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Effects of Ski-Resort Activities and Transhumance Livestock Grazing on Rangeland Ecosystems of Mountain Zireia, Southern Greece

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Abstract: The objective of the present study was to assess the impacts in time of the ski-resort infrastructure and transhumance livestock grazing on floristic composition, diversity, and rangeland health indices related to ecosystem stability and function. The study was carried out at a site under the pressure of ski resorts and livestock grazing (Ano Trikala) and a site only under the pressure of livestock grazing (Sarantapicho), both located at Mt Zireia, Southern Greece. The plant cover was measured at each site, and the floristic composition was calculated and classified into four functional groups: grasses, legumes, forbs, and woody species. Species richness, ecosystem function and stability landscape indices, diversity indices, and forage value were calculated. According to the results, the development of the ski resort in Ano Trikala had a neglectable negative impact on plant cover (reduced by 5%), while it had a minor impact on species richness and floristic diversity. Livestock grazing had a positive impact on maintaining plant cover in high values. These results suggest that livestock grazing can counterbalance the effects of ski resorts and related activities on plant cover and floristic diversity. Besides the relatively limited effects on the vegetation community, the ski resort significantly negatively impacted landscape composition, function, and stability. Forage value was 25% lower close to the ski resort, mainly due to the significantly lower percentage of legumes. Transhumance livestock grazing should be used as a management tool in ski-resort areas, as it benefits floristic diversity.

Keywords: diversity indices; forage value; species richness; vegetation cover; landscape stability

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Citation: Kyriazopoulos, A.P.; Karatassiou, M.; Parissi, Z.M.; Abraham, E.M.; Sklavou, P. Effects of Ski-Resort Activities and Transhumance Livestock Grazing on Rangeland Ecosystems of Mountain Zireia, Southern Greece. *Land* **2022**, *11*, 1462. https://doi.org/10.3390/land11091462

Academic Editor: Manuel Pulido Fernádez

Received: 26 July 2022
Accepted: 30 August 2022
Published: 2 September 2022

1. Introduction

Mountainous rangelands provide a wide range of valuable ecosystem services [1]. They are a source of high-quality forage for livestock [2], especially for the transhumance livestock farming system [3,4]. Moreover, mountainous rangelands have a crucial role in the conservation of biodiversity and landscape preservation [5] as well as in climate mitigation and water regulation [6]. In addition, rangelands as cultural landscapes [7] and protected natural reserves are attractive for recreational and touristic activities [8]. For all these reasons, rangeland ecosystems have substantial direct or indirect impact on local economies in mountainous areas.

The management status of these ecosystems has changed rapidly in recent decades due to social and economic changes that have led to land use/land cover changes. On the one hand, the transhumant livestock activity has decreased [9,10], while on the other hand, tourist pressure has increased. All these changes have environmental and economic impacts on the ecosystem, its services, and local communities [11].

Transhumance livestock grazing activities in mountainous areas have declined significantly in recent decades due to various socioeconomic reasons [9,10,12,13]. As a result, the extent and structure of mountain rangelands have changed [14,15], as livestock grazing has maintained them for centuries [16]. Woody species encroachment due to transhumance livestock grazing abandonment is among the essential changes that has occurred in these rangelands' lands [17–20] which negatively affects biodiversity [21].

Since the 1970s, human pressure on mountain ecosystems has increased in several developed countries due to the development of ski resorts [22] to cover the demands for recreational activities by the urban population. These activities generally have a positive economic impact on local communities in mountainous regions [23], but ski resorts were significantly correlated with adverse changes in the rangelands. Their development includes using heavy machinery to construct runs and constructing and maintaining access roads and other infrastructure. Harsh conditions in high altitudes and the mechanical damage caused to plants by the construction and maintenance of ski-resort infrastructure retards the recovery of the vegetation cover [24]. As a result, these infrastructures have been reported to cause a reduction in species richness and plant cover in the rangelands [25], increasing the risk of soil erosion as well as changing soil properties [26,27], which in turn may have negative impacts on ecosystem functioning and stability [28]. On the other hand, Allegrezza and coworkers [16] did not find any differences in floristic diversity among undisturbed alpine grassland and grasslands with ski runs covered with natural and artificial snow. It seems that differences in altitude, slope, different management practices applied, and time passed after the ski resort was built are among the factors affecting the floristic diversity in these ecosystems [29].

In some mountainous areas in the Mediterranean region, ski resorts coexist with extensive pasture-based livestock farming. However, there are a limited number of studies investigating both the effects of ski resorts and livestock grazing on plant communities and ecosystem function [30]. In this regard, Goñi and Gúzman [31] proposed that livestock grazing can prevent reductions in plant diversity caused due to ski resorts. A useful tool for assessing the impact of different management regimes on the rangeland ecosystem's function is the indices of rangeland health [32–34].

Recently, the goal of public governance and local communities is the sustainable development of rural areas, which includes three axes: the economic viability of local communities, social cohesion, and environmental sustainability. These three axes collide in some cases but are recognized as having the same weight and importance in ensuring sustainable development [35].

In this respect, the coexistence of tourism with pasture-based livestock is desirable and essential for the sustainability of the less favorable mountainous areas [36]. Moreover, tourist activities related to skiing and transhumance livestock are two non-rivalrous activities in terms of time, since skiing is carried out during the winter months, while livestock farming is carried out from spring to autumn. The question that arises is to what extent the creation and operation of ski centers conflict with transhumance livestock spatially and to what extent the use of rangelands by both activities ultimately leads to their degradation.

In as much as, to the best of our knowledge, there are no similar studies on the combined effect of pastoralism and touristic activities on rangeland ecosystems, we conducted the current study to gain insights on the impact of these activities on both floristic diversity and ecosystem function. The outcome of our analyses, as far as the interaction of pastoralism and touristic activities is regarded and their effects on the ecosystem as a whole, can provide a basis for designing and establishing strategies for the sustainable development of mountainous areas. This research was conducted in a mountainous area of Southern Greece, traditionally used by transhumance, while a ski resort has been present since the 2000s. We assessed the impact of the ski-resort infrastructure and livestock grazing on the rangeland ecosystems; specifically, as far as (1) floristic composition and diversity and (2) rangeland health indices related to ecosystem stability and function are concerned. We tested the hypothesis that ski resorts and transhumance livestock farming coexistence in Mediterranean mountainous areas results in severe degradation of the ecosystem.

2. Materials and Methods

2.1. The Study Area

The study was conducted in Mount (Mt) Zireia (Kyllini), which is located west of Korinthos city in the Peloponnese peninsula, Southern Greece in 2014, 2015, and 2019 (Figure 1). During the study period, the mean annual temperature was 12.67 ± 0.11 °C, and the mean monthly precipitation was 65.66 ± 5.66 mm. The climatic data (precipitation, temperature) were obtained from the nearest meteorological station (38°00′00″ N, 22°50′00″ E, 1077 m a.s.l). The climate is classified as Mediterranean, with warm winters and dry, and very hot summers, according to the bioclimatogram of Emberger and as Csa in the Köppen–Geiger classification (http://www.en.climate-data.org, 23 May 2022). The most important economic activities in the area are agriculture and livestock production. The transhumant sheep and goat system existed in the study area for centuries, but in the last decades significantly decreased. In the 1960s, 245 herders' families with 38,230 sheep and goats followed the transhumance system, while in 2020, only 54 families with 13,717 animals [9] continued to follow it.

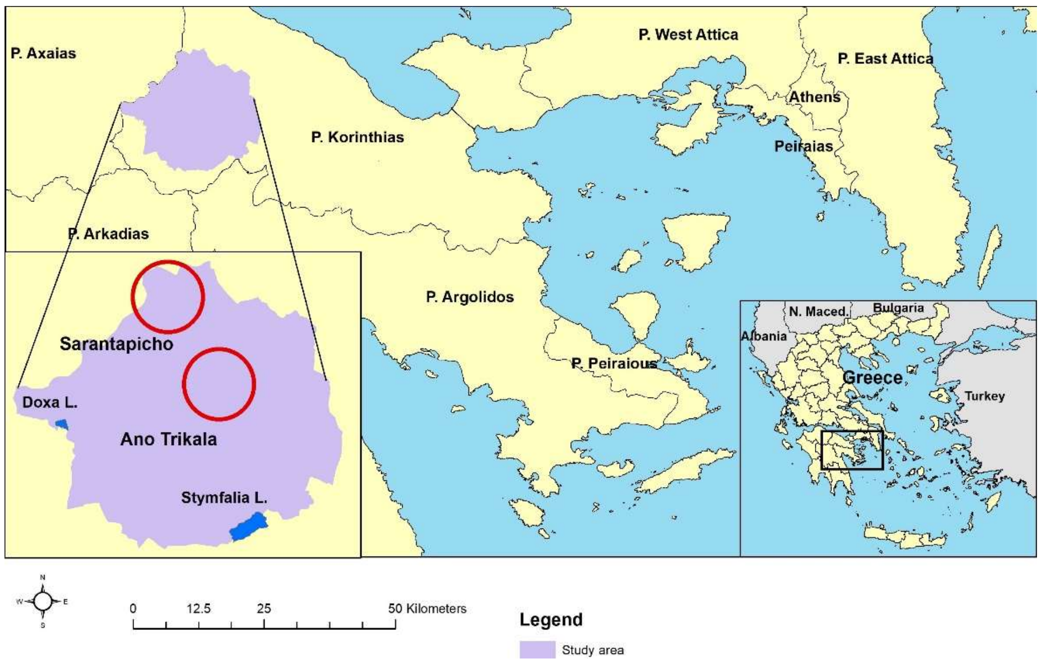

Figure 1. The study area in Mt Zireia in the Peloponnese peninsula. The red circles indicate the selected sites.

Mount Zireia is the second highest mountain of Peloponnese (2374 m). The rangelands of Mt Zireia, both grasslands, and shrublands, are public, and they are communally grazed, from April to October, by transhumant small ruminant flocks in a continuous grazing system. The ski resort was established in the site of Ano Trikala in 2007. After that, the local ski center and the artificial Lake Doxa attract visitors, inducing the development of tourism facilities.

Two sites were selected at the mountainous rangelands of Mt Zireia. The first was close to the village Ano Trikala (38°58′07″ N, 22°25′17″ E) in the area of the ski center and was grazed by sheep and goats from May to September. The second was close to the village Sarantapicho (38°01′30″ N, 22°23′05″ E) and was used by the livestock for the same period (Figure 1). The two sites were at about the same altitude (1350–1450 m), slope (less than 15%), exposure (NW), and similar grazing pressure (Figure 1).

2.2. Vegetation Data Collection and Analysis

Due to the homogeneity of the habitats, six experimental transects of 25 m each were established at each site, in a distance of 80–100 m between them. The plant cover was measured at the end of the growing season of 2014, 2015, and 2019 in each transect according to the line-and-point method, which is widely used in rangeland studies [37]. Transect lines are placed in a way so that every point has similar elevation. Transects were set up in vegetation and 100 recordings (per 25 cm) were conducted per transect. When the pin hit the canopy of a species, it was recorded. If the pin hit rocks, bare soil, or litter, the corresponding measurement was also recorded. The total number of live plant species hits was the plant cover. The floristic composition was calculated from plant cover measurements and classified into four functional plant groups: grasses, legumes, forbs, and woody. Legumes were presented separately from forbs because of their nutritional importance for small ruminants [38].

Floristic diversity, evenness, and dominance were determined for each transect [39] by the following indices [40–42]:

The Shannon–Wiener diversity index (H′) was calculated following the formula in Equation (1) below:

$$\mathrm{H}' = -\sum_{i=1}^{S} p_i \ln p_i \tag{1}$$

where S is the maximum recorded number of taxa, and p_i is the population frequency of the i-th taxa.

The Simpson diversity index (D) was calculated following the formula in Equation (2) below:

$$D = \frac{1}{C} \quad \text{where} \quad C = 1 - \sum_{i}^{Sobs} p_i^2 \tag{2}$$

The Pielou evenness index (J) was calculated following the formula in Equation (3) below:

$$J = \frac{H'}{\log(S)} \tag{3}$$

where H′ is the Shannon–Wiener diversity index.

The Buzas and Gibson evenness (E) was calculated following the formula in Equation (4) below:

$$E = \frac{eH'}{S} \tag{4}$$

The Margalef richness index (M) was calculated following the formula in Equation (5) below:

$$M = \frac{S - 1}{\ln(N)} \tag{5}$$

where N is the number of individuals of all taxa.

The Berger–Parker dominance index (d) was calculated following the formula in Equation (6) below:

$$d = \frac{N_{max}}{N_T} \tag{6}$$

where N_{max} is the number of records of the dominant taxon and N_T is the total number of records.

2.3. Development of Indices of Landscape Stability, Composition, and Function

Three ecosystem variables, including landscape composition, function, and stability, were utilized to create indices of rangeland health based on empirical data collected annually from each rangeland. Empirical data collected at the same time next to the six experimental transects from each rangeland were used to develop indices of rangeland health in terms of three ecosystem attributes: landscape composition, landscape function, and landscape stability [33,43,44].

Six attributes were used to calculate these indices (Table 1). The possible range of each attribute was divided into a number of ecologically meaningful classes (usually 5 or 6), and each class was then assigned a value according to its perceived effect upon composition, function, or stability. Thus, for example, the percentage of plant cover, which is a crucial component of composition and stability, was divided into five classes, thus: 0–10%—1, 10–25%—2, 25–50%—3, 50–75%—4, and >75%—5. Accordingly, a site with 65% of the soil covered by vegetation would receive a value of 4 for 'plant cover'. For 'function', herbage production was divided into five classes, thus: 0–700 kg ha^{-1}—1, 701–1400 kg ha^{-1}—2, 1401–2100 kg ha^{-1}—3, 2101–2800 kg ha^{-1}—4, and >2801 kg ha^{-1}—5, while soil erosion was also divided into five classes: very severe—1, severe—2, moderate—3, slight—4, and insignificant—5. Data on woody, legumes, and species richness were used as inputs for the composition and function indices such that a higher score indicated a greater cover of woody and legumes and / or a greater diversity of species. 'Species richness' was divided into five classes: 1–5 species—1, 6–10 species—2, 11–15 species—3, 16–20 species—4, and >21 species—5. Total score was calculated by adding the score of each attribute.

Table 1. Attributes, possible scores, and maximum scores used for calculating indices of landscape composition, function, and stability.

Attributes	Landscape Indices		
	Composition	**Function**	**Stability**
Plant cover (%)	1–5		1–5
Woody cover (%)	1–5		
Species richness	1–5		
Erosion		1–5	1–5
Herbage production (kg ha^{-1})		1–5	
Legumes (%)		0–5	
Range of scores	3–15	2–15	2–10
Total score		5–30	

2.4. Forage Value Index

The forage value index (FV) was used as an assessment of the plant community's nutritive value. The estimation of FV was based on the Klapp–Stählin index [45,46] after it was weighted with the species percentage in floristic composition. This index indicates the preference of the grazing animals for a plant species in relation to its abundance in the plant community. It was calculated as FV = p_i*FI_i, where pi is the percentage of i-th species in the floristic composition and FI is the forage index of i-th species ranging from 0 (unpalatable species) to 8 (preferable species) [47].

2.5. Statistical Analysis

A two-way analysis of variance (ANOVA) was performed to examine the influence of the factor site and the factor treatment (years after the ski resort establishment), and their interaction on the univariate measures: (1) plant cover, (2) functional group composition, (3) diversity indices, (4) rangeland health indices, and (5) forage value index. Data sets consisting of percentage values were arcsine-transformed to degrees prior to analysis [48]. The LSD at the 0.05 probability level was used to detect the differences among means [49]. All statistical analyses were performed using the SPSS statistical package v. 27.0 (IBM Corp. in Armonk, NY, USA).

3. Results

Significant differences ($p \leq 0.05$) between sites were recorded for plant cover, the functional groups legumes and forbs, the Simpson index, and the Berger–Parker dominance index (Table 2). Additionally, significant differences ($p \leq 0.05$) were recorded among the years for the functional groups grasses, legumes, and forbs, the species richness, the Simpson, Shannon, Margalef indices, and the Berger–Parker dominance index. The interaction of site and year was significant ($p \leq 0.05$) for forbs, the species richness, the Simpson, Shannon, and Margalef diversity indices, and the Berger–Parker dominance index (Table 2).

Table 2. Statistical significance of F ratios from the analysis of variance for plant cover, functional group composition, and diversity indices.

	Site	Year	Site * Year
Plant cover	*	NS	NS
Grasses	NS	*	NS
Legumes	*	*	*
Forbs	*	*	NS
Woody	NS	NS	NS
Species richness	NS	*	*
Simpson (D)	*	*	*
Shannon (H′)	NS	*	*
Buzas and Gibson (E)	NS	NS	NS
Margalef (M)	NS	*	*
Pielou (J)	NS	NS	NS
Berger–Parker (d)	*	*	*

* Significant (F Test at $p \leq 0.05$); NS $p > 0.05$.

The plant cover (across years) was higher in Sarantapicho rangeland. Functional group composition was differentiated between sites. The percentage of legumes was higher in Sarantapicho, while more forbs were presented in Ano Trikala. There was a slight trend of higher floristic diversity in Sarantapicho, without significant differences. Only the Simpson index was significantly higher, while the Berger–Parker dominance index was significantly lower in Sarantapicho (Table 3).

Table 3. Effects of site (across years) on plant cover, functional group composition, and diversity indices.

Attributes	Sites	
	Ano Trikala	Sarantapicho
Plant cover (%)	89.1 b *	93.8 a
Grasses (%)	29.9 a	36.5 a
Legumes (%)	10.0 b	18.3 a
Forbs (%)	43.9 a	31.0 b
Woody (%)	16.1 a	14.2 a
Species richness	17.1 a	17.6 a
Simpson (D)	8.2 b	9.4 a
Shannon (H′)	2.4 a	2.5 a
Buzas and Gibson (E)	0.69 a	0.71 a
Margalef (M)	3.6 a	3.6 a
Pielou (J)	0.87 a	0.88 a
Berger–Parker (d)	0.25 a	0.21 b

* Means within each row followed by the same letter are not significantly different ($p > 0.05$).

The percentage of forbs progressively increased, and it was significantly higher in 2019 compared to those recorded in 2014 and 2015 (Table 4). An opposite trend was recorded for grasses and woody species but without producing significant results. The percentage of legumes was significantly lower in 2014. Floristic diversity indices (species richness, Simpson, Shannon, Margalef) were significantly higher in 2015 compared to 2014, while in 2019, these indices had intermediate values without significantly differentiating from the other years. The Berger–Parker index of dominance followed an opposite trend.

Table 4. Effects of years (across sites) on plant cover, functional group composition, and diversity indices.

Attributes	Year			$LSD_{0.05}$
	2014	2015	2019	
Plant cover (%)	90.5 a *	93.3 a	90.5 a	
Grasses (%)	40.1 a	30.4 b	29.2 b	8.15
Legumes (%)	9.0 b	18.6 a	14.9 a	5.41
Forbs (%)	30.8 b	35.5 b	46.0 a	7.09
Woody (%)	20.1 a	15.5 a	10.0 a	
Species richness	15.5 b	19.2 a	17.3 ab	2.41
Simpson (D)	8.0 b	9.8 a	8.7 ab	1.74
Shannon (H′)	2.4 b	2.6 a	2.5 ab	0.16
Buzas and Gibson (E)	0.69 a	0.73 a	0.70 a	
Margalef (M)	3.2 b	4.0 a	3.6 ab	0.53
Pielou (J)	0.86 a	0.89 a	0.87 a	
Berger–Parker (d)	0.24 a	0.21 b	0.24 a	0.03

* Means within each row followed by the same letter are not significantly different ($p > 0.05$).

The percentage of legumes in Sarantapicho was significantly lower in 2014 compared to 2015 and 2019, while it was higher in 2015 compared to 2019 in Ano Trikala. The percentages of legumes were significantly higher in Sarantapicho than in Ano Trikala in 2015 and 2019, while no significant differences ($p > 0.05$) were detected between sites in 2014 (Figure 2).

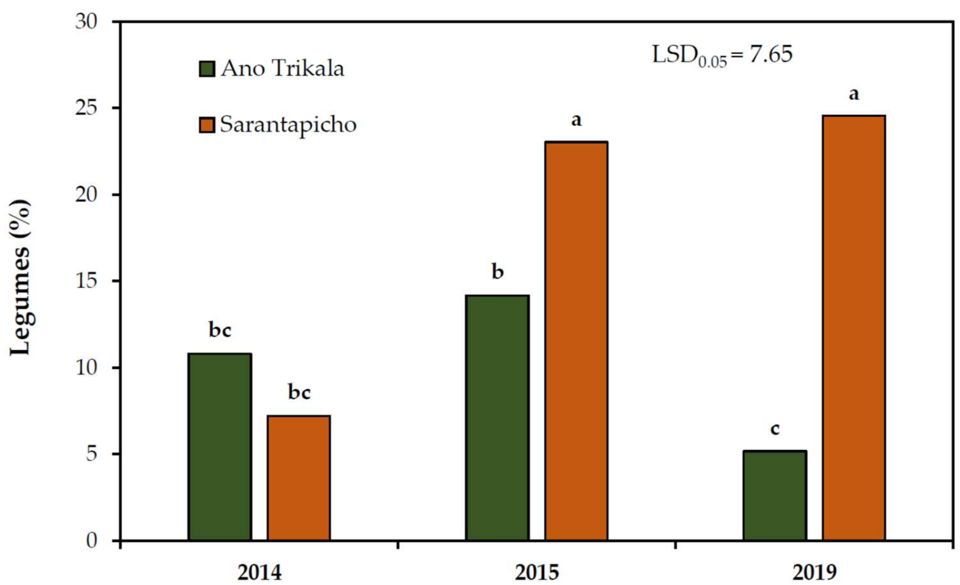

Figure 2. Effects of site and year on legumes percentage. Columns followed by the same letter are not significantly different ($p > 0.05$).

The species richness, Simpson, Shannon, and Margalef indices in Ano Trikala were significantly lower in 2014 compared to 2015 and 2019, while in Sarantapicho, no differences were recorded among years. The values of the Berger–Parker dominance index followed the opposite trend. Those indices were significantly (higher in Sarantapicho than in Ano Trikala only in 2014, while no significant differences ($p > 0.05$) were detected among sites in 2015 and 2019 (Table 5). Berger–Parker dominance index was significantly lower in Sarantapicho than in Ano Trikala in 2014 and 2015.

Table 5. Effects of site and year on the Species richness, Simpson (D), Shannon (H′), Margalef (M), and the Berger–Parker (d) dominance index.

Sites	Year	Species Richness	Indices			
			D	H′	M	d
Ano Trikala	2014	13.0 c *	6.6 b	2.16 b	2.7 c	0.28 a
	2015	20.3 a	9.8 a	2.66 a	4.3 a	0.23 b
	2019	18.0 ab	8.9 a	2.53 a	3.8 ab	0.24 ab
Sarantapicho	2014	18.0 ab	10.1 a	2.55 a	3.7 ab	0.20 bc
	2015	18.0 ab	9.9 a	2.54 a	3.7 ab	0.18 c
	2019	16.7 b	8.5 a	2.44 a	3.5 b	0.24 ab
$LSD_{0.05}$		3.4	1.8	0.22	0.75	0.04

* Means within each column followed by the same letter are not significantly different ($p > 0.05$).

Significant differences ($p \leq 0.05$) between sites were recorded for all the indices of landscape composition, function, stability, and forage value index (Table 6). Additionally, significant differences ($p \leq 0.05$) for the landscape function index and the total score of indices were recorded over the years. The interaction of site and year was significant ($p \leq 0.05$) for the landscape function index and the forage value index (Table 5).

Table 6. Statistical significance of F ratios from the analysis of variance for indices of landscape composition, function, and stability, and forage value index.

Landscape Indices	Site	Year	Site * Year
Total score	*	*	NS
Composition	*	NS	NS
Function	*	*	*
Stability	*	NS	NS
Forage value	*	NS	*

* Significant (F Test at $p \leq 0.05$); NS $p > 0.05$.

All the indices of landscape composition, function, stability, and forage value index were significantly ($p \leq 0.05$) higher in Sarantapicho compared to Ano Trikala (Table 7).

Table 7. Effects of site (across years) on indices of landscape composition, function, stability, and forage value index.

Landscape Indices	Sites	
	Ano Trikala	Sarantapicho
Total score	20.2 b *	24.48 a
Composition	12.8 b	13.5 a
Function	7.4 b	10.9 a
Stability	9.0 b	9.5 a
Forage Value	2.9 b	3.87 a

* Means within each row followed by the same letter are not significantly different ($p > 0.05$).

The landscape function index and the total score of indices were significantly lower in 2014 compared to those recorded in 2015 and 2019 (Table 8).

The landscape function index in Sarantapicho was significantly lower in 2014 compared to 2015 and 2019, while in Ano Trikala, no significant differences ($p > 0.05$) were detected among years. The landscape function index was significantly higher in Sarantapicho than in Ano Trikala in all the years (Figure 3).

The forage value index in Ano Trikala was significantly lower in 2019 compared to 2014, while in Sarantapicho no significant differences ($p > 0.05$) were detected among years.

The forage value index was significantly higher in Sarantapicho than in Ano Trikala only in 2019, while no significant differences were detected between sites in 2014 and 2019 (Figure 4).

Table 8. Effects of years (across sites) on the indices of landscape composition, function, stability, and forage value.

Landscape Indices	Year			$LSD_{0.05}$
	2014	2015	2019	
Total score	20.9 b *	23.3 a	22.7 a	1.4
Composition	12.8 a	13.5 a	13.2 a	
Function	8.2 b	9.8 a	9.5 a	1.2
Stability	9.2 a	9.2 a	9.3 a	
Forage Value	3.35 a	3.61 a	3.19 a	

* Means within each row followed by the same letter are not significantly different ($p > 0.05$).

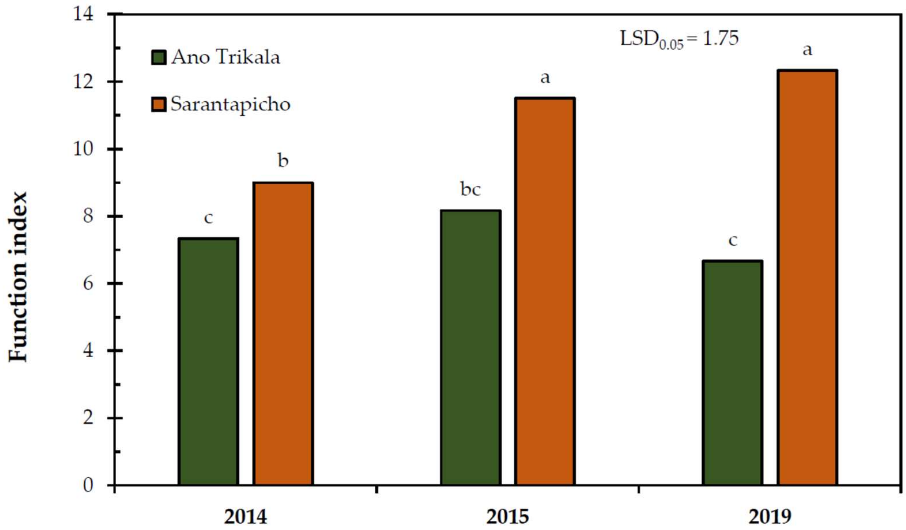

Figure 3. Effects of site and year on landscape function index. Columns followed by the same letter are not significantly different ($p > 0.05$).

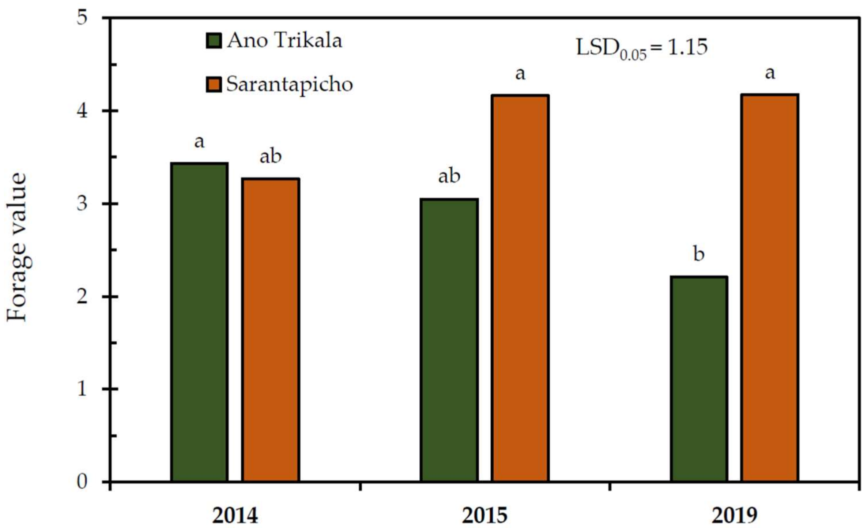

Figure 4. Effects of site and year on forage value index. Columns followed by the same letter are not significantly different ($p > 0.05$).

4. Discussion

Ski resorts and transhumance livestock farming are activities that often coexist in mountainous areas, which may strongly affect the structure and function of rangeland ecosystems. Nevertheless, our data and analyses cannot support the negative impact hypothesis for a representative mountain of South Mediterranean area.

The current study indicates that the development of the ski resort in Ano Trikala had a minimal negative impact on rangelands' plant cover. Ski-resort infrastructure and the increased number of visitors usually cause considerable trampling and other disturbances, leading to a decrease in plant cover [26,30,50]. In such sites, the soils are compacted, and as a result, plant growth is limited, infiltration rates and water-storage capacity are reduced, and soil erosion risk is high [51]. However, this was not the case in the ski resort in Ano Trikala, possibly because of the low-intensity touristic activities in the specific site. Transhumance livestock grazing has been reported to positively impact maintaining plant cover in high values [38]. This result is in accordance with those of Goñi and Gúzman [31], who also reported a minimum increase in bare soil in a grazed ski resort area in Spain. A slight reduction in plant cover was detected in Ano Trikala compared to Sarantapicho; plant cover was generally high in both mountainous rangelands, remaining stable over the years.

Regarding the vegetation composition, the percentage of legumes was lower in the mountainous rangeland close to the ski resort of Ano Trikala, while more forbs were present compared to the rangeland located away from the ski resort. These results are in accordance with previous findings in Spain [30]. Legumes have deeper root systems in general than grasses and forbs. The presence of ice, the reduced soil microporosity that causes poor aeration, and the trampling caused by visitors had increased negative effects on the legume roots compared to those of the other plant functional groups [30,52]. Thus, legumes were significantly less in the rangeland close to the ski resort. The negative impact of the ski resort on legumes is further confirmed by their significant reduction from 2014 to 2019 when the opposite trend was recorded for the rangelands located away from the ski resort. Forbs (across sites) were significantly more in 2019 compared to those recorded in 2014 and 2015, while an opposite trend was recorded for grasses. The differences in the contribution of these plant groups are probably related to grazing and the relative higher preference of sheep for legumes than for forbs when they are available [53], as well as to the differences in climatic over the years [9,38,54,55].

The ski-resort development in Ano Trikala generally had minimal effects on floristic diversity. However, it has been noted that the Simpson index was significantly lower, while the Berger–Parker dominance index was significantly higher compared to those recorded in the mountainous rangeland located away from the ski resort, indicating a slight decrease in floristic diversity at the expense of the increasing abundance of the dominant species near the ski resort. Previous studies [24,56] have reported reduced species richness and diversity close to ski resorts. However, there is evidence that livestock grazing can counterbalance the adverse effects of ski vehicles and visitors through micro-depressions due to trampling and exozoochoria, which can maintain diversity [22]. Thus, Goñi and Gúzman [31] recorded higher plant diversity in grazed ski runs than in non-grazed ones. Barrantes and coworkers [30] found that floristic diversity in grazed skiing areas increased between 1972 and 2005. The present study confirms this result as floristic diversity was also recorded to increase in 2019 compared to 2014 in rangelands close to the Ano Trikala ski resort, while in Sarantapicho biodiversity indices did not change among years. Floristic diversity (across sites) was higher in 2015 compared to 2014 and 2019, probably because of the annual fluctuations in rainfall and temperature [30].

The landscape was negatively affected by the ski resort and related activities. All the indices of landscape composition, function, and stability were significantly higher in the rangeland located in Sarantapicho, away from the ski resort. The increased soil erosion, reduced plant cover and herbage production, and the decreased legume percentage recorded in rangelands close to the ski resort in Ano Trikala constitute the main reasons for this result. Increased risk of soil erosion close to ski resorts has been reported in previous studies [26,57]. Moreover, significant decreases in productivity in rangelands in proximity to ski resorts have been reported by Gartzia and coworkers [58]. It has to be noted that the landscape function index remained low in this site during the years, while it progressively increased in the rangeland located away from the ski resort.

Forage value was significantly lower close to the ski resort. This result is related to the significantly lower percentage of legumes, which have high forage value, and the higher percentage of less palatable forbs. The lower forage value implies this area's decreased grazing capacity and a need for a reduced stocking rate. It is in accordance with the results of previous studies [30,31] that also reported lower pasture quality close to ski resorts. The result of the present study is further confirmed by the fact that forage value remained stable from 2014 to 2019, when it increased in the rangelands located away from the ski resort.

5. Conclusions

Proximity to ski resorts did not reduce plant cover seriously, while it had a minor impact on species richness and floristic diversity. These results suggest that livestock grazing can counterbalance the effects of ski resorts and related activities on plant cover and floristic diversity. On the other hand, the floristic composition was modified in the ski center area. These differences in species composition are reflected in forage value, which is reduced in the ski-resort area. Besides the relatively limited effects on the vegetation community, the ski resort had a significant negative impact on landscape composition, function, and stability.

Transhumance livestock grazing should be used as a management tool in ski-resort areas as it benefits floristic diversity. Low-intensity touristic activities have relatively limited effects on such areas, but some restoration activities may be needed in the future. Furthermore, the two activities could be complementary for the employment of the residents of local communities, as tourism is an activity most preferred by young people, while livestock farming is mainly employed by elderly people. Finally, monitoring these areas at both levels of landscape and vegetation is necessary for managers to make the appropriate decisions at the right time. In this respect, the landscape indices that were used in the present study could be a useful tool for future monitoring and management decisions.

Author Contributions: Conceptualization, A.P.K., M.K., Z.M.P. and E.M.A.; methodology, A.P.K., M.K., Z.M.P. and E.M.A.; software, A.P.K., M.K., Z.M.P. and E.M.A.; validation, A.P.K., M.K., Z.M.P., E.M.A. and P.S.; formal analysis, A.P.K., M.K. and E.M.A.; investigation M.K., Z.M.P., E.M.A. and P.S.; resources, M.K.; data curation, A.P.K., M.K., Z.M.P., E.M.A. and P.S.; writing—original draft preparation, A.P.K., M.K., Z.M.P. and E.M.A.; writing—review and editing. A.P.K., M.K., Z.M.P., E.M.A. and P.S.; visualization, A.P.K., M.K, Z.M.P. and E.M.A.; supervision, M.K.; project administration, M.K.; funding acquisition, M.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was part of the project «PACTORES, T8EPA2-00022» and was co-funded by the European Union (European Social Fund) and General Secretariat for Research and Innovation (GSRI) through the Action "ERA-Net".

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available in figures and tables provided in the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Reid, W.V.; Mooney, H.A.; Cropper, A.; Capistrano, D.; Carpenter, S.R.; Chopra, K.; Dasgupta, P.; Dietz, T.; Duraiappah, A.K.; Hassan, R. *Ecosystems and Human Well-Being-Synthesis: A Report of the Millennium Ecosystem Assessment*; Island Press: Washington, DC, USA, 2005.
2. Chan, K.M.A.; Shaw, M.R.; Cameron, D.R.; Underwood, E.C.; Daily, G.C. Conservation Planning for Ecosystem Services. *PLoS Biol.* **2006**, *4*, e379. [CrossRef]
3. Parissi, Z.M.; Karatassiou, M.; Sklavou, P. Chemical composition of a *Trifolium repens* L. population in a grazed mountainous grassland in Central Greece. *Options Méditerr. A* **2016**, *115*, 603–607.
4. Parissi, Z.M.; Karatassiou, M.; Abraham, E.M.; Gioufoglou, C.; Andreopoulos, S.; Drakopoulou, A.T. Forage quality of dominant plant species of mountainous grasslands in northern Greece. *Options Méditerr. A* **2021**, *126*, 79–84.
5. Ferrer, C.; Barrantes, O.; Broca, A. La noción de biodiversidad en los ecosistemas pascícolas españoles. *Pastos* **2011**, *31*, 129–184.
6. Bengtsson, J.; Bullock, J.M.; Egoh, B.; Everson, C.; Everson, T.; O'Connor, T.; O'Farrell, P.J.; Smith, H.G.; Lindborg, R. Grasslands—more important for ecosystem services than you might think. *Ecosphere* **2019**, *10*, e02582. [CrossRef]
7. Urban, E. *The Rural Landscape of Europe: How Man Has Shaped European Nature*; The Swedish Research Council Forms: Stockholm, Sweeden, 2009; 384p.
8. Feng, L.; Gan, M.; Tian, F.P. Effects of Grassland Tourism on Alpine Meadow Community and Soil Properties in the Qinghai-Tibetan Plateau. *Pol. J. Environ. Stud.* **2019**, *28*, 4147–4152. [CrossRef]
9. Karatassiou, M.; Parissi, Z.M.; Stergiou, A.; Chouvardas, D.; Mantzanas, K. Patterns of transhumant livestock system on Mount Zireia, Peloponnese, Greece. *Opt. Méditerr. A* **2021**, *126*, 197–200.
10. Ragkos, A. Transhumance in Greece: Multifunctioality as a Asset for Sustainable Development. In *Grazing Communities: Pastoralism on the Move and Biocultural Heritage Frictions*; Letzia, B., Ed.; Berghahn Books: Oxford, NY, USA, 2022; Volume 29, pp. 23–43.
11. Pătru-Stupariu, I.; Hossu, C.A.; Grădinaru, S.R.; Nita, A.; Stupariu, M.S.; Huzui-Stoiculescu, A.; Gavrilidis, A.A. A Review of Changes in Mountain Land Use and Ecosystem Services: From Theory to Practice. *Land* **2020**, *9*, 336. [CrossRef]
12. Teira, A.G.; Peco, B. Modelling Oldfield Species Richness in a Mountain Area. *Plant Ecol.* **2003**, *166*, 249–261. [CrossRef]
13. Chatzimichali, A. *Sarakatsanoi*, 2nd ed.; Angeliki Chatzimichali Foundation: Athens, Greece, 2007.
14. Barrio, I.C.; Bueno, C.G.; Nagy, L.; Palacio, S.; Grau, O.; Munilla, I.; García, M.B.; Garcia-Cervigón, A.I.; Gartzia, M.; Gazol, A.; et al. Alpine Ecology in the Iberian Peninsula: What Do We Know, and What Do We Need to Learn? *Mt. Res. Dev.* **2013**, *33*, 437–442. [CrossRef]
15. Chrysanthopoulou, G. Synergy of Climate and Grazing in the Evolution of Vegetation on Mount Kyllini. Master's Thesis, Aristotle University of Thessaloniki, Thessaloniki, Greece, 2020.
16. Allegrezza, M.; Cocco, S.; Pesaresi, S.; Courchesne, F.; Corti, G. Effect of snowpack management on grassland biodiversity and soil properties at a ski resort in the Mediterranean basin (central Italy). *Plant Biosyst.* **2017**, *151*, 1101–1110. [CrossRef]
17. Gartzia, M.; Alados, C.L.; Pérez-Cabello, F. Assessment of the effects of biophysical and anthropogenic factors on woody plant encroachment in dense and sparse mountain grasslands based on remote sensing data. *Prog. Phys. Geogr.* **2014**, *38*, 201–217. [CrossRef]
18. Nasiakou, S.; Vrahnakis, M.; Chouvardas, D.; Mamanis, G.; Kleftoyanni, V. Land Use Changes for Investments in Silvoarable Agriculture Projected by the CLUE-S Spatio-Temporal Model. *Land* **2022**, *11*, 598. [CrossRef]
19. Sidiropoulou, A.; Karatassiou, M.; Galidaki, G.; Sklavou, P. Landscape Pattern Changes in Response to Transhumance Abandonment on Mountain Vermio (North Greece). *Sustainability* **2015**, *7*, 15652–15673. [CrossRef]
20. Sklavou, P.; Karatassiou, M.; Parissi, Z.; Galidaki, G.; Ragkos, A.; Sidiropoulou, A. The Role of Transhumance on Land Use/Cover Changes in Mountain Vermio, Northern Greece: A GIS Based Approach. *Not. Bot. Horti Agrobot. Cluj-Napoca* **2017**, *45*, 589–596. [CrossRef]
21. Porqueddu, C.; Ates, S.; Louhaichi, M.; Kyriazopoulos, A.P.; Moreno, G.; del Pozo, A.; Ovalle, C.; Ewing, M.A.; Nichols, P.G.H. Grasslands in 'Old World' and 'New World' Mediterranean-climate zones: Past trends, current status and future research priorities. *Grass Forage Sci.* **2016**, *71*, 1–35. [CrossRef]
22. Isselin-Nondedeu, F.; Rey, F.; Bédécarrats, A. Contributions of vegetation cover and cattle hoof prints towards seed runoff control on ski pistes. *Ecol. Eng.* **2006**, *27*, 193–201. [CrossRef]
23. Genovese, D.; Culasso, F.; Giacosa, E.; Battaglini, L.M. Can Livestock Farming and Tourism Coexist in Mountain Regions? A New Business Model for Sustainability. *Sustainability* **2017**, *9*, 2021. [CrossRef]
24. Wipf, S.; Rixen, C.; Fischer, M.; Schmid, B.; Stoeckli, V. Effects of ski piste preparation on alpine vegetation. *J. Appl. Ecol.* **2005**, *42*, 306–316. [CrossRef]
25. Pignatti, E.; Pignatti, S.; Lucchese, F. Plant communities of the Stirling Range, Western Australia. *J. Veg. Sci.* **1993**, *4*, 477–488. [CrossRef]
26. Barni, E.; Freppaz, M.; Siniscalco, C. Interactions between Vegetation, Roots, and Soil Stability in Restored High-altitude Ski Runs in the Alps. *Arct. Antarct. Alp. Res.* **2007**, *39*, 25–33. [CrossRef]
27. Rixen, C.; Stoeckli, V.; Ammann, W. Does artificial snow production affect soil and vegetation of ski pistes? A review. *Perspect. Plant Ecol.* **2003**, *5*, 219–230. [CrossRef]

28. Mulder, C.P.H.; Uliassi, D.D.; Doak, D.F. Physical stress and diversity-productivity relationships: The role of positive interactions. *Proc. Natl. Acad. Sci. USA* **2001**, *98*, 6704–6708. [CrossRef] [PubMed]
29. Waldhardt, R.; Otte, A. Indicators of plant species and community diversity in grasslands. *Agric. Ecosyst. Environ.* **2003**, *98*, 339–351. [CrossRef]
30. Barrantes, O.; Reiné, R.; Ferrer, C. Changes in Land Use of Pyrenean Mountain Pastures—Ski Runs and Livestock Management—Between 1972 and 2005 and the Effects on Subalpine Grasslands. *Arct. Antarct. Alp. Res.* **2013**, *45*, 318–329. [CrossRef]
31. Goñi, D.; Gúzman, D. Cambios en la vegetación debidos a una estación de esquí alpino en el Pirineo. *Pirineos* **2001**, *156*, 87–118. [CrossRef]
32. Henderson, A.E.; Davis, S.K. Rangeland health assessment: A useful tool for linking range management and grassland bird conservation? *Rangel. Ecol. Manag.* **2014**, *67*, 88–98. [CrossRef]
33. Pellant, M.; Pyke, D.A.; Shaver, P.; Herrick, J.E. *Interpreting Indicators of Rangeland Health: Version 4*; US Department of the Interior, Bureau of Land Management, National Science and Technology Center, Branch of Publishing Services: Denver, CO, USA, 2005.
34. Pyke, D.; Herrick, J.; Shaver, P.; Pellant, M. Rangeland Health Attributes and Indicators for Qualitative Assessment. *J. Range Manag.* **2002**, *55*, 584–597. [CrossRef]
35. Nastis, S.A.; Papanagiotou, E. Dimensions of sustainable rural development in mountainous and less favored areas: Evidence from Greece. *J. Geogr. Inst. Jovan Cvijic SASA* **2009**, *59*, 111–131. [CrossRef]
36. Marín-Yaseli, M.L.; Martínez, T.L. Competing for meadows. *Mt. Res. Dev.* **2003**, *23*, 169–176. [CrossRef]
37. Cook, C.W.; Stubbendieck, J. *Range Research: Basic Problems and Techniques*; Society for Range Management: Denver, CO, USA, 1986; 341p.
38. Karatassiou, M.; Parissi, Z.M.; Panajiotidis, S.; Stergiou, A. Impact of Grazing on Diversity of Semi-Arid Rangelands in Crete Island in the Context of Climatic Change. *Plants* **2022**, *11*, 982. [CrossRef] [PubMed]
39. Abraham, E.M.; Aftzalanidou, A.; Ganopoulos, I.; Osathanunkul, M.; Xanthopoulou, A.; Avramidou, E.; Sarrou, E.; Aravanopoulos, F.; Madesis, P. Genetic diversity of Thymus sibthorpii Bentham in mountainous natural grasslands of Northern Greece as related to local factors and plant community structure. *Ind. Crops Prod.* **2018**, *111*, 651–659. [CrossRef]
40. Henderson, P.A. *Practical Methods in Ecology*; John Wiley & Sons: Hoboken, NJ, USA, 2009.
41. Magurran, A.E. Measuring biological diversity. *Curr. Biol.* **2021**, *31*, R1174–R1177. [CrossRef]
42. Magurran, A.E.; McGill, B.J. *Biological Diversity: Frontiers in Measurement and Assessment*; OUP Oxford: Oxford, UK, 2010.
43. Eldridge, D.J.; Koen, T.B. Detecting environmental change in eastern Australia: Rangeland health in the semi-arid woodlands. *Sci. Total Environ.* **2003**, *310*, 211–219. [CrossRef]
44. Noss, R.F. Indicators for Monitoring Biodiversity: A Hierarchical Approach. *Conserv. Biol.* **1990**, *4*, 355–364. [CrossRef]
45. Gusmeroli, F.; Della Marianna, G.; Puccio, C.; Corti, M.; Maggioni, L. Foraging indices of woody and herbaceous Alpine species for goat livestock. *Quad. SoZooAlp* **2007**, *4*, 73–82.
46. Werner, W.; Paulissen, D. Program VEGBASE database of indicator values of vascular plants after Ellenberg and their evaluation to the personal computer. In *Indicator Values of Plants in Central Europe. Scripta Geobotanica Scripta Geobotanica 18*, 1st ed.; Ellenberg, H., Weber, H.E., Düll, R., Wirth, V., Werner, W., Paulissen, D., Eds.; Goltze, V.W.: Gottingen, Germany, 1992; pp. 238–248.
47. Novak, J. Evaluation of grassland quality. *Ekol. Bratisl.* **2004**, *23*, 127–143.
48. Snedecor, G.W.; Cochran, W.G. *Statistical Methods*, 8th ed.; Iowa State University Press: Ames, IA, USA, 1989; Volume 54, pp. 71–82.
49. Steel, R.G.D.; Torrie, J.H. *Principles and Procedures of Statistics, a Biometrical Approach*, 2nd ed.; McGraw-Hill Kogakusha, Ltd.: New York, NY, USA, 1980.
50. Thompson, J.D.; Hutchinson, I. Cohabitation of Species in an Artificial Grass-Legume Community on Ski-Slopes on Whistler Mountain, British Columbia, Canada. *J. Appl. Ecol.* **1986**, *23*, 239–250. [CrossRef]
51. Roux-Fouillet, P.; Wipf, S.; Rixen, C. Long-term impacts of ski piste management on alpine vegetation and soils. *J. Appl. Ecol.* **2011**, *48*, 906–915. [CrossRef]
52. Delgado, R.; Sánchez-Marañón, M.; Martín-García, J.M.; Aranda, V.; Serrano-Bernardo, F.; Rosúa, J.L. Impact of ski pistes on soil properties: A case study from a mountainous area in the Mediterranean region. *Soil Use Manag.* **2007**, *23*, 269–277. [CrossRef]
53. Manousidis, T.; Iatridou, S.; Lempesi, A.; Kyriazopoulos, A.P. Grazing behavior and dietary preferences of sheep grazing a Mediterranean rangeland. *Options Méditerr. A* **2021**, *125*, 373–376.
54. Karatassiou, M.; Parissi, Z.M.; Sklavou, P. Interaction of climatic conditions and transhumant livestock system on two mountainous rangelands in Greece. *Option Mediter. A* **2016**, *115*, 661–665.
55. Koerner, S.E.; Collins, S.L.; Blair, J.M.; Knapp, A.K.; Smith, M.D. Rainfall variability has minimal effects on grassland recovery from repeated grazing. *J. Veg. Sci.* **2014**, *25*, 36–44. [CrossRef]
56. Forbes, B.C. Tundra Disturbance Studies, I: Long-term Effects of Vehicles on Species Richness and Biomass. *Environ. Conserv.* **1992**, *19*, 48–58. [CrossRef]
57. Gros, R.; Jocteur Monrozier, L.; Bartoli, F.; Chotte, J.L.; Faivre, P. Relationships between soil physico-chemical properties and microbial activity along a restoration chronosequence of alpine grasslands following ski run construction. *Appl. Soil Ecol.* **2004**, *27*, 7–22. [CrossRef]
58. Gartzia, M.; Pérez-Cabello, F.; Bueno, C.G.; Alados, C.L. Physiognomic and physiologic changes in mountain grasslands in response to environmental and anthropogenic factors. *Appl. Geogr.* **2016**, *66*, 1–11. [CrossRef]