high grazing intensity. The relationship in Vercenik Valley was also strong (R^2 = 0.684), though less steep, indicating a more gradual decline in NDVI.

In Sector 5, moderate correlations were observed in both valleys. Vercenik (R^2 = 0.6763) demonstrated a slightly stronger relationship than Finail (R^2 = 0.4344), reflecting moderate grazing effects and variability in vegetation response. Overall, these results highlight sector-specific differences in the sensitivity of NDVI to phytomass changes, largely influenced by local grazing pressure and vegetation composition.

In Finail Valley, vegetation is less diverse and dominated by grazing-resistant herbaceous species (e.g., *Trifolium pratense*, *Festuca ovina*, *Rumex acetosella*), resulting in low-phytomass but high-reflectance vegetation post-grazing. Strong negative correlations in Sectors 1 and 4 reflect high grazing pressure, while Sector 2 shows weak correlations due to limited grazing and greater species diversity. In contrast, Vercenik Valley hosts more diverse, moisture-adapted species (e.g., *Festuca woronowii*, *Briza marcowiczii*, *Dactylis glomerata*, *Carex atrata*) with broader leaves, potentially yielding similar NDVI values despite higher phytomass. Strong regressions in Sectors 2, 3, and 5 suggest evident grazing impacts. Overall, greater data scatter corresponds to increased heterogeneity in plant species composition.

NDVI and grazing sectors

In Finail Valley, NDVI values are generally at medium levels. The relationship between NDVI and area generally shows low correlation (R^2 is generally between 0.2–0.4). The densest NDVI areas are observed in S1 and S5 sectors. S3 and S4 show a more scattered and wavy distribution. The average NDVI rate is 0.64, and the densest vegetation is S1, S5 (Figure 4).

In general, the NDVI area is smaller and limited. Vercenik Valley is richer and more stable in terms of NDVI. High correlations between NDVI and area are observed in all sectors (R^2 values are generally 0.37–0.45). Especially in S3, S4, and S5 sectors, the NDVI value reaches 0.7 and above and spreads over large areas. This shows that the region has strong and widespread vegetation. The average NDVI value is 0.73, and the densest vegetation is S3, S5. In general, it has a wider and more homogeneous distribution.

Discussion

Pasture management strategies in the Finail and Vercenik Valleys reflect distinct approaches shaped by ecological contexts, cultural heritage, and socio-economic considerations. In the Finail Valley, grazing practices are characterized by a free grazing system, employed by shepherd Manni. Within this framework, the sheep flock is allowed to roam autonomously, selecting grazing sites based on the natural availability and quality of vegetation. The observed differences between pastures in terms of NDVI values and their seasonal dynamics align with studies using remote sensing to monitor vegetation productivity (Serrano, J, et al., 2019) and its effects on herbivore behavior (Borowik, T, et al., 2013) Grazing trajectory data contains rich spatiotemporal information, and analyzing the behavior of livestock based on spatiotemporal characteristics

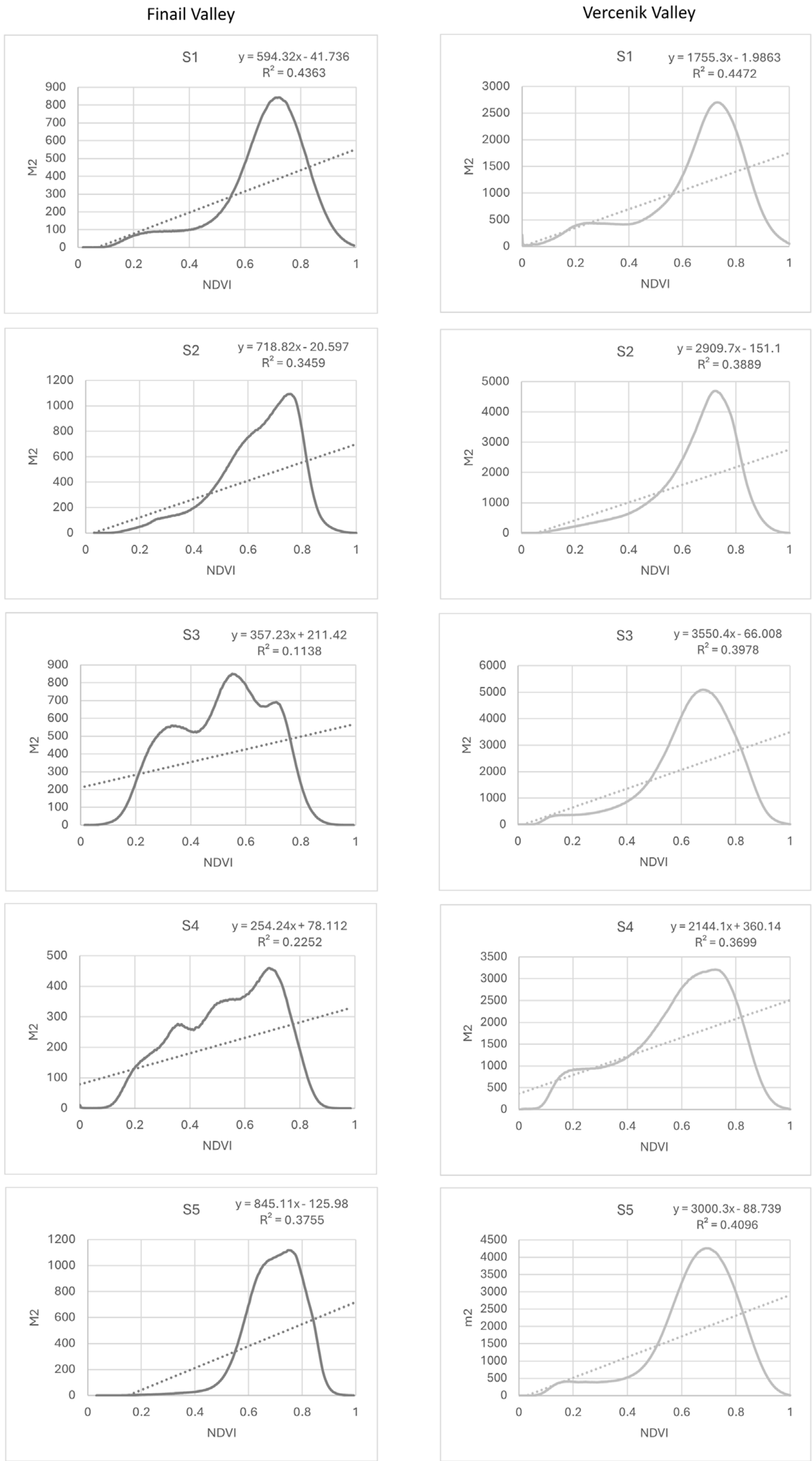

FIGURE 4
NDVI (Normalized Difference Vegetation Index) and square meters (m^2) for two valleys in post-grazing period (Finail and Vercenik Valley).

can establish a better connection between grassland nutrition and behavior (Gao, F., et al., 2023). The flock's movement patterns are not predetermined but instead guided by environmental cues such as weather conditions, topographical gradients, and the spatial distribution of palatable plant species. As a result, grazing activity typically progresses upward in elevation over the course of the season, following the phenological development of alpine vegetation.

The observed variations in NDVI–phytomass relationships are largely attributable to differences in grazing intensity and species composition. Accuracy of the satellite estimate was affected by the presence of dry (non-photosynthetically active) biomass, so that early summer estimates were consistently more accurate than late summer estimates (Todd S.W. et al., 1998). In Finail Valley, sectors with strong negative correlations (notably S1 and S4) were dominated by grazing-resistant, short-statured species. These species tend to produce low phytomass but maintain high NDVI values due to rapid post-grazing regrowth and dense canopy coverage. In contrast, Vercenik's plant communities were more diverse and included broader-leaved, taller species. These traits may contribute to higher spectral variability and more gradual NDVI responses to phytomass reduction, depending on grazing history and species dominance.

Vegetation indices have repeatedly proven to be broadly correlated with vegetation biophysical characteristics (Todd et al., 1998). Moreover, the heterogeneity in NDVI–phytomass relationships emphasizes the limitations of using NDVI as a sole proxy for productivity in post-disturbance conditions. The variation in R^2 values across sectors indicates that NDVI may be less reliable in areas with structurally or compositionally complex vegetation. Integrating these methods may help identify critical foraging areas and periods of resource scarcity, enabling targeted interventions to improve animal welfare and optimize pasture utilization (Berger-Tal et al., 2011). The combined use of the NDVI and movement ecology appears to represent a promising methodological framework for advancing our understanding of herbivore–vegetation interactions and promoting sustainable livestock management (Festa-Bianchet 1988).

This study demonstrates that the NDVI–phytomass relationship is highly context-dependent, influenced by grazing intensity and plant species composition. In alpine pastures, particularly after grazing events, NDVI alone may not accurately reflect phytomass without consideration of underlying vegetation characteristics. Effective use of remote sensing in rangeland monitoring should therefore integrate floristic data and sector-specific ecological knowledge. These findings are broadly consistent with previous research on herbivore foraging strategies, where animals adopt more extensive search patterns when resource availability is limited (Chynoweth et al., 2013). Higher NDVI values, indicative of greater forage availability, thus influencing grazing patterns (Bailey et al., 1996).

The analysis indicates that Vercenik Valley exhibits higher vegetation productivity and more uniform spatial distribution than Finail Valley. Elevated NDVI values, despite ongoing grazing, suggest the potential for sustainable grazing practices in Vercenik. In contrast, restoration measures may be needed in low-NDVI sectors of Finail (particularly S3 and S4). Preserving current grazing routes in Vercenik could support sustainable management without compromising NDVI richness. Temporal NDVI monitoring in both valleys is essential for assessing grazing impacts and climate change effects.

Future research

Future research should prioritize the development of multispectral or hyperspectral models that integrate species-specific reflectance characteristics and temporal recovery dynamics to enhance phytomass estimation in grazed ecosystems. Both free grazing and intensive rotational grazing contribute to the maintenance of mountain grasslands. Intensive rotational grazing as practiced in Vercenik Valley can be used to facilitate targeted restoration. These approaches underscore the value of traditional ecological knowledge in sustainable land management and highlight the need for policies that integrate context-specific, traditional grazing practices.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because I interviewed the shepherds and observed their flocks during the grazing. So, I didn't asked any private questions. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CW is the primary supervisor who guided the regional and ecological aspects of the research throughout the entire research period. EU is co-supervisor and helped to determine the species after herbarium specimen. All authors contributed to the revisions of the paper.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research has been funded by the Free University of Bolzano. OB was funded by the PhD study program Mountain Environment and Agriculture (MEA), Free University of Bozen-Bolzano. The publication fee was covered by Open Access Publishing Fund by UNIBZ.

Acknowledgments

We would like to thank the shepherds and their families in Val Senales and the Vercenik Valley for sharing their knowledge and their support during fieldwork. Thanks to support in anthropology from Prof. Elisabeth Tauber and thanks to Simon Stifter and Giacomo Mei for helping with the determination of the herbarium specimen.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

References

Austrheim, G., Asheim, L., Bjarnason, G., Feilberg, J., Fosaa, A. M., Holand, O., et al. (2008). Sheep grazing in the north atlantic region: a long term perspective on management, resource economy and ecology. *Vitenskapsmuseet, Rapport Zoology Series*. 3.

Bailey, D. W., Gross, J. E., Laca, E. A., Rittenhouse, L. R., Coughenour, M. B., Swift, D. M., et al. (1996). Mechanisms that result in large herbivore grazing distribution patterns. *J. Range Manag.* 49 (5), 386–400. doi:10.2307/4002919

Barbour (2007). Leader paradoxes and critical ethnographies. *Acad. Exch. Q.* 11 (2), 117–121. Available online at: https://www.thefreelibrary.com/Leader+paradoxes+and+critical+ethnographies.-a0172686672.

Berger-Tal, O., Polak, T., Oron, A., Lubin, Y., Kotler, B. P., and Saltz, D. (2011). Integrating animal behavior and conservation biology: a conceptual framework. *Behav. Ecol.* 22 (2), 236–239. doi:10.1093/beheco/arq224

Borowik, T., Pettorelli, N., Sonnichsen, L., and Jędrzejewska, B. (2013). Normalized difference vegetation index (NDVI) as a predictor of forage availability for ungulates in forest and field habitats. *Eur. J. Wildl. Res.* 59 (5), 675–682. doi:10.1007/s10344-013-0720-0

Braun-Blanquet, J. (1964). *Pflanzensoziologie: grundzüge der Vegetationskunde*. 3rd ed. Berlin: Springer-Verlag. doi:10.1007/978-3-7091-8110-2

Brinkmann, K., Patzelt, A., Dickhoefer, U., Schlecht, E., and Buerkert, A. (2009). Vegetation patterns and diversity along an altitudinal and a grazing gradient in the jabal al akhdar Mountain range of northern Oman. *J. Arid Environ.* 73, 1035–1045. doi:10.1016/j.jaridenv.2009.05.002

Chynoweth, M. W., Litton, C. M., Lepczyk, C. A., Hess, S. C., and Cordell, S. (2013). Biology and impacts of Pacific Island invasive species. 9.*Capra hircus*, the feral Goat (Mammalia: bovidae). *Pac. Sci.* 67 (2), 141–156. doi:10.2984/67.2.1

Clark, P. E., Seyfried, M. S., and Harris, B. (2001). Intermountain plant community classification using landsat TM and SPOT HRV data. *J. Range Manag.* 54 (2), 152–160. doi:10.2307/4003176

Colwell, J. E. (1974). Vegetation canopy reflectance. *Remote Sens. Environ.* 3, 175–183. doi:10.1016/0034-4257(74)90003-0

Diaz, S., Lavorel, S., Chapin, F. S., Tecco, P. A., Gurvich, D. E., and Grigulis, K. (2007). *Terrestrial ecosystems in a changing world*. Editors J. Canadell, D. E. Pataki, and L. F. Pitelka (Berlin: Springer), 79–91.

Donald, G. E., Edirisinghe, A., Henry, D. A., Gherardi, S. G., Gittins, S., and Mata, G. (2010). "Pasture growth rate for individual paddocks can be accurately predicted real-time from modis imagery, climate and soil data," in *Paper presented at the Australian Society of Animal Production 28th Biennial Conference*. 50, 611–615.

Festa-Bianchet, M. (1988). Seasonal range selection in bighorn sheep: Conflicts between forage quality, forage quantity, and predator avoidance. *Oecologia* 75 (4), 580–586. doi:10.1007/BF00776423

Festi, D., Putzer, A., and Oeggl, K. (2014). Mid and late Holocene land-use changes in the Ötztal Alps, territory of the Neolithic Iceman "Ötzi". *Quat. Int.* 353, 17–33. doi:10.1016/j.quaint.2013.07.052

Gao, F., Liu, T., Wang, H., Shi, H., Yuan, C., Song, S., et al. (2023). Spatial and temporal variation patterns of summer grazing trajectories of Sunit sheep. *Ecol. Inf.* 78, 102322. doi:10.1016/j.ecoinf.2023.102322

Güner, A., Aslan, S., Ekim, T., Vural, M., and Babaç, M. T. (2012). Türkiye bitkileri listesi (Damarlı bitkiler)

Güneş, F., and Ozhatay, N. (2000). Flora of Turkey and the East Aegean Islands.

Huntly, N. (1991). Herbivores and the dynamics of communities and ecosystems. *Annu. Rev. Ecol. Syst.* 22, 477–503. doi:10.1146/annurev.ecolsys.22.1.477

Maden, K. (1970). Plant collection and herbarium techniques. *Our Nat.* 2, 53–57. doi:10.3126/on.v2i1.327

Magnússon, B., and Magnússon, S. H. (1992). *Rannsóknir á gróðri og plöntuvali sauðfjár í beitartilraun á auðkúluheiði (vegetation and plant preferences of sheep in a grazing trial on an alpine heathland range in northern Iceland. In Icelandic with English summary). Rala Report 159* (Reykjavík: Agricultural Research Institute), 106.

Mandl, F. (2009). "Hallstatts bronzezeitliche Almen," in *Klimawandel in Österreich. Die letzten 20.000 Jahre. . . .und ein Blick voraus*. Editors R. Schmidt, C. Matulla, and R Psenner (Innsbruck: University Press). Alpine space - man and environment. 6, 97–104.

Olff, H., and Ritchie, M. E. (1998). Effects of herbivores on grassland plant diversity. *Trends Ecol. and Evol.* 13 (7), 261–265. doi:10.1016/S0169-5347(98)01364-0

Pauchard, A., Kueffer, C., Dietz, H., Daehler, C., Alexander, J., Edwards, P., et al. (2009). Ain't no mountain high enough: Plant invasions reaching new elevations. *Front. Ecol. Environ.* 7, 479–486. doi:10.1890/080072

Pettorelli, N., Ryan, S., Mueller, T., Bunnefeld, N., Jedrzejewska, B., Lima, M., et al. (2011). The normalized difference vegetation index (NDVI): Unforeseen successes in animal ecology. *Clim. Res.* 46, 15–27. doi:10.3354/cr00936

Pignatti, S. (1982). *Flora d'Italia*. Bologna: Edagricole.

Pimentel Gomes, F., and Garcia, C. H. (2002). *Statistics applied to agronomic and forestry experiments: exhibition with examples and guidelines for application use*. Piracicaba, São Paulo, Brazil: FEALQ.

Reeves, S., Kuper, A., and Hodges, B. D. (2008). Qualitative research methodologies: Ethnography. *Br. Med. J.* 337, a1020. doi:10.1136/bmj.a1020

Reitmaier, T. (2010). "Auf der Hut – Methodische Überlegungen zur prähistorischen Alpwirtschaft in der Schweiz," in Archäologie in den Alpen: Alltag und Kult. *Haus im Ennstal: ANISA, Verein für alpine Forschung*. Editors F. Mandl and H. Stadler, 219–238. doi:10.1177/0959683619854511

Rouse, J. W., Haas, R. H., Schell, J. A., and Deering, D. W. (1973). *Monitoring vegetation systems in the great plains with ERTS*. Washington, DC, USA: Goddard Space Flight Center, 309–317.

Schmidt, T., Schuster, C., Kleinschmit, B., and Forster, M. (2014). Evaluating an intra-annual time series for grassland classification—How many acquisitions and what seasonal origin are optimal? *IEEE J. Sel. Top. Appl. Earth Observations Remote Sens.* 7 (8), 3428–3439. doi:10.1109/JSTARS.2014.2347203

Serrano, J., Shahidian, S., and Marques da Silva, J. (2019). Evaluation of normalized difference water index as a tool for monitoring pasture seasonal and inter-annual variability in a mediterranean agro-silvo-pastoral system. *Water* 11 (1), 62. doi:10.3390/w11010062

Stohlgren, T. J., Schell, L. D., and Vanden Heuvel, B. (1999). How grazing and soil quality affect native and exotic plant diversity in rocky Mountain grasslands. *Ecol. Appl.* 9 (1), 45–64. doi:10.1890/1051-0761(1999)009[0045:HGASQA]2.0.CO;2

Todd, S. W., Hoffer, R. M., and Milchunas, D. G. (1998). Biomass estimation on grazed and ungrazed rangelands using spectral indices. *Int. J. Remote Sens.* 19 (3), 427–438. doi:10.1080/014311698216071

Tucker, C. J., Holben, B. N., Elgin, J. H., and McMurtrey, J. E. (1981). Remote sensing of total dry matter accumulation in winter wheat. *Remote Sens. Environ.* 11, 171–189. doi:10.1016/0034-4257(81)90018-3