

## **Increasing species richness masks contrasting community dynamics in Mediterranean coastal dunes: a long-term vegetation resurvey**

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### **Abstract**

1. Mediterranean coastal dunes have undergone substantial transformations over the last 70 years due to increasing anthropogenic pressure and environmental change. However, most studies on dune vegetation dynamics have been conducted at local scales or as one-off sampling events, limiting our understanding of long-term plant diversity trends across broader regions.
2. Here, we present the first national-scale assessment of long-term vegetation changes in Italian coastal dunes, based on ReSurveyDunes, a collaborative resurvey initiative. We analysed 519 vegetation plots originally surveyed several decades ago and resampled in 2023–2024 along the entire Italian coastline. We quantified temporal changes in species richness and community composition across three key dune habitats (upper beach, shifting dunes, and dune grasslands), with a focus on different ecological groups, and assessed habitat transitions over time.
3. Species richness increased across all habitats. However, this trend masked a marked decline of habitat-specialist psammophilous species, particularly in early-successional habitats. Upper beach and shifting dunes showed strong reductions in occurrence and cover of typical species, accompanied by increases in ruderal taxa and species typical of more stabilised or inland habitats. These patterns indicate a redistribution of species along the coastal zonation gradient. Accordingly, nearly one-third of plots changed EUNIS habitat type or disappeared, revealing the coexistence of inland-directed succession and stabilisation with localised degradation and habitat loss, especially in foredune habitats.
4. Our results show that apparent increases in species richness can conceal profound compositional and habitat-level changes. This highlights the importance of long-term, large-scale resurveys and of

complementing richness-based metrics with compositional and habitat-level indicators when evaluating vegetation changes in dynamic coastal dune ecosystems.

**Keywords:** coastal dune vegetation; diachronic analysis; habitat transitions; long-term change; Mediterranean; species richness; vegetation resurvey.

## ***Introduction***

European coastal dune habitats are currently in a critically poor conservation status, particularly in the Mediterranean (EEA, 2020; Heslenfeld et al., 2008; Janssen et al., 2016). This severe condition, which is consistent across biogeographical regions, is particularly alarming because dune habitats provide essential ecosystem services (Drius et al., 2019; Everard et al., 2010). Major threats arise from increasing human pressures, including overtourism, urban and agricultural expansion, industrial and harbour development (Schlacher et al., 2007), as well as from the spread of non-native and ruderal species (Gao et al., 2020; Géhu & Biondi, 1994). These pressures are widespread along European coasts (EEA, 2020; Janssen et al., 2016), and Italy is no exception. Italian coastal dune habitats are currently reported to be in a critically poor conservation status (Ercole et al., 2021), mirroring the general trends observed across the Mediterranean region. The most important pressures affecting Italian coastal dunes are urban and agricultural expansion (Carranza et al., 2020; Malavasi et al., 2013), tourism (Fantinato, 2019; Farris et al., 2013; Fenu et al., 2013), coastal erosion (Antonioli et al., 2017; Bazzichetto et al., 2020; Ciccarelli, 2014), and biological invasions (Carboni et al., 2010; de Francesco et al., 2023; Giulio et al., 2020; Marzialetti et al., 2025).

Temporal changes in Mediterranean coastal dune ecosystems have been investigated using various approaches, including remote-sensing (Bertacchi & Lombardi, 2014; Chelli et al., 2022; Foti et al., 2021; Garcia-Lozano et al., 2018; Šilc et al., 2020), analysis of extensive vegetation data (Prisco, Carboni, et al., 2016; Sperandii et al., 2018), and vegetation resurveys (Ciccarelli et al., 2025; Del Vecchio et al., 2015; Prisco, Carboni, et al., 2016; Sarmati, Sperandii, et al., 2025; Sperandii et al., 2021). Among these, the resurveying approach, consisting of re-sampling of historically surveyed vegetation plots (Kapfer et al., 2017), has proven particularly effective for tracking vegetation change in coastal dunes (Ciccarelli et al., 2025; Del Vecchio et al., 2015; Sperandii et al., 2021). Most resurvey studies conducted so far have consistently highlighted a long-term degradation of coastal dune systems, which has led to the replacement or simplification (homogenisation and loss of diagnostic species) of dune plant communities (Sciandrello et al., 2015; Sperandii et al., 2021), and the decline of key habitat specialists (Sarmati, Sperandii, et al., 2025; Sperandii et al., 2019, 2021).

So far, studies addressing temporal changes in the vegetation of Italian coastal dunes have predominantly focused on small (Ciccarelli et al., 2025; Cini et al., 2025; Del Vecchio et al., 2015; Prisco, Stanisci, et al., 2016; Sarmati, Sperandii, et al., 2025) to medium-size (Prisco, Carboni, et al., 2016; Sperandii et al., 2021) areas. This limitation has hindered national-scale assessments of temporal trends, which are essential for coordinating management and conservation of these threatened ecosystems. In this context, comprehensive and geographically representative databases of repeatedly sampled vegetation plots, such as ReSurveyEurope (Knollová et al., 2024) and LOTVS (Sperandii et al., 2022), represent a valuable, yet largely unexplored, resource for evaluating broad-scale vegetation change. However, coastal dune ecosystems remain underrepresented in such large-scale resurvey syntheses.

Building on ReSurveyDunes (Acosta et al., 2025), a collaborative database of more than 500 resurveyed vegetation plots spanning the entire Italian sandy coastline, we provide the first national-level overview of long-term vegetation changes in Italian coastal dunes. Focusing on herbaceous-chamaephytic coastal dune habitats, we aimed to: (i) analyse temporal trends in species richness and vegetation cover, with particular emphasis on typical, ruderal, and non-native species; (ii) identify the species that most contribute to changes in community composition; and (iii) assess habitat-specific trajectories of change over time.

## Materials and methods

### Study area

Italian dune systems occur along the Tyrrhenian, Adriatic, and Ionian coasts and display considerable geomorphological variability, driven by differences in sediment supply, wind regimes, coastal dynamics, and human activity (Antonioli et al., 2017). The dune systems included in the ReSurveyDunes database (Acosta et al., 2025) and analysed in the present study cover nearly 10% of the Italian sandy coastline (~360 km), spanning 11 administrative regions, two biogeographic regions (Mediterranean and Continental), and capturing a large share of the geographic and environmental heterogeneity of coastal dune systems in Italy (Fig. 1).

Across the study area, coastal dunes form a continuum of geomorphological and ecological units arranged along a pronounced sea-to-inland environmental gradient (Acosta et al., 2007). Along this gradient, vegetation follows a well-defined zonation pattern from pioneer annual species on the upper beach to perennial communities on fixed dunes, culminating in Mediterranean holm-oak forests (Acosta et al., 2009; Marcenò et al., 2018; Prisco et al., 2012).

Focusing on the herbaceous component of this coastal dune continuum, the upper beach represents the first vegetated zone, dominated by annual nitrophilous pioneer species. This community, largely restricted to Mediterranean coasts (Acosta et al., 2009; Doing, 1985), is highly dynamic and temporally unstable. Further inland, shifting dunes develop as reduced wind intensity promotes sand accumulation, facilitated by perennial rhizomatous dune-forming species (Prisco et al., 2012). Semi-fixed and fixed dunes support the most species-rich and structurally heterogeneous dune grasslands. On stable sands of the inner dune slopes, primary chamaephytic garrigues dominated by *Crucianella maritima* may develop. These communities are absent along the northern Adriatic coast (Prisco et al., 2012; Silan et al., 2017), where perennial grasslands are mainly composed of hemicryptophytes and chamaephytes often associated with mosses and lichens (Marcenò et al., 2018; Silan et al., 2017). Gaps within perennial vegetation are colonised by small annual therophytes, most commonly grasses and forbs (Prisco et al., 2012).



**Figure 1. Study area.** Distribution of resurveyed historical plots (marked in orange) along the Italian coastal dunes.

## Vegetation data

ReSurveyDunes (Acosta et al., 2025) consists of 519 historical Italian vegetation plot records (phytosociological relevés), originally recorded between 1974 and 2009 and resurveyed in 2023–2024. Specifically, the time span between the earliest and the most recent survey ranged from 15 to 50 years (mean = 30 years; median = 29 years). All historical plots were accurately relocated based on historical geographic coordinates or detailed topographic and location information (i.e. quasi-permanent vegetation plots; Kapfer et al., 2017). During the resurvey, vegetation was recorded within plots having the same size as the corresponding historical plot. The plot size ranged between 1 and 400 m<sup>2</sup> (median = 25 m<sup>2</sup>; mean = 35.4 m<sup>2</sup>). Historical as well as resurveyed plots included a complete list of vascular plant species, with species abundance estimated using the seven-grade Braun-Blanquet cover-abundance scale (Braun-Blanquet, 1964). Values were subsequently converted to percentage cover using the mean value of each Braun-Blanquet interval. Metadata associated with each plot included geographic coordinates, location accuracy, sampling year, plot size, and site information. Resurveyed plots with no vegetation were recorded as empty plots.

This study focuses on three herbaceous-chamaephytic coastal dune habitats: upper beach, shifting dunes, and dune grasslands. Historical and resurveyed plots were initially assigned to level-3 EUNIS habitat types using an expert-based approach based on the occurrence and abundance of typical species. To confirm this assignment, we applied an automated, expert-validated classification tool developed for the EUNIS hierarchy (Chytrý et al., 2020, 2025), which confirmed that 93.4% of the historical data had been correctly classified (Table 1).

**Table 1. European habitat types of the historical plots.** List of the EUNIS habitat types identified in the historical vegetation plots (Chytrý et al., 2025). For each habitat type, the corresponding EUNIS code, a brief description, including the associated EU habitat (Annex I of Habitats Directive 92/43/EEC), and a representative set of typical species for the study area are reported (Biondi et al., 2009; Biondi & Blasi, 2015; Chytrý et al., 2025). The number of historical plots assigned to each habitat type (n), together with their proportion of the total dataset, is indicated.

Coastal dune habitat	EUNIS code	Description	n (%)	Typical species
Upper Beach	N12	Mediterranean and Black Sea sand beach (EU habitat 1210 - Annual vegetation of drift lines)	78 (15%)	<i>Atriplex prostrata</i> , <i>Cakile maritima</i> subsp. <i>maritima</i> , <i>Euphorbia peplis</i> , <i>Glaucium flavum</i> , <i>Matthiola sinuata</i> , <i>Polygonum maritimum</i> , <i>Salsola kali</i> , <i>Soda inermis</i>
Shifting Dunes	N14	Mediterranean, Macaronesian and Black Sea shifting coastal dune (including EU habitats: 2110 - Embryonic shifting dunes; 2120 - Shifting dunes along the shoreline with <i>Ammophila arenaria</i> )	332 (64%)	<i>Achillea maritima</i> subsp. <i>maritima</i> , <i>Anthemis maritima</i> subsp. <i>maritima</i> , <i>Calamagrostis arenaria</i> subsp. <i>arundinacea</i> , <i>Centaurea apolepa</i> subsp. <i>subciliata</i> , <i>Convolvulus soldanella</i> , <i>Cyperus capitatus</i> , <i>Echinophora spinosa</i> , <i>Eryngium maritimum</i> , <i>Euphorbia paralias</i> , <i>Lotus creticus</i> , <i>Medicago marina</i> , <i>Pancratium maritimum</i> , <i>Silene succulenta</i> subsp. <i>corsica</i> , <i>Sporobolus pungens</i> , <i>Stachys maritima</i> , <i>Thinopyrum junceum</i>

Dune Grasslands	N16	Mediterranean and Macaronesian coastal dune grasslands, grey dune (including EU habitats: 2130 - Fixed coastal dunes with herbaceous vegetation, 2210 - Crucianellion maritimae fixed beach dune, and 2230 - Malcolmietalia dune grasslands)	109 (21%)	<i>Anchusa crispa</i> subsp. <i>crispa</i> , <i>Armeria pungens</i> , <i>Cerastium semidecandrum</i> , <i>Crucianella maritima</i> , <i>Cutandia maritima</i> , <i>Daucus pumilus</i> , <i>Ephedra distachya</i> , <i>Festuca fasciculata</i> , <i>Fumana procumbens</i> , <i>Helichrysum italicum</i> , <i>H. stoechas</i> , <i>Lagurus ovatus</i> , <i>Lomelosia argentea</i> , <i>Marcus-kochia ramosissima</i> , <i>Maresia nana</i> , <i>Matthiola tricuspidata</i> , <i>Medicago littoralis</i> , <i>Ononis diffusa</i> , <i>O. variegata</i> , <i>Phleum arenarium</i> , <i>Poacynum venetum</i> , <i>Poterium sanguisorba</i> , <i>Rostraria litorea</i> , <i>Seseli tortuosum</i> , <i>Silene colorata</i> , <i>S. gallica</i> , <i>S. niceensis</i> , <i>S. otites</i> subsp. <i>otites</i> , <i>S. velutina</i> , <i>Sonchus bulbosus</i> subsp. <i>bulbosus</i> , <i>Teucrium capitatum</i> L. subsp. <i>Capitatum</i>
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### Taxonomic harmonisation

Taxonomic concepts and nomenclature were standardised across both historical and resurveyed plots following Bartolucci et al. (2024). For non-native species, nomenclature followed Galasso et al. (2024).

To ensure consistency between historical and resurveyed plot compositions, we systematically checked for potential mismatches between species names, including cases where the same taxon was recorded under different names or where a historical taxon had subsequently been split into multiple entities but referred to the same biological unit. When a taxon was recorded in the historical plots both at the species and subspecies level, we retained the species-level identification for consistency, except in cases where only a single subspecies occurs in the study area, in which case the subspecies name was maintained.

Discrepancies in species nomenclature were resolved for 88 taxa (Supplementary Table S1).

### Species-level ecological groups

Within each habitat, all recorded species were classified into four mutually exclusive ecological groups: “typical species of the habitat”, “typical species of other habitats”, “ruderal species” and “non-native species”. For example, *Calamagrostis arenaria* subsp. *arundinacea* was classified as a “typical species of the habitat” when occurring in shifting dunes, but as a “typical species of other habitats” when recorded outside shifting dunes.

Typical species were defined as diagnostic and constant taxa associated with their corresponding habitat type, based on the characteristic species combinations provided in the Italian Interpretation Manual of the Habitats Directive (Biondi et al., 2009; Biondi & Blasi, 2015), and for EUNIS habitats (Chytrý et al., 2025). Typical species of dune habitats are key indicators of habitat integrity, are assumed to contribute substantially to habitat structure and functioning and are widely used as proxies for favourable conservation conditions (Bonari et al., 2021; Del Vecchio et al., 2015; Prisco et al., 2021). In contrast, ruderal and non-native taxa often indicate habitat degradation and disturbance (Biondi et al., 2012; Sarmati, Angiolini, et al., 2025).

Ruderal species (nitrophilous and synanthropic taxa typically associated with disturbed environments) were identified according to previously established classifications (Biondi et al., 2012; Del Vecchio et al., 2015; Prisco et al., 2017). For the analysis of non-native taxa, we considered only neophytes (i.e. species introduced after 1500 AD).

## Data Analyses

### 1. Temporal trends in species richness and cover

To assess long-term trends in coastal dune vegetation, we separately analysed temporal change in species richness (i.e., the total number of species recorded in the plot) and total cover (i.e., the sum of the cover of all species in the plot). To this aim, we fitted generalised linear mixed-effects models (GLMMs) using the *glmmTMB* R package (function *glmmTMB*; Brooks et al., 2017; R Core Team, 2022). Specifically, for species richness we assumed a Poisson distribution and used a 'log' link, whereas for cover we assumed a Beta distribution and used a 'logit' link. Furthermore, zero-inflated models were applied to species richness to account for excess zeros in species richness data, primarily due to historical plots that could not be relocated during the resurvey. The same modelling approach was then applied to examine changes in species richness within each ecological group.

Total cover required some transformations to be used in the model. First, since in some cases its value exceeded 100% due to overlapping vegetation layers, we rescaled it to the (0–1) interval. To achieve this, we divided the total cover of each plot by the maximum value observed across the dataset (Prisco, Carboni, et al., 2016; Sperandii et al., 2018). Second, to accommodate beta-regression requirements, total cover values equal to 0 or 1 were adjusted to slightly larger and smaller values, respectively, by adding or subtracting a small constant ( $\epsilon = 0.01$ ; Cribari-Neto & Zeileis, 2010). This was necessary because the Beta probability density function is not defined at 0 and 1. Finally, the same models were applied to evaluate temporal changes in species cover separately for each ecological group.

In the GLMMs, sampling time, habitat type, and their interaction were included as fixed effects. Both were treated as categorical, with sampling time at two levels (historical and resurveyed) and habitat type at three levels (upper beach, shifting dunes, and dune grasslands). Habitat type follows the historical plot classification, regardless of any changes observed during the resurvey. Additionally, we included plot size as a covariate to control for the variation in sampling area across plots. We then used the plot identifier nested within the site as random intercepts to account for the repeated measures design and the fact that multiple plots were sampled in each site.

We assessed model predictive performance using  $R^2$  values computed using the performance R package (Lüdecke et al., 2021). For standard GLMMs, we calculated both marginal and conditional  $R^2$  (function *r2*; Nakagawa & Schielzeth, 2013). For zero-inflated models, we computed likelihood-based Pseudo- $R^2$  (function *r2\_zeroinflated*), as variance-partitioning  $R^2$  measures are not available for these models.

Model diagnostics were visually inspected using simulation-based residuals in the DHARMA R package (function *simulateResiduals*; Hartig, 2024). To compare temporal differences in species richness and total cover within each habitat type, we extracted model-based contrasts between sampling times (i.e., historical vs. resurveyed) using estimated marginal means (EMMs) and ran post-hoc pairwise comparisons using the *emmeans* R package (functions *ref\_grid* and *contrast*; Lenth, 2025). For each model, the contrast estimates represent the effect of time on species richness or cover and were used to quantify temporal changes within habitats and species ecological groups. To facilitate interpretation on the response scale, 95% confidence intervals (CIs) were computed (function *confint*; R Core Team, 2022) and their endpoints exponentiated where appropriate (i.e. for species richness models with 'log' link). For species richness models, exponentiated estimates are interpreted as relative changes between historical and resurveyed plots, with values equal to 1 indicating no temporal change ( $\exp(0) = 1$ ). In this case, temporal effects were considered statistically significant when the endpoints of the 95% CIs did not overlap 1.

### 2. Changes in species composition

To identify the species contributing most to the average dissimilarity between historical and resurveyed plots within each habitat, we performed a SIMPER analysis based on Bray-Curtis dissimilarity (Bray & Curtis, 1957) and implemented with 999 permutations using the *vegan* R package (function *simper*;

Oksanen et al., 2025). The SIMPER analysis decomposes average Bray-Curtis dissimilarity into species-specific contributions, thereby identifying the taxa primarily responsible for differences within and between groups (Oksanen et al., 2025). For each time-period, we calculated the percentage contribution of each species to total dissimilarity and ordered taxa by their relative contribution. Temporal changes were assessed using permutation tests, and species were classified by habitat type and ecological group (i.e., typical species of the habitat, typical species of other habitats, ruderal species, and non-native species) to assess the relative contribution of each ecological group to community dynamics over time.

### 3. *Habitat transitions*

Assigning each vegetation plot at each time step to a level-3 EUNIS habitat type allowed the identification of habitat transitions within individual historical-resurvey plot pairs. For each pair, habitat-change trajectories were classified as follows:

- i) stable plots, which remained within the same EUNIS habitat type at both time steps;
- ii) progressive (successional) plots, which shifted towards more stabilised habitats, characterised by an increase in species typical of more inland habitats;
- iii) regressive (retrogressive succession) plots, which shifted towards less stabilised or early-successional habitats, characterised by an increase in species typical of more seaward habitats;
- iv) disappeared plots, historical plots that could not be resurveyed because they were completely unvegetated or submerged by the sea, reflecting vegetation loss driven by natural or anthropogenic processes.

Habitat trajectories were visualised using alluvial diagrams generated with *ggplot2* (function *ggplot*; Wickham, 2016) and *ggalluvial* R packages (functions *geom\_stratum* and *geom\_flow*; Brunson & Read, 2023).

## **Results**

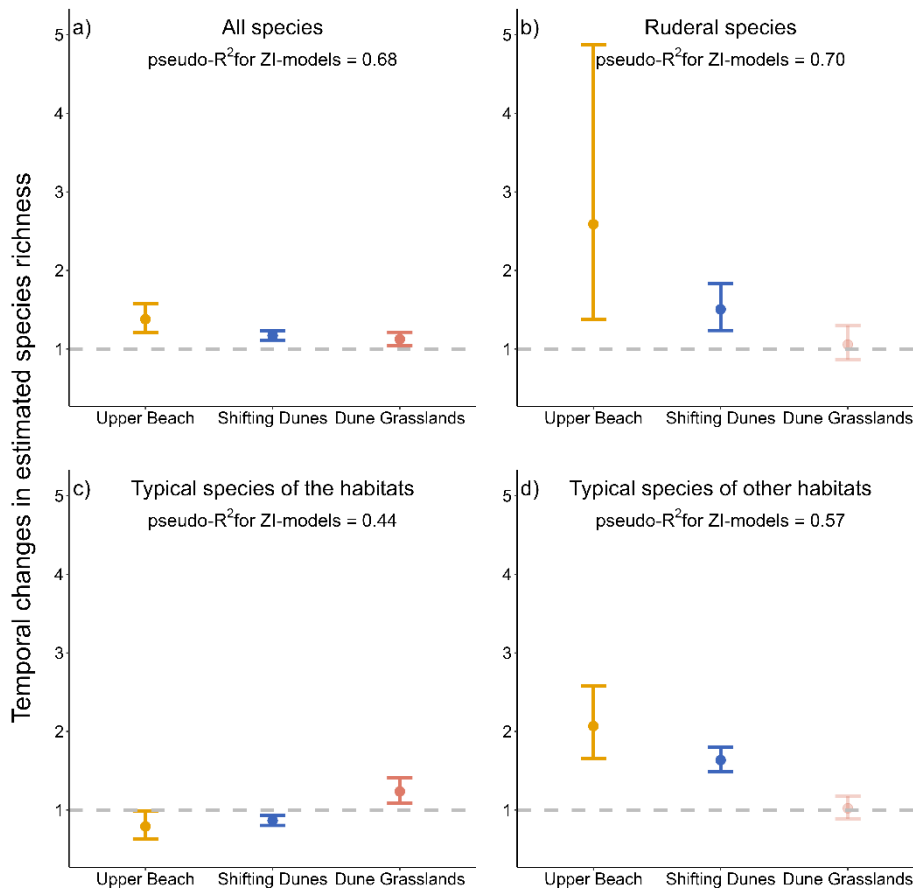
A total of 433 plant species were recorded across both historical and resurveyed plots, of which 20.3% were typical species of dune habitats ( $n = 88$ ). Of these, 1.8% ( $n = 8$ ) were associated with the upper beach, 4.4% ( $n = 19$ ) with shifting dunes, and 14% ( $n = 61$ ) with dune grasslands. Ruderal species accounted for 22% of the total dataset ( $n = 95$ ), whereas non-native species represented 7% ( $n = 30$ ). See Supplementary Material Fig. S1 and Table S2 for detailed composition of each species group within each habitat.

### 1. *Temporal trends in species richness and cover*

Temporal trends in species richness and cover showed complex dynamics, with overall increases in these metrics at the community level masking opposing trends among ecological groups.

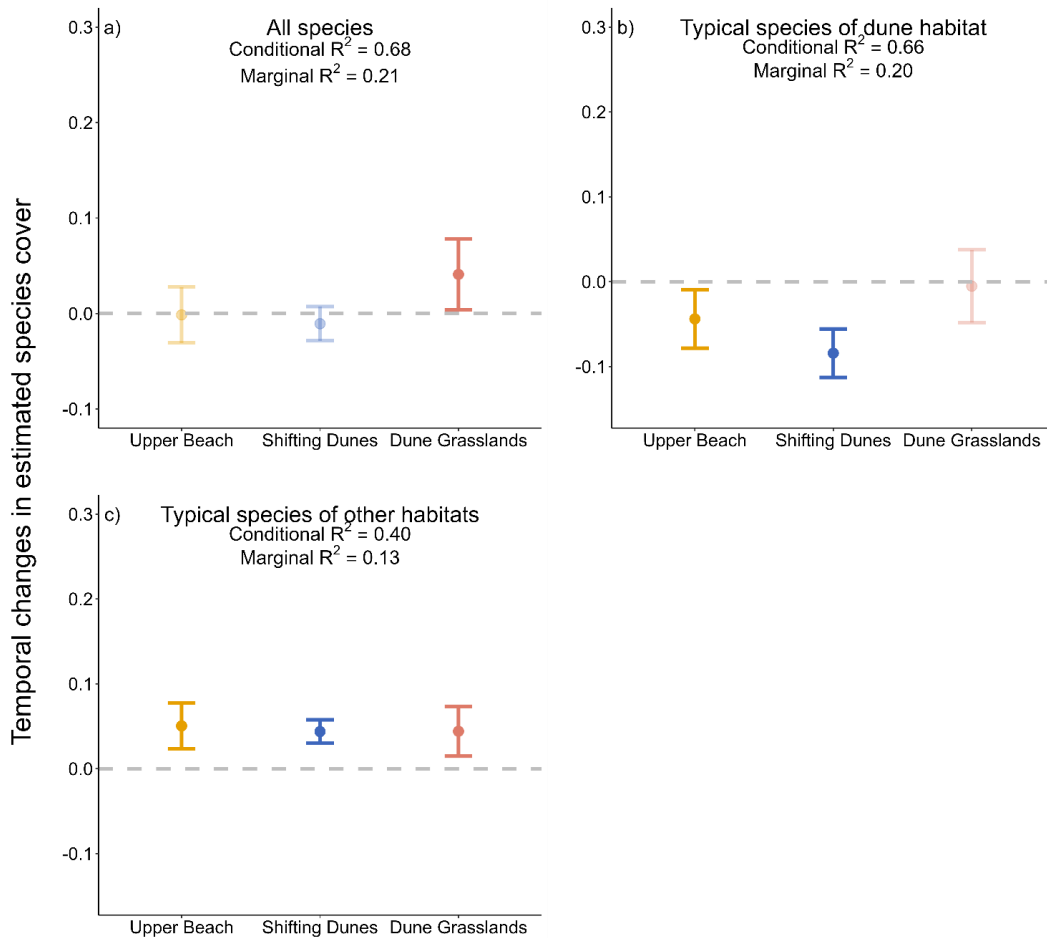
Mixed models revealed an increase in species richness over time in all habitats, with the largest increase observed in the upper beach (Fig. 2a; Supplementary Table S3).

Patterns varied markedly among ecological groups, especially between ruderal and typical species and were strongly habitat-dependent (Fig. 2b-d; Supplementary Table S3). The number of ruderal species significantly increased over time in the upper beach and shifting dunes, with the largest increase in the upper beach. On the contrary, the richness of typical species of the habitat decreased in the upper beach and shifting dunes, while slightly increasing in dune grasslands. Typical species of other habitats exhibited a pattern similar to that of ruderal species, with their number significantly increasing in both the upper beach and shifting dunes (Fig. 2d). Finally, non-native species showed only minor, non-significant changes over time and are therefore not shown (Supplementary Table S3).



**Figure 2. Results of mixed models assessing temporal changes in species richness.** Panels show modelled changes in species richness for (a) all species, (b) ruderal species, (c) typical species of the habitat, and (d) typical species of other habitats. These changes are depicted across three habitat types, indicated by different colours (EUNIS N12: upper beach, yellow; N14: shifting dunes, blue; N16: dune grasslands, orange). The y-axis represents the ratio of estimated mean species richness between resurveyed and historical plots. This ratio is obtained by exponentiating the slope parameter from the model, which estimates the effect of time-period on species richness on a log scale. The light grey dashed line at 1 indicates no change in mean species richness over time ( $\exp(0) = 1$ ). Dots represent exponentiated contrasts of estimated marginal means derived from zero-inflated models, while vertical lines indicate 95% confidence intervals (CIs). Coloured symbols denote statistically significant effects ( $p < 0.05$ ; 95% CI does not overlap 1), whereas semi-transparent coloured symbols indicate non-significant change (95% CI overlaps 1). Pseudo- $R^2$  values for each model are reported within the corresponding panels.

Concerning total cover, analyses focusing on all species showed that it significantly increased only in dune grasslands (Fig. 3a; Supplementary Table S4). Results for typical species of the habitat were consistent with those obtained for species richness, with a significant decrease in cover in the upper beach and shifting dunes (Fig. 3b). Regarding typical species of other habitats, their cover increased across all habitat types (Fig. 3c). Differences between marginal and conditional  $R^2$  indicate substantial variability among plots and sites, pointing to the role of spatial heterogeneity and local context in mediating temporal dynamics in coastal dune vegetation, beyond the effects captured by the fixed predictors alone. Models for ruderal and non-native species cover showed no significant temporal effects (not shown). Full results are provided in Supplementary Table S4.



**Figure 3. Results of mixed models assessing temporal changes in species cover.** Panels display modelled temporal changes in cover for (a) all species, (b) typical species of the habitat, and (c) typical species of other habitats across three habitat types, represented by different colours (EUNIS N12: upper beach, yellow; N14: shifting dunes, blue; N16: dune grasslands, red). The y-axis represents the relative change in cover between historical and resurveyed surveys on the logit scale. The light grey dashed line at 0 acts as a threshold indicating no change in cover between the two survey periods. Values above zero indicate increases in cover, whereas values below zero indicate decreases. Dots represent the exponentiated contrasts of estimated marginal means from zero-inflated models, with vertical lines indicating the associated 95% confidence intervals (CIs). Coloured symbols represent statistically significant effects ( $p < 0.05$ , 95% CI does not overlap 0), while semi-transparent coloured symbols indicate non-significant results (95% CI overlaps 0). Conditional and marginal  $R^2$  values for each model are provided within each panel.

## 2. Changes in species composition

SIMPER analysis (Fig. 4; Supplementary Table S5 and S6) revealed that the contributions of the different ecological groups to temporal community dissimilarity varied among habitats. Across habitats, temporal changes in species composition were primarily influenced by typical species of other habitats, while non-native and ruderal species contributed less to overall dissimilarity but showed a steady increase over time, particularly in shifting dunes and dune grasslands. Notably, typical species of the habitat decreased in shifting dunes, while they increased in dune grasslands. Complete species lists and SIMPER outputs are provided in the supplementary materials (Supplementary Tables S5 and S6).

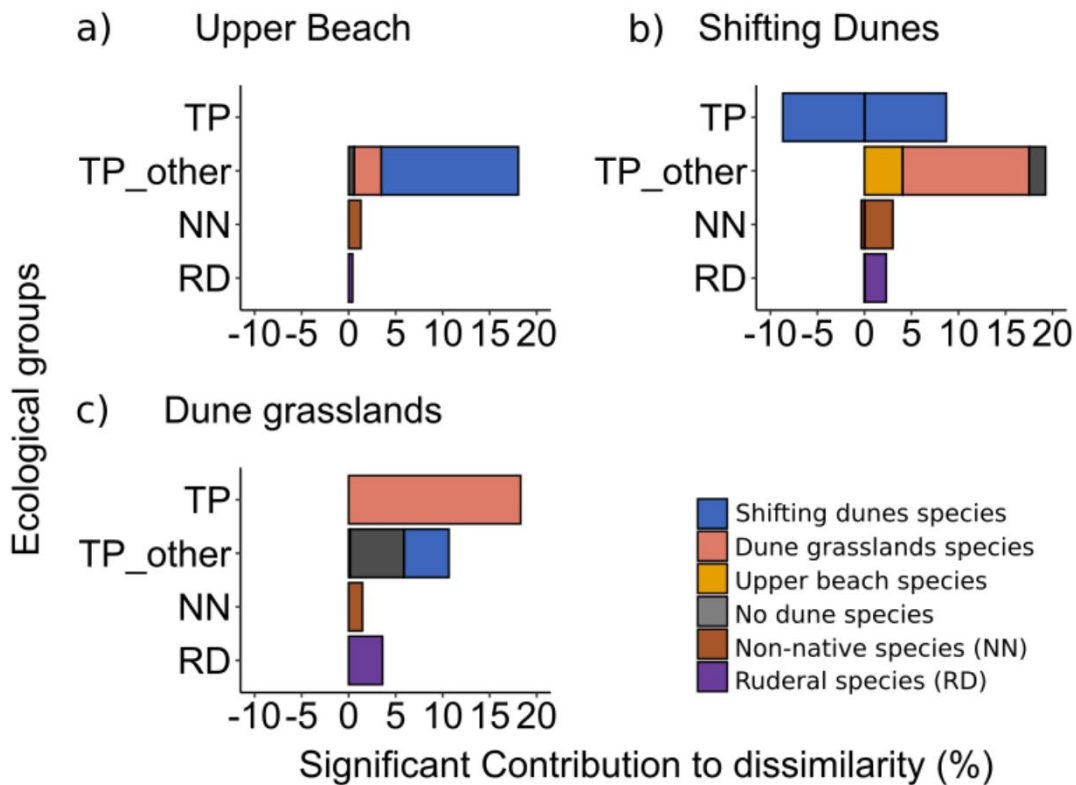
In the upper beach, species typical of other habitats (Fig. 4) contributed substantially to temporal community dissimilarity, with a net contribution of +18.1%. Specifically, resurveyed upper beach plots were characterised by an increase in abundance of species typical of shifting dunes (+14.6%) such as *Thinopyrum junceum*, *Medicago marina*, *Lotus creticus*, *Echinophora spinosa*, and *Calamagrostis arenaria* subsp.

*arundinacea*, along with a smaller contribution from dune grasslands species (+2.9%, e.g. *Helichrysum stoechas* subsp. *stoechas*). Although contributing to a lesser extent in dissimilarity, the ingression of taxa from dune shrub and saltmarsh habitats, such as *Juniperus macrocarpa* and *Halimione portulacoides*, is also noteworthy.

While the contributions of non-native and ruderal species to overall dissimilarity were relatively low (+1.3% and +0.4%, respectively), several non-native species not recorded in the historical plots were detected during the resurveys, including *Oenothera* sp. pl., *Oxalis pes-caprae*, *Cenchrus* sp. pl., and *Erigeron* sp. pl. In contrast, typical species of the upper beach did not significantly contribute to temporal dissimilarity.

In shifting dunes, typical species made significant individual contributions to temporal dissimilarity, yet their overall net contribution remained very low. Nevertheless, when examining individual contributions, most typical species of the habitat (e.g. *Calamagrostis arenaria* subsp. *arundinacea*, *Thinopyrum junceum*, and *Sporobolus pungens*) showed a decrease in abundance in the resurveyed plots, although not significant. A similar decreasing pattern was observed for *Echinophora spinosa* and *Eryngium maritimum*, which both exhibited a significant decline. The increase in abundance observed in shifting dunes was mainly driven by species typical of other habitats. In particular, typical species of dune grasslands contributed most to dissimilarity (+13.4%), including *Festuca fasciculata*, *Helichrysum stoechas* subsp. *stoechas*, *Ononis variegata*, and *Silene colorata*, all increasing in abundance in the resurveyed plots. A smaller contribution (+4.1%) was associated with the ingression of species typical of upper beach, (e.g. *Cakile maritima* subsp. *maritima*, *Salsola kali*, and *Euphorbia peplis*) as well as typical species of inner-dune woody communities, including *Pistacia lentiscus*, *Pinus pinaster* subsp. *pinaster*, and *Lotus hirsutus*. Non-native species (e.g. *Xanthium orientale*, *Oenothera* sp. pl., and *Carpobrotus* sp. pl.) were again the second most important contributors to the increase in abundances over time (+2.7%). The further ingression of invasive taxa, such as *Veronica persica*, *Cenchrus setaceus* and *Opuntia ficus-indica*, is noteworthy. Only one non-native taxon (*Cuscuta* sp. pl.) exhibited a negative trend. Ruderal species (e.g. *Sixalix atropurpurea*, *Hypochaeris radicata*, and *Plantago coronopus*; +2.3%) contributed least to dissimilarity, although their abundance showed an overall increasing trend.

Dune grasslands exhibited the strongest temporal changes in their typical species, which accounted for the largest share of dissimilarity (+18.3%). This pattern was mainly driven by increased abundances of annuals (e.g. *Festuca fasciculata*, *Ononis variegata* and *Medicago littoralis*). The second-largest contribution to dissimilarity (+10.7%) resulted from increasing abundances of species typical of other habitats, in particular shifting dunes (e.g. *Lotus creticus*, *Calamagrostis arenaria* subsp. *arundinacea*, and *Sporobolus pungens*) and woody fixed-dune communities (e.g. *Juniperus macrocarpa* and *Thymelaea tartonraira* subsp. *tartonraira*). Ruderal species showed their highest contribution to dissimilarity (e.g. *Plantago coronopus*; +3.6%), exceeding that of non-native species (e.g. *Carpobrotus* sp. pl., +1.5%). Notably, the establishment of the invasive tree *Ailanthus altissima* was also detected.



**Figure 4. Significant contributions of ecological groups to community dissimilarity based on SIMPER analysis.** Panels display the cumulative significant contributions of species within each ecological group to the total dissimilarity between historical and resurveyed plots across three habitat types: (a) upper beach, (b) shifting dunes, and (c) dune grasslands. Positive bars indicate an increase in the contribution, while negative bars indicate a decrease. Ecological groups are classified as follows: TP = typical species of the habitat, represented by different colours (EUNIS N12: upper beach, yellow; N14: shifting dunes, blue; N16: dune grasslands, red); NN = non-native (brown); RD = ruderal (purple). Typical species of other habitats are grouped as TP\_other and subdivided into the three habitat types (with their corresponding colour codes: yellow, blue, and red, respectively), and “no dune” (grey) which includes species from habitat outside the three herbaceous dune habitats investigated.

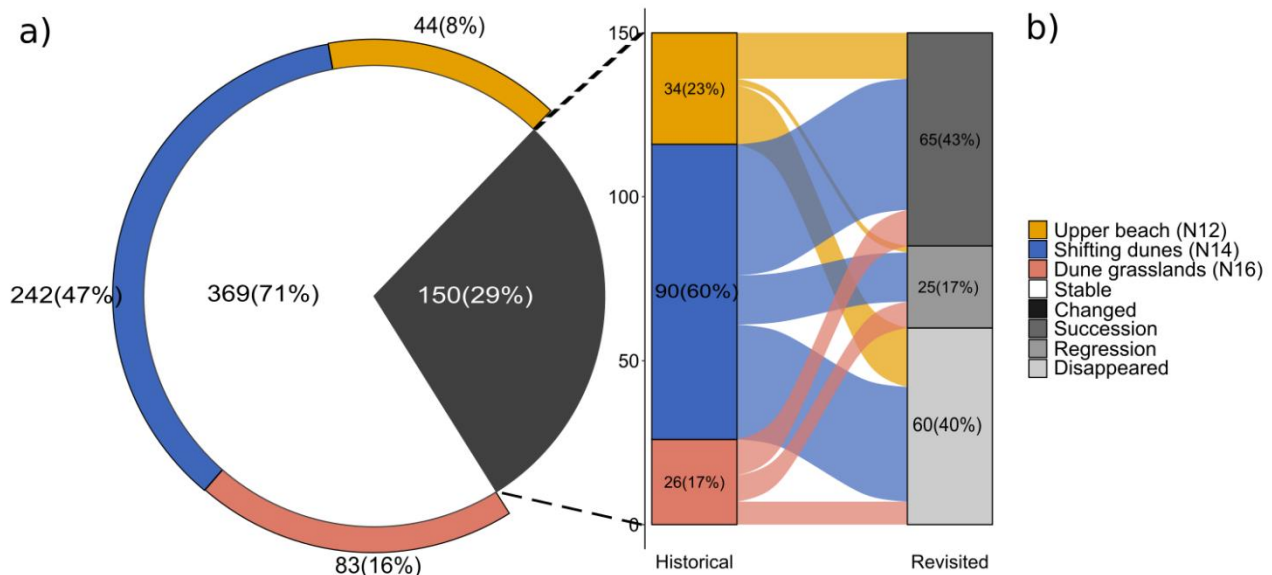
### 3. Habitat transitions

Approximately one-third of historical plots (29%) shifted to a different habitat type or could not be relocated during the resurvey (Fig. 5a). The upper beach was the most dynamic habitat, with 43.6% ( $n = 34$ ) of historical upper-beach plots reclassified during the resurvey. Shifting dunes followed, with 27.1% ( $n = 90$ ) of their historical plots changing habitat type, closely followed by dune grasslands (23.9%;  $n = 26$ ).

It is worth highlighting that, among the plots that changed or disappeared (29% of the total), approximately 57% exhibited either disappearance or regressive trajectories, exceeding that of plots showing positive successional advancement (approximately 43%). Within this 57%, 16.7% of plots followed regressive trajectories, shifting towards more seaward or early-successional habitats, whereas the rest could not be relocated. These regressive plots were characterised not only by a decline in typical species of the habitat and an increase in early-successional species, but also by an increase in ruderal, or non-native species (Fig. 5b).

In the upper beach, 41% of shifted plots showed a positive successional shift, 6% displayed regressive trends, and 53% disappeared. In shifting dunes, 44% of plots whose habitat type changed over time underwent positive successional shifts, 17% exhibited regressive trends, and 39% disappeared. Dune

grasslands showed a comparable pattern, with 42% of shifted plots showing positive successional shifts, 31% showing regressive trends, and 27% disappeared.



**Figure 5. Changes in habitat classification between historical and resurveyed plots.** The panel (a) shows the proportion of historical plots that remained stable (white area) or changed to a different habitat type (black area). Surrounding the stable plots, coloured semi-circular bands represent the percentage contribution of each habitat type (EUNIS N12: upper beach, yellow; N14: shifting dunes, blue; N16: dune grasslands, red). The panel (b) provides a detailed breakdown of habitat trajectories over time for the historical plots that changed. It distinguishes plots that underwent positive successional shifts towards more stabilised or inland habitat types (Succession; dark grey), plots that regressed towards earlier successional stages (Regression; light grey), and plots that disappeared (Disappeared; pale grey). See Table 1 for a description of habitat codes.

## Discussion

Our study shows that Italian coastal dune vegetation underwent habitat transitions and pronounced changes in species richness and composition over the past three decades. Total species richness increased, largely driven by taxa typical of more stabilised or inland habitats, as well as by ruderal species. In contrast, typical species of the individual habitats declined, particularly in the upper beach and shifting dunes, with only a subtle increase in dune grasslands. Changes in species cover were less pronounced but broadly mirrored richness patterns. Nearly one-third of plots transitioned to a different habitat type over time, reflecting a combination of localised successional advancement or regressive trends, and habitat loss, especially in the most dynamic early-successional habitats.

### 1. Temporal trends in species richness and cover

We observed an overall increase in species richness, and, to a lesser extent, in species cover over time. In coastal dunes, which are strongly subjected to anthropogenic pressures similar trends have been reported, but their interpretation depends on how different ecological groups of species (e.g. non-native, ruderal, or

habitat-typical taxa) respond to environmental change (Del Vecchio et al., 2015; Makowski & Finkl, 2019; Martínez et al., 2004).

In the upper beach and shifting dunes, typical species of the habitat declined in both richness and cover, whereas ruderal species increased in richness without a corresponding increase in cover. Ruderal species increased in richness without a corresponding increase in cover. This pattern is consistent with findings from other Italian coastal dune systems (Santoro et al., 2012; Prisco, Stanisci, et al., 2016; Sperandii et al., 2019). Their arrival is likely facilitated by persistent anthropogenic disturbances, which promote the dispersal of seeds and propagules into disturbed areas (Sarmati, Angiolini, et al., 2025; Valdesolo et al., 2022). In addition, the proximity of agricultural and rural landscapes may facilitate animal movements across habitats, allowing them to act as dispersal vectors and promote the spread of ruderal species from surrounding cultivated areas (Chandru et al., 2020; De Francesco et al., 2025). However, the harsh environmental conditions typical of coastal dunes likely limit the ability of these species to establish persistent populations and increase in cover.

At the same time, typical species of other habitats increased in both richness and cover, increasing biotic homogenization of plant communities (Daru et al., 2021; Fantinato et al., 2023). Altogether, this pattern indicates substantial shifts in community composition, likely reflecting modifications in the dune morphology and increased anthropogenic pressures (Acosta et al., 2007; Biondi et al., 2012; Del Vecchio et al., 2016; Hesp et al., 2010; Seer et al., 2015).

In dune grasslands, we observed an increase in the richness of typical species of the habitat, which might suggest well-preserved habitat conditions and a good conservation status. However, this result should be interpreted with caution, as it was largely driven by the greater presence of annual species characteristic of these environments (e.g., *Ononis variegata*, *Festuca fasciculata*, and *Silene colorata*). Such species are known to exhibit stronger spatial and interannual variability than perennial species (Feeley et al., 2020; Poppenwimer et al., 2023) and can take advantage of transient spatial gaps created by the decline or mortality of perennial plants (Biondi et al., 2012; Fischer et al., 2020; Friedman, 2020). This trend occurs alongside an increase in the cover of species from more inland habitats (e.g., *Juniperus macrocarpa*), reflecting concurrent changes towards more stabilized dune habitats, depending on local environmental conditions (Barrett-Mold & Burningham, 2010; Landi et al., 2012).

## 2. Changes in species composition

In the upper beach, we observed an increasing contribution of species typical of shifting dunes (e.g. *Thinopyrum junceum*, *Medicago marina*, and *Lotus creticus*) to overall compositional dissimilarity over time. These changes likely reflect a natural successional transition from pioneer upper-beach communities to perennial-dominated assemblages of shifting dunes, as previously documented only in a few well-preserved Mediterranean dune systems (Sarmati, Sperandii, et al., 2025). However, this successional trajectory appeared to be accompanied by an increase in species typical of dune grasslands (e.g. *Helichrysum stoechas* subsp. *stoechas*, and *Daucus pumilus*). Collectively, the simultaneous increase of shifting dunes species and the expansion of dune grasslands suggest a progressive homogenisation of plant composition along the natural dune zonation, likely promoted by coastal erosion, trampling and other anthropogenic pressures which compress dune habitats (Defeo et al., 2009; Prisco, Stanisci, et al., 2016; Schlacher et al., 2007; Sperandii et al., 2021). Given the substantial among-plot variability detected by mixed-effects models, the relative importance of these two processes likely varies among sites, depending on local geomorphological context and disturbance type and intensity.

In shifting dunes, compositional change was characterised by the decline of dune-building species, such as *Calamagrostis arenaria* subsp. *arundinacea* and *Thinopyrum junceum*, a pattern consistent with previous findings from Central Italy (Malavasi et al., 2016; Sperandii et al., 2021) and more broadly across the Mediterranean region (Bogdanović et al., 2018; Valcheva et al., 2021). Notably, a reduction in the cover of *Calamagrostis arenaria* subsp. *arundinacea*, a species whose vertical growth is stimulated by sand accretion,

may indicate erosional processes (Maun, 2009). This decline coincided with an increase in thermophilic perennial forbs, such as *Lotus creticus* and *Anthemis maritima* subsp. *maritima*, which are known to form replacement communities in disturbed shifting dunes (Acosta et al., 2007; Biondi et al., 2012; Sperandii et al., 2018). Their expansion could also be influenced by climate-driven processes, such as warming or altered precipitation in Mediterranean coastal systems (Del Vecchio et al., 2015; Vesperinas et al., 2001). Additionally, the establishment of species typical of early-successional habitats (e.g. *Cakile maritima* subsp. *maritima*) or of more inland communities, especially dune grasslands (e.g. *Festuca fasciculata* and *Ononis variegata*) contributed strongly to compositional change. Woody and sub-shrub species (e.g. *Juniperus macrocarpa* and *Pinus pinaster* subsp. *pinaster*) also emerged as contributors, suggesting an incipient shift towards late-successional or woody vegetation types (Álvarez-Molina et al., 2012; Sarmati, Sperandii, et al., 2025; Sperandii et al., 2019). In shifting dunes, changes in species composition over time likely reflect a combination of successional dynamics, with some plots responding to disturbances by reverting to early-successional habitats, while others progress naturally towards later-successional or woody vegetation types (Álvarez-Molina et al., 2012). However, the identification of clear trends in this habitat remains challenging, as the observed patterns are likely shaped by multiple interacting drivers, including land-use change and anthropogenic pressures (Malavasi et al., 2016; Prisco, Stanisci, et al., 2016; Van Der Hagen et al., 2023).

In dune grasslands, consistent with the richness pattern described above, the overall increase in habitat-typical species was mainly driven by annual species. The increase in annual species may partially overlap with declines in some perennial species typical of dune grasslands, such as *Helichrysum stoechas* subsp. *stoechas* and *Crucianella maritima*. Although a pronounced decline of *C. maritima* has been reported previously (Sciandrello et al., 2015; Sperandii et al., 2021), in the present study, it was not statistically significant.

Non-native species played a relatively minor role in driving temporal compositional change across coastal dune habitats, but their presence and spread still deserve attention. In the upper beach, non-native taxa contributed only marginally to the compositional dissimilarity over time, likely due to the extreme environmental conditions which make the establishment of new taxa challenging for most species (but see Del Vecchio et al., 2015). An exception is represented by the spread of *Oenothera* sp. pl., not recorded in historical surveys, which reflects a colonisation process (Acosta et al., 2006; de Francesco et al., 2023), likely facilitated both by anthropogenic disturbances (Buffa et al., 2021) and by the high-light conditions typical of this habitat, which may enhance the germination of their seeds (Buffa et al., 2021; Mihulka et al., 2006). Similarly, in dune grasslands, the establishment of invasive woody species is noteworthy. In particular, the expansion of *Ailanthus altissima*, one of the most widespread non-native plants in Italy, may have long-term implications for dune grassland structure and functioning (Lazzaro et al., 2020; Trotta et al., 2020). Taken together, our results suggest that non-native species are not currently the main driver of change, but their increasing presence may represent an emerging pressure on community composition and ecological function over time.

### 3. Habitat transitions

The spatial distribution of habitat changes showed successional shifts towards more inland stages along the entire gradient, consistent with the natural vegetation zonation sequence towards inland, and particularly pronounced in shifting dunes. While positive successional trends have previously been documented mainly at local scales in highly protected and well-preserved dune systems (Sarmati, Sperandii, et al., 2025), our results suggest that similar trajectories can also be detected across other coastal dune sites at the national scale.

Although a substantial proportion of plots showed transitions consistent with successional advancement, indicating stabilization processes, a similarly high proportion of plots in early-successional dune habitats (upper beach and shifting dunes) disappeared. This pattern indicates that the most pioneer and disturbance-dependent habitats experienced the strongest changes, in line with previous studies reporting pronounced shifts in the seaward and highly dynamic sectors of dune systems (Del Vecchio et al., 2015; Prisco, Carboni, et al., 2016; Sperandii et al., 2021). Plot disappearance was often associated with

shoreline retreat, submergence, or conversion to bare sand driven by tourism-related activities (e.g. construction of bathing facilities or mechanical beach cleaning), trampling, and urban expansion (Hernández-Cordero et al., 2018; Hesp et al., 2010), all widely recognised as major drivers of coastal dune habitat loss worldwide (Feagin et al., 2005; Garzo et al., 2025; Miot da Silva et al., 2008). Plot disappearance was more frequent along the Tyrrhenian and Ionian coasts, in agreement with projections of shoreline retreat and beach surface loss due to sea-level rise (Celata & Gioia, 2024).

Our results further indicated that some plots, particularly in dune grasslands, and a smaller proportion of shifting dune plots, experienced regression to earlier successional stages. Taken together with the inland-directed successional shifts described above, these findings indicate the coexistence of two contrasting and spatially heterogeneous trajectories: inland advancement and regression towards early-successional stages.

## **Conclusion**

Using an unprecedentedly comprehensive dataset, we analysed long-term coastal vegetation dynamics along the entire Italian coastline for the first time. Our results show that coastal dune dynamics are heterogeneous and locally contrasting rather than uniform and unidirectional. Vegetation change appears to be driven by the interplay between disturbance and successional processes, with inland stabilisation coexisting with vegetation homogenisation, regressive trends, and habitat loss along the coastal gradient. These patterns likely reflect the combined effects of coastal erosion, land-use change, tourism-related disturbance, and ongoing climate-driven environmental change, which together reshape dune morphology and ecological processes. Overall, our findings highlight the need for integrated, long-term plot-based resurveys combined with habitat-level assessments to support adaptive conservation and management strategies in Mediterranean coastal dune systems.

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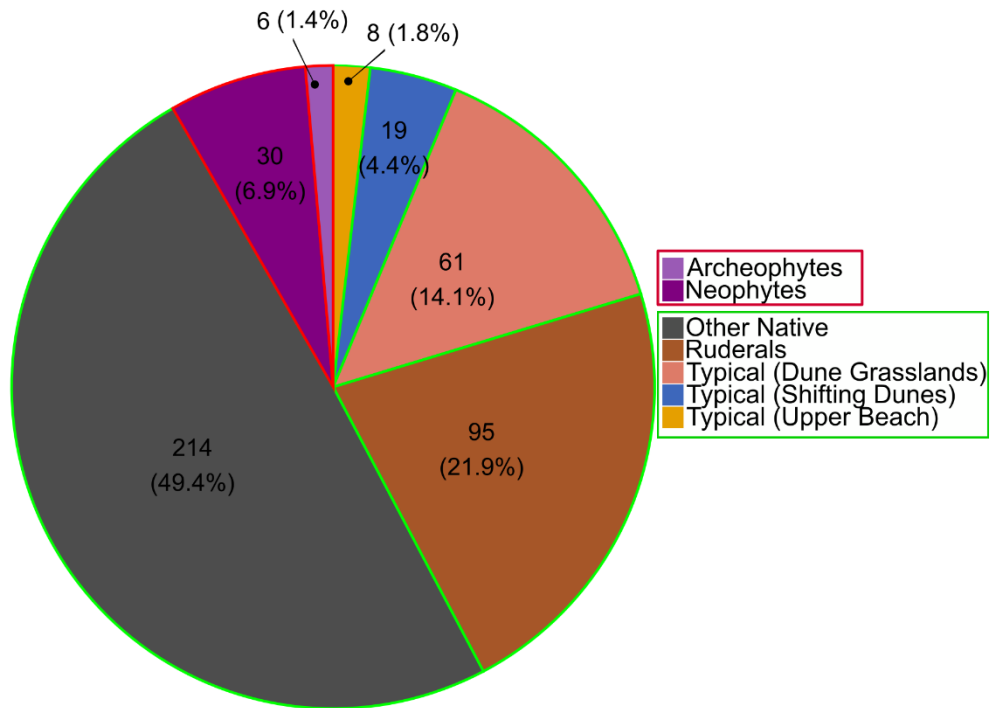
**Supplementary Material [Increasing species richness masks contrasting community dynamics in Mediterranean coastal dunes: a long-term vegetation resurvey]**

**Table S1. Taxonomic standardisation of species nomenclature in the historical plots.** List of taxa with inconsistent nomenclature in historical plots, standardised for consistent comparison across time steps. The table shown the corresponding resolved names, along with the rationale for each taxonomic resolution (resolved action). An exception was made for *Salsola kali*. According to the adopted checklists (Bartolucci et al., 2024; Galasso et al., 2024), all records of *Salsola kali* in the study area should be referred to *Salsola tragus*, as the occurrence of *S. kali* in Italy is now considered erroneous. However, the name *Salsola kali* is retained here because it is listed as a diagnostic species in the definitions of EUNIS habitat N12 and EU habitat 1210.

Original name	Resolved name	Resolved action
<i>Anthemis maritima</i>	<i>Anthemis maritima maritima</i>	only one subspecies in Italy
<i>Anthemis maritima maritima</i>	<i>Anthemis maritima maritima</i>	only one subspecies in Italy
<i>Artemisia campestris</i>	<i>Artemisia campestris variabilis</i>	only subspecies present, is endemic also
<i>Artemisia campestris variabilis</i>	<i>Artemisia campestris variabilis</i>	only subspecies present, is endemic also
<i>Bromus hordeaceus</i>	<i>Bromus hordeaceus</i> s.l.	at species level
<i>Bromus hordeaceus divaricatus</i>	<i>Bromus hordeaceus</i> s.l.	at species level
<i>Cakile maritima</i>	<i>Cakile maritima maritima</i>	only one subspecies in Italy
<i>Cakile maritima maritima</i>	<i>Cakile maritima maritima</i>	only one subspecies in Italy
<i>Carpobrotus</i>	<i>Carpobrotus</i> sp.pl.	ibridation problems
<i>Carpobrotus acinaciformis</i>	<i>Carpobrotus</i> sp.pl.	ibridation problems
<i>Carpobrotus edulis</i>	<i>Carpobrotus</i> sp.pl.	ibridation problems
<i>Cenchrus longispinus</i>	<i>Cenchrus</i> sp.pl.	complex or unclear nomenclatural history
<i>Cenchrus spinifex</i>	<i>Cenchrus</i> sp.pl.	complex or unclear nomenclatural history
<i>Cistus creticus</i>	<i>Cistus creticus</i> s.l.	complex or unclear nomenclatural history
<i>Cistus creticus eriocephalus</i>	<i>Cistus creticus</i> s.l.	complex or unclear nomenclatural history
<i>Corynephorus articulatus</i>	<i>Corynephorus</i> sp.pl.	complex or unclear nomenclatural history
<i>Corynephorus divaricatus</i>	<i>Coryn Ephorus</i> sp.pl.	complex or unclear nomenclatural history
<i>Cuscuta</i>	<i>Cuscuta</i> sp.pl.	complex or unclear nomenclatural history
<i>Cuscuta campestris</i>	<i>Cuscuta</i> sp.pl.	complex or unclear nomenclatural history
<i>Cuscuta cesattiana</i>	<i>Cuscuta</i> sp.pl.	complex or unclear nomenclatural history
<i>Dactylis glomerata</i>	<i>Dactylis glomerata</i> s.l.	at species level
<i>Dactylis glomerata hispanica</i>	<i>Dactylis glomerata</i> s.l.	at species level
<i>Daucus carota</i>	<i>Daucus carota</i> s.l.	at species level
<i>Daucus carota carota</i>	<i>Daucus carota</i> s.l.	at species level
<i>Daucus carota hispanicus</i>	<i>Daucus carota</i> s.l.	at species level
<i>Daucus carota maritimus</i>	<i>Daucus carota</i> s.l.	at species level
<i>Dittrichia viscosa</i>	<i>Dittrichia viscosa viscosa</i>	only one subspecies in Italy
<i>Dittrichia viscosa viscosa</i>	<i>Dittrichia viscosa viscosa</i>	only one subspecies in Italy
<i>Erigeron bonariensis</i>	<i>Erigeron</i> sp.pl.	complex or unclear nomenclatural history
<i>Erigeron canadensis</i>	<i>Erigeron</i> sp.pl.	complex or unclear nomenclatural history
<i>Erigeron sumatrensis</i>	<i>Erigeron</i> sp.pl.	complex or unclear nomenclatural history
<i>Festuca fasciculata</i>	<i>Festuca fasciculata</i> gr.	complex or unclear nomenclatural history
<i>Festuca pyramidata</i>	<i>Festuca fasciculata</i> gr.	complex or unclear nomenclatural history
<i>Galatella tripolium</i>	<i>Galatella tripolium pannonica</i>	only a single subspecies was recorded
<i>Galatella tripolium pannonica</i>	<i>Galatella tripolium pannonica</i>	only a single subspecies was recorded
<i>Helichrysum stoechas</i>	<i>Helichrysum stoechas stoechas</i>	only a single subspecies was recorded
<i>Helichrysum stoechas stoechas</i>	<i>Helichrysum stoechas stoechas</i>	only a single subspecies was recorded
<i>Hordeum murinum</i>	<i>Hordeum murinum</i> s.l.	at species level
<i>Hordeum murinum leporinum</i>	<i>Hordeum murinum</i> s.l.	at species level
<i>Limonium articulatum</i>	<i>Limonium contortirameum</i>	according with the new nomenclature
<i>Limonium contortirameum</i>	<i>Limonium contortirameum</i>	according with the new nomenclature
<i>Linum usitatissimum</i>	<i>Linum usitatissimum</i> s.l.	at species level
<i>Linum usitatissimum angustifolium</i>	<i>Linum usitatissimum</i> s.l.	at species level
<i>Lotus creticus</i>	<i>Lotus creticus</i> gr.	complex or unclear nomenclatural history

Lotus cytisoides	Lotus creticus gr.	complex or unclear nomenclatural history
Odontites luteus	Odontites luteus s.l.	at species level
Odontites luteus luteus	Odontites luteus s.l.	at species level
Oenothera biennis	Oenothera sp.pl.	complex or unclear nomenclatural history
Oenothera parviflora	Oenothera sp.pl.	complex or unclear nomenclatural history
Oenothera stucchii	Oenothera sp.pl.	complex or unclear nomenclatural history
Oenothera suaveolens	Oenothera sp.pl.	complex or unclear nomenclatural history
Picris hieracioides	Picris hieracioides s.l.	at species level
Picris hieracioides hieracioides	Picris hieracioides s.l.	at species level
Pinus pinaster	Pinus pinaster pinaster	only a single subspecies was recorded
Pinus pinaster pinaster	Pinus pinaster pinaster	only a single subspecies was recorded
Plantago coronopus	Plantago coronopus gr.	complex or unclear nomenclatural history
Plantago macrorhiza	Plantago coronopus gr.	complex or unclear nomenclatural history
Plantago weldenii	Plantago coronopus gr.	complex or unclear nomenclatural history
Polycarpon tetraphyllum	Polycarpon tetraphyllum s.l.	at species level
Polycarpon tetraphyllum alsinifolium	Polycarpon tetraphyllum s.l.	at species level
Polycarpon tetraphyllum diphyllum	Polycarpon tetraphyllum s.l.	at species level
Raphanus raphanistrum	Raphanus raphanistrum	at species level
Raphanus raphanistrum landra	Raphanus raphanistrum s.l.	at species level
Raphanus raphanistrum raphanistrum	Raphanus raphanistrum s.l.	at species level
Reseda alba	Reseda alba s.l.	at species level
Reseda alba alba	Reseda alba s.l.	at species level
Rumex acetosella	Rumex acetosella s.l.	at species level
Rumex acetosella pyrenaicus	Rumex acetosella s.l.	at species level
Rumex bucephalophorus	Rumex bucephalophorus s.l.	at species level
Rumex bucephalophorus bucephalophorus	Rumex bucephalophorus s.l.	at species level
Salsola kali	Salsola kali gr.	complex or unclear nomenclatural history
Salsola squarrosa controversa	Salsola kali gr.	complex or unclear nomenclatural history
Salsola tragus	Salsola kali gr.	complex or unclear nomenclatural history
Scolymus grandiflorus	Scolymus hispanicus gr.	at species level
Scolymus hispanicus	Scolymus hispanicus gr.	at species level
Scolymus hispanicus hispanicus	Scolymus hispanicus gr.	at species level
Seseli tortuosum	Seseli tortuosum s.l.	at species level
Seseli tortuosum tortuosum	Seseli tortuosum s.l.	at species level
Silene otites	Silene otites otites	only one subspecies in Italy
Silene otites otites	Silene otites otites	only one subspecies in Italy
Silene canescens	Silene colorata gr.	complex or unclear nomenclatural history
Silene colorata	Silene colorata gr.	complex or unclear nomenclatural history
Sonchus asper	Sonchus asper s.l.	at species level
Sonchus asper asper	Sonchus asper s.l.	at species level
Sonchus bulbosus	Sonchus bulbosus bulbosus	only one subspecies in Italy
Sonchus bulbosus bulbosus	Sonchus bulbosus bulbosus	only one subspecies in Italy
Teucrium capitatum capitatum	Teucrium capitatum capitatum	complex or unclear nomenclatural history
Teucrium polium	Teucrium capitatum capitatum	complex or unclear nomenclatural history

**Figure S1. Species composition by origin and ecological groups (n = 433).** All species were divided into main groups: native (green) and alien (red). Within each group, the number and relative percentage of species in each ecological category (e.g. typical, ruderal) are shown.



**Table S2. Number (plain text) and percentage (in italic) of total species observed across each ecological group for different habitat types, comparing historical and resurveyed plots.** The table reports the total occurrence of species as well as the breakdown by species group: non-native species (neophytes), ruderal species, typical species of the habitat, and typical species of other habitats.

Ecological groups	Upper beach (N12)				Shifting Dunes (N14)				Dune Grasslands (N16)			
	historical		resurveyed		historical		resurveyed		historical		resurveyed	
	n	%	n	%	n	%	n	%	n	%	n	%
all species	61	<i>14.1</i>	9	<i>22.2</i>	18	<i>43.4</i>	21	<i>50.7</i>	24	<i>56.8</i>	26	<i>60</i>
non-native	8	<i>1.8</i>	11	<i>2.5</i>	18	<i>4.2</i>	21	<i>4.8</i>	9	<i>2.1</i>	18	<i>4.2</i>
ruderal	13	<i>3</i>	19	<i>4.4</i>	42	<i>9.7</i>	51	<i>11.8</i>	55	<i>12.7</i>	51	<i>11.8</i>
typical species of the habitat	7	<i>1.6</i>	7	<i>1.6</i>	17	<i>3.9</i>	19	<i>4.4</i>	51	<i>11.8</i>	47	<i>10.9</i>
typical species of other habitats	24	<i>5.5</i>	44	<i>10.2</i>	66	<i>15.2</i>	74	<i>17.1</i>	51	<i>11.8</i>	58	<i>13.4</i>

**Table S3. Changes in the species richness over time across selected habitat types and ecological groups.**

Mixed models result for temporal changes in species richness across the three coastal habitat types: upper beach (EUNIS N12), shifting dunes (N14) and dune grasslands (N16). For each species group analysed, the estimate change in species richness, the standard error (SE), z-value, and p-value are provided. Significant trends are indicated by coloured arrows, green when positive, red for negative. Non-significant trends are denoted by a dashed line.

Ecological groups	Habitat types (EUNIS)	trend	estimate	SE	z-value	p-value
All Species	Upper Beach (N12)	↑	0.32	0.07	4.76	< 0.001
All Species	Shifting dunes (N14)	↑	0.16	0.03	6.16	< 0.001
All Species	Dune Grasslands (N16)	↑	0.12	0.04	3.05	0.002
Non-native Species	Upper Beach (N12)	--	0.24	0.18	1.34	0.18
Non-native Species	Shifting dunes (N14)	--	0.10	0.10	0.98	0.33
Non-native Species	Dune Grasslands (N16)	--	0.39	0.21	1.86	0.06
Typical Species of the Habitat	Upper Beach (N12)	↓	-0.23	0.11	-2.07	0.039
Typical Species of the Habitat	Shifting dunes (N14)	↓	-0.14	0.04	-3.74	0.002
Typical Species of the Habitat	Dune Grasslands (N16)	↑	0.21	0.07	3.17	0.002
Typical Species of Other Habitats	Upper Beach (N12)	↑	0.73	0.11	6.46	< 0.001
Typical Species of Other Habitats	Shifting dunes (N14)	↑	0.49	0.05	10.03	< 0.001
Typical Species of Other Habitats	Dune Grasslands (N16)	--	0.02	0.07	0.30	0.762
Ruderal Species	Upper Beach (N12)	↑	0.95	0.32	2.95	0.003
Ruderal Species	Shifting dunes (N14)	↑	0.41	0.10	4.08	< 0.001
Ruderal Species	Dune Grasslands (N16)	--	0.06	0.11	0.53	0.595

**Table S4. Temporal changes in the species abundances across selected habitat types and ecological groups.**

Mixed models result for temporal changes in species cover across the three coastal habitat types: upper beach (EUNIS N12), shifting dunes (N14) and dune grasslands (N16). For each species group (all species, non-native, typical species of the habitat, typical species of other habitat, and ruderal species) analysed, the estimate change in species richness, the standard error (SE), z-value, and p-value are provided. Significant trends are indicated by coloured arrows, green when positive, red for negative. Non-significant trends are denoted by a dashed line.

Species groups	Habitat types (EUNIS)	trend	estimate	SE	z-value	p-value
All species	Upper Beach (N12)	--	0.14	0.14	-0.10	0.921
All species	Shifting dunes (N14)	--	0.07	0.06	-1.17	0.241
All species	Dune Grasslands (N16)	↑	0.20	0.09	2.20	0.028
Non-native Species	Upper Beach (N12)	--	0.05	0.33	0.16	0.873
Non-native Species	Shifting dunes (N14)	--	0.22	0.16	1.40	0.161
Non-native Species	Dune Grasslands (N16)	--	0.38	0.27	1.42	0.156
Typical Species of the Habitat	Upper Beach (N12)	↓	-0.45	0.16	-2.74	0.006
Typical Species of the Habitat	Shifting dunes (N14)	↓	-0.51	0.07	-7.39	< 0.0001
Typical Species of the Habitat	Dune Grasslands (N16)	--	-0.03	0.11	-0.24	0.809
Typical Species of Other Species	Upper Beach (N12)	↑	0.72	0.18	4.10	< 0.0001
Typical Species of Other Species	Shifting dunes (N14)	↑	0.56	0.08	7.15	< 0.0001
Typical Species of Other Species	Dune Grasslands (N16)	↑	0.39	0.13	3.05	0.002
Ruderal Species	Upper Beach (N12)	--	0.02	0.17	0.10	0.923
Ruderal Species	Shifting dunes (N14)	--	0.14	0.08	1.77	0.076
Ruderal Species	Dune Grasslands (N16)	--	0.19	0.14	1.35	0.176

**Table S5. SIMPER contributions of species groups.** For each habitat type (EUNIS N12: upper beach; N14: shifting dunes; N16: dune grasslands), species were classified into ecological groups and assessed for significant increases or decreases in abundance between historical and resurveyed surveys. The reported contribution values represent each groups' share of the average dissimilarity between survey periods, along with the number of species contributing to decreases or increases in abundance and the resulting net contribution. Species groups: NN = non-native species, RD = ruderal species, TP = species typical of the habitat, TP\_other = species typical of other habitats. For example, TP\_other (N14) = refers to species typical of the shifting dunes habitat (N14), while TP\_other (no dune) = refers to species typical of other habitats than those investigated.

Habitat	Type	Contribution Decrease	Contribution Increase	N. species ↓	N. species ↑	Net contribution
Upper Beach	NN	0	1.30	0	4	1.30
Upper Beach	RD	0	0.42	0	3	0.42
Upper Beach	TP_other (N14)	0	14.59	0	8	14.59
Upper Beach	TP_other (N16)	0	2.87	0	9	2.87
Upper Beach	TP_other (no dune)	0	0.58	0	1	0.58
Shifting Dunes	NN	-0.33	3.02	1	15	2.69
Shifting Dunes	RD	-0.03	2.31	1	31	2.28
Shifting Dunes	TP	-8.67	8.71	2	7	0.03
Shifting Dunes	TP_other (N12)	0	4.07	0	6	4.07
Shifting Dunes	TP_other (N16)	0	13.44	0	30	13.44
Shifting Dunes	TP_other (no dune)	0	1.75	0	17	1.75
Dune Grasslands	NN	0	1.47	0	12	1.47
Dune Grasslands	RD	0	3.61	0	28	3.61
Dune Grasslands	TP	0	18.30	0	15	18.30
Dune Grasslands	TP_other (N12)	0	0.18	0	1	0.18
Dune Grasslands	TP_other (N14)	0	4.80	0	6	4.80
Dune Grasslands	TP_other (no dune)	0	5.68	0	29	5.68

**Table S6. Species that contributed to dissimilarity (SIMPER) between historical and resurveyed plots for each habitat type.** Output of SIMPER analysis showing the contribution of each species to the average dissimilarity between historical and resurveyed plots, grouped by habitat type (EUNIS N12: upper beach; N14: shifting dunes; N16: dune grasslands). sd = standard deviation; ratio = ratio of average dissimilarity to standard deviation. Statistically significant contributions to dissimilarity (p-value) are listed at the top of the table and highlighted in bold. Species groups: AR = Archeophytes; NN = non-native species; NT = refers to all native species not included in the other groups analysed; RD = ruderal species; TP = species typical of the habitat; TP\_other = species typical of other habitats. For example, TP\_other (N14) refers to species typical of the shifting dunes habitat (N14), whereas TP\_other (no dune) indicates species typical of other habitats not belonging to the three habitat types investigated.

Upper Beach Species	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Thinopyrum junceum</i>	<b>0.03</b>	<b>0.05</b>	<b>0.67</b>	<b>0.85</b>	<b>2.87</b>	<b>4.23</b>	<b>0.52</b>	<b>0.001</b>	TP_other (N14)
<i>Medicago marina</i>	<b>0.02</b>	<b>0.05</b>	<b>0.40</b>	<b>0.23</b>	<b>2.75</b>	<b>2.66</b>	<b>0.65</b>	<b>0.002</b>	TP_other (N14)
<i>Lotus creticus</i> gr.	<b>0.02</b>	<b>0.07</b>	<b>0.30</b>	<b>0.03</b>	<b>2.40</b>	<b>2.51</b>	<b>0.68</b>	<b>0.007</b>	TP_other (N14)
<i>Echinophora spinosa</i>	<b>0.02</b>	<b>0.04</b>	<b>0.40</b>	<b>0.20</b>	<b>1.60</b>	<b>2.23</b>	<b>0.70</b>	<b>0.023</b>	TP_other (N14)
<i>Calamagrostis arenaria arundinacea</i>	<b>0.02</b>	<b>0.04</b>	<b>0.37</b>	<b>0.12</b>	<b>1.13</b>	<b>2.09</b>	<b>0.72</b>	<b>0.014</b>	TP_other (N14)
<i>Helichrysum stoechas stoechas</i>	<b>0.01</b>	<b>0.04</b>	<b>0.23</b>	<b>0.00</b>	<b>1.12</b>	<b>1.24</b>	<b>0.82</b>	<b>0.024</b>	TP_other (N16)
<i>Juniperus macrocarpa</i>	<b>0.00</b>	<b>0.03</b>	<b>0.18</b>	<b>0.00</b>	<b>0.38</b>	<b>0.58</b>	<b>0.87</b>	<b>0.028</b>	TP_other (no dune)
<i>Anthemis maritima maritima</i>	<b>0.00</b>	<b>0.02</b>	<b>0.23</b>	<b>0.00</b>	<b>0.35</b>	<b>0.48</b>	<b>0.88</b>	<b>0.012</b>	TP_other (N14)
<i>Oenothera</i> sp.pl.	<b>0.00</b>	<b>0.01</b>	<b>0.36</b>	<b>0.00</b>	<b>0.30</b>	<b>0.45</b>	<b>0.89</b>	<b>0.004</b>	NN
<i>Daucus pumilus</i>	<b>0.00</b>	<b>0.02</b>	<b>0.19</b>	<b>0.00</b>	<b>0.28</b>	<b>0.39</b>	<b>0.90</b>	<b>0.034</b>	TP_other (N16)
<i>Oxalis pes-caprae</i>	<b>0.00</b>	<b>0.01</b>	<b>0.45</b>	<b>0.00</b>	<b>0.37</b>	<b>0.35</b>	<b>0.91</b>	<b>0.002</b>	NN
<i>Cenchrus</i> sp.pl.	<b>0.00</b>	<b>0.01</b>	<b>0.23</b>	<b>0.00</b>	<b>0.13</b>	<b>0.34</b>	<b>0.91</b>	<b>0.024</b>	NN
<i>Cyperus capitatus</i>	<b>0.00</b>	<b>0.01</b>	<b>0.25</b>	<b>0.05</b>	<b>0.12</b>	<b>0.32</b>	<b>0.92</b>	<b>0.046</b>	TP_other (N14)
<i>Festuca fasciculata</i> gr.	<b>0.00</b>	<b>0.01</b>	<b>0.26</b>	<b>0.00</b>	<b>0.22</b>	<b>0.31</b>	<b>0.92</b>	<b>0.008</b>	TP_other (N16)

<b>Upper Beach Species (continue)</b>	<b>average dissimilarity</b>	<b>sd</b>	<b>ratio</b>	<b>historical average abundance</b>	<b>resurveyed average abundance</b>	<b>relative contribution</b>	<b>cumulative contribution (%)</b>	<b>p-value</b>	<b>Species groups</b>
<b>Marcus- kochia ramosissima</b>	<b>0.00</b>	<b>0.01</b>	<b>0.28</b>	<b>0.00</b>	<b>0.18</b>	<b>0.21</b>	<b>0.93</b>	<b>0.011</b>	<b>TP_othe r (N16)</b>
<b>Silene colorata gr.</b>	<b>0.00</b>	<b>0.01</b>	<b>0.24</b>	<b>0.00</b>	<b>0.15</b>	<b>0.21</b>	<b>0.94</b>	<b>0.016</b>	<b>TP_othe r (N16)</b>
<b>Avena barbata</b>	<b>0.00</b>	<b>0.00</b>	<b>0.29</b>	<b>0.00</b>	<b>0.17</b>	<b>0.18</b>	<b>0.95</b>	<b>0.009</b>	<b>RD</b>
<b>Senecio leucanthemif olius</b>	<b>0.00</b>	<b>0.01</b>	<b>0.19</b>	<b>0.00</b>	<b>0.12</b>	<b>0.18</b>	<b>0.95</b>	<b>0.037</b>	<b>NT</b>
<b>Reichardia picroides</b>	<b>0.00</b>	<b>0.00</b>	<b>0.29</b>	<b>0.00</b>	<b>0.17</b>	<b>0.17</b>	<b>0.95</b>	<b>0.01</b>	<b>NT</b>
<b>Hypochaeris glabra</b>	<b>0.00</b>	<b>0.01</b>	<b>0.22</b>	<b>0.00</b>	<b>0.13</b>	<b>0.17</b>	<b>0.95</b>	<b>0.027</b>	<b>NT</b>
<b>Erigeron sp.pl.</b>	<b>0.00</b>	<b>0.01</b>	<b>0.18</b>	<b>0.00</b>	<b>0.08</b>	<b>0.17</b>	<b>0.96</b>	<b>0.049</b>	<b>NN</b>
<b>Seseli tortuosum tortuosum s.l.</b>	<b>0.00</b>	<b>0.00</b>	<b>0.24</b>	<b>0.00</b>	<b>0.13</b>	<b>0.15</b>	<b>0.96</b>	<b>0.015</b>	<b>TP_othe r (N16)</b>
<b>Mercurialis annua</b>	<b>0.00</b>	<b>0.01</b>	<b>0.21</b>	<b>0.00</b>	<b>0.10</b>	<b>0.13</b>	<b>0.96</b>	<b>0.038</b>	<b>RD</b>
<b>Lomelosia rutifolia</b>	<b>0.00</b>	<b>0.00</b>	<b>0.21</b>	<b>0.00</b>	<b>0.12</b>	<b>0.13</b>	<b>0.97</b>	<b>0.029</b>	<b>TP_othe r (N16)</b>
<b>Lagurus ovatus</b>	<b>0.00</b>	<b>0.00</b>	<b>0.22</b>	<b>0.00</b>	<b>0.13</b>	<b>0.13</b>	<b>0.97</b>	<b>0.032</b>	<b>TP_othe r (N16)</b>
<b>Orobanche minor</b>	<b>0.00</b>	<b>0.00</b>	<b>0.21</b>	<b>0.00</b>	<b>0.10</b>	<b>0.12</b>	<b>0.97</b>	<b>0.031</b>	<b>NT</b>
<b>Phleum arenarium</b>	<b>0.00</b>	<b>0.00</b>	<b>0.21</b>	<b>0.00</b>	<b>0.10</b>	<b>0.11</b>	<b>0.97</b>	<b>0.036</b>	<b>TP_othe r (N16)</b>
<b>Hypochaeris radicata</b>	<b>0.00</b>	<b>0.00</b>	<b>0.22</b>	<b>0.00</b>	<b>0.12</b>	<b>0.11</b>	<b>0.97</b>	<b>0.032</b>	<b>RD</b>
<b>Stachys maritima</b>	<b>0.00</b>	<b>0.00</b>	<b>0.18</b>	<b>0.00</b>	<b>0.07</b>	<b>0.06</b>	<b>0.99</b>	<b>0.05</b>	<b>TP_othe r (N14)</b>
<b>Cakile maritima maritima</b>	0.17	0.17	1.01	13.33	11.08	21.61	0.22	0.191	TP
<b>Salsola kali gr</b>	0.09	0.12	0.77	7.05	5.02	11.87	0.33	0.535	TP
<b>Xanthium orientale</b>	0.08	0.12	0.65	5.10	3.32	10.07	0.44	0.372	NN
<b>Matthiola tricuspidata</b>	0.04	0.07	0.50	2.07	3.15	4.59	0.48	0.237	<b>TP_othe r (N16)</b>
<b>Glaucium flavum</b>	0.03	0.11	0.29	1.52	1.82	3.82	0.56	0.882	TP

Upper Beach Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Euphorbia peplis</i>	0.03	0.05	0.60	1.82	1.02	3.57	0.60	0.28	TP
<i>Polygonum maritimum</i>	0.02	0.08	0.30	1.85	0.63	2.99	0.63	0.785	TP
<i>Eryngium maritimum</i>	0.02	0.03	0.47	0.38	0.95	2.01	0.74	0.106	TP_othe r (N14)
<i>Sporobolus pungens</i>	0.01	0.04	0.39	0.33	0.92	1.89	0.76	0.054	TP_othe r (N14)
<i>Phragmites australis</i>	0.01	0.05	0.26	0.57	0.63	1.54	0.78	0.878	NT
<i>Limbarda crithmoides longifolia</i>	0.01	0.03	0.42	0.20	0.90	1.54	0.79	0.061	TP_othe r (no dune)
<i>Cynodon dactylon</i>	0.01	0.04	0.26	0.20	0.62	1.27	0.81	0.213	RD
<i>Convolvulus soldanella</i>	0.01	0.02	0.49	0.43	0.17	1.16	0.83	0.118	TP_othe r (N14)
<i>Pancratium maritimum</i>	0.01	0.03	0.25	0.12	0.37	0.92	0.84	0.159	TP_othe r (N14)
<i>Atriplex prostrata</i>	0.01	0.02	0.41	0.25	0.20	0.83	0.85	0.872	TP
<i>Raphanus raphanistrum s.l.</i>	0.01	0.03	0.18	0.22	0.23	0.74	0.85	0.705	RD
<i>Rumex bucephalophorus s.l.</i>	0.01	0.04	0.13	0.00	0.63	0.66	0.86	0.097	NT
<i>Euphorbia paralias</i>	0.00	0.02	0.32	0.10	0.40	0.62	0.87	0.285	TP_othe r (N14)
<i>Sida inermis</i>	0.00	0.02	0.29	0.12	0.13	0.58	0.88	0.198	TP
<i>Dittrichia viscosa viscosa</i>	0.00	0.02	0.18	0.22	0.08	0.40	0.89	0.797	RD
<i>Cutandia maritima</i>	0.00	0.01	0.28	0.03	0.15	0.40	0.90	0.06	TP_othe r (N16)
<i>Paspalum vaginatum</i>	0.00	0.01	0.26	0.15	0.00	0.36	0.90	0.502	NN
<i>Achillea maritima maritima</i>	0.00	0.01	0.19	0.03	0.30	0.36	0.91	0.086	TP_othe r (N14)
<i>Ambrosia psilostachya</i>	0.00	0.01	0.23	0.07	0.07	0.28	0.92	0.407	NN
<i>Elymus repens repens</i>	0.00	0.01	0.15	0.03	0.10	0.25	0.93	0.191	RD

Upper Beach Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Amorpha fruticosa</i>	0.00	0.02	0.13	0.22	0.00	0.24	0.93	0.931	TP_othe r (no dune)
<i>Cuscuta sp.pl.</i>	0.00	0.02	0.13	0.22	0.00	0.24	0.93	0.931	RD
<i>Thinopyrum acutum</i>	0.00	0.01	0.21	0.12	0.00	0.22	0.93	0.948	NT
<i>Arundo donax</i>	0.00	0.01	0.17	0.03	0.03	0.19	0.94	0.384	NN
<i>Beta vulgaris maritima</i>	0.00	0.00	0.31	0.15	0.03	0.19	0.94	0.95	RD
<i>Silene niceensis</i>	0.00	0.01	0.13	0.00	0.22	0.19	0.94	0.095	TP_othe r (N16)
<i>Halimione portulacoides</i>	0.00	0.01	0.23	0.12	0.03	0.19	0.94	0.964	TP_othe r (no dune)
<i>Sporobolus pumilus</i>	0.00	0.01	0.21	0.03	0.08	0.18	0.95	0.325	NN
<i>Convolvulus sepium</i>	0.00	0.01	0.16	0.07	0.00	0.18	0.95	0.882	NT
<i>Senecio inaequidens</i>	0.00	0.01	0.17	0.00	0.07	0.16	0.96	0.06	NN
<i>Medicago rigidula</i>	0.00	0.01	0.21	0.12	0.00	0.15	0.96	0.963	TP_othe r (no dune)
<i>Ambrosia tenuifolia</i>	0.00	0.01	0.17	0.03	0.03	0.14	0.96	0.738	NN
<i>Lysimachia arvensis</i>	0.00	0.00	0.26	0.03	0.10	0.14	0.96	0.109	RD
<i>Lobularia maritima</i>	0.00	0.01	0.16	0.03	0.03	0.12	0.97	0.785	TP_othe r (no dune)
<i>Poacynum venetum</i>	0.00	0.01	0.17	0.03	0.03	0.11	0.97	0.825	TP_othe r (N16)
<i>Sonchus oleraceus</i>	0.00	0.01	0.16	0.00	0.05	0.11	0.97	0.077	RD
<i>Pinus pinaster pinaster</i>	0.00	0.01	0.14	0.00	0.03	0.11	0.98	0.086	TP_othe r (no dune)
<i>Cyperus esculentus</i>	0.00	0.01	0.12	0.00	0.03	0.09	0.98	0.127	NN
<i>Pistacia lentiscus</i>	0.00	0.01	0.12	0.00	0.05	0.09	0.98	0.117	TP_othe r (no dune)
<i>Sonchus asper s.l.</i>	0.00	0.00	0.18	0.00	0.08	0.08	0.98	0.058	RD

Upper Beach Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Medicago littoralis	0.00	0.00	0.13	0.00	0.05	0.08	0.98	0.104	TP_othe r (N16)
Sonchus maritimus	0.00	0.01	0.12	0.03	0.00	0.08	0.98	0.847	RD
Hordeum marinum	0.00	0.01	0.12	0.03	0.00	0.08	0.98	0.847	RD
Glycyrrhiza glabra	0.00	0.01	0.12	0.03	0.00	0.08	0.98	0.847	NT
Mentha aquatica aquatica	0.00	0.00	0.13	0.03	0.00	0.04	1.00	0.93	NT
Anisantha rigida	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.084	RD
Malva parviflora	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.097	RD
Centaurium pulchellum pulchellum	0.00	0.00	0.13	0.03	0.00	0.03	1.00	0.94	NT
Juncus maritimus	0.00	0.00	0.13	0.03	0.00	0.03	1.00	0.94	TP_othe r (no dune)
Echium plantagineum	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.094	RD
Narcissus tazetta	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.094	NT
Solanum nigrum	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.094	RD
Urtica dioica	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.094	RD
Brassica fruticulosa fruticulosa	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.092	NT
Solidago virgaurea litoralis	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.084	NT
Smilax aspera	0.00	0.00	0.12	0.00	0.02	0.03	1.00	0.117	TP_othe r (no dune)
Glebionis coronaria	0.00	0.00	0.13	0.00	0.03	0.03	1.00	0.095	RD
Quercus ilex	0.00	0.00	0.13	0.00	0.02	0.03	1.00	0.104	TP_othe r (no dune)
Silene otites otites	0.00	0.00	0.13	0.00	0.03	0.02	1.00	0.077	TP_othe r (N16)
Coleostephus myconis	0.00	0.00	0.13	0.00	0.02	0.02	1.00	0.084	NT

<b>Upper Beach</b> Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Anisantha rigida	0	0	0.13	0	0.03	0.03	1	0.084	RD
Malva parviflora	0	0	0.13	0	0.03	0	1	0.097	RD
Crithmum maritimum	0	0	0.12	0.03	0	0	0.99	0.929	TP_othe r (no dune)
Juncus maritimus	0	0	0.13	0.03	0	0	1	0.94	TP_othe r (no dune)
Echium plantagineum	0	0	0.13	0	0.03	0	1	0.094	RD
Narcissus tazetta	0	0	0.13	0	0.03	0	1	0.094	NT
Solanum nigrum	0	0	0.13	0	0.03	0	1	0.094	RD
Urtica dioica	0	0	0.13	0	0.03	0	1	0.094	RD
Brassica fruticulosa fruticulosa	0	0	0.13	0	0.03	0	1	0.092	NT
Solidago virgaurea litoralis	0	0	0.13	0	0.03	0	1	0.084	NT
Smilax aspera	0	0	0.12	0	0.02	0	1	0.117	TP_othe r (no dune)
Glebionis coronaria	0	0	0.13	0	0.03	0	1	0.095	RD
Quercus ilex	0	0	0.13	0	0.02	0	1	0.104	TP_othe r (no dune)
Silene otites otites	0	0	0.13	0	0.03	0	1	0.077	TP_othe r (N16)
Coleostephus myconis	0	0	0.13	0	0.02	0	1	0.084	NT

<b>Shifting Dunes</b> Species	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<b>Echinophora spinosa</b>	<b>0.04</b>	<b>0.06</b>	<b>0.66</b>	<b>4.51</b>	<b>2.64</b>	<b>4.60</b>	<b>0.33</b>	<b>0.001</b>	<b>TP</b>
<b>Eryngium maritimum</b>	<b>0.03</b>	<b>0.06</b>	<b>0.61</b>	<b>3.70</b>	<b>2.96</b>	<b>4.08</b>	<b>0.41</b>	<b>0.001</b>	<b>TP</b>
<b>Pancratium maritimum</b>	<b>0.03</b>	<b>0.06</b>	<b>0.46</b>	<b>1.34</b>	<b>3.28</b>	<b>3.30</b>	<b>0.49</b>	<b>0.001</b>	<b>TP</b>
<b>Lotus creticus gr.</b>	<b>0.03</b>	<b>0.06</b>	<b>0.39</b>	<b>0.99</b>	<b>3.51</b>	<b>2.95</b>	<b>0.58</b>	<b>0.001</b>	<b>TP</b>

Shifting Dunes Species	average dissimilarit y	sd	ratio	historical average abundanc e	resurveye d average abundance	relative contributio n	cumulative contributio n (%)	p- value	Species groups
<i>Cakile maritima</i> <i>maritima</i>	0.02	0.05	0.37	1.07	2.03	2.39	0.60	0.001	TP_other (N12)
<i>Festuca fasciculata</i> gr.	0.02	0.05	0.37	0.37	2.83	2.25	0.65	0.001	TP_other (N16)
<i>Anthemis maritima</i> <i>maritima</i>	0.02	0.05	0.32	0.47	2.21	2.05	0.69	0.001	TP
<i>Helichrysum stoechas</i> <i>stoechas</i>	0.01	0.05	0.30	0.49	1.51	1.66	0.70	0.008	TP_other (N16)
<i>Ononis variegata</i>	0.01	0.04	0.34	0.53	1.72	1.63	0.72	0.001	TP_other (N16)
<i>Xanthium orientale</i>	0.01	0.03	0.41	0.55	0.97	1.37	0.73	0.002	NN
<i>Silene colorata</i> gr.	0.01	0.02	0.58	0.40	1.24	1.12	0.76	0.001	TP_other (N16)
<i>Silene niceensis</i>	0.01	0.02	0.39	0.57	0.75	0.94	0.77	0.016	TP_other (N16)
<i>Lomelosia rutifolia</i>	0.01	0.04	0.21	0.17	1.18	0.93	0.78	0.001	TP_other (N16)
<i>Salsola kali</i> gr.	0.01	0.01	0.52	0.35	0.75	0.91	0.79	0.002	TP_other (N12)
<i>Cutandia maritima</i>	0.01	0.02	0.42	0.51	0.68	0.91	0.80	0.032	TP_other (N16)
<i>Juniperus macrocarpa</i>	0.01	0.02	0.31	0.07	0.89	0.83	0.81	0.001	TP_other (no dune)
<i>Phleum arenarium</i>	0.01	0.02	0.27	0.25	0.70	0.80	0.82	0.001	TP_other (N16)
<i>Medicago littoralis</i>	0.01	0.02	0.41	0.07	0.91	0.75	0.83	0.001	TP_other (N16)
<i>Matthiola tricuspidata</i>	0.01	0.03	0.19	0.13	0.78	0.71	0.84	0.001	TP_other (N16)
<i>Oenothera</i> sp.pl.	0.00	0.01	0.28	0.26	0.36	0.50	0.85	0.036	NN
<i>Sixalix atropurpurea</i>	0.00	0.02	0.19	0.28	0.32	0.46	0.86	0.035	RD
<i>Crucianella maritima</i>	0.00	0.02	0.17	0.24	0.30	0.45	0.87	0.013	TP_other (N16)
<i>Euphorbia peplis</i>	0.00	0.01	0.32	0.18	0.25	0.44	0.87	0.031	TP_other (N12)
<i>Carpobrotus</i> sp.pl.	0.00	0.03	0.14	0.01	0.43	0.44	0.87	0.002	NN
<i>Hypochoeris radicata</i>	0.00	0.01	0.33	0.14	0.39	0.43	0.88	0.011	RD

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Reichardia picroides</i>	0.00	0.01	0.41	0.16	0.30	0.41	0.89	0.006	NT
<i>Cuscuta</i> sp.pl.	0.00	0.01	0.34	0.25	0.03	0.33	0.90	0.003	NN
<i>Euphorbia terraccina</i>	0.00	0.01	0.30	0.11	0.26	0.32	0.90	0.001	TP
<i>Plantago coronopus</i> gr.	0.00	0.02	0.15	0.02	0.43	0.31	0.91	0.002	RD
<i>Pistacia lentiscus</i>	0.00	0.03	0.08	0.03	0.33	0.26	0.91	0.024	TP_other
<i>Daucus pumilus</i>	0.00	0.01	0.25	0.08	0.24	0.26	0.92	0.043	TP_other (N16)
<i>Polygonum maritimum</i>	0.00	0.01	0.29	0.07	0.17	0.25	0.92	0.045	TP_other (N12)
<i>Erigeron</i> sp.pl.	0.00	0.01	0.26	0.07	0.23	0.23	0.92	0.002	NN
<i>Helichrysum italicum tyrrhenicum</i>	0.00	0.02	0.07	0.09	0.13	0.20	0.93	0.048	TP_other (N16)
<i>Anisantha rigida</i>	0.00	0.01	0.17	0.11	0.27	0.20	0.93	0.013	RD
<i>Solidago virgaurea virgaurea</i>	0.00	0.01	0.19	0.05	0.20	0.19	0.93	0.022	NT
<i>Pinus pinaster pinaster</i>	0.00	0.02	0.08	0.00	0.18	0.18	0.94	0.005	TP_other (no dune)
<i>Lysimachia arvensis</i>	0.00	0.01	0.26	0.01	0.17	0.17	0.94	0.001	RD
<i>Lotus hirsutus</i>	0.00	0.01	0.16	0.03	0.19	0.17	0.94	0.004	TP_other (no dune)
<i>Silene otites otites</i>	0.00	0.01	0.18	0.04	0.18	0.17	0.94	0.037	TP_other (N16)
<i>Anthemis arvensis</i>	0.00	0.02	0.09	0.00	0.27	0.16	0.95	0.003	RD
<i>Seseli tortuosum tortuosum</i> s.l.	0.00	0.00	0.28	0.05	0.14	0.15	0.95	0.008	TP_other (N16)
<i>Ambrosia tenuifolia</i>	0.00	0.01	0.12	0.03	0.12	0.14	0.95	0.01	NN
<i>Cenchrus</i> sp.pl.	0.00	0.01	0.13	0.03	0.11	0.14	0.95	0.005	NN
<i>Raphanus raphanistrum</i> s.l.	0.00	0.00	0.20	0.05	0.08	0.12	0.95	0.032	RD
<i>Marcus-kochia ramosissima</i>	0.00	0.00	0.23	0.02	0.11	0.10	0.96	0.008	TP_other (N16)
<i>Salvia rosmarinus</i>	0.00	0.01	0.08	0.01	0.06	0.09	0.96	0.035	TP_other (no dune)
<i>Hypochaeris glabra</i>	0.00	0.00	0.22	0.01	0.10	0.09	0.96	0.001	NT

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Senecio inaequidens</i>	0.00	0.00	0.17	0.03	0.05	0.09	0.96	0.003	NN
<i>Anisantha tectorum</i>	0.00	0.01	0.11	0.02	0.08	0.09	0.96	0.003	RD
<i>Andryala integrifolia</i>	0.00	0.00	0.23	0.02	0.11	0.08	0.96	0.004	TP_other (N16)
<i>Medicago minima</i>	0.00	0.00	0.19	0.02	0.06	0.08	0.96	0.008	TP_other (N16)
<i>Polycarpon tetraphyllum</i> s.l.	0.00	0.00	0.17	0.01	0.08	0.08	0.96	0.001	TP_other (N16)
<i>Rumex bucephalophorus</i> s.l.	0.00	0.00	0.15	0.01	0.06	0.08	0.97	0.005	NT
<i>Trifolium arvense</i>	0.00	0.01	0.06	0.00	0.13	0.07	0.97	0.012	NT
<i>Polypogon maritimus</i> <i>maritimus</i>	0.00	0.00	0.19	0.04	0.05	0.07	0.97	0.048	TP
<i>Avena barbata</i>	0.00	0.00	0.15	0.02	0.05	0.07	0.97	0.005	RD
<i>Odontites luteus</i> s.l.	0.00	0.00	0.19	0.01	0.09	0.07	0.97	0.001	TP_other (no dune)
<i>Cerastium ligusticum</i>	0.00	0.01	0.11	0.00	0.09	0.07	0.97	0.001	NT
<i>Urospermum dalechampii</i>	0.00	0.00	0.16	0.01	0.05	0.07	0.97	0.001	RD
<i>Linum strictum</i>	0.00	0.00	0.12	0.00	0.10	0.07	0.97	0.002	NT
<i>Soda inermis</i>	0.00	0.01	0.10	0.00	0.06	0.06	0.97	0.002	TP_other (N12)
<i>Arundo donax</i>	0.00	0.00	0.16	0.01	0.05	0.06	0.97	0.012	AR
<i>Glycyrrhiza glabra</i>	0.00	0.01	0.08	0.01	0.06	0.06	0.98	0.008	NT
<i>Erodium laciniatum</i> <i>laciniatum</i>	0.00	0.01	0.08	0.02	0.06	0.06	0.98	0.04	NT
<i>Orobanche minor</i>	0.00	0.00	0.18	0.00	0.07	0.05	0.98	0.001	NT
<i>Periploca graeca</i>	0.00	0.00	0.08	0.00	0.06	0.05	0.98	0.002	NT
<i>Anisantha diandra</i>	0.00	0.00	0.15	0.00	0.06	0.05	0.98	0.001	TP_other (N16)
<i>Catapodium rigidum</i>	0.00	0.00	0.14	0.01	0.04	0.04	0.98	0.014	RD
<i>Echium plantagineum</i>	0.00	0.00	0.13	0.02	0.02	0.03	0.98	0.031	RD
<i>Cerastium semidecandrum</i>	0.00	0.00	0.14	0.01	0.03	0.03	0.98	0.006	TP_other (N16)

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Lysimachia foemina</i>	0.00	0.00	0.15	0.00	0.05	0.03	0.98	0.001	NT
<i>Allium sphaerocephalon sphaerocephalon</i>	0.00	0.00	0.11	0.01	0.02	0.03	0.99	0.04	RD
<i>Scirpoides holoschoenus</i>	0.00	0.00	0.08	0.00	0.06	0.03	0.99	0.006	TP_other (no dune)
<i>Anisantha rubens</i>	0.00	0.00	0.07	0.00	0.02	0.02	0.99	0.004	NT
<i>Papaver rhoeas rhoeas</i>	0.00	0.00	0.07	0.00	0.05	0.02	0.99	0.006	RD
<i>Sonchus oleraceus</i>	0.00	0.00	0.12	0.01	0.02	0.02	0.99	0.012	RD
<i>Sonchus asper s.l.</i>	0.00	0.00	0.07	0.00	0.02	0.02	0.99	0.01	RD
<i>Vicia pseudocracca</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.003	NT
<i>Asparagus acutifolius</i>	0.00	0.00	0.11	0.00	0.02	0.02	0.99	0.026	TP_other (no dune)
<i>Rhagadiolus stellatus</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.005	NT
<i>Avellinia festucoides</i>	0.00	0.00	0.08	0.00	0.02	0.02	0.99	0.006	TP_other (N16)
<i>Atriplex prostrata</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.004	TP_other (N12)
<i>Limonium contortirameum</i>	0.00	0.00	0.05	0.00	0.01	0.02	0.99	0.012	TP_other (no dune)
<i>Avena sterilis</i>	0.00	0.00	0.06	0.00	0.04	0.02	0.99	0.013	AR
<i>Cota tinctoria</i>	0.00	0.00	0.06	0.00	0.04	0.02	0.99	0.013	NT
<i>Lactuca sativa serriola</i>	0.00	0.00	0.06	0.00	0.04	0.02	0.99	0.013	RD
<i>Trifolium campestre</i>	0.00	0.00	0.06	0.00	0.04	0.02	0.99	0.013	RD
<i>Phillyrea angustifolia</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.005	TP_other (no dune)
<i>Ononis natrix ramosissima</i>	0.00	0.00	0.08	0.00	0.02	0.02	0.99	0.005	TP_other (N16)
<i>Allium polyanthum</i>	0.00	0.00	0.05	0.00	0.01	0.01	0.99	0.006	TP_other (no dune)
<i>Calendula arvensis</i>	0.00	0.00	0.05	0.00	0.01	0.01	0.99	0.006	RD
<i>Veronica persica</i>	0.00	0.00	0.09	0.00	0.02	0.01	0.99	0.002	NN
<i>Imperata cylindrica</i>	0.00	0.00	0.08	0.00	0.01	0.01	0.99	0.004	TP_other (no dune)

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Herniaria glabra</i>	0.00	0.00	0.08	0.00	0.01	0.01	0.99	0.006	NT
<i>Plantago albicans</i>	0.00	0.00	0.06	0.00	0.01	0.01	0.99	0.011	TP_other (N16)
<i>Allium commutatum</i>	0.00	0.00	0.08	0.00	0.01	0.01	0.99	0.005	TP_other (no dune)
<i>Festuca incurva</i>	0.00	0.00	0.06	0.00	0.01	0.01	0.99	0.011	NT
<i>Cenchrus setaceus</i>	0.00	0.00	0.08	0.00	0.01	0.01	0.99	0.006	NN
<i>Cyperus esculentus</i>	0.00	0.00	0.05	0.00	0.01	0.01	1.00	0.012	AR
<i>Robinia pseudoacacia</i>	0.00	0.00	0.05	0.00	0.01	0.01	1.00	0.011	NN
<i>Medicago orbicularis</i>	0.00	0.00	0.08	0.00	0.01	0.01	1.00	0.004	NT
<i>Silene gallica</i>	0.00	0.00	0.08	0.00	0.01	0.01	1.00	0.004	TP_other (N16)
<i>Clematis flammula</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.011	TP_other (no dune)
<i>Cachrys pungens</i>	0.00	0.00	0.05	0.00	0.01	0.01	1.00	0.009	NT
<i>Armeria pungens</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.011	TP_other (N16)
<i>Scrophularia canina</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.009	NT
<i>Erysimum crassistylum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.011	NT
<i>Senecio vulgaris</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.01	NT
<i>Helichrysum litoreum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.011	TP_other (N16)
<i>Festuca geniculata geniculata</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.008	NT
<i>Seseli tortuosum maritimum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.01	TP_other (N16)
<i>Juniperus phoenicea</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.01	TP_other (no dune)
<i>Lolium rigidum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.006	RD
<i>Citrullus lanatus</i>	0.00	0.00	0.05	0.00	0.00	0.01	1.00	0.015	AR
<i>Clinopodium nepeta</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.012	RD
<i>Trifolium scabrum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.008	NT
<i>Myrtus communis</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.012	TP_other (no dune)

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Helichrysum italicum siculum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.008	TP_other (N16)
<i>Mercurialis annua</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.01	RD
<i>Solanum nigrum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.005	RD
<i>Trifolium striatum</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.005	NT
<i>Vicia dasycarpa</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.007	NT
<i>Squilla pancratium</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.01	TP_other (no dune)
<i>Crepis neglecta corymbosa</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.008	RD
<i>Ononis reclinata</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.008	NT
<i>Saxifraga tridactylites</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.008	RD
<i>Trifolium nigrescens</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.008	NT
<i>Centaurea apolepa subciliata</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.011	TP
<i>Macrobriza maxima</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.007	RD
<i>Rostraria cristata</i>	0.00	0.00	0.06	0.00	0.01	0.01	1.00	0.011	NT
<i>Carlina gummifera</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.011	NT
<i>Jasione montana</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.009	NT
<i>Anthemis peregrina</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.006	TP
<i>Clematis vitalba</i>	0.00	0.00	0.05	0.00	0.00	0.00	1.00	0.012	RD
<i>Lonicera caprifolium</i>	0.00	0.00	0.05	0.00	0.00	0.00	1.00	0.012	NT
<i>Silene bellidifolia</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.009	NT
<i>Thapsia garganica</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.009	NT
<i>Geranium purpureum</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.012	RD
<i>Petrorhagia prolifera</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.012	NT
<i>Cladanthus mixtus</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.007	TP_other (N16)
<i>Opuntia ficus- indica</i>	0.00	0.00	0.06	0.00	0.01	0.00	1.00	0.01	NN

<b>Shifting Dunes Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<b>Anisantha fasciculata</b>	<b>0.00</b>	<b>0.00</b>	<b>0.06</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>1.00</b>	<b>0.007</b>	<b>NT</b>
<b>Chenopodium album</b>	<b>0.00</b>	<b>0.00</b>	<b>0.06</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>1.00</b>	<b>0.009</b>	<b>RD</b>
<b>Galium aparine</b>	<b>0.00</b>	<b>0.00</b>	<b>0.06</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>1.00</b>	<b>0.009</b>	<b>RD</b>
<b>Lamium amplexicaule</b>	<b>0.00</b>	<b>0.00</b>	<b>0.06</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>1.00</b>	<b>0.009</b>	<b>RD</b>
<b>Geranium molle</b>	<b>0.00</b>	<b>0.00</b>	<b>0.06</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>1.00</b>	<b>0.009</b>	<b>NT</b>
<b>Medicago lupulina</b>	<b>0.00</b>	<b>0.00</b>	<b>0.06</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>1.00</b>	<b>0.007</b>	<b>RD</b>
Calamagrostis arenaria arundinacea	0.13	0.17	0.78	13.80	10.16	15.45	0.15	0.959	TP
Thinopyrum junceum	0.11	0.13	0.85	12.43	10.72	13.16	0.29	0.999	TP
Sporobolus pungens	0.03	0.09	0.38	3.76	1.67	4.09	0.37	0.999	TP
Medicago marina	0.03	0.06	0.54	3.06	2.84	3.83	0.45	0.939	TP
Sporobolus pumilus	0.03	0.10	0.26	2.64	1.49	3.17	0.52	0.999	NN
Achillea maritima maritima	0.03	0.07	0.37	3.22	1.07	3.04	0.55	0.977	TP
Convolvulus soldanella	0.02	0.05	0.44	1.81	1.63	2.35	0.62	0.865	TP
Cyperus capitatus	0.02	0.04	0.40	1.35	1.35	2.06	0.67	0.874	TP
Euphorbia paralias	0.01	0.03	0.37	1.01	0.62	1.37	0.75	0.332	TP
Crithmum maritimum	0.01	0.05	0.17	0.61	0.36	0.89	0.80	0.866	TP_other (no dune)
Centaurea sphaerocephala sphaerocephala	0.01	0.03	0.20	0.58	0.24	0.63	0.84	0.999	TP_other (N16)
Lagurus ovatus	0.00	0.01	0.39	0.22	0.45	0.48	0.85	0.058	TP_other (N16)
Matthiola sinuata	0.00	0.01	0.37	0.38	0.28	0.46	0.86	0.947	TP_other (N12)
Poacynum venetum	0.00	0.04	0.09	0.30	0.27	0.43	0.88	0.284	TP_other (N16)
Ambrosia psilostachya	0.00	0.02	0.18	0.29	0.16	0.40	0.89	0.858	NN
Limbarda crithmoides longifolia	0.00	0.01	0.25	0.14	0.43	0.40	0.89	0.051	TP_other (no dune)

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Cynodon dactylon</i>	0.00	0.01	0.27	0.15	0.29	0.34	0.90	0.402	RD
<i>Scolymus hispanicus</i> gr.	0.00	0.01	0.26	0.26	0.17	0.29	0.91	0.145	RD
<i>Rostraria litorea</i>	0.00	0.02	0.12	0.16	0.15	0.23	0.92	0.252	TP_other (N16)
<i>Silene succulenta corsica</i>	0.00	0.02	0.12	0.13	0.09	0.22	0.93	0.941	TP
<i>Launaea fragilis</i>	0.00	0.01	0.29	0.15	0.09	0.20	0.93	0.417	NT
<i>Dittrichia viscosa viscosa</i>	0.00	0.01	0.12	0.19	0.05	0.18	0.94	0.997	RD
<i>Daucus carota</i> s.l.	0.00	0.01	0.17	0.10	0.11	0.17	0.94	0.984	RD
<i>Sonchus bulbosus bulbosus</i>	0.00	0.01	0.17	0.06	0.10	0.15	0.95	0.887	TP_other (N16)
<i>Glaucium flavum</i>	0.00	0.00	0.23	0.06	0.09	0.13	0.95	0.125	TP_other (N12)
<i>Solidago virgaurea litoralis</i>	0.00	0.00	0.20	0.10	0.00	0.11	0.95	0.993	NT
<i>Verbascum sinuatum</i>	0.00	0.00	0.16	0.06	0.07	0.09	0.96	0.057	RD
<i>Thinopyrum acutum</i>	0.00	0.00	0.19	0.09	0.01	0.09	0.96	0.994	NT
<i>Phragmites australis</i>	0.00	0.00	0.18	0.06	0.04	0.09	0.96	0.595	NT
<i>Hedypnois rhagadioloides</i>	0.00	0.00	0.21	0.03	0.07	0.08	0.97	0.316	NT
<i>Silene velutina</i>	0.00	0.01	0.06	0.14	0.00	0.07	0.97	0.995	TP_other (N16)
<i>Smilax aspera</i>	0.00	0.00	0.17	0.02	0.05	0.07	0.97	0.088	TP_other (no dune)
<i>Ononis diffusa</i>	0.00	0.00	0.13	0.07	0.03	0.07	0.97	0.867	TP_other (N16)
<i>Diploaxis tenuifolia</i>	0.00	0.01	0.09	0.07	0.00	0.06	0.97	0.992	RD
<i>Artemisia campestris variabilis</i>	0.00	0.00	0.09	0.07	0.00	0.05	0.98	0.997	TP_other (N16)
<i>Senecio leucanthemifolius</i>	0.00	0.00	0.14	0.02	0.04	0.05	0.98	0.187	NT
<i>Anisantha madritensis</i>	0.00	0.00	0.14	0.03	0.03	0.05	0.98	0.989	RD
<i>Reseda alba</i> s.l.	0.00	0.00	0.15	0.02	0.03	0.04	0.98	0.111	RD
<i>Lobularia maritima</i>	0.00	0.00	0.11	0.02	0.02	0.04	0.98	0.34	TP_other (no dune)

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Rubia peregrina</i>	0.00	0.00	0.13	0.03	0.02	0.04	0.98	0.972	TP_other (no dune)
<i>Anisantha sterilis</i>	0.00	0.00	0.13	0.01	0.03	0.04	0.98	0.068	RD
<i>Parapholis incurva</i>	0.00	0.00	0.12	0.01	0.03	0.04	0.98	0.067	NT
<i>Oxalis pes-caprae</i>	0.00	0.00	0.14	0.01	0.04	0.03	0.98	0.11	NN
<i>Amorpha fruticosa</i>	0.00	0.00	0.14	0.03	0.01	0.03	0.98	1	NN
<i>Pinus pinea</i>	0.00	0.00	0.10	0.01	0.02	0.03	0.98	0.479	TP_other (no dune)
<i>Asphodelus tenuifolius</i>	0.00	0.00	0.12	0.01	0.02	0.03	0.98	0.086	NT
<i>Chondrilla juncea</i>	0.00	0.00	0.10	0.02	0.01	0.03	0.98	0.992	RD
<i>Convolvulus sepium</i>	0.00	0.00	0.06	0.04	0.00	0.03	0.98	0.994	NT
<i>Sonchus tenerrimus</i>	0.00	0.00	0.13	0.03	0.01	0.03	0.98	0.997	RD
<i>Echium sabulicola sabulicola</i>	0.00	0.00	0.14	0.03	0.02	0.03	0.98	0.991	TP_other (N16)
<i>Picris hieracioides hieracioides</i>	0.00	0.00	0.09	0.02	0.01	0.03	0.99	0.163	RD
<i>Ephedra distachya</i>	0.00	0.00	0.11	0.01	0.03	0.02	0.99	0.164	TP_other (N16)
<i>Silene vulgaris</i>	0.00	0.00	0.13	0.03	0.01	0.02	0.99	0.998	RD
<i>Plantago lanceolata</i>	0.00	0.00	0.11	0.01	0.01	0.02	0.99	0.272	RD
<i>Catapodium balearicum</i>	0.00	0.00	0.09	0.01	0.01	0.02	0.99	0.976	RD
<i>Bituminaria bituminosa</i>	0.00	0.00	0.09	0.01	0.01	0.02	0.99	0.089	RD
<i>Daphne gnidium</i>	0.00	0.00	0.08	0.00	0.01	0.02	0.99	0.097	TP_other (no dune)
<i>Ambrosia maritima</i>	0.00	0.00	0.09	0.02	0.00	0.02	0.99	0.998	TP_other (N16)
<i>Senecio transiens</i>	0.00	0.00	0.07	0.02	0.00	0.02	0.99	0.996	TP_other (N16)
<i>Agave americana americana</i>	0.00	0.00	0.09	0.01	0.02	0.02	0.99	0.598	NN
<i>Bromopsis ramosa ramosa</i>	0.00	0.00	0.11	0.02	0.01	0.02	0.99	0.616	NT
<i>Medicago rigidula</i>	0.00	0.00	0.07	0.01	0.00	0.02	0.99	0.994	NT

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Pinus halepensis</i> <i>halepensis</i>	0.00	0.00	0.07	0.01	0.01	0.02	0.99	0.15	TP_other (no dune)
<i>Dactylis</i> <i>glomerata</i> s.l.	0.00	0.00	0.10	0.02	0.00	0.02	0.99	0.997	RD
<i>Verbascum</i> <i>niveum</i> <i>garganicum</i>	0.00	0.00	0.10	0.01	0.02	0.02	0.99	0.393	NT
<i>Vitex agnus-</i> <i>castus</i>	0.00	0.00	0.05	0.01	0.00	0.01	0.99	0.986	TP_other (no dune)
<i>Beta vulgaris</i> <i>maritima</i>	0.00	0.00	0.08	0.01	0.01	0.01	0.99	0.176	RD
<i>Euphorbia peplus</i>	0.00	0.00	0.09	0.00	0.01	0.01	0.99	0.084	RD
<i>Onobrychis</i> <i>caput-galli</i>	0.00	0.00	0.07	0.01	0.01	0.01	0.99	0.948	NT
<i>Juncus acutus</i> <i>acutus</i>	0.00	0.00	0.08	0.01	0.01	0.01	0.99	0.197	TP_other (no dune)
<i>Triticum vagans</i>	0.00	0.00	0.07	0.00	0.01	0.01	0.99	0.078	NT
<i>Sonchus</i> <i>maritimus</i>	0.00	0.00	0.08	0.01	0.01	0.01	0.99	0.884	NT
<i>Equisetum</i> <i>ramosissimum</i>	0.00	0.00	0.08	0.01	0.01	0.01	0.99	0.838	RD
<i>Hordeum</i> <i>murinum</i> s.l.	0.00	0.00	0.08	0.01	0.00	0.01	0.99	0.995	RD
<i>Maresia nana</i>	0.00	0.00	0.08	0.01	0.01	0.01	0.99	0.155	TP_other (N16)
<i>Plantago</i> <i>crassifolia</i>	0.00	0.00	0.07	0.01	0.00	0.01	0.99	0.994	NT
<i>Dysphania</i> <i>atriplicifolia</i>	0.00	0.00	0.08	0.01	0.00	0.01	0.99	0.999	NN
<i>Paspalum</i> <i>vaginatum</i>	0.00	0.00	0.05	0.01	0.00	0.01	0.99	0.98	NN
<i>Silene beguinotii</i>	0.00	0.00	0.05	0.01	0.00	0.01	0.99	0.976	TP_other (N16)
<i>Sonchus arvensis</i>	0.00	0.00	0.08	0.01	0.00	0.01	0.99	0.998	RD
<i>Stachys maritima</i>	0.00	0.00	0.08	0.01	0.00	0.01	0.99	0.768	TP
<i>Ipomoea indica</i>	0.00	0.00	0.06	0.01	0.00	0.01	0.99	0.988	NN
<i>Helichrysum</i> <i>italicum italicum</i>	0.00	0.00	0.08	0.02	0.00	0.01	0.99	0.998	TP_other (N16)
<i>Pulicaria</i> <i>dysenterica</i>	0.00	0.00	0.08	0.01	0.00	0.01	0.99	0.996	NT
<i>Erica multiflora</i>	0.00	0.00	0.07	0.00	0.00	0.01	1.00	0.86	TP_other (no dune)

Shifting Dunes Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
<i>Arenaria leptoclados leptoclados</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.992	NT
<i>Juncus subulatus</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.99	TP_other (no dune)
<i>Urospermum picroides</i>	0.00	0.00	0.08	0.01	0.00	0.01	1.00	0.996	NT
<i>Carlina corymbosa</i>	0.00	0.00	0.08	0.01	0.01	0.01	1.00	0.787	RD
<i>Atriplex halimus</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.992	TP_other (no dune)
<i>Lotus corniculatus</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.992	NT
<i>Frankenia laevis laevis</i>	0.00	0.00	0.05	0.01	0.00	0.01	1.00	0.99	TP_other (no dune)
<i>Anethum foeniculum</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.987	RD
<i>Carduus pycnocephalus pycnocephalus</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.987	RD
<i>Geranium rotundifolium</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.987	NT
<i>Lolium multiflorum</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.995	RD
<i>Crepis vesicaria</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.993	NT
<i>Trigonella sulcata</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.993	NT
<i>Catapodium pauciflorum</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.993	NT
<i>Sherardia arvensis</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.992	RD
<i>Teucrium chamaedrys</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.992	TP_other (no dune)
<i>Blackstonia perfoliata</i>	0.00	0.00	0.07	0.01	0.00	0.01	1.00	0.979	NT
<i>Tamarix africana</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.993	TP_other (no dune)
<i>Carex hispida</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.993	NT
<i>Elymus repens repens</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.993	RD
<i>Fumaria capreolata capreolata</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.995	RD
<i>Silene nummica</i>	0.00	0.00	0.06	0.01	0.00	0.01	1.00	0.995	TP_other (N16)

<b>Shifting Dunes</b> Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p- value	Species groups
Centaurium tenuiflorum tenuiflorum	0.00	0.00	0.05	0.00	0.00	0.01	1.00	0.981	NT
Limonium narbonense	0.00	0.00	0.05	0.00	0.00	0.01	1.00	0.981	TP_other (no dune)
Rumex crispus	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.991	NT
Silene conica	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.991	NT
Arenaria serpyllifolia	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.996	NT
Agrostis stolonifera	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.995	NT
Leontodon hispidus	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.995	NT
Lotus rectus	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.995	NT
Vitis vinifera	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.995	NT
Epilobium hirsutum	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.994	NT
Populus alba	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.994	NT
Symphotrichum squamatum	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.994	NN
Anchusa undulata hybrida	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.989	TP_other (N16)
Cachrys sicula	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.989	NT
Beta macrocarpa	0.00	0.00	0.06	0.01	0.00	0.00	1.00	0.994	NT
Parapholis cylindrica	0.00	0.00	0.05	0.00	0.00	0.00	1.00	0.99	NT

<b>Dune Grasslands</b> Species	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<b>Festuca fasciculata gr.</b>	<b>0.06</b>	<b>0.09</b>	<b>0.64</b>	<b>5.14</b>	<b>9.49</b>	<b>6.37</b>	<b>0.06</b>	<b>0.026</b>	TP
<b>Ononis variegata</b>	<b>0.04</b>	<b>0.09</b>	<b>0.46</b>	<b>3.96</b>	<b>6.26</b>	<b>4.40</b>	<b>0.16</b>	<b>0.024</b>	TP
<b>Lotus creticus gr.</b>	<b>0.02</b>	<b>0.04</b>	<b>0.50</b>	<b>2.32</b>	<b>3.18</b>	<b>2.29</b>	<b>0.38</b>	<b>0.03</b>	TP_othe r (N14)
<b>Medicago littoralis</b>	<b>0.02</b>	<b>0.04</b>	<b>0.44</b>	<b>1.48</b>	<b>3.64</b>	<b>2.08</b>	<b>0.40</b>	<b>0.001</b>	TP
<b>Silene colorata gr.</b>	<b>0.02</b>	<b>0.03</b>	<b>0.63</b>	<b>2.51</b>	<b>2.52</b>	<b>1.98</b>	<b>0.42</b>	<b>0.04</b>	TP
<b>Plantago coronopus gr.</b>	<b>0.02</b>	<b>0.05</b>	<b>0.36</b>	<b>0.68</b>	<b>3.34</b>	<b>1.84</b>	<b>0.48</b>	<b>0.001</b>	RD

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Juniperus macrocarpa</i>	0.02	0.04	0.39	0.29	2.70	1.72	0.50	0.001	TP_other (no dune)
<i>Calamagrostis arenaria arundinacea</i>	0.01	0.04	0.31	0.47	2.07	1.43	0.54	0.001	TP_other (N14)
<i>Cutandia maritima</i>	0.01	0.04	0.26	1.15	2.07	1.05	0.62	0.033	TP
<i>Carpobrotus sp.pl.</i>	0.01	0.03	0.25	0.81	0.82	0.91	0.63	0.034	NN
<i>Sporobolus pungens</i>	0.01	0.01	0.49	0.33	1.25	0.77	0.67	0.001	TP_other (N14)
<i>Thymelaea tartonraira tartonraira</i>	0.01	0.05	0.12	0.04	0.79	0.63	0.71	0.001	TP_other (no dune)
<i>Erodium laciniatum laciniatum</i>	0.01	0.02	0.27	0.25	1.03	0.60	0.71	0.03	NT
<i>Rumex bucephalophorus s.l.</i>	0.01	0.02	0.26	0.25	0.79	0.56	0.73	0.013	NT
<i>Cistus salviifolius</i>	0.00	0.04	0.11	0.05	0.69	0.51	0.74	0.002	TP_other (no dune)
<i>Fumana procumbens</i>	0.00	0.03	0.11	0.05	0.73	0.42	0.76	0.005	TP
<i>Anchusa crispa crispa</i>	0.00	0.03	0.14	0.19	0.42	0.40	0.77	0.043	TP
<i>Crithmum maritimum</i>	0.00	0.03	0.13	0.17	0.40	0.39	0.78	0.045	TP_other (no dune)
<i>Sonchus bulbosus bulbosus</i>	0.00	0.01	0.36	0.25	0.27	0.32	0.80	0.02	TP
<i>Teucrium capitatum capitatum</i>	0.00	0.01	0.24	0.11	0.37	0.31	0.81	0.011	TP
<i>Pistacia lentiscus</i>	0.00	0.01	0.21	0.08	0.43	0.28	0.82	0.005	TP_other (no dune)
<i>Silene succulenta corsica</i>	0.00	0.02	0.13	0.03	0.25	0.27	0.83	0.001	TP_other (N14)
<i>Paronychia argentea</i>	0.00	0.02	0.14	0.11	0.40	0.27	0.83	0.045	NT

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Matthiola tricuspidata</i>	0.00	0.01	0.23	0.12	0.30	0.25	0.84	0.017	TP
<i>Ailanthus altissima</i>	0.00	0.02	0.10	0.00	0.40	0.23	0.85	0.003	NN
<i>Juniperus phoenicea</i>	0.00	0.01	0.14	0.04	0.42	0.22	0.86	0.041	TP_othe r (no dune)
<i>Anthemis arvensis</i>	0.00	0.01	0.18	0.06	0.53	0.21	0.87	0.011	RD
<i>Smilax aspera</i>	0.00	0.01	0.38	0.11	0.24	0.21	0.87	0.007	TP_othe r (no dune)
<i>Tripidium ravennae ravennae</i>	0.00	0.01	0.16	0.00	0.30	0.21	0.87	0.001	TP_othe r (no dune)
<i>Poterium sanguisorba</i>	0.00	0.01	0.24	0.09	0.25	0.20	0.88	0.005	TP
<i>Anisantha diandra</i>	0.00	0.01	0.15	0.00	0.27	0.20	0.88	0.002	TP
<i>Asparagus acutifolius</i>	0.00	0.01	0.17	0.08	0.18	0.18	0.88	0.012	TP_othe r (no dune)
<i>Salsola kali gr.</i>	0.00	0.01	0.27	0.09	0.16	0.18	0.88	0.011	TP_othe r (N12)
<i>Daucus carota s.l.</i>	0.00	0.01	0.20	0.09	0.24	0.18	0.89	0.008	RD
<i>Dittrichia viscosa viscosa</i>	0.00	0.01	0.18	0.03	0.28	0.18	0.89	0.002	RD
<i>Schoenus nigricans</i>	0.00	0.01	0.13	0.02	0.19	0.18	0.89	0.001	TP_othe r (no dune)
<i>Seseli tortuosum tortuosum s.l.</i>	0.00	0.01	0.23	0.06	0.25	0.17	0.89	0.048	TP
<i>Quercus ilex</i>	0.00	0.01	0.15	0.00	0.22	0.17	0.89	0.001	TP_othe r (no dune)
<i>Lysimachia arvensis</i>	0.00	0.00	0.32	0.04	0.22	0.15	0.90	0.005	RD
<i>Tamarix gallica</i>	0.00	0.01	0.14	0.00	0.25	0.13	0.90	0.001	TP_othe r (no dune)
<i>Linum strictum</i>	0.00	0.01	0.23	0.03	0.15	0.13	0.91	0.009	NT

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Echium plantagineum</i>	0.00	0.01	0.13	0.00	0.18	0.13	0.91	0.002	RD
<i>Erigeron</i> sp.pl.	0.00	0.00	0.31	0.02	0.20	0.13	0.91	0.001	NN
<i>Rubia peregrina</i>	0.00	0.00	0.28	0.05	0.14	0.12	0.91	0.002	TP_other (no dune)
<i>Clematis flammula</i>	0.00	0.01	0.20	0.02	0.29	0.12	0.92	0.001	TP_other (no dune)
<i>Crataegus monogyna</i>	0.00	0.01	0.11	0.00	0.16	0.12	0.92	0.001	NT
<i>Urospermum dalechampii</i>	0.00	0.00	0.26	0.02	0.17	0.11	0.92	0.001	RD
<i>Clematis vitalba</i>	0.00	0.01	0.13	0.06	0.13	0.11	0.92	0.028	RD
<i>Periploca graeca</i>	0.00	0.01	0.09	0.00	0.13	0.10	0.93	0.002	NT
<i>Sonchus oleraceus</i>	0.00	0.01	0.10	0.01	0.13	0.10	0.93	0.005	RD
<i>Hypochaeris glabra</i>	0.00	0.00	0.24	0.00	0.15	0.10	0.93	0.002	NT
<i>Senecio leucanthemifolius</i>	0.00	0.00	0.19	0.05	0.07	0.09	0.93	0.042	NT
<i>Polycarpon tetraphyllum</i> s.l.	0.00	0.00	0.24	0.03	0.14	0.09	0.94	0.002	TP
<i>Daphne gnidium</i>	0.00	0.01	0.12	0.01	0.14	0.08	0.94	0.038	TP_other (no dune)
<i>Scabiosa triandra</i>	0.00	0.01	0.11	0.02	0.13	0.08	0.94	0.016	NT
<i>Erica multiflora</i>	0.00	0.01	0.12	0.00	0.15	0.08	0.95	0.001	TP_other (no dune)
<i>Cerastium ligusticum</i>	0.00	0.00	0.24	0.00	0.13	0.08	0.95	0.001	NT
<i>Lavandula stoechas stoechas</i>	0.00	0.01	0.12	0.00	0.16	0.07	0.95	0.001	TP_other (no dune)
<i>Pinus pinaster pinaster</i>	0.00	0.01	0.12	0.00	0.15	0.07	0.95	0.002	TP_other (no dune)
<i>Chondrilla juncea</i>	0.00	0.00	0.26	0.04	0.10	0.07	0.95	0.047	RD

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Geranium molle</i>	0.00	0.00	0.21	0.02	0.08	0.07	0.95	0.003	NT
<i>Odontites luteus</i> s.l.	0.00	0.00	0.21	0.02	0.09	0.07	0.95	0.029	TP_othe r (no dune)
<i>Centaurium erythraea</i>	0.00	0.01	0.10	0.00	0.13	0.07	0.96	0.002	NT
<i>Anacyclus radiatus radiatus</i>	0.00	0.01	0.10	0.00	0.13	0.06	0.96	0.003	RD
<i>Geranium purpureum</i>	0.00	0.00	0.19	0.00	0.10	0.06	0.96	0.001	RD
<i>Phragmites australis</i>	0.00	0.01	0.10	0.00	0.13	0.06	0.96	0.003	NT
<i>Orobanche minor</i>	0.00	0.00	0.23	0.03	0.08	0.06	0.96	0.003	NT
<i>Ononis reclinata</i>	0.00	0.01	0.10	0.00	0.13	0.06	0.96	0.002	NT
<i>Helichrysum italicum italicum</i>	0.00	0.00	0.21	0.03	0.09	0.06	0.96	0.044	TP
<i>Quercus robur</i>	0.00	0.00	0.19	0.00	0.08	0.06	0.96	0.001	NT
<i>Phillyrea angustifolia</i>	0.00	0.00	0.17	0.00	0.08	0.05	0.97	0.001	TP_othe r (no dune)
<i>Linum usitatissimum</i> s.l.	0.00	0.00	0.22	0.00	0.10	0.05	0.97	0.001	NT
<i>Cenchrus</i> sp.pl.	0.00	0.00	0.22	0.02	0.10	0.05	0.97	0.03	NN
<i>Thapsia garganica</i>	0.00	0.00	0.22	0.02	0.08	0.05	0.97	0.021	NT
<i>Scabiosa columbaria</i>	0.00	0.00	0.13	0.00	0.06	0.05	0.97	0.001	RD
<i>Echium vulgare</i>	0.00	0.00	0.19	0.02	0.06	0.05	0.97	0.025	RD
<i>Trigonella wojciechowskii</i>	0.00	0.00	0.17	0.00	0.06	0.04	0.97	0.002	NT
<i>Veronica persica</i>	0.00	0.00	0.20	0.00	0.07	0.04	0.97	0.001	NN
<i>Silene italica</i>	0.00	0.00	0.13	0.00	0.05	0.04	0.97	0.001	RD
<i>Ervilia hirsuta</i>	0.00	0.00	0.16	0.00	0.06	0.04	0.97	0.001	RD

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Myosotis arvensis</i>	0.00	0.00	0.16	0.00	0.06	0.04	0.97	0.001	RD
<i>Brachypodium retusum</i>	0.00	0.00	0.13	0.00	0.05	0.04	0.97	0.001	TP_other (no dune)
<i>Vitis vinifera</i>	0.00	0.00	0.10	0.00	0.13	0.04	0.98	0.004	NT
<i>Lonicera caprifolium</i>	0.00	0.00	0.12	0.00	0.04	0.03	0.98	0.001	NT
<i>Salvia rosmarinus</i>	0.00	0.00	0.12	0.00	0.04	0.03	0.98	0.002	TP_other (no dune)
<i>Rubus ulmifolius</i>	0.00	0.00	0.17	0.00	0.06	0.03	0.98	0.001	RD
<i>Geranium columbinum</i>	0.00	0.00	0.13	0.00	0.04	0.03	0.98	0.001	RD
<i>Clinopodium nepeta</i>	0.00	0.00	0.14	0.00	0.06	0.03	0.98	0.001	RD
<i>Lysimachia foemina</i>	0.00	0.00	0.17	0.00	0.06	0.03	0.98	0.002	NT
<i>Linum trigynum</i>	0.00	0.00	0.16	0.00	0.04	0.03	0.98	0.001	NT
<i>Centaurea apolepa subciliata</i>	0.00	0.00	0.14	0.00	0.04	0.02	0.99	0.001	TP_other (N14)
<i>Colutea arborescens</i>	0.00	0.00	0.09	0.00	0.03	0.02	0.99	0.001	NT
<i>Juniperus communis</i>	0.00	0.00	0.09	0.00	0.03	0.02	0.99	0.001	TP_other (no dune)
<i>Ruscus aculeatus</i>	0.00	0.00	0.09	0.00	0.03	0.02	0.99	0.002	TP_other (no dune)
<i>Pinus halepensis halepensis</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.002	TP_other (no dune)
<i>Festuca incurva</i>	0.00	0.00	0.10	0.00	0.03	0.02	0.99	0.002	NT
<i>Moraea sisyrinchium</i>	0.00	0.00	0.14	0.00	0.04	0.02	0.99	0.002	NT
<i>Oxalis pes-caprae</i>	0.00	0.00	0.14	0.00	0.04	0.02	0.99	0.002	NN
<i>Senecio vulgaris</i>	0.00	0.00	0.14	0.00	0.04	0.02	0.99	0.003	NT

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Squilla pancracion</i>	0.00	0.00	0.14	0.00	0.05	0.02	0.99	0.002	TP_other (no dune)
<i>Medicago lupulina</i>	0.00	0.00	0.12	0.00	0.03	0.02	0.99	0.002	RD
<i>Arundo donax</i>	0.00	0.00	0.10	0.00	0.03	0.02	0.99	0.001	AR
<i>Cytisus laniger</i>	0.00	0.00	0.10	0.00	0.03	0.02	0.99	0.001	TP_other (no dune)
<i>Limbarda crithmoides longifolia</i>	0.00	0.00	0.10	0.00	0.03	0.02	0.99	0.002	TP_other (no dune)
<i>Hypericum perforatum</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	NT
<i>Luzula campestris</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	NT
<i>Oxalis dillenii</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	NN
<i>Squilla maritima</i>	0.00	0.00	0.10	0.00	0.03	0.02	0.99	0.003	TP_other (no dune)
<i>Catapodium pauciflorum</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.002	NT
<i>Poa annua</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.002	RD
<i>Arabis hirsuta</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	RD
<i>Brachypodium pinnatum</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	NT
<i>Iris germanica</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	AR
<i>Sedum gr maximum</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	NT
<i>Vincetoxicum hirundinaria</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.001	NT
<i>Medicago orbicularis</i>	0.00	0.00	0.10	0.00	0.03	0.02	0.99	0.002	NT
<i>Allium vineale</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.003	NT
<i>Anacamptis morio</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.003	NT
<i>Buglossoides arvensis</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.003	NT
<i>Pteridium aquilinum</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.003	RD

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Senecio inaequidens</i>	0.00	0.00	0.09	0.00	0.02	0.02	0.99	0.002	NN
<i>Romulea rollii</i>	0.00	0.00	0.14	0.00	0.03	0.01	0.99	0.001	NT
<i>Eudianthe coeli-rosa</i>	0.00	0.00	0.10	0.00	0.02	0.01	0.99	0.003	NT
<i>Avena sterilis</i>	0.00	0.00	0.10	0.00	0.03	0.01	1.00	0.003	AR
<i>Erica scoparia scoparia</i>	0.00	0.00	0.10	0.00	0.03	0.01	1.00	0.001	NT
<i>Euphorbia dendroides</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.002	NT
<i>Convolvulus arvensis</i>	0.00	0.00	0.10	0.00	0.03	0.01	1.00	0.003	RD
<i>Reseda lutea</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.003	RD
<i>Ajuga chamaepitys</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.002	NT
<i>Colchicum autumnale</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.002	NT
<i>Medicago polymorpha</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.002	RD
<i>Koeleria splendens</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.003	NT
<i>Arabis glabra</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.003	NT
<i>Populusxcana densis</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.003	NN
<i>Prunus spinosa</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.003	NT
<i>Umbilicus rupestris</i>	0.00	0.00	0.14	0.00	0.02	0.01	1.00	0.001	NT
<i>Stachys maritima</i>	0.00	0.00	0.09	0.00	0.01	0.01	1.00	0.002	TP_othe r (N14)
<i>Petrorhagia prolifera</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.003	NT
<i>Lotus conimbricensis</i>	0.00	0.00	0.09	0.00	0.01	0.01	1.00	0.002	NT
<i>Scorzonera laciniata</i>	0.00	0.00	0.10	0.00	0.02	0.01	1.00	0.003	NT
<i>Myosotis ramosissima ramosissima</i>	0.00	0.00	0.10	0.00	0.01	0.00	1.00	0.003	RD
<i>Ephedra distachya</i>	0.05	0.13	0.41	5.68	5.67	5.57	0.12	0.996	TP

<b>Dune Grasslands Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Helichrysum stoechas stoechas	0.04	0.09	0.46	4.85	2.15	4.23	0.21	0.999	TP
Crucianella maritima	0.03	0.07	0.37	3.07	2.46	2.96	0.24	0.992	TP
Centaurea sphaerocephala sphaerocephala	0.03	0.07	0.38	3.21	2.38	2.94	0.26	1	TP
Armeria pungens	0.02	0.06	0.40	2.91	1.88	2.43	0.29	1	TP
Pancratium maritimum	0.02	0.04	0.55	1.94	3.19	2.39	0.31	0.056	TP_othe r (N14)
Helichrysum italicum tyrrhenicum	0.02	0.06	0.33	2.94	1.78	2.31	0.34	0.997	TP
Thinopyrum junceum	0.02	0.04	0.52	1.75	3.50	2.31	0.36	0.058	TP_othe r (N14)
Anthemis maritima maritima	0.02	0.04	0.47	1.99	2.63	1.95	0.44	0.117	TP_othe r (N14)
Lomelosia rutifolia	0.02	0.06	0.28	1.88	1.80	1.88	0.46	0.971	TP
Medicago marina	0.01	0.03	0.46	1.07	2.51	1.56	0.51	0.092	TP_othe r (N14)
Cerastium semidecandrum	0.01	0.04	0.35	1.17	1.50	1.53	0.53	0.054	TP
Echinophora spinosa	0.01	0.02	0.54	1.28	1.39	1.36	0.56	0.175	TP_othe r (N14)
Phleum arenarium	0.01	0.05	0.27	1.51	0.75	1.34	0.57	0.981	TP
Cyperus capitatus	0.01	0.03	0.41	2.06	1.33	1.25	0.58	1	TP_othe r (N14)
Eryngium maritimum	0.01	0.03	0.39	1.71	0.94	1.22	0.59	0.998	TP_othe r (N14)
Lagurus ovatus	0.01	0.03	0.35	1.00	1.29	1.16	0.60	0.177	TP
Rostraria litorea	0.01	0.04	0.26	0.53	1.74	1.00	0.63	0.072	TP
Sixalix atropurpurea	0.01	0.03	0.26	0.63	1.09	0.89	0.64	0.127	RD
Ambrosia psilostachya	0.01	0.03	0.24	0.80	0.62	0.78	0.65	0.957	NN

<b>Dune Grasslands Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Silene rosulata sanctae-theresiae	0.01	0.04	0.19	1.04	0.40	0.78	0.66	0.88	NT
Daucus pumilus	0.01	0.03	0.28	0.90	1.26	0.77	0.67	0.056	TP
Poacynum venetum	0.01	0.05	0.13	0.86	0.37	0.75	0.68	0.902	TP
Scrophularia ramosissima	0.01	0.03	0.20	0.63	0.63	0.72	0.69	0.996	TP
Silene niceensis	0.01	0.02	0.30	0.47	0.83	0.68	0.70	0.17	TP
Achillea maritima maritima	0.01	0.02	0.26	0.84	0.52	0.66	0.70	0.992	TP_othe r (N14)
Anisantha rigida	0.01	0.02	0.25	0.33	0.88	0.59	0.72	0.3	RD
Convolvulus soldanella	0.01	0.01	0.39	0.75	0.52	0.58	0.73	0.989	TP_othe r (N14)
Euphorbia terracina	0.00	0.02	0.28	0.35	0.84	0.50	0.74	0.205	TP_othe r (N14)
Artemisia campestris variabilis	0.00	0.02	0.17	0.89	0.04	0.45	0.75	1	TP
Poa bulbosa	0.00	0.01	0.30	0.54	0.25	0.44	0.75	0.994	TP
Osyris alba	0.00	0.02	0.19	0.43	0.31	0.43	0.76	0.096	TP_othe r (no dune)
Plantago crassifolia	0.00	0.02	0.16	0.75	0.00	0.41	0.76	1	NT
Dasypyrum villosum	0.00	0.02	0.18	0.53	0.23	0.41	0.77	0.983	RD
Euphorbia paralias	0.00	0.01	0.33	0.29	0.38	0.39	0.78	0.365	TP_othe r (N14)
Trifolium nigrescens	0.00	0.02	0.17	0.53	0.17	0.39	0.78	0.96	NT
Verbascum niveum garganicum	0.00	0.01	0.23	0.18	0.51	0.34	0.79	0.08	NT
Anisantha sterilis	0.00	0.02	0.17	0.59	0.08	0.33	0.79	1	RD
Xanthium orientale	0.00	0.01	0.29	0.47	0.12	0.33	0.79	0.999	NN
Medicago minima	0.00	0.01	0.31	0.38	0.19	0.33	0.80	0.999	TP

<b>Dune Grasslands Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Cynodon dactylon	0.00	0.01	0.45	0.27	0.30	0.32	0.80	0.147	RD
Echium sabulicola sabulicola	0.00	0.02	0.17	0.44	0.22	0.31	0.81	0.993	TP
Hormuzakia aggregata	0.00	0.02	0.14	0.41	0.13	0.31	0.81	0.996	TP
Hypochaeris radicata	0.00	0.01	0.51	0.25	0.27	0.29	0.82	0.975	RD
Parapholis filiformis	0.00	0.03	0.10	0.37	0.03	0.28	0.82	0.997	NT
Lomelosia argentea	0.00	0.01	0.21	0.25	0.48	0.28	0.82	0.074	TP
Anisantha tectorum	0.00	0.01	0.22	0.16	0.23	0.26	0.83	0.058	RD
Arenaria serpyllifolia	0.00	0.01	0.25	0.31	0.12	0.25	0.83	0.999	NT
Reichardia picroides	0.00	0.01	0.47	0.25	0.24	0.25	0.84	0.994	NT
Silene conica	0.00	0.01	0.26	0.29	0.13	0.25	0.84	0.999	NT
Marcus-kochia ramosissima	0.00	0.01	0.18	0.17	0.17	0.25	0.84	0.986	TP
Seseli tortuosum maritimum	0.00	0.01	0.20	0.19	0.28	0.25	0.85	0.693	TP
Helianthemum nummularium	0.00	0.02	0.11	0.41	0.02	0.25	0.85	1	NT
Anisantha madritensis	0.00	0.01	0.23	0.25	0.13	0.23	0.85	0.999	RD
Cakile maritima maritima	0.00	0.01	0.37	0.17	0.20	0.22	0.86	0.927	TP_other (N12)
Silene otites otites	0.00	0.01	0.39	0.16	0.23	0.22	0.86	0.933	TP
Vicia pseudocracca	0.00	0.01	0.25	0.19	0.21	0.22	0.86	0.367	NT
Andryala integrifolia	0.00	0.01	0.22	0.20	0.24	0.21	0.86	0.337	TP
Trifolium scabrum	0.00	0.01	0.37	0.21	0.16	0.21	0.87	0.229	NT
Silene nummica	0.00	0.01	0.18	0.28	0.04	0.19	0.88	1	TP

<b>Dune Grasslands Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Erodium cicutarium</i>	0.00	0.00	0.36	0.20	0.13	0.19	0.88	0.964	NT
<i>Catapodium rigidum</i>	0.00	0.00	0.33	0.14	0.12	0.15	0.89	0.969	RD
<i>Corynephorus sp.pl.</i>	0.00	0.01	0.27	0.10	0.14	0.15	0.90	0.305	TP
<i>Euphorbia cyparissias</i>	0.00	0.00	0.33	0.13	0.12	0.15	0.90	0.387	RD
<i>Oenothera sp.pl.</i>	0.00	0.00	0.34	0.10	0.15	0.14	0.90	0.412	NN
<i>Carex liparocarpos</i>	0.00	0.00	0.33	0.12	0.12	0.14	0.90	0.295	NT
<i>Silene vulgaris</i>	0.00	0.00	0.32	0.13	0.10	0.13	0.90	0.838	RD
<i>Thinopyrum acutum</i>	0.00	0.01	0.19	0.09	0.16	0.13	0.91	0.803	NT
<i>Petrorhagia saxifraga</i>	0.00	0.00	0.30	0.12	0.08	0.12	0.91	0.613	TP
<i>Equisetum ramosissimum</i>	0.00	0.00	0.30	0.14	0.07	0.12	0.91	0.999	RD
<i>Scirpoides holoschoenus</i>	0.00	0.01	0.15	0.06	0.15	0.12	0.91	0.161	TP_other (no dune)
<i>Lobularia maritima</i>	0.00	0.00	0.24	0.16	0.03	0.12	0.92	0.932	TP_other (no dune)
<i>Sabulina tenuifolia</i>	0.00	0.01	0.15	0.13	0.06	0.12	0.92	0.733	NT
<i>Rhamnus alaternus alaternus</i>	0.00	0.01	0.15	0.13	0.08	0.12	0.92	0.82	TP_other (no dune)
<i>Verbascum sinuatum</i>	0.00	0.00	0.26	0.06	0.11	0.11	0.92	0.059	RD
<i>Cuscuta sp.pl.</i>	0.00	0.00	0.26	0.10	0.05	0.11	0.92	0.998	NN
<i>Trifolium campestre</i>	0.00	0.00	0.28	0.15	0.04	0.11	0.93	0.998	RD
<i>Matthiola sinuata</i>	0.00	0.00	0.27	0.10	0.09	0.11	0.93	0.998	TP_other (N12)
<i>Plantago lanceolata</i>	0.00	0.00	0.30	0.09	0.09	0.10	0.93	0.316	RD
<i>Raphanus raphanistrum s.l.</i>	0.00	0.00	0.27	0.08	0.09	0.10	0.93	0.89	RD

<b>Dune Grasslands Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Arenaria leptoclados leptoclados</i>	0.00	0.00	0.26	0.11	0.05	0.10	0.93	1	NT
<i>Solidago virgaurea litoralis</i>	0.00	0.00	0.23	0.14	0.00	0.10	0.93	1	NT
<i>Bromus hordeaceus s.l.</i>	0.00	0.00	0.28	0.18	0.00	0.09	0.94	1	RD
<i>Festuca ambigua</i>	0.00	0.00	0.23	0.14	0.02	0.09	0.94	0.999	NT
<i>Diptotaxis tenuifolia</i>	0.00	0.01	0.13	0.18	0.00	0.09	0.94	1	RD
<i>Lotus hirsutus</i>	0.00	0.00	0.26	0.07	0.06	0.08	0.94	0.999	TP_othe r (no dune)
<i>Euphorbia peplis</i>	0	0	0.22	0.09	0.04	0	0.94	0.895	TP_othe r (N12)
<i>Stachys romana</i>	0	0.01	0.1	0.13	0	0	0.94	0.999	NT
<i>Thymus pulegioides</i>	0	0.01	0.11	0.13	0.02	0	0.94	0.998	NT
<i>Jasione montana</i>	0	0	0.22	0.03	0.12	0	0.94	0.067	NT
<i>Hedypnois rhagadioloide s</i>	0	0	0.19	0.15	0.06	0	0.95	0.102	NT
<i>Oenanthe lachenalii</i>	0	0.01	0.1	0.13	0	0	0.95	0.999	NT
<i>Cistus creticus s.l.</i>	0	0.01	0.11	0.15	0	0	0.95	1	TP_othe r (no dune)
<i>Dactylis glomerata s.l.</i>	0	0	0.2	0.1	0.02	0	0.95	0.867	RD
<i>Bassia laniflora</i>	0	0	0.23	0.06	0.06	0	0.95	0.192	NT
<i>Blackstonia perfoliata</i>	0	0	0.18	0.05	0.05	0	0.95	0.948	NT
<i>Sonchus arvensis</i>	0	0.01	0.11	0.15	0	0	0.95	1	RD
<i>Veronica arvensis</i>	0	0	0.24	0.11	0.02	0	0.95	1	NT
<i>Trifolium arvense</i>	0	0	0.24	0.13	0	0.01	0.96	1	NT

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Launaea fragilis	0	0	0.21	0.05	0.07	0	0.96	0.948	NT
Glaucium flavum	0	0	0.21	0.04	0.06	0	0.96	0.088	TP_othe r (N12)
Avena barbata	0	0	0.21	0.04	0.06	0	0.96	0.087	RD
Tribulus terrestris	0	0	0.21	0.08	0.02	0	0.96	0.997	RD
Pinus pinea	0	0	0.16	0.06	0	0	0.96	0.999	TP_othe r (no dune)
Plantago arenaria	0	0	0.21	0.09	0.02	0	0.96	0.999	TP
Stachys recta	0	0	0.22	0.04	0.06	0	0.96	0.132	TP
Catapodium balearicum	0	0	0.16	0.05	0.03	0	0.97	0.966	RD
Teucrium flavum	0	0	0.15	0.13	0.06	0	0.97	0.936	TP_othe r (no dune)
Trifolium striatum	0	0	0.19	0.04	0.04	0	0.97	0.199	NT
Avellinia festucoides	0	0	0.19	0.06	0.03	0	0.97	0.999	TP
Leontodon rosanoi	0	0	0.16	0.07	0	0	0.97	0.999	NT
Polygonum maritimum	0	0	0.14	0.04	0.02	0	0.97	0.128	TP_othe r (N12)
Teucrium chamaedrys	0	0	0.19	0.08	0	0	0.97	1	TP_othe r (no dune)
Parapholis incurva	0	0	0.16	0.04	0.02	0	0.97	0.977	NT
Hordeum murinum s.l.	0	0	0.16	0.06	0	0	0.97	0.999	RD
Valerianella locusta	0.00	0.00	0.16	0.02	0.04	0.04	0.97	0.06	NT
Rostraria cristata	0.00	0.00	0.16	0.05	0.02	0.04	0.97	0.98	NT
Scolymus hispanicus gr.	0.00	0.00	0.15	0.04	0.02	0.04	0.98	0.999	RD
Rumex acetosella s.l.	0.00	0.00	0.17	0.05	0.02	0.04	0.98	0.998	RD

<b>Dune Grasslands Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
<i>Euphorbia pithyusa cupanii</i>	0.00	0.00	0.13	0.05	0.00	0.04	0.98	0.999	TP_othe r (no dune)
<i>Helianthemum apenninum</i>	0.00	0.00	0.17	0.05	0.02	0.04	0.98	0.978	NT
<i>Muscari comosum</i>	0.00	0.00	0.16	0.04	0.02	0.04	0.98	0.756	NT
<i>Limonium contortirameum</i>	0.00	0.00	0.13	0.05	0.00	0.03	0.98	0.999	TP_othe r (no dune)
<i>Reseda alba s.l.</i>	0.00	0.00	0.16	0.06	0.00	0.03	0.98	1	RD
<i>Anthoxanthum odoratum</i>	0.00	0.00	0.16	0.04	0.02	0.03	0.98	0.673	NT
<i>Poa sylvicola</i>	0.00	0.00	0.17	0.04	0.02	0.03	0.98	0.998	NT
<i>Sherardia arvensis</i>	0.00	0.00	0.17	0.07	0.00	0.03	0.98	1	RD
<i>Silene gallica</i>	0.00	0.00	0.17	0.07	0.00	0.03	0.98	1	TP
<i>Urospermum picroides</i>	0.00	0.00	0.17	0.06	0.00	0.03	0.98	0.999	NT
<i>Tuberaria guttata</i>	0.00	0.00	0.17	0.06	0.00	0.03	0.98	1	NT
<i>Centranthus calcitrapae calcitrapae</i>	0.00	0.00	0.13	0.05	0.00	0.03	0.98	1	NT
<i>Phleum subulatum</i>	0.00	0.00	0.10	0.13	0.00	0.03	0.98	0.999	NT
<i>Bromus squarrosus</i>	0.00	0.00	0.14	0.05	0.00	0.03	0.98	0.998	NT
<i>Aeluropus littoralis littoralis</i>	0.00	0.00	0.13	0.05	0.00	0.03	0.98	1	TP_othe r (no dune)
<i>Sporobolus pumilus</i>	0.00	0.00	0.13	0.02	0.03	0.03	0.98	0.308	NN
<i>Juniperus turbinata</i>	0.00	0.00	0.12	0.04	0.00	0.03	0.98	1	TP_othe r (no dune)
<i>Lysimachia linum-stellatum</i>	0.00	0.00	0.09	0.03	0.00	0.03	0.98	0.998	NT
<i>Linum tenuifolium</i>	0.00	0.00	0.14	0.02	0.03	0.03	0.98	0.347	NT
<i>Arabidopsis thaliana</i>	0.00	0.00	0.13	0.02	0.02	0.03	0.98	0.183	RD

<b>Dune Grasslands Species (continue)</b>	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Lolium rigidum	0.00	0.00	0.14	0.06	0.00	0.03	0.98	1	RD
Allium carinatum	0.00	0.00	0.13	0.02	0.02	0.03	0.98	0.105	NT
Beta vulgaris maritima	0.00	0.00	0.13	0.04	0.00	0.02	0.99	0.999	RD
Trigonella sulcata	0.00	0.00	0.13	0.04	0.00	0.02	0.99	0.999	NT
Trifolium stellatum	0.00	0.00	0.13	0.02	0.02	0.02	0.99	0.974	NT
Alyssum alyssoides	0.00	0.00	0.13	0.04	0.00	0.02	0.99	0.998	NT
Draba verna	0.00	0.00	0.14	0.04	0.00	0.02	0.99	0.998	RD
Pallenis spinosa spinosa	0.00	0.00	0.14	0.05	0.00	0.02	0.99	0.999	RD
Maresia nana	0.00	0.00	0.14	0.02	0.02	0.02	0.99	0.941	TP
Avena fatua	0.00	0.00	0.14	0.02	0.02	0.02	0.99	0.348	AR
Sesamoides interrupta	0.00	0.00	0.10	0.03	0.00	0.02	0.99	0.999	NT
Lathyrus sphaericus	0.00	0.00	0.14	0.02	0.02	0.02	0.99	0.901	NT
Medicago rigidula	0.00	0.00	0.10	0.03	0.00	0.02	0.99	0.999	NT
Hippocrepis biflora	0.00	0.00	0.09	0.02	0.00	0.02	0.99	0.998	NT
Sedum sexangulare	0.00	0.00	0.14	0.04	0.00	0.02	0.99	1	NT
Hyparrhenia hirta	0.00	0.00	0.09	0.02	0.00	0.02	0.99	0.998	NT
Pulicaria dysenterica	0.00	0.00	0.10	0.03	0.00	0.02	0.99	0.998	NT
Ambrosia maritima	0.00	0.00	0.10	0.03	0.00	0.02	0.99	1	TP
Cynanchica pyrenaica cynanchica	0.00	0.00	0.10	0.03	0.00	0.02	0.99	1	NT
Carlina corymbosa	0.00	0.00	0.14	0.04	0.00	0.02	0.99	0.999	RD
Lonicera implexa implexa	0.00	0.00	0.10	0.03	0.00	0.02	0.99	0.999	TP_othe r (no dune)

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Macrobriza maxima	0.00	0.00	0.10	0.03	0.00	0.01	0.99	0.999	RD
Trifolium lappaceum	0.00	0.00	0.13	0.01	0.01	0.01	0.99	0.338	NT
Picris hieracioides hieracioides	0.00	0.00	0.10	0.03	0.00	0.01	1.00	0.999	RD
Corrigiola litoralis litoralis	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	TP
Plantago lagopus	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	TP
Sonchus asper s.l.	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	RD
Hirschfeldia incana incana	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	NT
Trifolium cherleri	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	NT
Triticum vagans	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	NT
Crepis bellidifolia	0.00	0.00	0.10	0.03	0.00	0.01	1.00	0.999	NT
Frankenia laevis laevis	0.00	0.00	0.10	0.03	0.00	0.01	1.00	0.999	TP_othe r (no dune)
Rubus caesius	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	NT
Asparagus horridus	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	TP_othe r (no dune)
Hornungia petraea	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.998	NT
Potentilla verna	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.998	NT
Saxifraga tridactylites	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.998	RD
Ziziphora acinos	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.998	RD
Sedum acre	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.998	NT
Tragus racemosus	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.998	NT
Jacobaea maritima bicolor	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	TP_othe r (no dune)

Dune Grasslands Species (continue)	average dissimilarity	sd	ratio	historical average abundance	resurveyed average abundance	relative contribution	cumulative contribution (%)	p-value	Species groups
Fumaria capreolata	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	RD
Euphorbia helioscopia	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	RD
Ranunculus bulbosus	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	NT
Capsella bursa-pastoris	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	RD
Filago germanica	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	NT
Lolium perenne	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	RD
Phagnalon saxatile	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	NT
Salvia pratensis	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	RD
Lepidium campestre	0.00	0.00	0.10	0.02	0.00	0.01	1.00	0.999	RD
Sonchus maritimus	0.00	0.00	0.10	0.02	0.00	0.01	1.00	1	NT
Petrorhagia dubia	0.00	0.00	0.10	0.01	0.00	0.01	1.00	0.999	NT
Senecio transiens	0.00	0.00	0.10	0.01	0.00	0.01	1.00	0.999	TP

### Supplementary References

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