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Assessment of Soil Seed Bank Diversity Across North and South Facades in Shaqlawa Natural Rangeland, Erbil Governorate

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ABSTRACT
Shaqlawa Natural Rangeland, located in the Erbil Governorate of the northern region of Iraq, is an important ecological landscape with varied topographical and microclimatic conditions. The aim of this study was to assess the diversity and composition of the soil seed bank and its implication for forage productivity on the northern and southern facades of the rangeland. A total of 1,087 seeds representing 36 plant species were germinated, with Fabaceae and Poaceae dominating as the most common families. The seed bank comprised mainly native, C_3 annual forbs that possessed high regenerative ability and ecological adaptability. Slope aspect and altitude had an evident impact on species richness and functional diversity. North slopes, with their more humid and cooler microclimate, were more favorable for higher diversity in plant functional characteristics like photosynthetic pathways, life forms, and taxonomic families. The number of monocotyledonous species was lower than dicotyledons, and no C_4 species were encountered. Maximum weed richness was at North × High Elevation, and maximum native species richness was at North × Medium Elevation. These findings indicate that north slopes and higher elevations favor more diversity of annual species, particularly weeds, and lower areas favor perennial species. These processes can be used to inform land management to enable native species restoration and the control of invasive species in rangeland systems.
Although both annuals and monocots were more common at higher elevations, dicot and perennial species dominated at middle to lower elevations. Remarkably, weed cover was more prevalent at higher elevation, mainly on north-facing slopes, an indicator that is critical of the need for invasive plant management. In general, the findings support the central role played by topographic and microclimatic gradients in the modulation of soil seed bank diversity and present useful data to inform sustainable rangeland management, renovation planning, and biodiversity conservation planning.

***Keywords*:** Soil seed bank; biodiversity; Topographic gradient; Microclimate; Natural Rangeland.

INTRODUCTION

Rangelands are vast natural environments dominated by grasses, forbs, shrubs, and sparsely vegetated areas, typically in dry, semi-dry, or mountainous regions [1;2]. Rangelands are rarely appropriate for intensive agriculture but are used for livestock grazing, wildlife habitat, and other ecosystem processes such as water filtration, soil erosion, and sequestration of carbon [3]. Rangelands cover 30–40% of the Earth's terrestrial surface [4]. Millions of individuals, particularly in dry and rural regions, depend on rangeland ecosystem use for agricultural purposes and livestock grazing. Rangelands are, however, highly vulnerable to environmental changes and human activities, notably deforestation, intensification of land use, and overgrazing [5;6]. The most important factor of rangeland plant recolonization is the soil seed bank (SSB), or the pool of living seeds stored in the soil [7]. The soil seed bank acts as a buffer against disturbance, such as grazing and severe weather, by storing a pool of seeds that can germinate and begin vegetation when it is suitable. In all but the most unusual ecosystems, the seed bank within the soil is a source of vital support for ensuring vegetative cover, particularly after disturbances like droughts, fires, or grazing. The seed bank is considered an essential reservoir for ecosystem restoration and recuperation, enabling plant communities to recolonize and maintain biodiversity [8;9]. Soil seed bank and vegetative cover are dynamic and dependent on each other. Vegetative cover, especially in rangelands, fixes the composition and density of the soil seed bank by controlling seed predation, seed dispersal, and microclimate conditions that promote seed survival [10;11]. Simultaneously, the viability of soil seed bank governs vegetative cover ability to regrow following disturbance. Vegetative cover is depleted where there is heavy grazing, removing the seed stock from the seed bank and therefore undermining its ability to guarantee future regeneration. In the long term, this can establish a feedback loop where decreasing the seed bank declines vegetative regeneration, especially of perennial species [12]. By promoting strategies that maintain both the vegetative cover and soil seed banks, there is hope of making rangelands sustainable for animal production and biodiversity conservation. Therefore, the objective of this study is to contrast the diversity of the soil seed bank at the north and south facades of the rangeland.

Material and methods

Geographical location of Study Site

This study was conducted at two sites in the natural range land of the region, as illustrated in Figure 1. The first is northeast of Shaqlawa in the mountain area of Mawaran village with coordinates N 36.42784 and E 044.30972. The second one is southwest of Shaqlawa in Mawaran village at coordinates N 36.44181 and E 044.32816. Both locations are indicative of the varied ecological features of the Shaqlawa district, situated in the northeastern part of Erbil Governorate, in the Kurdistan Region of Iraq. The study sought to evaluate the pastoral land of such areas by subdividing it into three broad zones based on soil type, land form, and vegetation. Sub-points were made in each broad zone totaling five. Three randomly selected 1-meter square areas were used at each sub-point for precise measurement. Stratification sampling ensured data on land and vegetation could be gathered with precision.

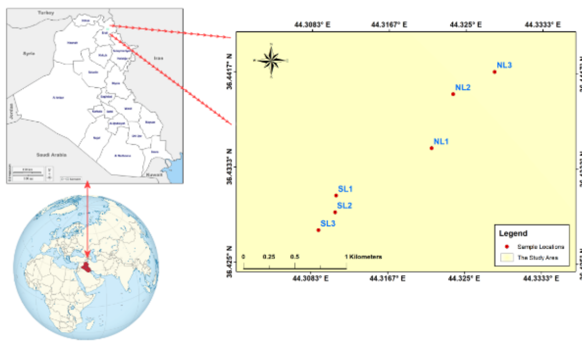

Figure 1 : Site of study area , Across North and South Facades in ShaqlawaNatural Rangeland, Erbil Governorate

Soil conditions of the research area

This research examines the variation in physical and chemical characteristics of soil samples from research area. The findings show considerable variation across major parameters. Northern face samples are richer in calcium carbonate (CaCO□) compared to Sothern face samples and may be good at buffering soil pH. Northern face has the greatest amount of organic matter, which would allow for maximum nutrient availability and ease of microbial activity. Soil pH is consistent across all samples ranging from 7.3 to 7.6, indicating neutral to slightly alkaline pH. However, the electrical conductivity (EC) values are different, with Northern face showing the highest EC, indicating a higher concentration of salt in this sample.

Climate condition

The climate condition during the period of study at the closest were recorded. Monthly climate measurements of September 2024 to June 2025 with temperature, rainfall, solar radiation, soil temperature, and soil moisture trends were observed. September is the hottest month (max: 32.8°C) and solar radiation (185.8 W/m²) and receives the least rainfall (3.5 mm), resulting in dry soil (10.1% moisture). October has declining temperatures (average temperature 20.6°C) and slightly less radiation, but still low precipitation (2 mm), with dry soil. November has a shift to wetter (62 mm precipitation), which raises soil moisture (18.4%). December is the coldest (average temperature 8.3°C) with moderate rain (29.5 mm) and highest soil moisture (28.2%), typical of winter conditions.

Sampling Method for Soil Seed Bank Composition

The soil seed bank experiment was initiated in September 2024 to assess seed bank composition. Sampling was conducted after natural germination had ceased but before the dispersal of newly formed seeds. Six plots, located at different altitudes on the northeast and southwest slopes of Mawaran Village, were selected for soil collection. Each plot measured 20 × 20 meters, and five random sampling points were established within each plot. At each point, three sub-samples were taken using a soil auger (10 cm diameter × 5 cm depth) and then combined to form one composite sample. In total, 90 composite samples were collected across the study area. All samples were labeled, sealed in zip-lock bags, and transported to the plastic houses at Salahaddin University–Erbil, College of Agricultural Engineering Sciences, Department of Forestry. The collected samples were then used for seed bank identification and further analysis.

Sample Analysis

The seedling emergence technique was employed in the determination of the soil seed bank composition in the soils studied. Preparation of the samples involved the removal of trash and small stones and sieving for homogeneity. Each sample was placed in a greenhouse to enable germination under controlled conditions. Prepared soil samples were planted in marked and randomized rectangular pots (30 cm × 12 cm × 10 cm) to respective elevation points according to a Completely Randomized Design (CRD).A 1 cm layer of peat moss was put in every pot, followed by 4 kg of soil, watering the samples right away with 7.5 liters per plot. Watering was then shifted to 2.5 liters every three days and to once a week as the temperature dropped. Seedling emergence was monitored at regular intervals, and extensive data were collected for ascertaining species composition, density, and adaptability to healthy pasture conditions.

Germination Data Gathering and Organization

Species Identification

Separated the plant species yielded by the soil samples. Placed the germinated plants into separate categories such as grasses, legumes, forbs, or shrubs.

Germination Counts

Counted total germinated seedlings by species. Prepared a regular count for an analysis of the patterns of germination within a specific span of time.

Germination Rate

Calculated germination rate in terms of percentage of the entire soil seed bank.

Functional Group Data

Categorized germinated plants into functional groups, i.e., perennials or annuals.

Statistical analysis

The data on soil seed bank composition were analyzed using two-way ANOVA, followed by Duncan's multiple range test at a significance level of $p = 0.05$ to compare the treatment means. All statistical analyses were performed using the MINITAB software package, version 21.

Results and Discussion

Soil Seedbank Composition and Species identification

A total of 1,087 seeds germinated from the soil seed bank, representing 36 plant species. Fabaceae and Poaceae were the most dominant families, indicating a strong presence of nitrogen-fixing plants and grasses important for soil fertility and erosion control. All germinated species followed the C3 photosynthetic pathway, reflecting adaptation to temperate conditions, with no C4 species detected. The majority were annual plants, particularly annual forbs, followed by annual grasses, perennial forbs, and perennial grasses, suggesting a community adapted to rapid establishment and seasonal changes. Dicotyledonous species were more abundant than monocotyledonous ones, typical of Mediterranean and temperate rangelands where broadleaf plants dominate. Most species were indigenous, reflecting healthy ecological diversity and resilience. Overall, the seed bank composition, dominated by native C3 annuals from Fabaceae and Poaceae, highlights strong regeneration capacity and provides valuable insight for rangeland conservation and management strategies.

Germinated Species and Percentage Composition

Table 1 summarizes the germination results, highlighting species dominance and distribution within the soil seed bank. *Centaurium erythraea* had the highest germination, contributing 18.86% of the total seeds, followed by *Lolium multiflorum* (11.22%) and *Galium aparine* (9.84%). Grasses such as *Bromus spp*. (8.28%), *Poa bulbosa* (6.07%), and Poa bulbifera (3.86%) further emphasized the ecological importance of Poaceae species. *Medicago polymorpha* (5.98%) represented the Fabaceae family's contribution to soil enrichment. Several species, including Anemone coronaria and *Hedypnois rhagadioloides*, showed moderate presence, while rare species like *Crepis sancta*, *Poa annua*, and *Euphorbia denticulata* were each represented by a single seed. The overall pattern reveals a seed bank dominated by a few species but rich in biodiversity, with Poaceae and Fabaceae families playing central roles in supporting the rangeland's regeneration and ecological resilience.

Table 1. Total Number of Germinated Seeds for Each Species and Their Percentage Composition (%)

Scientific Name	Total Number of Germinates	Percentage Composition (%)
Anagallis arvensis	46	4.23
Anemone coronaria	71	6.53
Anthemis arvensis	14	1.29
Bromus spp.	90	8.28
Hedypnois rhagadioloides	10	0.92
Coronilla scorpioides	9	0.83

Crepis sancta	1	0.09
Crupina crupinastrum	2	0.18
Daucus carota	45	4.14
Erodium cicutarium	4	0.37
Euphorbia denticulata	1	0.09
Euphorbia helioscopia	8	0.74
Filago germanica	4	0.37
Galium aparine	107	9.84
Hordeum spp.	11	1.01
Hymenocarpos circinnatus	7	0.64
Lactuca serriola	10	0.92
Lamium amplexicaule	5	0.46
Linum usitatissimum	3	0.28
Lolium multiflorum	122	11.22
Medicago polymorpha	65	5.98
Onobrychis viciifolia	21	1.93
Parentucellia viscosa	6	0.55
Pimpinella saxifraga	13	1.20
Plantago coronopus	3	0.28
Poa annua	1	0.09
Poa bulbifera	42	3.86
Poa bulbosa	66	6.07
Scorpiurus muricatus	41	3.77
Sherardia arvensis	3	0.28
Centaurium erythraea	205	18.86
Torilis spp.	10	0.92
Trifolium spp.	8	0.74
Veronica polita	26	2.39
Vicia sativa	2	0.18
Micropus supinus L.	5	0.46
Total	1087	100

Impact of Environmental Factors (Facades and Elevations) on Plant Category Distribution in Soil Seed Bank Composition

Table 2 presents the effects of slope aspect (facades), elevation, and their interaction on the percentage distribution of plant functional groups (annual grasses, perennial grasses, annual forbs, and perennial forbs) in the soil seed bank. North-facing slopes consistently exhibited higher species richness across all categories compared to south-facing slopes, particularly in annual grasses (15.42 vs. 3.25), annual forbs (35.33 vs. 18.17), perennial forbs (7.17 vs. 2.25), and perennial grasses (5.83 vs. 3.17). This pattern is attributed to the cooler and more humid microclimate on north slopes, enhancing seed germination and diversity, especially for moisture-sensitive species [13].

Elevation also significantly influenced plant category distribution. Annual grasses showed increasing richness with altitude, peaking at high elevations (15.88), whereas perennial grasses were most abundant at low elevations (8.38). Annual forbs were richest at high (31.88) and medium elevations (29.13), while perennial forbs peaked at medium elevation (6.50), reflecting their preference for moderate climatic conditions [14]. The interaction of facade and elevation further highlighted significant variations in species distribution, with the north-high elevation combination recording the highest richness in annual grasses and forbs.

Table 2. Effects of Facades and Elevations on Plant Categories in Soil Seed Bank Composition at the Study Area. *Means that do not share a letter are significantly different.*

Factors	Annual Grasses	Perennial Grasses	Annual Forbs	Perennial Forbs
Facades				
North	15.42 a	5.83 a	35.33 a	7.17 a
South	3.25 b	3.17 b	18.17 b	2.25 b
Elevation				
Low Elevation	3.50 c	8.38 a	19.25 b	4.38 b
Medium Elevation	8.63 b	1.75 b	29.13 a	6.50 a
High Elevation	15.88 a	3.38 b	31.88 a	3.25 b
Interaction (Facade × Elevation)				

North × Low Elevation	5.75 c	5.75 b	25.75 b	7.75 b
North × Medium Elevation	12.00 b	0.50 c	37.00 a	11.50 a
North × High Elevation	28.50 a	3.25 bc	43.25 a	2.25 cd
South × Low Elevation	1.25 d	11.00 a	12.75 c	1.00 d
South × Medium Elevation	5.25 c	3.00 bc	21.25 b	1.50 d
South × High Elevation	3.25 cd	3.50 bc	20.50 b	4.25 c

Effect of Environmental Factors (Facades and Elevations) on Plant Family Richness in Soil Seed Bank Composition

Table 3 highlights the impact of elevation, slope aspect (facades), and their interaction on plant family richness in the study area's soil seed bank. The study of six major families (Poaceae, Gentianaceae, Fabaceae, Rubiaceae, Ranunculaceae, and Apiaceae) reveals that topography and climate significantly influence soil seed bank diversity. North-facing slopes generally exhibited higher plant family richness than south-facing slopes, especially for Poaceae (18.58 vs. 9.08), Gentianaceae (13.00 vs. 4.08), Fabaceae (8.25 vs. 3.75), and Ranunculaceae (5.75 vs. 0.91), suggesting that cooler, more humid conditions on north slopes favor these families [15;16]. However, Apiaceae was more abundant on south-facing slopes (3.25 vs. 2.25), indicating a preference for drier conditions. Rubiaceae showed no significant difference between the two aspects (4.58 in both cases). Elevation also influenced family richness, with higher elevations supporting greater richness in Poaceae (19.25), Gentianaceae (12.00), and Fabaceae (8.50), likely due to cooler temperatures and lower competition. Medium elevations were more favorable for Rubiaceae (7.50) and Ranunculaceae (5.25), while Apiaceae was relatively stable across elevations [17;18]. Notably, north-facing slopes at high elevations provided the most favorable microhabitats, supporting peak richness in Poaceae (31.75), Gentianaceae (16.00), and Fabaceae (12.00).

Table 3. Effects of Facades and Elevation on Top Plant Family Richness in Soil Seed Bank Composition for the Study Area. *Means that do not share a letter are significantly different.*

Factors	Poaceae	Gentianaceae	Fabaceae	Rubiaceae	Ranunculaceae	Apiaceae
			Facades			
North	18.58 a	13.00 a	8.25 a	4.58 a	5.75 a	2.25 b
South	9.08 b	4.08 b	3.75 b	4.58 a	0.92 b	3.25 a
			Elevation			
Low Elevation	11.88	7.50 b	2.75 c	1.63 c	3.38 ab	2.50 a
Medium Elevation	10.38 b	6.13 b	6.75 b	7.50 a	5.25 a	3.00 a
High Elevation	19.25 a	12.00 a	8.50 a	4.63 b	1.38 b	2.75 a
		Interaction (Facades × Elevation)				
North × Low Elevation	11.50 bc	10.75 bc	3.00 cd	2.00 d	6.75 a	1.50 b
North × Medium Elevation	12.50 b	12.25 ab	9.75 b	5.25 bc	9.25 a	4.25 a
North × High Elevation	31.75 a	16.00 a	12.00 a	6.50 b	1.25 b	1.00 b
South × Low Elevation	12.25 bc	4.25 d	2.50 d	1.25 d	0.00 b	3.50 a
South × Medium Elevation	8.25 cd	0.00 e	3.75 cd	9.75 a	1.25 b	1.75 b
South × High Elevation	6.75 d	8.00 cd	5.00 c	2.75 cd	1.50 b	4.50 a

4.5: Influence of Environment on Species Life Form in Soil Seed Bank

Table 4 presents the impact of slope elevation and aspect (north or south) on the distribution of perennial and annual species in the seed bank. The findings indicate that: Aspect has a significant effect on richness of annuals: north slopes are richer in annuals (50.75) than south slopes (21.42), which may be due to cooler, damper conditions favoring seed germination and survival. Richness of perennials varied little with aspect (10.33 vs. 8.08), suggesting more long-lived perennials are less influenced by aspect. Elevation influences both life types: Annual richness declines with elevation—highest at high elevations (47.75), then moderate (37.75), and lowest at low elevations (22.75). This may be due to lower temperatures and less decay, with greater seed accumulation. Perennial richness is highest at low elevations (12.75) and falls off with altitude, perhaps due to better growth conditions at low elevations. Combined effects: Highest annual richness (71.75) was at north-facing high sites, which are conducive to annuals from cool wet habitats. Lowest (14.00) was at south-facing low sites, which are warm and dry. Richness of perennials was highest at north × low (13.50) and south × low (12.00), and it indicates lower elevations support perennial stability. South × medium had lowest perennial richness (4.50), and it suggests heat and dryness are limiting. On average, annuals are more responsive to environmental change, with a preference for cooler, wetter sites, whereas perennials prefer stability and the lower elevations. These findings suggest that the north-facing, higher elevation sites be reserved for annuals and low-elevation sites for perennial community maintenance, both of which are critical for ecosystem recovery and resilience [19].

Effects of Facades and elevation onto life spam among the species richness at soil seed bank composition for the study area. *Means that do not share a letter are significantly different.*

Factors	Annual	Perennial
Facades		
North	50.75 a	10.33 a
South	21.42 b	8.08 a
Elevation		
Low Elevation	22.75 c	12.75 a
Medium Elevation	37.75 b	8.25 b
High Elevation	47.75 a	6.63 b
Interaction (Facades × Elevation)		
North × Low Elevation	31.50 c	13.50 a
North × Medium Elevation	49.00 b	12.00 ab
North × High Elevation	71.75 a	5.50 c
South × Low Elevation	14.00 d	12.00 ab
South × Medium Elevation	26.50 c	4.50 c
South × High Elevation	23.75 cd	7.75 bc

Impact of Environmental Conditions (Elevation and Facades) on Spatial Distribution of Weeds and Indigenous Species in Soil Seed Bank

Table 4.5 examines the influence of slope aspect (facades) and altitude on the diversity of weed and native species in the soil seed bank of the study area. The results highlight key patterns that explain biodiversity trends, habitat integrity, and the role of invasive species in the ecosystem.

North-facing slopes show higher species richness for both weeds (31.33) and native species (29.75) compared to south-facing slopes (weeds: 19.08, natives: 10.42). This is attributed to the cooler, more humid microclimates found on the north slopes. However, the higher abundance of weeds also suggests strong competition from invasive species, which affect native species [20;21]. Weed richness increases with altitude, peaking at high elevations (33.88), likely due to optimal abiotic conditions or disturbance. In contrast, native species richness remains relatively consistent across different elevations, indicating that other factors, such as dispersal limitations, may influence their distribution [22;23]. The highest weed richness is found at North × High Elevation (50.25), while native species richness peaks at North × Medium Elevation (34.25). Native species are least abundant on south-facing slopes, particularly at medium elevation (7.50), due to heat and moisture stress [24].

Table 5. Effects of Facades and elevation on Spatial Distribution of Weeds and Indigenous Species in Soil Seed Bank. Means that do not share a letter are significantly different.

Factors	Weed	Native
Facades		
North	31.333 a	29.750 a
South	19.0833 b	10.4167 b
Elevation		
Low Elev.	16.625 c	18.875 a
Medium Elev.	25.125 b	20.875 a
High Elev.	33.875 a	20.500 a
Interaction Facades * Elevation		
North × Low Elev.	17.00 cd	28.00 a
North × Medium Elev.	26.75 b	34.25 a
North × High Elev.	50.25 a	27.00 a
South × Low Elev.	16.25 d	9.75 b
South × Medium Elev.	23.50 bc	7.50 b
South × High Elev.	17.50 cd	14.00 b

Conclusion

This study highlights the significant role of environmental factors, particularly slope aspect (facades) and elevation, in shaping soil seed bank composition. North-facing slopes exhibited higher species richness for both weeds and native species, likely due to cooler, more humid conditions that favor germination. In contrast, south-facing slopes, with drier and warmer conditions, had lower species richness, especially for native species. Elevation further influenced species distribution, with weed richness increasing at higher elevations, possibly due to favorable abiotic conditions or disturbances. Native species richness remained relatively consistent across elevations, suggesting dispersal limitations and other ecological factors at play. The highest weed richness was found at North × High Elevation, while native species peaked at North × Medium Elevation. These findings indicate that higher elevations and north-facing slopes support a greater diversity of annual species, particularly weeds, while low-elevation sites favor perennial species. Understanding these dynamics can guide land management practices, helping to promote native species restoration and manage invasive species in rangeland ecosystems.

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تقييم تنوع بنك البذور الأرضي عبر الواجهتين الشمالية والجنوبية في المراعي الطبيعية في شقلاوة، محافظة أربيل

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الخلاصة

تُعد مراعي شقلاوة الطبيعية، الواقعة في محافظة أربيل شمال العراق، منظومة بيئية مهمة تتميز بتباين واضح في الخصائص الطوبوغرافية والظروف المناخية الدقيقة. هدفت هذه الدراسة إلى تقييم التنوع والتكوين البيولوجي لبنك البذور في التربة، ومدى تأثيره على إنتاجية العلف في الواجهتين الشمالية والجنوبية للمراعي. تم تسجيل 1,087 بذرة مُنبتة تعود إلى 36 نوعًا نباتيًا، وكانت العائلتان النباتيتان السائدتان هما البقوليات ***(Fabaceae)*** والنجيليات ***(Poaceae).*** تألف بنك البذور بشكل رئيسي من أنواع حولية محلية تنتمي إلى نباتات الفوربس ***(C_3)*** ، وتتميز بقدرة عالية على التجدد والتكيف البيئي.

أظهرت النتائج أن جهة الميل والانحدار والارتفاع لهما تأثير واضح على غنى الأنواع والتنوع الوظيفي. فقد وفرت المنحدرات الشمالية، ذات المناخ الأكثر برودة ورطوبة، ظروفًا مثالية لزيادة تنوع الصفات الوظيفية النباتية، مثل مسارات التمثيل الضوئي، وأنماط الحياة، والانتماء التصنيفي. كان عدد الأنواع أحادية الفلقة أقل من ثنائية الفلقة، ولم تُسجل أي أنواع من نباتات. ***(C_4)***

سُجلت أعلى نسبة لغنى الأعشاب الضارة في التفاعل بين الشمال والارتفاعات العالية، بينما بلغ التنوع الأقصى للنباتات المحلية في تفاعل الشمال والارتفاعات المتوسطة. تشير هذه النتائج إلى أن المنحدرات الشمالية والارتفاعات العالية تعزز تنوع الأنواع الحولية، خصوصًا الأعشاب الضارة، في حين تفضل المناطق المنخفضة الأنواع المعمرة. يمكن توظيف هذه الديناميكيات لتوجيه استراتيجيات إدارة الأراضي بما يدعم استعادة الأنواع المحلية والسيطرة على الأنواع الغازية في النظم الرعوية.

رغم أن النباتات الحولية وأحادية الفلقة كانت أكثر شيوعًا في الارتفاعات العالية، فإن النباتات المعمرة وثنائية الفلقة هيمنت على المناطق المتوسطة والمنخفضة. ومن اللافت أن كثافة الأعشاب الضارة كانت أعلى عند الارتفاعات العالية، خاصة في المنحدرات الشمالية، مما يعكس أهمية إدارة النباتات الغازية. بشكل عام، تؤكد النتائج على الدور المحوري للتدرجات الطوبوغرافية والمناخية الدقيقة في تشكيل تنوع بنك البذور في التربة، وتوفر بيانات مفيدة تدعم الإدارة المستدامة للمراعي، وتخطيط استعادتها، وحفظ التنوع البيولوجي.

الكلمات المفتاحية: بنك البذور الأرضي؛ التنوع الحيوي؛ التدرج الطبوغرافي؛ المناخ الدقيق؛ المراعي الطبيعي.