A TAXONOMIC OVERVIEW OF FIRST YEAR POST-FIRE VEGETATION IN *PINUS BRUTIA* FORESTS: REGENERATION MODES AND GROWTH FORMS AFTER A MEGAFIRE

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Abstract. Fire is a recurrent disturbance in Mediterranean pine forests, yet the first year of post-fire plant recovery remains poorly documented in Türkiye, despite its importance for understanding vegetation trajectories and informing restoration. In this study, we surveyed the first-year post-fire plant community in Turkish red pine (*Pinus brutia* Ten.) forests burned during the 2021 Marmaris megafire in southwestern Anatolia. We conducted five repeated botanical surveys across 24 permanent plots and recorded plant taxa, growth forms, post-fire regeneration strategy, and phytogeographic affinities. Across the burned areas, we recorded 233 taxa, belonging to 52 families. Fabaceae, Asteraceae, Poaceae, and Lamiaceae were the most species-rich families. The post-fire flora included 12 local endemics restricted to southwestern Anatolia, and nearly half of the recorded taxa belonged to Eastern Mediterranean and Mediterranean phytogeographic elements. Seeders dominated overall, whereas resprouting was especially prevalent among woody taxa and geophytes. By contrast, most herbaceous taxa, particularly annual forbs and annual graminoids, were associated with post-fire recruitment from seed. Resprouter-to-seeder and woody-to-herbaceous ratios increased from broadly distributed taxa to Mediterranean and especially Eastern Mediterranean elements, indicating that regionally restricted taxa were more strongly associated with resprouting persistence and woody growth forms. These findings show that recently burned *Pinus brutia* forests support high taxonomic and functional diversity in the first post-fire year. Early post-fire surveys are therefore essential for understanding regeneration dynamics and for guiding biodiversity-sensitive restoration in Mediterranean fire-prone landscapes.
Keywords: *post-fire regeneration, Pinus brutia, Mediterranean Basin, first post-fire year, seeders, resprouting, phytogeography, megafire*

Introduction

Fire has acted as a major ecological force shaping natural ecosystems over millions of years (Pausas et al., 2025). Ecosystems in which this selective pressure has been persistent and dominant through geological time are commonly characterized as fire-prone ecosystems (Keeley and Pausas, 2022). Mediterranean-type ecosystems, in particular, have been strongly structured by recurrent, seasonal fires throughout their evolutionary history (Rundel et al., 2016). These ecosystems typically have exceptionally high plant diversity and are often dominated by shrub-rich vegetation (Esler et al., 2018). In these plant communities, the adaptive traits of plants have been selected that enhance survival

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and persistence after fire at the individual and/or population level (Keeley et al., 2011). Mediterranean floras exhibit a suite of fire-related traits, including germination stimulated by heat shock and smoke, post-fire resprouting, thick bark, serotiny, persistence via soil seed banks, and fire-stimulated flowering (Paula et al., 2009; Moreira et al., 2010; Keeley et al., 2012). Among these, regeneration via seeding and resprouting is widely observed as the two principal post-fire strategies providing plant community recovery (Pausas and Keeley, 2014; Day et al., 2020).

Post-fire regeneration via seeding can originate from multiple propagule sources, including the soil seed bank, canopy-stored seed banks, and seed rain arriving from adjacent unburned areas (Keeley and Pausas, 2022). In fire-prone ecosystems, dormant seeds retained in soil or canopy banks—often persisting from a few years to many decades or longer—may be released from dormancy and triggered to germinate by physical cues such as heat shock and by chemical cues associated with smoke-derived compounds (Pausas and Lamont, 2022). This phenomenon, described as fire-stimulated germination, is observed in fire-prone ecosystems (Keeley et al., 2012). Specifically, species that do not resprout after fire and re-establish exclusively through recruitment from seed are termed obligate seeders (Pausas and Keeley, 2014). In addition, many annuals with life cycles closely aligned with fire are described as monopyric species (Pausas and Keeley, 2014), while taxa that occur at high abundance in the first post-fire year but become rare or undetectable until the next fire are referred to as pyroendemics or fire ephemerals (Pate et al., 1985; Tavşanoğlu et al., 2017). Conversely, species that demonstrate an absence of effective post-fire recruitment from propagule and instead exhibit a primary persistence through sprouting are classified as obligate resprouters (Pausas and Keeley, 2014). The persistence of obligate resprouter in the plant community is ensured by the presence of both belowground (Pausas et al., 2018) and aboveground tissues (Pausas and Keeley, 2017), which are defined as shoot banks. These shoot banks enable the emergence of new shoots, thus contributing to the recovery of the plant community (Clarke et al., 2013). Species that establish after a fire both through resprouts and propagules are defined as facultative resprouters (Pausas and Lamont, 2022). As a result of these regeneration dynamics, the plant community before and after the fire exhibits a high degree of similarity in terms of plant diversity (Han et al., 2015; Parra and Moreno, 2018). Nonetheless, even when many taxa persist, post-fire assembly typically involves shifts in abundance, spatial distribution, and biotic interactions (Stevens-Rumann and Morgan, 2019). For example, taxa established in the first post-fire year may gain competitive advantages during early post-fire community development (De Luis et al., 2008). Through post-fire regeneration strategies, species that maintain their presence within the community are able to create a new vegetation structure (Clarke et al., 2013).

Post-fire vegetation reassembly is a core component of the fire regime and can influence subsequent fire severity and spread by shaping fuel structure and continuity (Keeley and Pausas, 2022). Fire regimes are further driven by demographic change (Pausas and Fernández-Muñoz, 2012), forest management strategies (Lindenmayer and Noss, 2006), and climate change, which together alter fire intensity and severity, burn size, frequency, and seasonality (Shen et al., 2025). Across many regions, both fire severity and the size of burned areas have increased substantially (Moreira et al., 2020). The societal effects of increasing trend in fires and their severities have become especially apparent over the last decade, as evidenced by the widespread ecological damage and profound social trauma generated by large wildfire disasters in many countries including Australia, the USA, Chile, and Greece (Rosenthal et al., 2021; Cruwys et al., 2024). Recent statistics indicate a rapid

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increase in the mean burned area and a rising frequency of large fires in Türkiye (Atmiş et al., 2023; OGM, 2025). The southwest of Anatolia is particularly one of the most fire-prone regions in Türkiye, experienced frequent and severe fires in recent decades (Avcı and Korkmaz, 2021). Many of these fires are lightning-induced and burned only limited area, but human-caused fires in the region resulted in large areas burned (Öztürk et al., 2024). These major wildfire events cause substantial socio-economic impacts (Kavgacı and Başaran, 2023), and concerns raised through ignoring biodiversity in post-fire restoration activities (Tavşanoğlu and Pausas, 2022). However, since low-altitude forests and shrublands in Mediterranean region are highly fire resilient thanks to their fire-adapted traits (Paula et al., 2009), a successful post-fire recovery is expected after even large wildfires in the region. Indeed, severe fires are not ecological disasters but essential processes that have shaped biodiversity in many fire-prone regions (Pausas, 2026).

Although research on wildfire impacts on ecosystems in Türkiye has increased over the last decade, the evidence base remains limited and geographically restricted. Within the research of fire ecology in Türkiye, studies have addressed a wide range of topics, including fire-related germination (Ergan, 2017; Tavşanoğlu et al., 2017; Çatav et al., 2018; Kazancı and Tavşanoğlu, 2019), remote sensing assessments of fire effects (Tonbul et al., 2016; Avcioglu et al., 2025), fire behaviour modelling (Bilgili and Sağlam, 2003), fire-risk analysis (Sağlam et al., 2008; Güney et al., 2016; Satir et al., 2016), vegetation modelling under contrasting fire regimes (Bahar, 2018), plant flammability (Neyişçi, 1996; Aktepe and Tavşanoğlu, 2025), fire-regime characterization (Bekar and Tavşanoğlu, 2017; Şahan et al., 2022; Öztürk et al., 2024), and evaluations of post-fire management and policy (Ürker et al., 2018; Tavşanoğlu and Pausas, 2022). However, studies investigating post-fire plant communities remained limited (Peşmen and Oflas, 1971; Tavşanoğlu and Gürkan, 2009, 2014; Kavgacı et al., 2010; Turkmen and Duzenli, 2011; Ergan, 2017), and despite its critical importance for subsequent community trajectories and management decisions, the first-year post-fire plant community has been poorly documented in Türkiye. This knowledge gap is particularly consequential in the southern and western Mediterranean regions of the country, where recent observations of unusually large and severe fires have heightened uncertainty about the fate of vegetation and biodiversity. Therefore, surveys of flora and vegetation during the first post-fire year are essential to the prediction of post-fire community development in forests and shrublands in Mediterranean region of Türkiye.

In this study, we surveyed assessed the first-year post-fire plant community in a Turkish red pine (*Pinus brutia* Ten.) forest following the 2021 Marmaris megafire (southwestern Anatolia, Türkiye), using repeated botanical surveys. Specifically, we ask: (1) What is the taxonomic composition and richness of the first-year post-fire flora, and which families and growth forms dominate? (2) What is the relationship between post-fire regeneration strategies, growth forms, and phytogeographic elements? By providing a detailed account of early post-fire species composition and functional structure, our study contributes to filling key knowledge gaps on first-year post-fire community dynamics in this fire-prone region.

Materials and methods

Sampling area

Marmaris area (Muğla province, southwestern Anatolia), one of the regions in Türkiye most frequently affected by forest fires, was selected as the study area due to the burning

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of 12,387 ha of forest area on 29 July 2021 (Tüfekcioğlu et al., 2022). The study area has a Mediterranean climate (type 'Cs') according to the Köppen-Geiger climate classification; this climate type includes mild and rainy winters and hot and dry summers (Kottek et al., 2006). According to data obtained from the General Directorate of Meteorology, the annual average rainfall in Marmaris and its surroundings was recorded as 1228 mm between 1963 and 2018. During this period, the average annual temperature in Marmaris was 19°C, while the number of rainy days was 95.2 days (Balcıoğlu, 2021). During the summer months, there is a dry period lasting up to five months (between May to September), characterized by high temperatures and no or limited rainfall. The higher precipitation levels during wet period (from October to April) recorded in Marmaris compared to neighboring regions are attributed to the topographical characteristics of the region. The region, which rises to 1000 m a.s.l. over a short distance, has a steep gradient and a fractured structure (Ege et al., 2024), causing moisture from the sea to fall as precipitation in the region before reaching the interior. Marmaris and its surroundings is dominated by various woody vegetation types, including semi-closed and open Turkish red pine (*Pinus brutia*) forests, closed and open maquis shrublands, and phrygana vegetation (Tüfekcioğlu and Tavşanoğlu, 2022).

Field survey

Twenty-four permanent plots (50 m × 50 m; 0.25 ha) were established within the 2021 Marmaris megafire perimeter inside Marmaris National Park and were selected to represent first-year post-fire vegetation in *P. brutia* forests on serpentine substrates. Plot locations were chosen based on pre-fire vegetation information and field verification to ensure that each plot corresponded to areas that were confirmed as *P. brutia* forest prior to the fire and underlain by serpentine bedrock, thereby minimizing edaphic heterogeneity among plots. To reduce effects of recent fire history, we restricted plot placement to stands that had last burned more than 20 years prior to the 2021 event. All plots were situated within the same burned *P. brutia*–serpentine vegetation context in Marmaris National Park, were located within a low-elevation range (0–300 m a.s.l.), and spanned multiple slope aspects (NE, E, SE, SW, W, and NW). We established our plots within portions of the burn area classified as moderate–high to high fire severity based on the differenced Normalized Burn Ratio (dNBR) (Tüfekcioğlu et al., 2022). Vegetation was surveyed during five field campaigns of 5–7 days each in April, May, June and November 2022, and March 2023. This temporal design aimed to capture seasonal turnover in detectability and phenology, including early- and late-spring species as well as autumn-emerging life forms such as geophytes. All 24 plots were surveyed during each campaign using the same field protocol. Repeated visits were intended to increase inventory completeness by capturing taxa with contrasting phenology across the year. The repeated surveys also aimed to sample a broad range of functional groups within the post-fire plant community, including annual and perennial herbaceous taxa, geophytes and woody taxa, as well as dominant, rare and endemic species. Within each plot, we recorded all observed seed plant taxa including gymnosperms and angiosperms, and we did not survey non-vascular plants such as bryophyes or vascular seedless plants such as pteridophytes. All observed taxa were recorded on standardized field forms and assigned unique identifiers. For taxonomic verification, up to two individuals per observed taxon were collected as voucher specimens, pressed and dried, and subsequently curated and identified at the Hacettepe University Functional Ecology Laboratory. Identifications were based on Flora of Turkey and the East Aegean Islands (Davis, 1965–1985), Turkish Plants Data Service

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(Bakis et al., 2011), List of Plants Türkiye (Güner et al., 2012), Illustrated Flora of Türkiye (Güner, 2018), and by comparison with reference material from the Hacettepe University Department of Biology Herbarium (HUB) and the Herbarium of the Department of Pharmaceutical Botany, Faculty of Pharmacy, Hacettepe University. Taxa not identified to species were retained at genus level only when comparative voucher material confirmed they represented distinct taxa within plots.

Growth form

Plant growth form was determined from field observations and corroborated using standard Mediterranean plant growth form definitions in the floristic literature (Davis, 1965-1985, BROT 2.0 database, Tavşanoğlu and Pausas, 2018). Each taxon was assigned to a single growth form category (e.g., tree, large shrub, shrub, subshrub, liana, annual forb, perennial forb, annual graminoid, perennial graminoid, geophyte, holoparasite). We also collapsed growth forms into woody versus herbaceous categories; as woody taxa included subshrubs, shrubs, large shrubs, lianas, and trees, whereas herbaceous taxa included annual and perennial forbs and graminoids, geophytes and holoparasites. Using this data, woody–herbaceous ratios in plots were calculated.

Regeneration strategy

For each taxon that was recorded, a post-fire regeneration strategy was assigned on the basis of field evidence from repeated surveys (e.g. emergence from basal/epicormic shoots or belowground organs vs. recruitment as seedlings), complemented by species-level trait information from the Flora of Turkey (Davis, 1965-1985) and the BROT 2.0 database (Tavşanoğlu and Pausas, 2018) when field observations were ambiguous for trait reference. Taxa were classified as seeder, obligate resprouters, facultative resprouters, or planted. Obligate resprouters comprised species persisting after fire through vegetative recovery from belowground buds or surviving aboveground tissues (e.g., root crowns, lignotubers, rhizomes, bulbs/corms), whereas seeders comprised species whose post-fire presence was attributable primarily to germination from the soil or canopy seed bank or dispersed seeds. Facultative resprouters are species in which were observed both resprouting and germinating from seed after fire. Planted taxa were defined when planting pits and planted seedlings were observed in the field and these observations were confirmed with local units of the General Directorate of Forestry (OGM). We calculated the resprouter/seeder ratio to summarize regeneration strategy composition across groups.

Phytogeographic classification and distribution categories

Each taxon was assigned a phytogeographic distribution category using Flora of Turkey (Davis, 1965-1985) and Plants of the World Online data (POWO, Royal Botanic Gardens, Kew). We defined plant distribution geographies from narrow to broad sense, and categorized them as Eastern Mediterranean, Mediterranean, Euro-Siberian, Irano-Turanian, Mediterranean + other phytogeographics. In addition, some species were assigned as cosmopolitan (those with wide distribution without any phytogeographic association), and introduced (those with alien to regional flora). We grouped taxa into four classes: Eastern Mediterranean endemics, Mediterranean endemics, Others (taxa distributed in the Mediterranean and other plant geography, or distributed outside the Mediterranean), and All taxa combined (the pooled dataset). These categories were used

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to quantify how taxonomic richness, regeneration strategies, growth-form structure, and geophyte occurrence varied among phytogeographic elements in the first post-fire year. Genus-level taxa were included in total richness, but were coded as unknown when species-level trait information was required (e.g. phytogeographic regions) and were excluded from ratio-based summaries.

Results

Across the 24 permanent plots, we recorded a total of 233 plant taxa (*Table 1* and *Table A1* in the *Appendix*) belonging to 52 families. These richness values represent the cumulative flora detected across five seasonal surveys spanning 24 permanent 0.25-ha plots (6 ha total). Fabaceae was the most species-rich family (33 taxa), followed by Asteraceae (30 taxa), Poaceae (26 taxa), Lamiaceae (12 taxa), and Brassicaceae (11 taxa) (*Fig. 1*). Together, these five families accounted for 48.1% of all recorded taxa, whereas the remaining 51.9% were distributed across the other 47 families. At the genus level, *Trifolium* was the most species-rich genus (13 species), followed by *Allium* and *Bromus* (*Fig. 2*).

Table 1. *Phytogeographic patterns of taxonomic richness, post-fire regeneration strategies, growth forms, and geophyte occurrence in first year post-fire vegetation. Plant taxa were assigned to four phytogeographic groups: Eastern Mediterranean endemics, Mediterranean endemics, others, and all taxa combined. For each group, the table shows the number and percentage of taxa, families, and geophytes. Post-fire regeneration strategies are summarized as counts of resprouters (r) and seeders (s) and their r/s ratio. Growth forms are summarized as counts of woody (w) and herbaceous (h) taxa and their w/h ratio. Woody taxa comprise subshrubs, shrubs, large shrubs, lianas, and trees, whereas herbaceous taxa comprise annual and perennial forbs and graminoids, and geophytes*

	Taxon		Family		Resprouter/seeder		Woody/herbaceous		Geophyte	
	n	%	n	%	n(r - s)	r/s ratio	n(w - h)	w/h ratio	n	%
Eastern Mediterranean	49	21	23	44.2	30 - 17	1.76	15 - 34	0.44	13	43.3
Mediterranean	116	49.8	40	76.9	58 - 53	1.09	32 - 84	0.38	24	80
Others	111	47.6	35	67.3	30 - 84	0.36	17 - 94	0.18	2	6.7
All	233	100	52	100	88 - 137	0.64	49 - 184	0.27	30	100

Among taxa for which post-fire regeneration strategy could be assigned, 137 taxa (58.8%) were classified as seeders, persisting in the burned areas through post-fire germination, whereas 88 taxa (37.8%) were classified as resprouters, persisting through vegetative recovery from surviving tissues (*Table 1*). In addition, six taxa were classified as facultative resprouter, exhibiting both resprouting and seed-based regeneration. Within the study area, *Pinus brutia*, *Ceratonia siliqua* L., *Liquidambar orientalis* Mill., and *Cupressus sempervirens* L. were observed to have been planted as part of restoration activities implemented by local units of the General Directorate of Forestry. Of these, *C. siliqua* and *C. sempervirens* were treated as plantation taxa. By contrast, *P. brutia* was not treated as plantation because we observed widespread post-fire recruitment consistent with establishment from seed, and *L. orientalis* was not treated as plantation because it was observed to persist and re-establish primarily via resprouting. *P. brutia* was the most extensive species which was used for active restoration practice. Nevertheless, it was abundant in the post-fire community through seedling emergence, it was recorded as a seeder.

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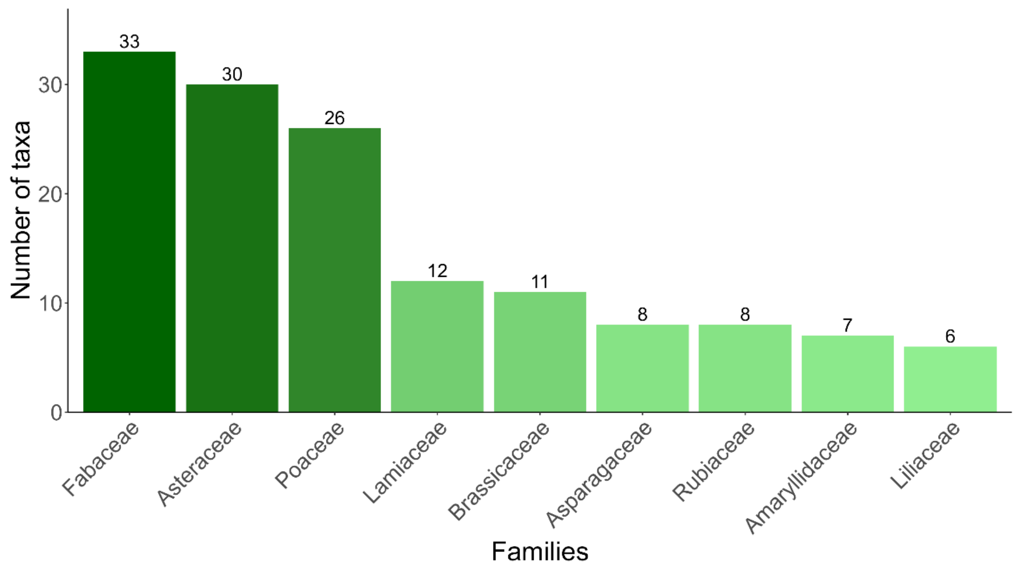

Figure 1. *The nine families with the highest taxon counts recorded during first-year post-fire surveys*

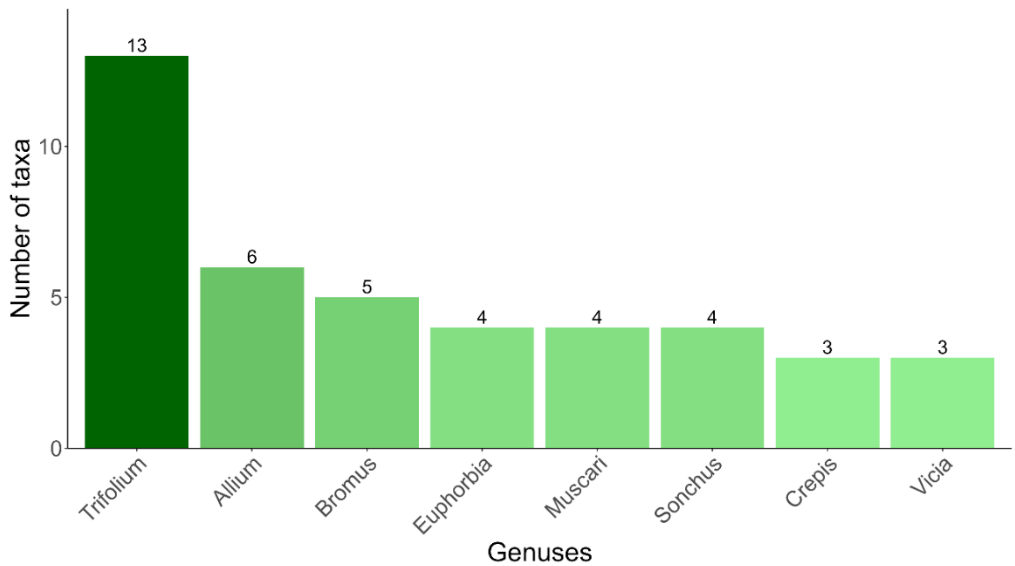

Figure 2. *Taxonomic richness of the eight most species-rich genera in the first-year post-fire plant community*

We recorded a wide range of growth forms, including trees, large shrubs, shrubs, subshrubs, lianas, annual and perennial forbs and graminoids, geophytes, holoparasites, biennials, and variable forbs (*Fig. 3*). Of the 233 taxa, annual forbs were most frequent (36.9% of all taxa), followed by geophytes (12.9%), perennial forbs (12.4%), annual graminoids (7.3%), subshrubs (6.9%), large shrubs (5.6%), perennial graminoids (4.3%), and shrubs (4.3%) (*Fig. 3*). When growth forms are classified into structural categories, the flora comprised 184 herbaceous taxa, and 49 woody taxa (*Table 1*). It was observed that the vast majority of the germinated species were annual forbs, perennial forbs, and annual graminoid taxa. This finding was recorded as 88.3% of the total number of

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germinated species (*Fig. 3*). In contrast, geophytes (100%), large shrubs (92%), subshrubs (81%), lianas (100%), perennial graminoids (90%), shrubs (70%), perennial grasses (38%) and two tree species were found to persist in the study area by resprouting (*Fig. 3*). Overall, most herbaceous taxa persisted through post-fire germination (71.2%), whereas most woody taxa persisted via resprouting (75.5%), indicating survival at the individual or population level (*Fig. 3*).

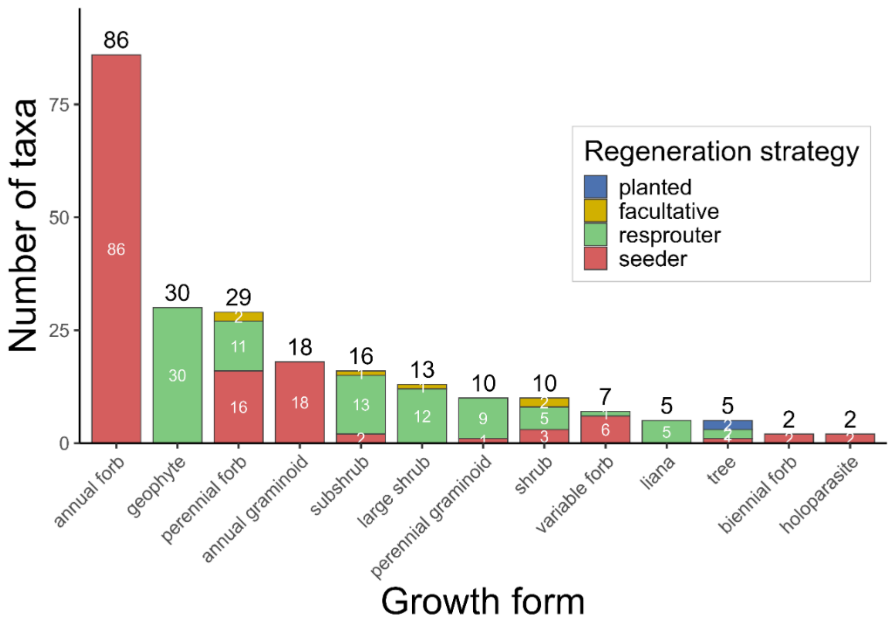

Figure 3. *Taxon richness across growth forms and post-fire regeneration strategies in the first year after fire*

Phytogeographic was assigned based on each taxon's distribution limits. Taxa were classified into the following phytogeographic groups: Eastern Mediterranean, Mediterranean, Irano–Turanian, Euro–Siberian, Mediterranean + others, cosmopolitan, and introduced (*Table 1*). A total of 49 taxa were restricted to the Eastern Mediterranean endemics, of which 12 taxa were determined to be local endemics in southwestern Anatolia. The endemic taxa of southwestern Anatolia comprised *Fritillaria mughlae* Teksen and Aytaç, *Eryngium thorifolium* Boiss., *Leopoldia buseana* Yıldırım, *Cytisopsis pseudocytisus* subsp. *reeseana* (Guyot) Lassen, *Clypeola ciliata* Boiss., *Liquidambar orientalis* Mill., *İberis carica* Bornm., *Sideritis leptoclada* O. Schwarz and P. H. Davis, *Verbascum lydium* Boiss., *Thliphthisa brevifolia* (Vent.) P. Caputo and Del Guacchio, *Hypericum aviculariifolium* Jaub. and Spach, *Allium sandrasicum* Kollmann, Özhatay and Bothmer. Apart from these species, *Fritillaria bithynica* Baker and *Campanula lyrata* subsp. *lyrata* Lam. taxa, which are endemic to Türkiye and have a distribution range extending beyond southwestern Anatolia, were observed in the study area.

In addition, 67 taxa were distributed across both the Eastern Mediterranean and other parts of the Mediterranean Basin and were therefore assigned to the Mediterranean endemics. The results revealed that approximately half of the recorded flora comprised taxa belonging to the Eastern Mediterranean and Mediterranean elements combined. Beyond the Mediterranean Basin, we recorded Irano–Turanian (seven taxa) and Euro–Siberian (five taxa) elements. A further 44 taxa occurred both within the Mediterranean

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Basin and in other phytogeographic regions and were classified as Mediterranean + others (*Table 1*). Species with very broad distributions and records across multiple global regions were classified as cosmopolitan, comprising 54 taxa. One taxon (*Erigeron canadensis* L.) was considered introduced to Türkiye. In addition to the species mentioned above, the phytogeographic category could not be assigned for six taxa that had been identified only at the genus level. According to the classification made to understand the relationships between the Mediterranean and other phytogeographic regions, the flora comprised 111 taxa classified as Others (taxa occurring beyond the Mediterranean), 116 taxa classified as Mediterranean endemics, and 49 taxa classified as Eastern Mediterranean endemics. Across phytogeographic groups, seeders were more frequent among broadly distributed taxa (Others) than among range-restricted elements. Among the 137 seeder taxa, 61.3% belonged to the Others group and 38.7% to Mediterranean endemics, whereas only 12.4% of seeder taxa were Eastern Mediterranean endemics. Among the 88 resprouter taxa, 34.1% belonged to the Others phytogeographic group, whereas 65.9% were classified as Mediterranean endemics; in addition, 34.1% of resprouters were Eastern Mediterranean elements (*Table 1; Fig. 4*).

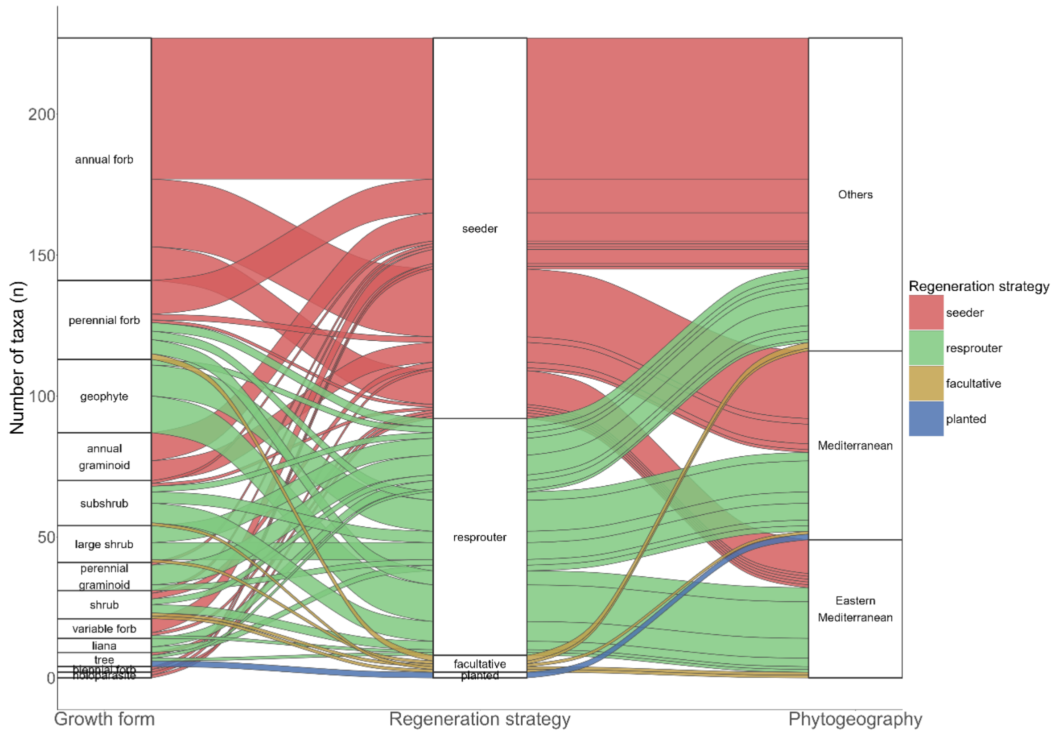

Figure 4. *Joint distribution of first-year post-fire taxa by growth form, regeneration strategy, and phytogeographic origin. Alluvial diagram summarizing the joint distribution of recorded plant taxa across three categorical dimensions: growth form (left axis), post-fire regeneration strategy (center axis; seeder, resprouter, facultative, planted), and phytogeographic affinity (right axis; Eastern Mediterranean, Mediterranean, Others). The height of each stratum represents taxon richness (number of taxa) within that category, and the width of each flow corresponds to the number of taxa shared between connected categories*

The resprouter-to-seeder ratio (r/s) varied markedly among phytogeographic groups. Across the entire flora, the r/s ratio was found to be 0.64, but this ratio declined to 0.36 within the Others category. Conversely, it increased to 1.09 within the Mediterranean

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endemics and to 1.76 within the Eastern Mediterranean endemics (*Table 1*). Consistent with these patterns, taxa with more regional distributions were predominantly associated with resprouting-based persistence, whereas taxa with broader distributions were dominated by seed-dependent recruitment. Growth-form groups showed comparable phytogeographic differences. Across all taxa combined, the woody-to-herbaceous ratio (w/h) was 0.27, decreasing to 0.18 in Others, but increasing to 0.38 in Mediterranean endemics and further to 0.44 in Eastern Mediterranean (*Table 1*). Of the 30 geophyte taxa recorded, 24 were distributed in the Mediterranean Basin, including 13 restricted to the Eastern Mediterranean. When woody taxa and geophytes were considered jointly, 61% of the Eastern Mediterranean element (30 taxa) consisted of resprouters, comprising 13 geophytes, 10 subshrubs/shrubs, six perennial forbs, and one tree (*Fig. 4*).

Additionally, we observed specialized resprouting organs provide plant persistence post-fire (*Fig. 5*). Among woody taxa, we observed structures such as lignotubers (e.g. *Erica manipuliflora*) and woody rhizomes (e.g. *Quercus coccifera*). Within herbaceous taxa, we recorded an even broader range of organs, including bulbs (e.g. *Fritillaria mughlae*, *Allium sandrasicum*), corms (e.g. *Crocus pallasii*), rhizomes (e.g. *Iris unguicularis*), and tubers (e.g. *Sonchus bulbosus* subsp. *microcephalus*) (*Fig. 5*).

Figure 5. *Bud-bank (resprouting) organs of representative post-fire taxa recorded in the first year after fire. Photographs illustrate belowground perennating structures supporting post-fire resprouting: (a) Euphorbia apios L. (tuber), (b) Ruscus aculeatus L. (rhizome), (c) Crocus pallasii Goldb. (corm), and d) post-fire flowering of Leopoldia buseana Yıldırım (bulb not shown)*

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Discussion

Our first-year post-fire floristic survey indicates that burned areas supported high species richness and functional diversity, consistent with previous work showing that early post-fire vegetation in Mediterranean-type ecosystems can support substantial plant diversity (Keeley et al., 2005; Pausas and Ribeiro, 2017). In this study, the presence of 233 taxa in a narrow area of 6 ha across 24 study sites of 0.25 ha each is local post-fire richness within our sampled *Pinus brutia* landscape, consistent with the high diversity typical of Mediterranean floras. The distribution of this richness across 52 families further suggests that post-fire communities in these forests encompass considerable phylogenetic breadth and associated functional variation. Patterns in family representation were also consistent with established post-fire floristic trends in the Mediterranean Basin. In particular, Fabaceae is frequently reported as highly represented in post-fire communities (Ergan, 2017; Kazanis et al., 2024), and our finding that Fabaceae was the most taxon-rich family mirrors earlier regional studies (Arianoutsou and Thanos, 1996; Kavgacı et al., 2010). Beyond Fabaceae, families commonly abundant after fire—including Asteraceae, Poaceae, and Lamiaceae—were also among the most species-rich in our dataset (Fidelis and Zirondi, 2021; Kazanis et al., 2024). Most taxa within these families were recorded as annual seeders, consistent with the widespread dominance of seed-recruiting annual forbs and graminoids during the early post-fire stage in Mediterranean ecosystems (Kavgacı et al., 2010; Ergan, 2017). Accordingly, in the 2021 Marmaris mega-fire area, we observed particularly high representation of annual herbaceous and annual graminoid taxa. The prominence of annual seeders may be associated with the strong role of fire-stimulated recruitment from persistent propagule banks. Annuals are well known to exploit post-fire resource pulses and open microsites, with germination stimulated by heat- and smoke-related cues (Moreira et al., 2010). More broadly, many taxa in Mediterranean-type ecosystems possess traits that provide persistence under recurrent fire through survival and regeneration at the individual or population level. In our study, we observed multiple regeneration strategies consistent with this framework, including persistence via the soil and canopy seed bank, post-fire germination, and post-fire resprouting supported by protected bud banks (Keeley and Pausas, 2022).

Shrubland is a defining feature of Mediterranean-type ecosystems, and multiple studies have documented the capacity of diverse shrub growth forms to persist after fire via resprouting and to rapidly occupy substantial space during early post-fire succession (Saura-Mas and Lloret, 2007; Vilà-Cabrera et al., 2008). Consistent with this pattern, we found that 30 woody taxa spanning subshrub, shrub, and large-shrub growth forms resprouted within our plots. This result in our plots is consistent with the prevalence and diversity of shrub-dominated vegetation in Mediterranean post-fire communities (Keeley et al., 2011). Geophytes represented another growth-form group with particularly strong resprouting capacity in our survey in which all geophyte taxa (100%) were observed as resprouters. In addition to resprouting, Mediterranean endemic geophytes are known to exhibit fire-stimulated flowering (Beck et al., 2024). Evidence from Mediterranean ecosystems indicates that chemicals derived from post-fire ash and charred materials can trigger both sprouting and flowering in geophytes (Lamont and Downes, 2011). We especially observed many flowering geophytes in the first autumn and spring after the fire. Field surveys revealed numerous flowering individuals of several geophyte species, specifically *Gladiolus illyricus*, *Allium stamineum*, and the endemic *Leopoldia buseana* (pers. obs., *Fig 5*).

Belowground organs not only contain dormant buds enabling post-disturbance resprouting, but also store and supply key resources, including nutrients, water, and

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carbon reserves (Pausas et al., 2017). Owing to the protective insulation provided by the soil (Auld and Bradstock, 1996), these organs and associated tissues can escape lethal heating during fire, allowing rapid shoot production from surviving buds. Consistent with this mechanism, the phytogeographic pattern in regeneration strategies indicated a progressive increase in the resprouter-to-seeder ratio (r/s) from all taxa (0.64) to Eastern Mediterranean elements (1.76). This finding suggests that more regionally restricted taxa were associated with resprouting-based persistence. A wide diversity of specialized resprouting organs allow plant persistence under recurrent disturbance in Mediterranean ecosystems, such as wildfire (Pausas et al., 2017). In this study, we observed that numerous specialized organs, such as lignotuber and woody rhizome in woody taxa, and bulb, corm, rhizome and tuber in herbaceous taxa, particularly geophytes. Buried bud banks promote persistence in fire-prone ecosystems by insulating meristems from lethal heating, thereby enabling post-fire resprouting. Plants exhibit diverse bud-bearing resprouting organs that differ in morphology, anatomy, and evolutionary origin (Pausas et al., 2017). Finally, the occurrence of additional resprouting organs described from other fire-prone biomes in recent years (e.g. xylopodia in the Cerrado) highlight the need to test whether analogous structures or functional equivalents occur in Eastern Mediterranean floras (Bombo et al., 2024).

Our field surveys, together with previous work from the region, indicate that fire-stimulated germination enables many annual and perennial taxa to occur abundantly during the first post-fire year (Ergan, 2017; Kavgacı et al., 2010). Germination is commonly triggered by disruption of physical and/or physiological dormancy through heat shock and smoke-related chemical cues (Baskin and Baskin, 2014). This mechanism is especially important in families exhibiting physical dormancy associated with hard, water-impermeable seed coats, such as Fabaceae and Cistaceae, where heat shock can break dormancy and promote recruitment following fire (Ergan, 2017; Luna et al., 2019). In our dataset, 28 Fabaceae taxa were classified as seeders, and four Cistaceae taxa were also recorded as seeders. Among these, *Cistus creticus* and *Cistus salviifolius* are well known as frequent components of post-fire communities in southwestern Anatolia (Tavşanoğlu and Gürkan, 2005; Ergan, 2017), and their germination has been documented to increase following heat shock (Thanos and Georghiou, 1988; Tavşanoğlu, 2011; Kazancı and Tavşanoğlu, 2019). In addition, families that were highly represented in our surveys —particularly Asteraceae, Poaceae, and Lamiaceae— include taxa whose germination can be stimulated by smoke and smoke-derived compounds such as karrikins and cyanohydrin (Ergan, 2017; Çatav et al., 2018; Tavşanoğlu and Pausas, 2018). For example, several Lamiaceae taxa distributed in southwestern Anatolia exhibit increased germination under aqueous smoke treatments across a range of concentrations (Çatav et al., 2014). These physical and chemical fire-related mechanisms are thought to promote high post-fire recruitment and thereby generate dense first-year populations in Mediterranean floras (Lamont and Downes, 2011). Taken together, these processes support the view that first-year post-fire vegetation can harbor distinctive taxonomic, functional, and phylogenetic diversity, underscoring the need for multidimensional assessments of post-fire communities.

Our inference is constrained by the absence of pre-fire vegetation data and the lack of paired unburned reference plots, which limits our ability to evaluate fire effect. In addition, because the first post-fire year often represents a period of peak floristic expression, our inventory captures a temporally narrow window of community development and may over-represent annual of the flora. Accordingly, the patterns

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reported here should be interpreted as a descriptive first-year baseline, and longer-term monitoring and reference-based comparisons will be needed to evaluate persistence and successional trajectories.

Anthropogenic climate change, demographic shifts, and forest management policies are dramatically altering fire regimes (Pausas and Fernández-Muñoz, 2012; Moreira et al., 2020; Ellis et al., 2022), leading an increase in the frequency and intensity of megafires across many ecosystems. Under fire regime characterized by increasing fire frequency and more drought-prone conditions, understanding how the balance between resprouting and seed-based recruitment shifts in lowland Mediterranean plant communities is an increasingly important research priority (Moreira et al., 2020). Species richness is widely used as a biodiversity-based indicator of post-fire recovery and resilience, and has been explicitly included among bio-indicators applied to evaluate post-fire resilience in Mediterranean pine forests across fire-severity gradients (González-De Vega et al., 2016), although richness alone does not capture all dimensions of recovery. Because the process of recovery via resprouting or germination can respond differently to fire severity therefore variation in fire severity can generate altering post-fire vegetation structures (Maia et al., 2012; Crotteau et al., 2013). Moreover, pre-fire floristic composition and vegetation structure can influence fire severity and thereby modify post-fire recovery pathways (Lee et al., 2014). Furthermore, fires of varying severity can lead to the formation of heterogeneous habitat mosaics (Laterza et al., 2026). Post-fire restoration may activities influence the composition of first-year vegetation and local floristic patterns, highlighting the need for targeted studies that explicitly evaluate restoration effects in fire-prone Mediterranean forests (Tavşanoğlu and Pausas, 2022). However, we recommend that post-fire restoration treatments be planned and implemented to align with the regeneration strategies documented in our surveys and the dominant natural recovery pathways of the local flora. In the context of coupled changes in fire regimes and vegetation dynamics, first-year post-fire vegetation surveys are becoming increasingly critical for the prediction of future vegetation trajectories.

Conclusion

Our study provides the considerable post-fire plant diversity of recently burned *Pinus brutia* forests and reveals the contribution of multiple taxonomic and functional groups to early post-fire recovery. Using repeated botanical surveys across 24 permanent plots following the 2021 Marmaris megafire, we provide a first-year baseline of post-fire plant community composition in burned *Pinus brutia* forests of southwestern Anatolia. The recorded flora was taxonomically diverse and encompassed multiple growth forms and post-fire regeneration strategies, including both resprouting and seed-based recruitment. By documenting how regeneration modes and growth-form structure are distributed across taxa and phytogeographic elements, our study contributes empirical reference data for interpreting early post-fire community reassembly in this fire-prone region. Future studies in *Pinus brutia* forests should focus on the first post-fire year, as this period appears to be critical for understanding early post-fire regeneration dynamics.

Author contributions. G.E. and Ç.T. conceived the study; G.E. and Ç.T. designed the sampling framework and field protocol; G.E. and G.Z. conducted the field surveys and compiled the dataset; G.Z. identified and verified plant taxa; G.E. wrote the first draft of the manuscript; all authors contributed to data interpretation, revised the manuscript critically for intellectual content, and approved the final version.

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APPENDIX

Table A1. *List of plant taxa recorded in the first post-fire year, including family, growth form, post-fire regeneration strategy, and phytogeographic distribution*

Family	Taxon	Growth form	Regenera. strategy	Phytogeography
Altingiaceae	*Liquidambar orientalis* Mill.	Tree	Resprouter	Eastern Mediterranean
Amaranthaceae	*Amaranthus retroflexus* L.	Annual forb	Seeder	Cosmopolit
Amaranthaceae	*Chenopodium album* L.	Annual forb	Seeder	Cosmopolit
Amaryllidaceae	*Allium fuscum* Waldst. & Kit.	Geophyte	Resprouter	Eastern Mediterranean
Amaryllidaceae	*Allium nigrum* L.	Geophyte	Resprouter	Mediterranean
Amaryllidaceae	*Allium sandrasicum* Kollmann, Özhatay & Bothmer	Geophyte	Resprouter	Eastern Mediterranean
Amaryllidaceae	*Allium* sp.1	Geophyte	Resprouter	NA
Amaryllidaceae	*Allium* sp.2	Geophyte	Resprouter	NA
Amaryllidaceae	*Allium stamineum* Boiss.	Geophyte	Resprouter	Mediterranean
Amaryllidaceae	*Narcissus serotinus* L.	Geophyte	Resprouter	Mediterranean
Anacardiaceae	*Pistacia lentiscus* L.	Large shrub	Resprouter	Mediterranean
Anacardiaceae	*Pistacia terebinthus* L.	Large shrub	Resprouter	Mediterranean
Anacardiaceae	*Rhus coriaria* L.	Large shrub	Resprouter	Cosmopolit
Apiaceae	*Bupleurum gracile* d'Urv.	Annual forb	Seeder	Eastern Mediterranean
Apiaceae	*Daucus guttatus* Sibth. & Sm.	Annual forb	Seeder	Mediterranean + other
Apiaceae	*Eryngium thorifolium* Boiss.	Perennial forb	Resprouter	Eastern Mediterranean
Apiaceae	*Scandix australis* L. subsp. *grandiflora* (L.) Thell.	Annual forb	Seeder	Cosmopolit
Apiaceae	*Turgenia latifolia* (L.) Hoffm.	Annual forb	Seeder	Mediterranean + other
Apocynaceae	*Nerium oleander* L.	Large shrub	Facultative	Cosmopolit
Araceae	*Arisarum vulgare* Targ.-Tozz. subsp. *vulgare* Targ.-Tozz.	Geophyte	Resprouter	Mediterranean
Araliaceae	*Hedera helix* L.	Liana	Resprouter	Cosmopolit
Aristolochiaceae	*Aristolochio guichardii* Davis & Khan	Geophyte	Resprouter	Eastern Mediterranean
Asparagaceae	*Asparagus aphyllus* L. subsp. *orientalis* (Baker.) P.H.Davis	Liana	Resprouter	Mediterranean
Asparagaceae	*Drimia maritima* (L.) Stearn	Geophyte	Resprouter	Mediterranean
Asparagaceae	*Leopoldia buseana* Yıldırım	Geophyte	Resprouter	Eastern Mediterranean
Asparagaceae	*Muscari comosum* (L.) Mill.	Geophyte	Resprouter	Mediterranean + other
Asparagaceae	*Muscari macrocarpum* Sweet	Geophyte	Resprouter	Eastern Mediterranean
Asparagaceae	*Muscari* sp. 1	Geophyte	Resprouter	NA
Asparagaceae	*Muscari* sp.2	Geophyte	Resprouter	NA
Asparagaceae	*Ruscus aculeatus* L.	Subshrub	Resprouter	Mediterranean + other
Asteraceae	*Anthemis chia* L.	Annual forb	Seeder	Eastern Mediterranean
Asteraceae	*Anthemis cretica* L.	Perennial forb	Seeder	Mediterranean + other
Asteraceae	*Bellis sylvestris* Cirillo	Perennial forb	Seeder	Mediterranean
Asteraceae	*Centaurea urvillei* DC. subsp. *urvillei* DC.	Perennial forb	Resprouter	Eastern Mediterranean
Asteraceae	*Centaurea virgata* Lam.	Perennial forb	Resprouter	Irano-Turanian

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Family	Taxon	Growth form	Regenera. strategy	Phytogeography
Asteraceae	*Crepis foetida* L.	Annual forb	Seeder	Mediterranean + other
Asteraceae	*Crepis sancta* (L.) Bornm.	Annual forb	Seeder	Mediterranean + other
Asteraceae	*Crepis setosa* Haller f.	Annual forb	Seeder	Euro-Siberian
Asteraceae	*Dittrichia viscosa* (L.) Greuter	Subshrub	Resprouter	Mediterranean
Asteraceae	*Echinops spinosissimus* subsp. *bithynicus* (Boiss.) Greuter	Perennial forb	Seeder	Mediterranean + other
Asteraceae	*Erigeron canadensis* L.	Annual forb	Seeder	Introduced
Asteraceae	*Filago eriocephala* Guss.	Annual forb	Seeder	Eastern Mediterranean
Asteraceae	*Helichrysum orientale* (L.) Gaertn.	Subshrub	Resprouter	Mediterranean
Asteraceae	*Hypochaeris achyrophorus* L.	Annual forb	Seeder	Mediterranean
Asteraceae	*Jurinea mollis* (L.) Rchb.	Perennial forb	Seeder	Mediterranean + other
Asteraceae	*Lactuca serriola* L.	Biennial forb	Seeder	Cosmopolit
Asteraceae	*Lapsana communis* L.	Variable forb	Seeder	Cosmopolit
Asteraceae	*Leontodon tuberosus* L.	Perennial forb	Resprouter	Mediterranean
Asteraceae	*Logfia gallica* (L.) Coss. & Germ.	Annual forb	Seeder	Mediterranean + other
Asteraceae	*Picnomon acarna* (L.) Cass.	Annual forb	Seeder	Mediterranean
Asteraceae	*Pilosella piloselloides* (Vill.) Sojâk	Perennial forb	Seeder	Mediterranean + other
Asteraceae	*Ptilostemon chamaepeuce* (L.) Less.	Shrub	Resprouter	Eastern Mediterranean
Asteraceae	*Scorzonera elata* Boiss.	Perennial forb	Resprouter	Eastern Mediterranean
Asteraceae	*Senecio vulgaris* L.	Annual forb	Seeder	Cosmopolit
Asteraceae	*Sonchus asper* (L.) Hill	Annual forb	Seeder	Cosmopolit
Asteraceae	*Sonchus asper* subsp. *glaucescens* (Jord.) Ball	Variable forb	Seeder	Cosmopolit
Asteraceae	*Sonchus bulbosus* subsp. *microcephalus* (Rech.f.) N.Kilian & Greuter	Geophyte	Resprouter	Eastern Mediterranean
Asteraceae	*Sonchus oleraceus* L.	Variable forb	Seeder	Cosmopolit
Asteraceae	*Taraxacum serotinum* (Waldst. & Kit.) Poir.	Perennial forb	Seeder	Mediterranean + other
Asteraceae	*Urospermum picroides* (L.) Scop. ex F.W.Schmidt	Annual forb	Seeder	Mediterranean + other
Boraginaceae	*Alkanna tinctoria* (L.) Tausch subsp. *tinctoria*	Perennial forb	Seeder	Mediterranean
Boraginaceae	*Echium angustifolium* Mill.	Perennial forb	Seeder	Eastern Mediterranean
Boraginaceae	*Myosotis cadmea* Boiss.	Annual forb	Seeder	Mediterranean
Brassicaceae	*Biscutella didyma* L.	Annual forb	Seeder	Mediterranean + other
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	Annual forb	Seeder	Cosmopolit
Brassicaceae	*Cardamine hirsuta* L.	Annual forb	Seeder	Cosmopolit
Brassicaceae	*Clypeola ciliata* Boiss.	Annual forb	Seeder	Eastern Mediterranean
Brassicaceae	*Draba verna* L.	Annual forb	Seeder	Cosmopolit
Brassicaceae	*Erysimum smyrnaeum* Boiss. & Balansa	Variable forb	Seeder	Eastern Mediterranean
Brassicaceae	*Isatis lusitanica* L.	Annual forb	Seeder	Mediterranean + other
Brassicaceae	*İberis carica* Bornm.	Annual forb	Seeder	Eastern Mediterranean
Brassicaceae	*Malcolmia chia* (L.) DC.	Annual forb	Seeder	Eastern Mediterranean
Brassicaceae	*Odontarrhena corsica* (Duby) Španiel, Al-Shehbaz, D.A.German & Marhold	Subshrub	Resprouter	Eastern Mediterranean
Brassicaceae	*Sisymbrium officinale* (L.) Scop.	Annual forb	Seeder	Cosmopolit
Campanulaceae	*Asyneuma limonifolium* (L.) Janchen subsp. *limonifolium* (L.) Janchen	Perennial forb	Resprouter	Mediterranean
Campanulaceae	*Campanula delicatula* Boiss.	Annual forb	Seeder	Eastern Mediterranean
Campanulaceae	*Campanula lyrata* subsp. *lyrata* Lam.	Variable forb	Resprouter	Eastern Mediterranean
Campanulaceae	*Legousia pentagonia* (L.) Thell.	Annual forb	Seeder	Mediterranean + other
Capparaceae	*Capparis spinosa* L.	Shrub	Resprouter	Cosmopolit
Caprifoliaceae	*Scabiosa sicula* L.	Annual forb	Seeder	Eastern Mediterranean
Caprifoliaceae	*Valerianella echinata* (L.) DC.	Annual forb	Seeder	Mediterranean
Caryophyllaceae	*Cerastium pumilum* Curtis	Annual forb	Seeder	Cosmopolit
Caryophyllaceae	*Minuartia hybrida* subsp. *hybrida* (Vill.) Schischk.	Annual forb	Seeder	Mediterranean
Caryophyllaceae	*Polycarpon tetraphyllum* (L.) L.	Annual forb	Seeder	Cosmopolit
Caryophyllaceae	*Silene gallica* L.	Annual forb	Seeder	Cosmopolit
Caryophyllaceae	*Stellaria media* (L.) Vill.	Annual forb	Seeder	Cosmopolit
Cistaceae	*Cistus creticus* L.	Shrub	Seeder	Mediterranean
Cistaceae	*Cistus salviifolius* L.	Shrub	Seeder	Mediterranean + other
Cistaceae	*Fumana arabica* (L.) Spach	Subshrub	Seeder	Mediterranean + other
Cistaceae	*Tuberaria guttata* (L.) Fourr.	Annual forb	Seeder	Mediterranean + other
Cupressaceae	*Cupressus sempervirens* L.	Tree	Planted	Mediterranean
Cyperaceae	*Carex flacca* subsp. *erythrostachys* (Hoppe) Holub	Perennial graminoid	Resprouter	Mediterranean
Cyperaceae	*Schoenus nigricans* L.	Perennial graminoid	Resprouter	Cosmopolit
Dioscoreaceae	*Dioscorea communis* (L.) Caddick & Wilkin	Liana	Resprouter	Mediterranean + other

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Dipsacaceae	*Knautia integrifolia* (L.) Bert. subsp. *integrifolia* (L.) Bert	Annual forb	Seeder	Mediterranean
Ephedraceae	*Ephedra foeminea* Forssk.	Large shrub	Resprouter	Mediterranean + other
Ericaceae	*Erica manipuliflora* Salisb	Shrub	Resprouter	Eastern Mediterranean
Euphorbiaceae	*Euphorbia acanthothamnos* Heldr. & Sartori	Subshrub	Resprouter	Eastern Mediterranean
Euphorbiaceae	*Euphorbia apios* L.	Geophyte	Resprouter	Eastern Mediterranean
Euphorbiaceae	*Euphorbia helioscopia* L.	Annual forb	Seeder	Cosmopolit
Euphorbiaceae	*Euphorbia rigida* M.Bieb.	Perennial forb	Resprouter	Mediterranean + other
Fabaceae	*Calicotome villosa* (Poir.) Link	Shrub	Facultative	Mediterranean
Fabaceae	*Ceratonia siliqua* L.	Tree	Planted	Mediterranean
Fabaceae	*Cercis siliquastrum* L.	Tree	Resprouter	Cosmopolit
Fabaceae	*Cytisopsis pseudocytisus* subsp. *reeseana* (Guyot) Lassen	Subshrub	Facultative	Eastern Mediterranean
Fabaceae	*Cytisus eriocarpus* Boiss.	Subshrub	Seeder	Eastern Mediterranean
Fabaceae	*Genista acanthoclada* DC.	Shrub	Facultative	Eastern Mediterranean
Fabaceae	*Hippocrepis unisiliquosa* L. subsp. *unisiliquosa* L.	Annual forb	Seeder	Mediterranean + other
Fabaceae	*Lathyrus setifolius* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Lathyrus sphaericus* Retz.	Annual forb	Seeder	Mediterranean
Fabaceae	*Lotus angustissimus* L.	Annual forb	Seeder	Cosmopolit
Fabaceae	*Lotus edulis* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Lupinus pilosus* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Medicago minima* var. *minima* (L.) Bartal.	Annual forb	Seeder	Cosmopolit
Fabaceae	*Medicago radiata* L.	Annual forb	Seeder	Irano-Turanian
Fabaceae	*Ornithopus compressus* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Scorpiurus muricatus* L.	Annual forb	Seeder	Mediterranean + other
Fabaceae	*Trifolium angustifolium* L.	Annual forb	Seeder	Mediterranean + other
Fabaceae	*Trifolium arvense* L.	Annual forb	Seeder	Cosmopolit
Fabaceae	*Trifolium campestre* Schreb.	Annual forb	Seeder	Cosmopolit
Fabaceae	*Trifolium cherleri* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Trifolium clypeatum* L.	Annual forb	Seeder	Eastern Mediterranean
Fabaceae	*Trifolium grandiflorum* Schreb.	Annual forb	Seeder	Mediterranean + other
Fabaceae	*Trifolium hirtum* All.	Annual forb	Seeder	Mediterranean
Fabaceae	*Trifolium lappaceum* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Trifolium lucanicum* Gasp.	Annual forb	Seeder	Mediterranean
Fabaceae	*Trifolium patens* Schreb.	Annual forb	Seeder	Mediterranean + other
Fabaceae	*Trifolium repens* L.	Perennial forb	Seeder	Cosmopolit
Fabaceae	*Trifolium stellatum* L. var. *stellatum* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Trifolium tomentosum* L.	Annual forb	Seeder	Mediterranean + other
Fabaceae	*Trigonella monspeliaca* L.	Annual forb	Seeder	Mediterranean
Fabaceae	*Vicia cracca* L.	Perennial forb	Seeder	Cosmopolit
Fabaceae	*Vicia hybrida* L.	Annual forb	Seeder	Mediterranean + other
Fabaceae	*Vicia lenticula* (Hoppe) Janka	Annual forb	Seeder	Mediterranean + other
Fagaceae	*Quercus coccifera* L.	Large shrub	Resprouter	Mediterranean
Fagaceae	*Quercus infectoria* Oliv.	Large shrub	Resprouter	Euro-Siberian
Hypericaceae	*Hypericum avicularifolium* Jaub. & Spach	Perennial forb	Resprouter	Eastern Mediterranean
Hypericaceae	*Hypericum empetrifolium* Willd.	Subshrub	Resprouter	Eastern Mediterranean
Iridaceae	*Crocus pallasii* Goldb.	Geophyte	Resprouter	Mediterranean
Iridaceae	*Gladiolus anatolicus* (Boiss.) Stapf	Geophyte	Resprouter	Eastern Mediterranean
Iridaceae	*Gladiolus illyricus* W.D.J.Koch	Geophyte	Resprouter	Mediterranean
Iridaceae	*Iris unguicularis* Poir.	Geophyte	Resprouter	Mediterranean
Iridaceae	*Romulea tempskyana* Freyn	Geophyte	Resprouter	Eastern Mediterranean
Lamiaceae	*Ajuga orientalis* L.	Perennial forb	Seeder	Mediterranean + other
Lamiaceae	*Lamium amplexicaule* L.	Annual forb	Seeder	Cosmopolit
Lamiaceae	*Lavandula stoechas* L. subsp. *stoechas*	Subshrub	Resprouter	Mediterranean
Lamiaceae	*Origanum onites* L.	Subshrub	Resprouter	Eastern Mediterranean
Lamiaceae	*Phlomis lycia* D.Don	Shrub	Resprouter	Eastern Mediterranean
Lamiaceae	*Salvia rosmarinus* Spenn.	Shrub	Seeder	Mediterranean
Lamiaceae	*Salvia viridis* L.	Annual forb	Seeder	Mediterranean
Lamiaceae	*Satureja thymbra* L.	Subshrub	Resprouter	Eastern Mediterranean
Lamiaceae	*Sideritis leptoclada* O.Schwarz & P.H.Davis	Perennial forb	Resprouter	Eastern Mediterranean
Lamiaceae	*Teucrium chamaedrys* L.	Subshrub	Resprouter	Mediterranean + other
Lamiaceae	*Teucrium polium* L.	Subshrub	Resprouter	Mediterranean
Lamiaceae	*Vitex agnus-castus* L.	Large shrub	Resprouter	Cosmopolit
Liliaceae	*Fritillaria bithynica* Baker	Geophyte	Resprouter	Eastern Mediterranean
Liliaceae	*Fritillaria mughlae* Teksen & Aytaç	Geophyte	Resprouter	Eastern Mediterranean
Liliaceae	*Gagea graeca* (L.) Irmsch.	Geophyte	Resprouter	Eastern Mediterranean

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Liliaceae	*Gagea peduncularis* (C.Presl) Pascher	Geophyte	Resprouter	Mediterranean
Liliaceae	*Tulipa orphanidea* Boiss. ex Heldr.	Geophyte	Resprouter	Eastern Mediterranean
Liliaceae	*Tulipa undulatifolia* Boiss.	Geophyte	Resprouter	Mediterranean + other
Linaceae	*Linum trigynum* L.	Annual forb	Seeder	Cosmopolit
Linaceae	*Linum virgultorum* Boiss. & Heldr. ex Planch.	Annual forb	Seeder	Eastern Mediterranean
Malvaceae	*Alcea biennis* Winterl	Perennial forb	Seeder	Mediterranean + other
Malvaceae	*Malva cretica* Cav.	Annual forb	Seeder	Mediterranean
Myrtaceae	*Myrtus communis* L.	Large shrub	Resprouter	Cosmopolit
Oleaceae	*Phillyrea latifolia* L.	Large shrub	Resprouter	Mediterranean
Orchidaceae	*Serapias vomeracea* (Burm.f.) Briq.	Geophyte	Resprouter	Mediterranean
Orobanchaceae	*Orobanche minor* Sm.	Holoparasite	Seeder	Cosmopolit
Orobanchaceae	*Orobanche pubescens* d'Urv.	Holoparasite	Seeder	Mediterranean
Papaveraceae	*Fumaria judaica* Boiss.	Annual forb	Seeder	Eastern Mediterranean
Papaveraceae	*Fumaria petteri* Reichb.	Annual forb	Seeder	Eastern Mediterranean
Papaveraceae	*Roemeria argemone* (L.) C.Morales, R.Mend. & Romero García	Annual forb	Seeder	Mediterranean + other
Pinaceae	*Pinus brutia* Ten.	Tree	Seeder	Eastern Mediterranean
Plantaginaceae	*Linaria chalepensis* (L.) Mill.	Annual forb	Seeder	Mediterranean + other
Plantaginaceae	*Linaria pelisseriana* (L.) Mill.	Annual forb	Seeder	Mediterranean
Plantaginaceae	*Misopates orontium* (L.) Raf.	Annual forb	Seeder	Irano-Turanian
Plantaginaceae	*Plantago bellardii* All.	Annual forb	Seeder	Mediterranean + other
Plantaginaceae	*Plantago coronopus* L.	Variable forb	Seeder	Cosmopolit
Poaceae	*Aegilops umbellulata* Zhuk.	Annual graminoid	Seeder	Irano-Turanian
Poaceae	*Aira elegantissima* Schur	Annual graminoid	Seeder	Cosmopolit
Poaceae	*Andropogon distachyos* L.	Perennial graminoid	Seeder	Mediterranean + other
Poaceae	*Avena barbata* subsp. *barbata* Pott ex Link	Annual graminoid	Seeder	Mediterranean
Poaceae	*Brachypodium distachyon* (L.) P.Beauv.	Annual graminoid	Seeder	Mediterranean
Poaceae	*Brachypodium pinnatum* (L.) P. Beauv.	Perennial graminoid	Resprouter	Euro-Siberian
Poaceae	*Briza maxima* L.	Annual graminoid	Seeder	Cosmopolit
Poaceae	*Bromus fasciculatus* C.Presl	Annual graminoid	Seeder	Mediterranean
Poaceae	*Bromus madritensis* L.	Annual graminoid	Seeder	Mediterranean + other
Poaceae	*Bromus scoparius* L.	Annual graminoid	Seeder	Mediterranean + other
Poaceae	*Bromus* sp. 1	Annual graminoid	Seeder	NA
Poaceae	*Bromus tectorum* L.	Annual graminoid	Seeder	Cosmopolit
Poaceae	*Catapodium rigidum* (L.) C.E.Hubb.	Annual graminoid	Seeder	Cosmopolit
Poaceae	*Chrysopogon gryllus* (L.) Trin.	Perennial graminoid	Resprouter	Mediterranean + other
Poaceae	*Cynosurus echinatus* L.	Annual graminoid	Seeder	Mediterranean
Poaceae	*Dactylis glomerata* L. subsp. *hispanica* (Roth) Nyman	Perennial graminoid	Resprouter	Mediterranean + other
Poaceae	*Festuca salzmannii* (Boiss.) Boiss. ex Coss.	Annual graminoid	Seeder	Mediterranean
Poaceae	*Gastridium phleoides* (Nees & Meyen) C.E.Hubb.	Annual graminoid	Seeder	Mediterranean
Poaceae	*Hordeum murinum* subsp. *leporinum* (Link) Arcang.	Annual graminoid	Seeder	Cosmopolit
Poaceae	*Milium vernale* M.Bieb. subsp. v*ernale*	Annual graminoid	Seeder	Mediterranean + other
Poaceae	*Nardus stricta* L.	Perennial graminoid	Resprouter	Euro-Siberian
Poaceae	*Oloptum thomasii* (Duby) Banfi & Galasso	Perennial graminoid	Resprouter	Mediterranean
Poaceae	*Phalaris brachystachys* Link	Annual graminoid	Seeder	Mediterranean
Poaceae	*Poa annua* L.	Annual graminoid	Seeder	Cosmopolit
Poaceae	*Poa bulbosa* L.	Perennial graminoid	Resprouter	Cosmopolit
Poaceae	*Stipa holosericea* Trin.	Perennial graminoid	Resprouter	Irano-Turanian
Polygonaceae	*Polygonum arenastrum* Bor.	Annual forb	Seeder	Cosmopolit
Polygonaceae	*Polygonum cognatum* Meissn.	Perennial forb	Seeder	Irano-Turanian
Primulaceae	*Anagallis arvensis* L.	Variable forb	Seeder	Cosmopolit
Primulaceae	*Lysimachia linum-stellatum* L.	Annual forb	Seeder	Mediterranean
Rosaceae	*Cotoneaster nummularius* Fisch. & C.A.Mey.	Shrub	Resprouter	Cosmopolit
Rosaceae	*Crataegus monogyna* Jacq.	Large shrub	Resprouter	Cosmopolit
Rosaceae	*Sanguisorba minor* Scop. subsp. *minor*	Perennial forb	Facultative	Cosmopolit
Rosaceae	*Sarcopoterium spinosum* (L.) Spach	Subshrub	Resprouter	Eastern Mediterranean
Rubiaceae	*Callipeltis aperta* Boiss. & Buhse	Annual forb	Seeder	Mediterranean + other
Rubiaceae	*Crucianella latifolia* L.	Annual forb	Seeder	Mediterranean
Rubiaceae	*Cruciata taurica* (Pall. ex Willd.) Ehrend.	Perennial forb	Seeder	Irano-Turanian
Rubiaceae	*Galium murale* (L.) All.	Annual forb	Seeder	Mediterranean + other
Rubiaceae	*Galium setaceum* Lam.	Annual forb	Seeder	Cosmopolit
Rubiaceae	*Rubia tenuifolia* d'Urv.	Liana	Resprouter	Mediterranean
Rubiaceae	*Sherardia arvensis* L.	Annual forb	Seeder	Cosmopolit

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Family	**Taxon**	**Growth form**	**Regenera. strategy**	**Phytogeography**
Rubiaceae	*Thliphthisa brevifolia* (Vent.) P.Caputo & Del Guacchio	Subshrub	Resprouter	Eastern Mediterranean
Santalaceae	*Osyris alba* L.	Large shrub	Resprouter	Mediterranean
Santalaceae	*Thesium procumbens* C.A.Mey.	Perennial forb	Seeder	Cosmopolit
Scrophulariaceae	*Scrophularia lucida* L.	Perennial forb	Resprouter	Mediterranean
Scrophulariaceae	*Scrophularia peregrina* L.	Annual forb	Seeder	Mediterranean
Scrophulariaceae	*Verbascum lydium* Boiss.	Biennial forb	Seeder	Eastern Mediterranean
Scrophulariaceae	*Verbascum sp.*	Perennial forb	Seeder	NA
Scrophulariaceae	*Veronica cymbalaria* Bodard	Annual forb	Seeder	Mediterranean
Smilacaceae	*Smilax aspera* L.	Liana	Resprouter	Cosmopolit
Solanaecae	*Vincetoxicum fuscatum* subsp. *fuscatum* Rchb.f.	Perennial forb	Resprouter	Euro-Siberian
Styracaceae	*Styrax officinalis* L.	Large shrub	Resprouter	Mediterranean
Verbenaceae	*Verbena officinalis* L.	Perennial forb	Facultative	Cosmopolit
Xanthorrhoeaceae	*Asphodelus aestivus* Brot.	Geophyte	Resprouter	Mediterranean

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