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Influence of forest cover type on understory plant biodiversity in the forests of Latakia Governorate, Syria

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ABSTRACT: This study aimed to assess the effect of forest cover type on understory plant biodiversity using compositional and trait-based indicators across different forest habitat types in Latakia Governorate, Syria, during 2022–2023. Vegetation surveys were conducted in 67 plots (400 m² each) across five habitat types: Natural oak forests, Maquis, Natural coniferous forests, Planted coniferous forests, and Burned forests. Compositional diversity was evaluated using species richness, Simpson index, Shannon index, and evenness. Categorical trait composition was assessed through sexual system, pollination mode, life form, and dispersal mode. A total of 350 species from 73 families were recorded, representing approximately 10.4% of Syria's total flora. Burned forests showed the highest species richness (194 species) and diversity indices, while Natural oak forests showed the lowest. Trait distributions differed significantly among habitats: dioecious, phanerophyte, and geophyte species dominated natural oak forests and Maquis, whereas hermaphroditic, hemicryptophyte, and therophyte species dominated disturbed habitats. Wind pollination and wind dispersal were more prevalent in coniferous forests, while insect pollination and animal dispersal characterized Maquis. The integration of compositional and trait-based approaches is valuable for monitoring biodiversity in Mediterranean forest habitats.

KEY WORDS: compositional diversity, trait distribution, diversity indices, Hill numbers, forest habitats, Mediterranean forests.

INTRODUCTION

Mediterranean forests constitute a unique ecosystem type characterized by high heterogeneity in climatic, topographic, and edaphic conditions, alongside a long history of human-induced disturbances. This has resulted in a remarkable diversity of plant species and their functional strategies (Aurelle *et al.,* 2022). Furthermore, these forests play a crucial role in conserving biodiversity, enhancing ecosystem resilience, and providing numerous essential services to the region's inhabitants (Nocentini *et al.,* 2022; Solano *et al.,* 2025; Köhl *et al*., 2020). However, they are among the most fragile ecosystems in the face of natural and anthropogenic disturbances — such as fires, overgrazing, and climate change — which necessitates a clear understanding of their functioning and imposes special management rules (Peñuelas and Sardans, 2021; Bou Dagher-Kharrat *et al.,* 2022; Hunault-Fontbonne and Eyvindson, 2023).

The herbaceous layer holds significant importance in the plant diversity dynamics of forest ecosystems. Although it represents only a small fraction of forest biomass, it constitutes over 80% of their plant diversity (Gilliam, 2007). Nevertheless, plant communities in this layer often lack adequate attention, and there remains a knowledge gap necessary for conserving and restoring herbaceous species in various endangered habitats (Geng *et al.,* 2024). In fact, diversity in this layer is linked to the structure and composition of the overlying forest cover through interactions with local environmental conditions — such as temperature, humidity, and light provided by the canopy (Park and Cheon, 2025; Vallé *et al.,* 2025) — as well as with management practices applied to the forest stand (Spicer *et al.,* 2023). Additionally, the herbaceous layer in forest stands responds more rapidly to environmental changes compared to tree and shrub layers. Therefore, the relationship between plant diversity in this layer and forest cover type reflects the response to various disturbances, making it a sensitive and effective indicator for assessing the impact of forest cover type and environmental factors on the structure and function of the forest ecosystem (Helm *et al.,* 2017). Moreover, the herbaceous layer can play a vital role in natural regeneration, soil protection, and nutrient flow regulation, and can serve as an effective indicator of ecosystem restoration success in planted forests (Zhao *et al.,* 2021).

Traditionally, studies on forest plant biodiversity have relied on a compositional approach using quantitative diversity indices and counts of genera and families. Despite the importance of these indices in describing plant community structure, they alone are often insufficient to explain how communities respond to environmental gradients and various disturbances, or to understand the implications of these changes for ecosystem function. This has led to growing interest in the trait-based approach (formerly "functional approach"), which considers categorical trait composition (formerly "functional diversity") as a component of biodiversity (Nock *et al*., 2016; Díaz *et al*., 2016). Unlike traditional biodiversity measures that focus on species number or abundance, trait composition focuses on the ecological roles species play and how they contribute to ecosystem processes such as nutrient cycling, energy flow, and pollination (Coutinho *et al*., 2024). Thus, functional trait

distribution reflects the functioning and stability of the forest ecosystem (Kaushik *et al.,* 2021; Bishaya *et al.,* 2024; Deng *et al.,* 2025) and serves as a strong indicator of its resilience to disturbances (Chen *et al.,* 2025). Plant functional traits are also important tools for explaining mechanisms of adaptation, coexistence, competition, and response to environmental stresses (Funk *et al.,* 2016; Dalle Fratte *et al.,* 2025; Liu *et al*., 2024). Furthermore, disturbance plays the strongest role in shaping trait differences among species due to reduced competition intensity caused by damage to the vegetation cover, which provides diverse opportunities for species growth and reproduction (Smith *et al.,* 2022).

Forest cover is linked to the dominant tree species and their growth form (conifers, broadleaved evergreens, or deciduous). This cover is a primary factor controlling forest habitat characteristics through its influence on canopy closure, light intensity reaching the forest floor, soil moisture, organic matter accumulation, and nutrient cycling. Consequently, The Syrian flora comprises approximately 3,383 species belonging to 1,031 genera and 150 families (FSOL, 2025). Forests cover about 2.5% of Syria's total area, with Latakia Governorate harboring the largest continuous forest tracts in the country, dominated by *Pinus brutia Ten., Quercus spp., and Cupressus sempervirens L*. Major forest complexes in Syria include the Al-Bayr and Al-Bassit massifs in Latakia, the Al-Kahf Reserve in Tartous, and the woodlands of the coastal mountain range extending southward (Nahal, 2012). Studies from neighboring regions, including Palestine (Ghazal, 2008), Lebanon (Bou Dagher-Kharrat *et al*., 2022), Jordan (Nawash *et al*., 2014), and Turkey (Kavgacı *et al*., 2021), have highlighted the importance of forest cover type in shaping understory plant communities. However, detailed studies from Syria remain limited. The forests of Latakia Governorate lie within the coastal Mediterranean zone of Syria. They are characterized by a clear diversity of forest cover, representing different habitat types varying in degradation severity, including mature natural forests, degraded forests (Maquis), natural and planted coniferous forests (Shater, 2013), as well as areas previously affected by fires. Despite the ecological importance of these habitats, studies on plant biodiversity in these forests remain limited, especially those focusing on the herbaceous layer and integrating compositional and functional approaches within a comparative framework across multiple forest habitats.

Therefore, this study aimed to evaluate the influence of forest cover type on the plant biodiversity of the herbaceous layer in five different forest habitat types in Latakia Governorate, Syria, by adopting two integrated approaches: a compositional approach based on the Hill numbers diversity framework (Chao *et al*., 2014a,b), and a trait-based approach analyzing categorical trait composition (sexual system, pollination mode, life form, and dispersal mode). Specifically, we tested the following hypotheses:

H_1: Forest cover type significantly affects the categorical trait composition of herbaceous layer plants.

H_2: Disturbed habitats (Burned and Planted forests) exhibit higher compositional diversity but different trait distributions compared to closed-canopy habitats (Natural oak forests and Maquis).

MATERIALS AND METHODS

Study Site

The research was conducted in Latakia Governorate, located in western Syria. It covers an area of 2300 km², about 1.2% of Syria's total area. The governorate extends from approximately 35°30' to 35°50' N and 35°40' to 36°10' E. It is divided into two distinct altitudinal zones: the coastal plains, rising to 200-300 m above sea level, and the mountains, extending from northeast to southwest. These mountains form the Al-Bayr and Al-Bassit massif in the north, composed mainly of green rocks of igneous origin, and the coastal mountain range in the south, consisting mostly of calcareous rocks from the Secondary Era, particularly the Jurassic and Cretaceous periods, as well as the Tertiary and Quaternary periods (Nahal, 2012). The climate is Mediterranean, with hot, dry summers and stormy, rainy, and relatively cool winters, and moderate temperatures in spring and autumn (Qara Falah, 2015).

Sampling

Sixty-seven square plots, each 400 m² (20 × 20 m), were designated to cover the main forest areas in the governorate (Fig. 1). Ali *et al*. (2020) successfully applied a decision tree algorithm to Sentinel-2 imagery for forest classification in Syria, providing a methodological basis for habitat stratification in the present study. Plots were distributed across various parent rocks, elevations, and aspects within five habitat types: Natural oak forests (13 plots), Maquis (14 plots), Natural coniferous forests (17 plots), Planted coniferous forests (12 plots), and Burned forests (11 plots) (Fig. 1).

Data Collection

In each plot, general site data were collected, and vegetation surveys were conducted using the Braun-Blanquet method (Braun and Furrer, 1913), with two surveys per plot (one in spring-summer and one in autumn-winter). Plant species were identified and classified using the Nouvelle flore du Liban et de la Syrie (Mouterde, 1966, 1970, 1983) and the Flora Syria Online (FSOL, 2025). Life forms were determined according to Raunkiaer (1934).

Functional traits were assessed using four categories: (1) sexual system; (2) pollination mode; (3) life form according to Raunkiaer (1934); (4) dispersal mode (Coutinho *et al*., 2024). Data on functional traits for

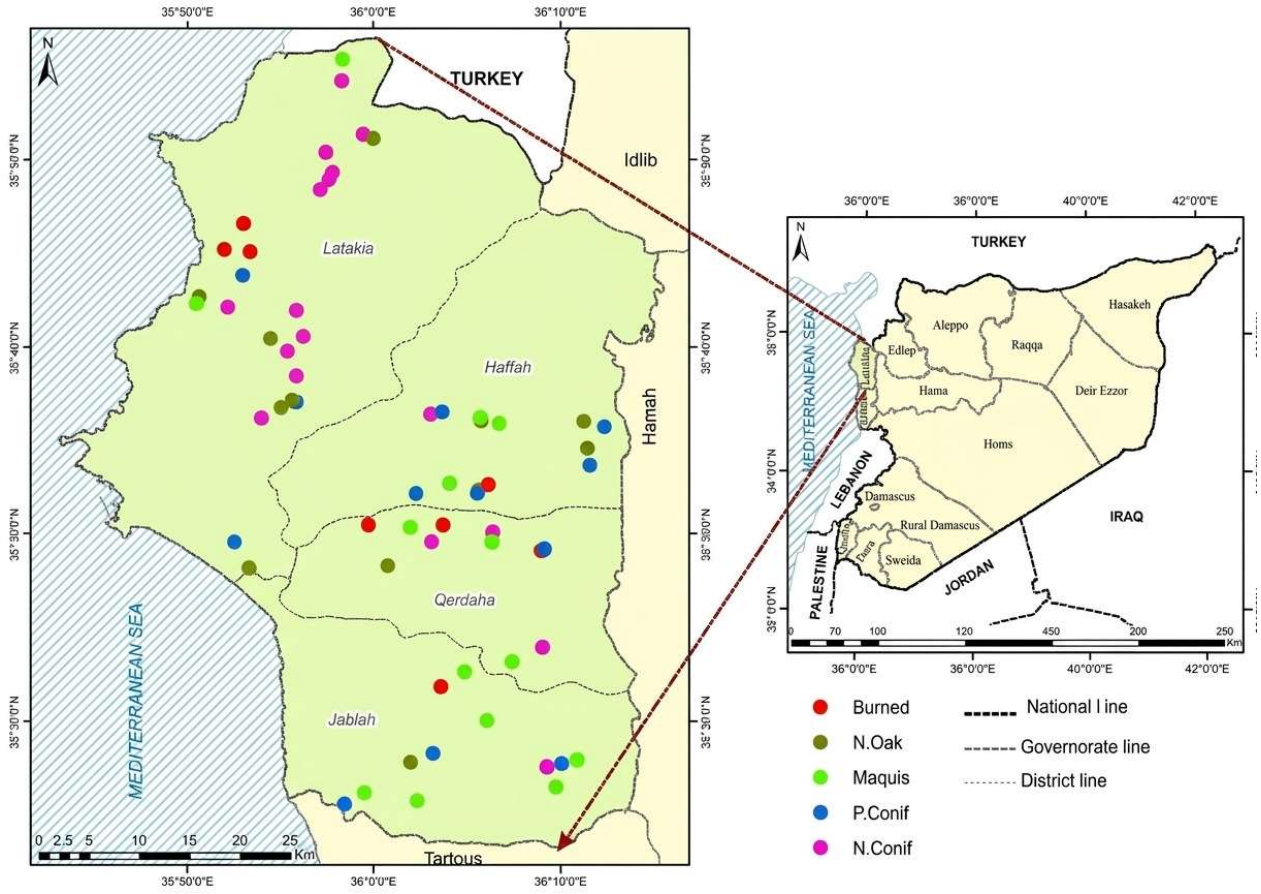

Fig. 1. Location map of the study area in Latakia Governorate, Syria, showing the distribution of 67 sample plots (400 m² each) across five forest habitat types: Natural oak forests (NO, n=13), Maquis (MQ, n=14), Natural coniferous forests (NC, n=17), Planted coniferous forests (PC, n=12), and Burned forests (BF, n=11).

recorded species were collected using the BASEFLORE database (Julve, 1998) and Mouterde (1966, 1970, 1983). For species not found in these sources, data were supplemented through personal expertise and scientific references (Van Der Pijl, 1982; Abrol, 2012; Cardoso *et al*., 2018; Midolo *et al*., 2024).

Compositional Diversity Indices

To align with modern ecological standards, we adopted the Hill numbers framework (Chao *et al*., 2014a,b). Hill numbers represent the effective number of species: q=0 (species richness), q=1 (exponential of Shannon entropy), and q=2 (inverse of Simpson concentration). These were calculated using the iNEXT package in R. Additionally, traditional indices (Simpson, Shannon, evenness) were computed using PAST 5.2.2 for comparison with previous studies. The number of taxonomic units common to all habitats and unique to each habitat was calculated using InteractiVenn (Heberle *et al*., 2015).

Statistical Analysis

Kruskal-Wallis and Mann-Whitney tests (with Bonferroni correction, $\alpha = 0.05/10 = 0.005$) were used for trait comparisons. Means and SD are reported in Table 1 to facilitate comparison with other studies. Medians showed the same patterns. Principal Component Analysis (PCA) was performed on habitat × trait percentage matrix after excluding traits with zero variance. KMO value was 0.466 (< 0.5), indicating that PCA results are exploratory only and should be interpreted with caution. SPSS software was used.

RESULTS

Compositional Diversity

A total of 350 plant species were recorded across all studied sites, representing approximately 10.4% of the total species recorded in Syria (3,383 species; FSOL, 2025). The most frequent species across all sites was *Quercus coccifera L.* (Fagaceae), recorded in 55 plots (82.1% of studied plots), while 110 species (31.4% of total recorded species) appeared in only one plot. The full checklist of 350 recorded species, including their families, life forms, chorotypes, and endemic/native status, is provided in Table S2 (Supplementary Material). Burned forests were the richest habitat in terms of species (194

Table 1. Hill numbers (mean ± standard deviation) for the five studied habitats in Latakia Governorate, Syria. Different superscript letters (a, b, c, d) indicate significant differences between habitats (Kruskal-Wallis with Bonferroni correction, α = 0.005).

Habitat	Species richness (q = 0)	Exp Shannon (q = 1)	Inv Simpson (q = 2)
Natural Oak For.	25 ± 4^{a}	20.7 ± 5.2^{a}	14.3 ± 3.1^{a}
Maquis	32 ± 5^{ab}	29.9 ± 6.1^{ab}	24.6 ± 4.2^{b}
Natural Coniferous For.	34 ± 4^{b}	32.4 ± 5.5^{b}	27.8 ± 3.8^{bc}
Planted Coniferous For.	37 ± 4^{b}	35.4 ± 4.8^{b}	31.5 ± 4.0^{c}
Burned Forests	68 ± 6^{c}	53.1 ± 7.3^{c}	45.0 ± 6.5^{d}

species), followed by Planted coniferous forests (186), Natural coniferous forests (175), Maquis (148), and Natural oak forests (127) (Fig. 2).

The number of species common to all five studied habitats was 50 (14.3% of total). Burned forests had 52 unique species (14.9%), planted coniferous forests 31 (8.9%), Natural coniferous forests 30 (8.6%), Maquis 17 (4.9%), and Natural oak forests 14 (4%) (Fig. 2A). The total number of species recorded in only one habitat was 144.

The most frequent species in burned sites was *Pinus brutia Ten.* (11 plots); in Natural oak forests, *Ruscus aculeatus L.* (11 plots); in Planted coniferous forests, *Quercus coccifera L.* (10 plots); in Natural coniferous forests, *Pinus brutia Ten.* (17 plots). In Maquis, *Quercus coccifera L., Pistacia terebinthus L., and Asparagus acutifolius L.* were each recorded in 14 plots.

A total of 232 genera were recorded (22.5% of Syria's 1,031 genera; FSOL, 2025). *Trifolium* was the most represented genus (14 species), followed by *Lathyrus* (7) and *Euphorbia* (6). The number of genera represented by only one species was 173. A total of 47 genera (20.2%) were common to all five habitats (Fig. 2B). Burned forests had 26 unique genera (11.2%), Planted coniferous 18 (7.8%), Natural coniferous 12 (5.2%), Natural oak 9 (3.9%), Maquis 8 (3.5%) (Fig. 2B).

Seventy-three families were recorded (48.7% of Syria's 150 families; FSOL 2025). Fabaceae dominated (58 species), followed by Asteraceae (38), Lamiaceae (30). A total of 36 families (49.3%) were common to all habitats (Fig. 4). Burned, Planted coniferous, and Maquis each had three unique families; Natural coniferous and Natural oak each had two (Fig. 2C). The ten most abundant species and families for each habitat type are presented in Supplementary Table S1.

The species-to-genus (S/G) and genus-to-family (G/F) ratios were nearly identical across all habitats ($\log(S/G) \approx 1.05$; $\log(G/F) \approx 1.19–1.23$), suggesting that the taxonomic structure of the herbaceous layer is stable at this spatial scale and is not strongly affected by habitat type or disturbance (data not shown).

Hill numbers showed the expected hierarchical pattern, $q = 0 > q = 1 > q = 2$, across all habitats. The values show a clear diversity gradient (Table 1): Burned forests exhibited the highest diversity (q=2 = 45.0), followed by Planted Coniferous (q=2 = 31.5), Natural

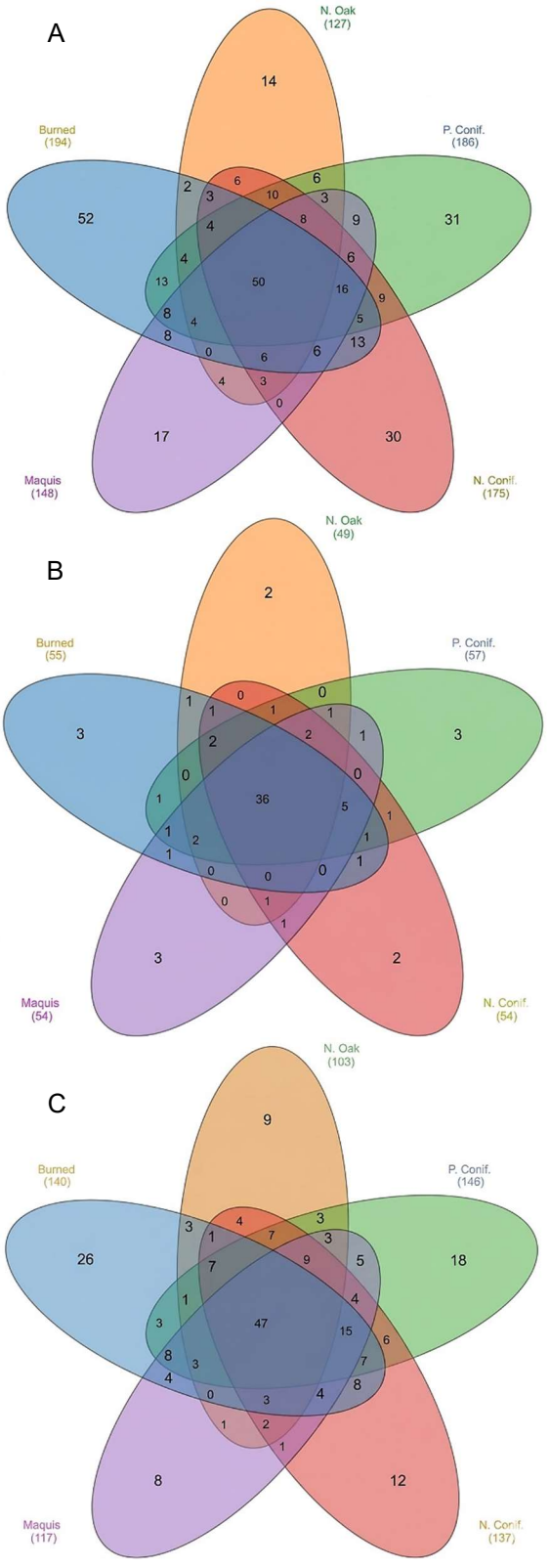

Fig. 2. Venn diagram showing the number of shared and unique **A.** Plant species (Total species = 350), **B.** Plant genera (Total genera = 232). **C.** Plant families (Total families = 73) among the five studied habitats. Numbers in overlapping regions indicate taxonomic units shared by the corresponding habitat groups.

Table 2. Average proportions (± standard deviation) of categorical traits (%) in the five studied habitats. Different superscript letters (a, b, c) indicate significant differences between habitats (Kruskal-Wallis test with Bonferroni correction, α = 0.005). (Full table including chamaephytes, barochory, autochory, and rare sexual systems is available upon request).

Trait	Natural Oak For.	Maquis	Natural Coniferous For.	Planted Coniferous For.	Burned Forest
Sexual system					
Hermaphroditic	57.1±9^{a}	67.4±6^{ab}	67.2±6^{ab}	70.6±4^{b}	78.6±3^{c}
Dioecious	20.1±7^{a}	18.5±4^{a}	14.5±4^{ab}	10.9±3^{b}	7.9±2^{b}
Monoecious	16.0±3^{a}	8.3±2^{b}	13.3±2^{a}	12.1±2^{ac}	8.9±2^{bc}
Pollination					
Entomogamy	63.9±4ab	66.6±3a	60.8±3bc	56.8±4c	65.6±4^{ab}
Anemogamy	26.8±4ab	21.6±3b	27.3±4a	25.9±2a	16.0±3^{c}
Entomo-autogamy	7.6±3a	9.7±2ab	10.5±2ab	14.4±5bc	16.2±3^{c}
Life form					
Phanerophytes	38.4±7^{a}	37.1±6^{a}	37.2±5^{a}	28.4±4^{b}	20.9±3^{c}
Geophytes	21.1±4^{a}	10.8±3^{bc}	14.1±3^{b}	11.5±3^{bc}	8.2±2^{c}
Hemicryptophytes	23.9±7^{a}	24.9±4^{a}	29.1±6^{ab}	33.0±5^{b}	31.4±3^{b}
Therophytes	6.1±3^{a}	9.8±3^{a}	6.8±3^{a}	12.5±5^{a}	26.5±4^{b}
Dispersal					
Zoochory	64.1±4^{ab}	67.3±5^{a}	57.5±4^{b}	58.8±4^{b}	56.4±5^{b}
Anemochory	11.9±4^{a}	7.8±3^{a}	17.4±2^{b}	18.2±3^{b}	20.5±4^{b}

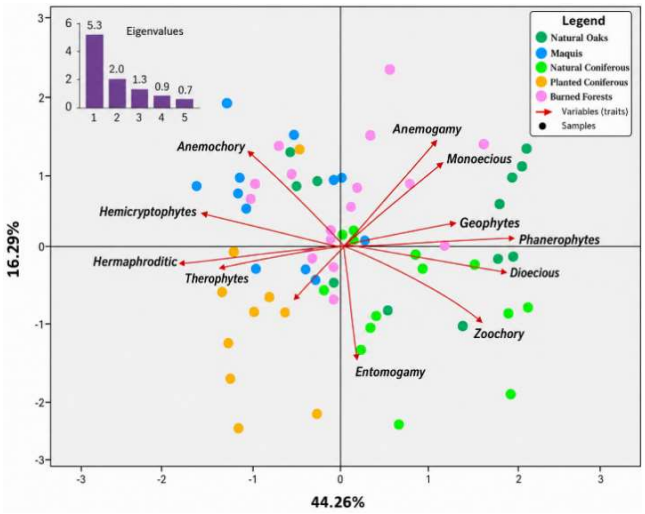

Fig. 3. Principal Component Analysis (PCA) biplot of functional traits (vectors) and sample plots (points) across the first two principal components (PC1: 44.26%, PC2: 16.29%). The sample plots are color-coded according to the five studied habitats: Natural Oak forests (dark green), Maquis (blue), Natural Coniferous forests (light green), Planted Coniferous forests (orange), and Burned forests (purple). Full names of functional traits (e.g., Phanerophytes, Therophytes, Entomogamy, Zoochory, etc.) are displayed directly on the biplot axes (vectors), and their proportions across habitats are presented in Table 2. The separation of habitats along PC1 and PC2 reflects functional differentiation driven by forest cover type and disturbance history.

Coniferous (q=2 = 27.8), Maquis (q=2 = 24.6), and Natural Oak forests (q=2 = 14.3), with significant differences ($p < 0.005$) among most habitats.

Categorical Trait Composition

Sexual system: Burned forests had the highest proportion of hermaphroditic species (78.6%), Natural oak forests the lowest (57.1%). Dioecious species were highest in Natural oak forests (20.1%) and lowest in Burned forests (7.9%). Monoecious species followed a similar trend (Table 2).

Pollination mode: Entomogamy dominated all habitats (56.8–66.6%), highest in Maquis (66.6%), lowest in Planted coniferous (56.8%). Anemogamy was highest in Natural coniferous forests (27.3%) and lowest in Burned forests (16.0%). Mixed entomo-autogamy was highest in Burned forests (16.2%) (Table 2).

Life forms: Phanerophytes were highest in Natural oak forests (38.4%), lowest in Burned (20.9%). Geophytes highest in Natural oak forests (21.1%), lowest in Burned (8.2%). Hemicryptophytes highest in Planted coniferous forests (33.0%), lowest in Natural oak forests (23.9%). Therophytes highest in Burned forests (26.5%), lowest in Natural oak (6.1%) (Table 2).

Dispersal modes: Zoochory was highest in Maquis (67.3%), lowest in Burned forests (56.4%). Anemochory highest in Burned forests (20.5%), lowest in Maquis (7.8%) (Table 2).

Table 2 shows the proportions of categorical traits across habitats. Significant differences ($p < 0.005$ after Bonferroni correction) were observed for most traits, as indicated by superscript letters.

Principal Component Analysis: KMO = 0.466 (< 0.5), Bartlett's $\chi^2 = 735.017$, $p < 0.001$. PC1 explained 44.26%, PC2 16.29% (total 60.55%). Dioecious species, phanerophytes, geophytes, and zoochores correlated positively with PC1 (Natural oak and Maquis samples). Hermaphroditic species, hemicryptophytes, and therophytes correlated negatively with PC1 (Burned and Planted coniferous samples). Anemochory, anemogamy, and monoecious species correlated positively with PC2 (coniferous forests). Entomogamy, zoochory, and chamaephytes correlated negatively with PC2 (Maquis and Burned) (Fig. 3).

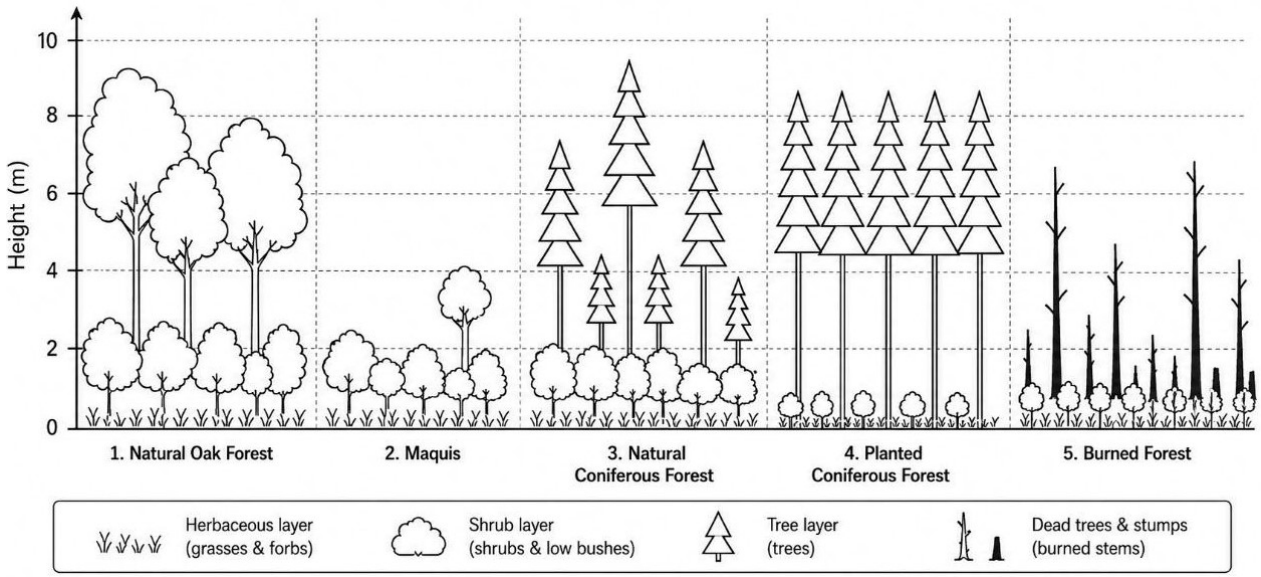

Fig. 4. Conceptual vegetation profile of the five studied habitats in Latakia Governorate, Syria, illustrating the vertical structure (tree, shrub, and herbaceous layers) across (1) Natural Oak forest, (2) Maquis, (3) Natural Coniferous forest, (4) Planted Coniferous forest, and (5) Burned forest. The profile illustrates the ecological gradient from tree-dominated (Natural Oak) to herbaceous-dominated (Burned) habitats. The progressive increase in herbaceous cover and density from left to right is consistent with the increase in Hill numbers (q=2, from 14.3 to 45.0, Table 1) and the proportion of therophytes (from 6.1% to 26.5%, Table 2). Dead trees and stumps are depicted in the burned habitat, indicating recent fire disturbance, which promotes herbaceous plant colonization.

Figure 4 illustrates a conceptual vegetation profile of the five habitats, synthesized from field observations. The profile is consistent with the structural gradient from tree-dominated (Natural Oak) to herbaceous-dominated (Burned) habitats, consistent with the increasing q=2 values and the rising proportion of therophytes (from 6.1% in Natural Oak to 26.5% in Burned forests, Table 2).

DISCUSSION

The present study demonstrated high proportions of various taxonomic units relative to the limited area studied compared to Syria's total area, especially families, where nearly half of the country's families were recorded. This reflects the biogeographical and ecological importance of the Latakia region and its habitat diversity.

The occurrence of *Quercus coccifera* L. in 82% of plots reflects its broad ecological amplitude. This species is a characteristic sclerophyllous evergreen of the eastern Mediterranean, tolerating a wide range of edaphic conditions, from calcareous to siliceous substrates. Its deep root system, ability to resprout vigorously after fire and grazing, and high phenotypic plasticity allow it to dominate both mature forests and degraded maquis, making it a keystone species in the region.

The low number of species common to all five habitats (only 14.3%) indicates high ecological specialization, where each habitat imposes strong selective conditions on plant species. This specialization is confirmed by the low number of unique species in natural oak forests (14 species), confirming that this environment is the most stable and selective, favoring specialized and shade-tolerant species. This may also explain the high frequency of *Ruscus aculeatus L.* in this habitat. In contrast, burned forests hosted 52 unique species, most of which are light-demanding. Many studies have documented the effect of habitat type, such as oak and burned forests, on the ecological specialization of plant species (Kermavnar and Kutnar, 2020; Baraloto *et al.,* 2021; Charles *et al.,* 2025; Vallé *et al.,* 2025).

The various plant diversity indices (Hill numbers) showed a good ability to track the effect of vegetation structure, composition, and disturbances on diversity. Index values gradually increased from closed habitats to open or disturbance-affected habitats. Natural oak forests recorded the lowest values for all studied indices, while burned forests recorded the highest. This reflects the influence of forest cover on the abundance and distribution of herbaceous layer plants through factors such as light, soil composition, and structure. In oak forests, tree species dominate, allowing insufficient light penetration due to their high density. Fire removes the dense forest cover and releases resources by increasing light and nutrient availability to the herbaceous layer, and reducing competition due to decreased dominance of perennial woody species. This allows the spread of many relatively evenly distributed species, leading to higher levels of richness, evenness, and diversity. This explains the high presence of the genus *Trifolium* in this habitat (11 species), as its nitrogen-fixing ability may give it a competitive advantage in post-fire soils. Many studies have reported similar results in different regions

worldwide. For instance, Dormann *et al.* (2020) documented the effect of tree layer composition and structure on resource availability (especially light) in the herbaceous layer of several temperate forests in Germany. In an analytical study covering 7,255 sites in France, Vallé *et al.,* (2025) demonstrated the effect of tree cover on herbaceous layer species distribution through various factors such as light availability and soil structure (Lopez-Carrasco *et al*., 2015). This is also consistent with many studies examining early post-fire successional stages in Mediterranean forest systems (Özkan and Gökbulak, 2017; Fernández-García *et al.,* 2021; Rybar *et al.,* 2023).

The results also showed a clear association between the proportions of plant categorical traits and habitat type, reflecting different adaptive strategies of these communities to prevailing environmental conditions. Dioecious species, phanerophytes, geophytes, and zoochores were associated with most Natural oak and Maquis samples, as well as some Natural coniferous forest samples. This can be explained by these forests representing the most stable and dense environment, allowing dioecious species to pollinate easily, allowing perennial woody species to dominate and grow vertically to compete for light, and allowing geophytes to survive drought or shade through underground storage organs. These results align with many worldwide studies. Wei *et al.* (2021) documented differences in the distribution of flower sex types in plants based on forest type, environmental conditions, disturbance patterns, and management practices. Ramírez and Briceño (2022) noted an association of dioecious species with tree-dominated communities and late-successional stages. Numerous studies have also documented the effect of forest habitat on the proportion of geophytes (Yener and Akdeniz, 2020; Taura and Gudžinskas, 2025). Chapman and McEwan (2018) found an interaction between functional traits and habitat conditions, with communities of low trait diversity inhabiting areas subject to high environmental stress.

Conversely, hermaphroditic species, therophytes, and hemicryptophytes were primarily associated with burned and planted coniferous forests. This reflects the adaptation of these species to disturbed environments due to the reproductive flexibility of hermaphroditic species capable of self-pollination in these settings, along with the ability of annual and hemicryptophyte species to exploit available resources like light and nutrients from post-disturbance ash, giving them a competitive advantage for rapid spread in open and disturbed environments. Furthermore, the growth form of these species and the position of their renewal buds near the soil surface give them a high capacity to survive fire and regenerate quickly in early successional stages. These results are consistent with those of Kisvarga *et al.,* (2025), who showed a higher proportion of self-pollination in harsh or isolated environments where pollinators are scarce, and with many other studies that have documented a higher proportion of annual and hemicryptophyte species in burned forest sites (Wójcik *et al.,* 2022; Yiğit, 2025) and in planted sites (McKeon *et al.,* 2023; Sangry *et al*., 2024; Waheed *et al.,* 2024) in many regions worldwide.

Additionally, plants with anemogamy and anemochory, along with monoecious species, were associated with a large proportion of samples dominated by tree components (Natural oaks, Natural conifers, Planted conifers). This pattern is typically associated with tall woody plants capable of sending pollen over long distances (Friedman and Barrett, 2009; Slik *et al.,* 2024). In contrast, plants with entomogamy, zoochory, and chamaephytes were primarily associated with burned samples and maquis samples. This can be explained by the abundance of flowering species in these two habitat types due to good light conditions, strongly attracting pollinators. The significant proportion of chamaephytes in burned forests, in addition to their dominance in maquis, can also be explained by their ability to vegetatively reproduce after fire due to the protection of their root systems. Many of these shrubby species produce fruits consumed and dispersed by birds and mammals, such as *Pistacia terebinthus L*., *Phillyrea latifolia L.,* and *Arbutus andrachne L*. This explains the high proportion of animal-dispersed species in these habitats. These results align with literature on the proportions of wind and insect pollination in different environments. Ackerman (2000) recorded a high proportion of wind pollination in coniferous forests due to the abundance of wind-pollinated species. Herrera (2020) stated that habitat type is a primary indicator of insect pollinator composition, as some herbaceous species flourish in burned areas and are adapted to insect pollination. Charles *et al.* (2025) demonstrated the strong link between fire regimes in ecosystems and functional interactions among species (pollination, seed dispersal, food provision). Salazar-Tortosa *et al.* (2019) found a close link between dispersal morphology and environmental conditions, with each mode dominating under specific abiotic conditions. Shater *et al.* (2018) recorded a high proportion of animal dispersal in maquis forest stands in the Al-Kahf Reserve in Tartous, Syria. Di Biase *et al.* (2021) recorded a high proportion of phanerophytes and geophytes in natural forests at mid-altitudes in a Mediterranean climate zone in central Italy, while Barbero *et al.* (1990) recorded high proportions of chamaephytes in maquis due to their ability to adapt to the harsh, dry conditions that dominate there.

In the eastern Mediterranean region, Quercus calliprinos Webb. (syn. Q. coccifera L. subsp. calliprinos) is recognized as a diagnostic species for distinct plant associations in forest communities (Öztürk and Altay, 2021). Similarly, Quercus palaestini K. is an endemic oak species of the Levant region. Recent phytosociological

studies by Ighbareyeh *et al*. (2022) in Palestine further confirm the ecological significance of these oak species in structuring eastern Mediterranean forest communities, which aligns with our findings in the Natural Oak habitats of Latakia. PCA explained only 60.55% of the variance, leaving 39.45% unexplained. Unmeasured environmental factors (e.g., soil properties, microclimate, grazing intensity) likely contribute to the remaining variation.

This study is correlational and cannot establish causation. Further experimental and long-term monitoring studies are needed to confirm causal relationships between forest cover type and herbaceous layer biodiversity.

Furthermore, many studies have shown that trait diversity does not necessarily match taxonomic diversity along vegetation cover gradients. This explains the discrepancy between compositional and trait-based diversity results in different habitats depending on their disturbance conditions (Erdos *et al.,* 2023).

The herbaceous layer in different forest habitats of Latakia Governorate is characterized by remarkable plant diversity, both in terms of taxonomic units and compositional diversity indices (Hill numbers), as well as categorical trait composition and their distribution. The nature of the forest cover, linked to the dominant tree species, influences the plant diversity of the herbaceous layer. Compositional diversity indices are higher in more disturbed habitats, with burned sites being the richest and most diverse. Many categorical traits also show a strong association with habitat type and disturbance intensity.

CONCLUSION

This study demonstrates that forest cover type and disturbance history are significantly associated with biodiversity and categorical trait composition of the herbaceous layer in Latakia Governorate. Burned forests exhibited the highest species diversity (q=2 = 45.0) and the greatest proportion of therophytes (26.5%), suggesting that post-fire conditions are associated with increased herbaceous plant colonization. In contrast, Natural Oak forests, dominated by *Quercus calliprinos* and *Q. palaestini,* harbored the lowest herbaceous diversity (q=2 = 14.3), possibly because of dense canopy cover and thick litter accumulation. Planted coniferous forests showed higher diversity than their natural counterparts, possibly reflecting management practices that create light gaps. We recommend integrating fire-adapted herbaceous species into afforestation plans and prioritizing the conservation of mixed *Pinus–Quercus* mosaics to sustain regional biodiversity. Future research should explore the long-term dynamics of post-fire regeneration and the role of soil seed banks in shaping understory composition.

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