Assessing sampling coverage of species distribution in biodiversity databases

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Running title: Sampling coverage by box-counting

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Abstract

Aim: Biodiversity databases are valuable resources for understanding plant species distributions and dynamics, but they may insufficiently represent the actual geographic distribution and climatic niches of species. Here we propose and test a method to assess sampling coverage of species distribution in biodiversity databases in geographic and climatic space.

Location: Europe.

Methods: Using a test selection of 808,794 vegetation plots from the European Vegetation Archive (EVA), we assessed the sampling coverage of 564 European vascular plant species across both their geographic ranges and realized climatic niches. Range maps from the Chorological Database Halle (CDH) were used as background reference data to capture species geographic ranges and to derive species climatic niches. To quantify sampling coverage, we developed a box-counting method, the Dynamic Match Coefficient (DMC), which quantifies how much a set of occurrences of a given species matches with its geographic range or climatic niche. DMC is the area under the curve measuring the match between occurrence data and background reference (geographic range or climatic niche) across grids with variable resolution. High DMC values indicate good sampling coverage. We applied null models to compare observed DMC values with expectations from random distributions across species ranges and niches.

Results: Comparisons with null models showed that, for most species, actual distributions within EVA are deviating from null model expectations and are more clumped than expected in both geographic and climatic space. Despite high interspecific variation, we found a positive relationship in DMC values between geographic and climatic space, but sampling coverage was in general more random across geographic space.

Conclusion: Because DMC values are species-specific and most biodiversity databases are clearly biased in terms of sampling coverage of species occurrences, we recommend using DMC values as covariates in macroecological models that use species as the observation unit.

Keywords: Chorological Database Halle (CDH), climatic niche, Dynamic Match Coefficient (DMC), European Vegetation Archive (EVA), macroecology, multi-scale, realized niche, sampling bias, spatial scale, species range, vascular plant, vegetation-plot databases.

1 Introduction

Large-scale biodiversity databases (e.g. Global Biodiversity Information Facility (GBIF), Edwards, Lane, & Nielsen, 2000; Botany Information and Ecology Network (BIEN), Enquist, Condit, Peet, Schildhauer, & Thiers, 2009; sPlot, Bruelheide et al., 2019) are valuable resources for understanding species distributions and dynamics. Possible applications include broad-scale analyses across species or community types (e.g. Bruelheide et al., 2018; Jiménez-Alfaro et al., 2018), species distribution models (SDM) (Gomes et al., 2018; Wasof et al., 2015); and monitoring biodiversity changes over time (Bertrand et al., 2011; Jandt, von Wehrden, & Bruelheide, 2011). For broad-scale analyses covering the entire range of species, the quality of the sampling coverage across a given species range or throughout its realized niche is crucial. Hence, consistent data distribution is highly desirable across both the geographic and environmental space (Broennimann & Guisan, 2008; Pearman, Guisan, Broenniman, & Randin, 2008; Troia & McManamay, 2016). However, biodiversity databases often suffer from sampling gaps and biases limiting their application potential. Because of the uneven collection effort (Daru et al., 2018; Soria-Auza & Kessler, 2007; Speed et al., 2018) often caused by difficult access to some areas (Sousa-Baena, Garcia, & Peterson, 2014), broad regions of the world remain poorly sampled. Even comprehensive databases of species occurrences in well-surveyed regions are prone to geographic (Yang, Ma, & Kreft, 2013) and taxonomic biases (Pyke & Ehrlich, 2010; Soberón, Jiménez, Golubov, & Koleff, 2007). In an in-depth evaluation, Meyer, Weigelt, & Kreft (2016) found severe geographical bias in the GBIF database (Edwards et al., 2000), concluding that data limitations are rather the rule than the exception for most species and regions.

Species distribution models (SDM) are commonly used for macroecological niche analyses. They represent the estimation of species occurrence probabilities based on observed geographic distributions. Thereby, SDMs are sensitive to poor sampling coverage, especially if spatial bias results in climatically biased sampling (Fourcade, Engler, Rödder, & Secondi, 2014). In such situations, SDMs tend to misestimate species climatic niches (Titeux et al., 2017). Thus, for reliable analyses of biodiversity distribution patterns, sampling coverage needs to be representative for both the climatic and geographic space (Hortal, Jiménez-Valverde, Gómez, Lobo, & Baselga, 2008; Troia & McManamay, 2016). Unbiased sampling is typically obtained by meeting two interrelated requirements: sufficient sample size and even coverage of geographical and environmental gradients. Towards coarser spatial resolution, good coverage is easier to achieve and, as a consequence, sampling bias typically decreases. Consequently, the negative impact of sampling bias is clearly related to spatial grain. Several studies have analyzed the importance of spatial scaling in niche studies (e.g. Pearman et al., 2008; Soberón et al., 2007; Hortal, Borges, & Gaspar, 2006). Recently, procedures have been developed to assess the completeness of a spatial dataset at different spatial resolutions in geographic space (*KnowBR*, Lobo et al., 2018; *downscale*, Marsh, Barwell, Gavish, & Kunin, 2018). At large spatial extent, climate is among the most important factors determining species distributions (Woodward, 1986). However, although including climate seems straightforward, until now, few studies have accounted for how evenly occurrence data cover species ranges in climatic space (e.g. Bruelheide et al., 2018). To our knowledge, no study has explicitly tested the degree to which the spatial distribution of occurrences represents the geographical range as well as the climatic niche of the sampled species.

Here we test the spatial and climatic coverage of plant occurrence data using an example dataset of the European Vegetation Archive (EVA). EVA is a key macroecological resource that incorporates information from 57 countries on approximately 1.5 million vegetation plots containing more than 10,000 vascular plant species (Chytrý et al., 2016). EVA data are used for various research objectives, yet the degree of unevenness in sampling effort across Europe's geographic and environmental space is unclear. A species distribution database covering EVA's spatial extent, but otherwise independent from EVA, is the Chorological Database Halle (CDH) (Welk et al., unpubl.). CDH stores georeferenced information (range polygons and point occurrences) on the distribution range of more than 1,200 European vascular plant species. Species distribution data from CDH have already been used in several biodiversity studies (e.g. Csergő et al., 2017; San-Miguel-Ayanz, de Rigo, Caudullo, Houston Durrant, & Mauri, 2016; Schleuning et al., 2016) and as basis for biogeographical experiments on plant range limits (Bütof et al., 2012; Hofmann, Bütof, Welk, & Bruelheide, 2013; Welk, Welk, & Bruelheide, 2014). Here, we made use of expert-based range maps stored in CDH to extract information on both species geographic ranges and climatic niches and assess the sampling coverage of species occurrences stored in EVA across each of these two backgrounds (geographic and climatic).

To quantify sampling coverage, we developed the Dynamic Match Coefficient (DMC), a measure based on the area-under-the-curve (AUC) derived from threshold-independent box-counting statistics across variable spatial grains. We compared the observed DMC values with the values of plots randomly distributed across the species range and niche. Thereby, we produced an expected null reference distribution (Nunes & Pearson, 2017) within both the geographic and climatic space for a given sampling effort (sample size) and corresponding to the observed species frequency in the database. This enabled us to evaluate the observed plot distribution in geographic space (DMC_{GEO}) and climatic space (DMC_{CLIM}) in comparison to expectations of randomly distributed plots across the species range and realized climatic niche. We tested four hypotheses on sampling coverage of species occurrences across both the geographic and climatic space:

(1) Sampling coverage within the climatic space depends strongly on good sampling coverage across the geographic space because climatic conditions are spatially autocorrelated. We expect a positive correlation between sampling coverage in the geographic and climatic space.

(2) Sampling coverage is less representative in the climatic space than in the geographic space. The reason is the asymmetric transferability between points in the climatic and geographic space: a single point within the climatic space might translate to several geographic locations, while a single geographic location can only translate to one point in the climatic space. An increase in sampling coverage within the geographic space might thus be without positive effect on sampling coverage within the climatic space.

(3) Given the general sampling issues of biodiversity databases mentioned above and the heterogeneous nature of their source data, we expect that sampling coverage of the realized niches of plant species by such data is largely imperfect because of an underdispersed (clumped) distribution of species observations within the geographic space and supposedly also within the climatic space.

(4) Finally, for a given range size and macroclimatic niche size, we expect sampling coverage to increase with increasing sample size.

2 Material and Methods

We assessed the sampling coverage of European vascular plant species ranges (using species range data from the Chorological Database Halle, CDH) by a test selection of species occurrence data taken from vegetation plots from the European Vegetation Archive (EVA, Chytrý et al., 2016). We did this both in the geographic space (distribution range data from CDH) and in the climatic space (realized climatic niche space derived from CDH geographical distributions). We focused on species presence data (i.e. locations of vegetation plots in which the focal species was recorded) and examined the relationship between the geographic and climatic sampling coverage, as well as interspecific variability. The study area comprised all European countries plus Turkey, Georgia, Armenia and Azerbaijan (Figure 1a).

2.1 Background data on species geographic range and climatic niche

The Chorological Database Halle (CDH) stores information on distribution ranges of about 17,000 vascular plant taxa. For 5,583 taxa, maps were compiled based on published distribution range maps (Meusel, Jäger, & Weinert, 1965; Meusel, Jäger, Rauschert, & Weinert, 1978; Meusel & Jäger, 1992), national and floristic databases and further maps from floristic literature (see bibliographic details in Index Holmiensis, Tralau, 1969-1981; Lundqvist & Nordenstam, 1988; Lundqvist, 1992; Lundqvist & Jäger, 1995-2007). CDH data can be requested for research objectives via http://chorologie.biologie.uni-halle.de/choro/. We retrieved from CDH the available geographical information for the distribution ranges of 1,200 European vascular plant species in electronic format (range polygons and point occurrences) in October 2015. The species range information was processed as raster layers of 2.5-min cell resolution, which is about 15 km² in Central Europe (Figure 1a). The multi-dimensional climatic space (climatic niche) was determined by principal components analysis (PCA) of 19 bioclimatic variables from Worldclim with 2.5-min cell resolution (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005) (for detailed information see Appendix S1 in the Supporting Information).

2.2 Vegetation plots

A test selection of vegetation plots was provided by the European Vegetation Archive in October 2015, containing information on 10,082 species from 933,228 vegetation plots. This selection included all the plots that were available in EVA at that time. Data for intraspecific taxa such as subspecies were merged at the species level. Further, we matched species names and checked for synonyms according to (i) the taxonomic reference list for Germany (German SL version 1.2, Jansen & Dengler, 2008) and (ii) all taxonomic reference lists available via the R package 'taxize' (Chamberlain & Szöcs, 2013; Chamberlain et al., 2018). We excluded trees, bryophytes, lichens, fungi, algae and species exotic to Europe. We also excluded 67,200 vegetation plots with location uncertainty larger than 10 km and 417 species that occurred in less than 10 plots.

After matching EVA and CDH species, 808,794 vegetation plots contained at least one of the 564 vascular plant species (herbs, dwarf shrubs and shrubs) with available digitized geographic distribution data in CDH. A list of these species and all the databases that provided vegetation plot data can be found in Appendices S2 and S3 in the Supporting Information. The 808,794 vegetation plots from EVA were heterogeneously distributed across the study area in the geographic space. While some geographic regions were represented very well and with high density (e.g. the Czech Republic, the Netherlands), other regions were represented sparsely (e.g. Norway, Sweden, Finland, Belarus, parts of Russia; Figure 1a). In contrast to geographic space, the study area was well represented by EVA vegetation plots in climatic space, except some marginal parts of the climatic background space (Figure 1b). The maximum density of species was 396 species per 2.5 min raster cell in geographic space (Figure 2a) and 528 species per cell in climatic space (Figure 2b). Stacked CDH ranges of the

564 study species covered 98.5% of the study area in geographic space (154,455 raster cells of 2.5-min in total) (Figure 2a) and 100% in climatic space (9,931 cells in total; Figure 2b).

2.3 Dynamic Match Coefficient (DMC) - a measure of plot sampling coverage across spatial scales

Sampling bias is mainly a result of two interrelated issues: insufficient number of samples and inadequate sample distribution. The impact of sampling bias is related to spatial scale (spatial extent and grain size) and should decrease with increasing grain size. The spatial arrangement of sampling locations could be evaluated by classical methods of point pattern analysis (Boots & Getis, 1988; Wiegand & Moloney, 2013). However, there are two main issues related to the spatial pattern in the ecological domain of the data of interest. First, because of the generally irregular, often non-contiguous geometry of plant distribution ranges, traditional Euclidean geometry often fails to estimate characteristics of point patterns correctly (Pentland, 1984). Second, species ranges and niches cannot be regarded as merely geometric phenomena. Spatio-temporal population processes often result in complex range structures of genetic diversity, demographic performance and abundance (Peterson et al., 2011; Ricklefs, 2004).

To measure how well, i.e. how uniform vs. clustered and simultaneously how dense or scarce vegetation plots containing the focal species are located across the species` range or niche, we developed a measure inspired by fractal dimension analysis (Hall & Wood, 1993), which we call the Dynamic Match Coefficient (DMC). The DMC represents a measure of cell matches between a point pattern and spatial layers that are iterated across different raster cell resolutions (grain sizes), from fine to coarse (Figure 3). Here, 20 iterative scaling steps were used, which resulted in a maximum achievable DMC of 2000 (20 × 100% match). The obtained values were standardized to 0-1. For all species, the starting grain size in geographic space was 1/20th of the respective species maximum North-South and East-West range extent. Hence, the initial grain size was smaller for small-range species (e.g. 50 km × 20 km for *Centaurea deustiformis*) than for large-range species (e.g. 211 km × 273 km for *Plantago major*) (see Appendices S2 and S4.1 in the Supporting Information for distribution of initial grain sizes in DMC calculations). Among the chosen starting grain sizes for the geographic space, even the finest grid cells (50 km × 20 km) are at a spatial resolution where climate conditions are considered the most important (Pearson & Dawson, 2003). The scaling procedure used in the climatic space was similar to that in the geographic space. Here the initial grain size was derived as the 1/20th fraction of the respective species maximum niche extent along the first two PCA axes. High DMC values indicate high sampling coverage, i.e. a more regular distribution and density of EVA vegetation plots across a species distribution range or within its realized climatic niche. In contrast, low DMC values indicate underdispersed sampling coverage, i.e. clumped distribution and/or inappropriately low density of EVA vegetation plots across a species distribution range or within its realized climatic niche (Figure 3).

Figure 4 shows how the DMC approach works for the geographic and climatic space and for two contrasting species: *Hieracium murorum*, a species with clumped distribution in EVA plots, and *Calluna vulgaris*, a species with a more regular distribution in EVA plots, both in the species range and in the realized climatic niche (Figure 4a). Range size and the number of vegetation plots are similar in both species. The cell match ratio between species range and EVA vegetation plots was calculated in 20 iterations from fine to coarse raster cell resolution for both species in the geographic and climatic space (Figure 4b). The cell match ratio at the 20 single raster steps was summed up, and this sum is what we term the final DMC value of a species in the geographic space (DMC_{GEO}) and climatic space (DMC_{CLIM}). For *Hieracium murorum*, DMC values reached 0.42 and 0.58 for the geographic (DMC_{GEO}) and climatic (DMC_{CLIM}) space, respectively. For *Calluna vulgaris*, DMC values reached 0.74 for both the geographic (DMC_{GEO}) and climatic (DMC_{CLIM}) space.

2.4 Observed vs. expected distributions

In order to quantify how far the observed DMC deviates from an expected random distribution, we applied a null model simulation (Nunes & Pearson, 2017) for each species. We randomly distributed a number of species occurrences for each species (n = number of plots containing the species) across its geographic range and climatic niche. We calculated the DMC_{GEO} and DMC_{CLIM} values for 100 such random distributions in the geographic and climatic space, respectively, and compared the simulated DMC distribution with the observed value. To quantify the deviation of the observed DMC value from the median of the simulated ideal random distribution (DMC_{NULL}) we calculated a DMC ratio as:

$$DMC\ ratio\ =\ \frac{(DMC\ NULL - DMC\ observed)}{DMC\ observed}$$

A high DMC ratio corresponds to an underdispersed distribution of the EVA plots containing the species, while a low DMC ratio corresponds to a more random distribution. A negative ratio corresponds to an overdispersed distribution.

2.5 Effect of sample size on the DMC value

We analysed the effect of sample size (number of EVA plots containing a given species) on DMC values while accounting for range size (or niche size) by applying linear models with DMC_{GEO} (or DMC_{CLIM}) values as the response variable, sample size as the main explanatory variable and range size (resp. niche size) as a covariate to correct for potential confounding effects of range size or niche size. In a first step, for each species, the percentage match of the species range (derived from CDH) by the respective EVA vegetation plots where the species occurred was calculated at 2.5-min raster cell resolution. Multiple occurrences per raster cell were reduced to presence-absence data per species and 2.5-min raster cell. In the second step, species ranges and the respective vegetation plots were projected into the climatic space. The study area in the climatic space is well represented by its first two PCA axes, which explain 88.0% of the data variance (for details see Appendix S1 in Supporting Information). Finally, the percentage of a species climatic niche matched by vegetation plots where the species occurred was calculated as the ratio of PCA cells of the respective EVA vegetation plots where the species occurred to all raster cells matched by the species range in the PCA space (species percentage match of its range and niche by EVA vegetation plots is provided in Appendix S2 in the Supporting Information).

3 Results

Overall, sampling coverage of European vascular plant species ranges by EVA vegetation plots was more complete within the geographic space than within the climatic space (Figure 5), i.e. consistently higher DMC values were within the geographic space (DMC_{GEO}). The mean of DMC_{GEO} was slightly higher than that of DMC_{CLIM}, with values of 0.56 and 0.49, respectively. Species DMC_{GEO} values ranged from 0.08 to 0.94. For half of the species the DMC_{GEO} was between 0.48 and 0.65 (25th and 75th percentile). DMC_{CLIM} values ranged from 0.08 to 0.82 and for half of the species the DMC_{CLIM} was between 0.40 and 0.60 (25th and 75th percentile). We found a highly significant positive correlation (Spearman´s rho = 0.768; $p < 0.001$) between species geographic DMC values (DMC_{GEO}) and their climatic DMC values (DMC_{CLIM}) (Figure 5). DMC_{CLIM} values were higher than DMC_{GEO} values for only 119 species (21.1%), while 445 species (78.9%) had higher DMC_{GEO} values than DMC_{CLIM} values. Furthermore, some species showed a high deviation in DMC values between the geographic and climatic space. For instance, *Arabis alpina* was more randomly sampled within the climatic space (DMC_{CLIM}: 0.55) than within the geographic space (DMC_{GEO}: 0.24), while this was the opposite for *Vinca major* (DMC_{GEO}: 0.63, DMC_{CLIM}: 0.29). In general a positive relationship between species range size and niche size could be observed (Spearman´s rho = 0.805; p <0.001; Appendix S4.2 in Supporting Information).

3.1 Deviation of the observed DMC from the expected random distribution

We found a positive correlation between the observed DMC values and the expected DMC values, based on our null model, for both the geographic space (weaker, Spearman´s rho = 0.389; p <0.001) and the climatic space (stronger, Spearman´s rho = 0.824; p <0.001) (Figures 6a and 6b). Importantly, a large majority (92.0%) of the observed species distributions in EVA were significantly underdispersed in both the geographic and climatic space. This is indicated by the position of most of the points above the 1:1 line, especially in the climatic space. Exceptionally, for a small number of species in the geographic space (43 species, 7.6%) (Figure 6a) and for two species in the climatic space (Figure 6b), the observed DMC values were higher than the null random expectation, indicating overdispersion.

For each species, we calculated the deviation of the observed DMC values from the null model DMC values in geographic and climatic space. While a low deviation of the observed DMC values from the null expectation indicates a more regular distribution of occurrences for a given species across its reference range or realized climatic niche, a high deviation indicates an underdispersed (more clumped) distribution. We found a positive correlation for the deviation of observed DMC values from the null model DMC values between geographic and climatic space (Spearman´s rho = 0.615; p <0.001). Despite a higher variability, DMC deviation from the null model was on average slightly lower in geographic space (min_{DEV_GEO}: -0.31, max_{DEV_GEO}: 2.47, $median_{DEV\_GEO}$: 0.46) than in climatic space (min_{DEV_CLIM}:-0.10, max_{DEV_CLIM}:2.09, $median_{DEV\_CLIM}$:0.47, see Figure 7).

3.2 Effect of sample size on DMC values

In geographic space, the percentage match of species ranges by EVA vegetation plots containing the same species (measured as the percentage of the range containing the EVA plots at 2.5-min raster cell resolution) ranged from 0.01% to 67.6%. For half of the species, the percentage match was between 0.5% and 2.3% (25^{th} and 75^{th} percentile), with a mean of 1.1% in the geographic space. In the climatic space, the percentage match of species niches by EVA vegetation plots ranged from 0.5% to 72.7% and for half of the species the percentage match was between 7.6% and 22.1% (25^{th} and 75^{th} percentile), with a mean of 14.1%. The applied linear models revealed a positive effect of sample size (vegetation plots) on DMC values while accounting for range size or niche size in both the geographic space (multiple R^2: 0.212) and climatic space (multiple R^2: 0.571). We found a significantly positive correlation between the percentage match of the species range by EVA plots in both the geographic space (Spearman´s rho= 0.726; p <0.001) and climatic space (Spearman´s rho= 0.901; p <0.001) (Figure 8a and b). Furthermore, we encountered a significantly negative relationship between percentage match of species ranges by EVA vegetation plots and deviation from the null model in the geographic space (Spearman´s rho= -0.601; p <0.001) and climatic space (Spearman´s rho= -0.651; p <0.001) (Figure 8c and d). Apart from this, a significantly positive correlation between the percentage match of the species range by EVA plots in the geographic space and climatic space could be found (Spearman´s rho= 0.865; p <0.001; Appendix S4.3 in Supporting Information).

4 Discussion

4.1 Plot sampling coverage across spatial scales

In line with the general positive relationship between range size and niche size (see Appendix S4.2 in Supporting Information), we assumed that (1) a species will be well sampled throughout its multidimensional climatic niche (reaching high DMC_{CLIM} values) only if it is well sampled throughout its geographic range (high DMC_{GEO} values). The demonstrated positive correlation between DMC_{CLIM} and DMC_{GEO} confirms the first hypothesis. However, the relationship was far from perfect, since there are also species that are well sampled within the geographic space (reaching high DMC_{GEO} values) but less well sampled in the climatic space (reaching low DMC_{CLIM} values), and vice versa. Exceptions from the suggested positive relationship can arise especially due to high spatial heterogeneity in climatic conditions, e.g. in mountain regions (Hirst, Griffin, Sexton, & Hoffmann, 2017; Köckemann, Buschmann, & Leuschner, 2009).

Because of the one-to-n relationship between climatic and geographic data points we expected (2) a sparser species sample coverage (lower DMC values) in the climatic space. Accordingly, we found that the sampling coverage (DMC value) of species distribution in EVA was more random in the geographic space (DMC_{GEO}) than in the climatic space (DMC_{CLIM}) for 77.9% of the studied species. This more random sampling coverage in geographic space is explainable by the niche–biotope duality (Hutchinson, 1978). The same combination of climate factors can occur in only one location in geographic space, but will more likely occur in several localities with increasing spatial extent (Colwell & Rangel, 2009; Soberón & Nakamura, 2009). However, the rules that define the niche–biotope duality are not reciprocal (Colwell & Rangel, 2009; Soberón & Nakamura, 2009), and the climatic niche of a species might be fully captured even if only a part of its geographic distribution was sampled (Guisan, Petitpierre, Broennimann, Daehler, & Kueffer, 2014). This seems to be the case for 22.9% of the studied species that occupy ranges with highly heterogeneous climatic conditions (e.g. in mountain regions as mentioned above). For those species, the sampling coverage was higher in the climatic space (DMC_{CLIM}) than in geographic space (DMC_{GEO}).

Large-scale biodiversity databases consist of heterogeneous, non-systematically sampled datasets with underdispersed observations within the geographic space and supposedly also within the climatic space. We therefore expected (3) the sampling coverage of species geographic ranges and climatic niches to be largely imperfect due to sampling biases. Accordingly, we found limited sampling coverage for most of the studied species. In almost all cases, the observed species distributions in EVA significantly underrepresented both the species geographic range and climatic niche space. It is achievable to identify species which are poorly represented in biodiversity databases relative to their geographic ranges or realized climatic niches (Boakes et al., 2010; Hoffmann et al., 2014). Since the observed and expected DMC values were highly positively correlated, the applied null model approach supports the usefulness of the presented DMC metric to assess sampling bias in the distribution of species occurrences in biodiversity databases.

We assumed that (4) on condition that range size and climatic niche size are correlated, sampling coverage increases with increasing sample size. The applied linear models revealed a positive effect of sample size on DMC values while accounting for range size and niche size, which supports our fourth hypothesis. Nevertheless, especially for the geographical space, high percentage cover of species range by the EVA plots cannot directly indicate high DMC values. In general, the correlation of percentage match of a species range by the EVA plots at 2.5-min raster cell resolution with DMC values was highly positive in geographic space. Nevertheless, there were species with higher percentage match that only reached lower DMC values while there were also species with lower percentage match that reached higher DMC values. Our results show that the number and thereby the density of observations across a species distribution range remains crucial. On the one hand, too small number of plots representing a species distribution range may be a sample of insufficient size even if the plots are distributed randomly (as suggested by the null model calculations). On the other hand, even a large number of vegetation plots may underrepresent a species range if their spatial distribution is underdispersed. Consequently, both clumping and density of occurrence observations have to be considered, computed and estimated simultaneously to evaluate the representativeness of biodiversity databases.

4.2 Possible applications of the DMC

Occurrence data and distribution maps for species of various taxa are increasingly being made available from biodiversity databases (e.g. Map Of Life, Jetz, McPherson, & Guralnick (2012); The IUCN Red List, IUCN (2019); Euro+Med Plantbase, Euro+Med (2019); The PLANTS Database, USDA, NRCS (2019)).

(I) Our DMC approach enables evaluation and comparison of the coverage of occurrence data across irregular and even non-contiguous background spaces. Thus, it helps identifying species with a suitable representation of their range / niche by existing point samples. In species distribution modelling, uneven or inconsistent representation of environmental gradients by occurrence records can strongly influence the model accuracy (Tessarolo, Rangel, Araújo, & Hortal, 2014), which can result in limited applicability for climate change predictions (Araújo & Guisan, 2006; Titeux et al., 2017).

(II) The DMC value calculation is applicable in both the climatic and geographic space and can help evaluate the coverage of species samples for species distribution modelling. Using such information derived from the DMC metric inside the modelling framework of SDM is likely to improve SDM predictive performance. Nevertheless, independent information on species geographic distribution is needed to correctly evaluate point sampling coverage for SDM studies. It is not recommended to generate range models based on sampling data of unknown coverage. While $DMC_{(GEO)}$ values generated this way might be used to gather information on species geographic point sampling quality, $DMC_{(CLIM)}$ values might be highly biased. Without independently generated distribution information, $DMC_{(CLIM)}$ values are not applicable for SDM evaluation. Since observed and expected DMC values (see the applied null model approach) were highly positively correlated, the deviation from the expected DMC is a suitable measure for the representativeness of species occurrence data. A high deviation corresponds to an underdispersed distribution of plots, while a low deviation corresponds to a more random distribution of plots and a negative deviation corresponds to an overdispersed distribution of plots.

(III) Data limitations (i.e. lack of fine-resolution data of species occurrences over large spatial extents) will remain the norm for most species and regions, and best-possible use should be made of limited information (Hoffmann et al., 2014; Meyer et al., 2016). Here, based on the curves resulting from the DMC calculations it would be possible to determine the raster cell resolution where results of the analyses are least vulnerable to errors due to the existing sampling gaps by calculating the inflection point of the DMC curve. Nevertheless, one must be aware that the achievable raster cell resolution always depends on the spatial extent of the study (e.g. regional, continental or global scale) (Hartley & Kunin, 2003; Pearson & Dawson, 2003; Willis & Whittaker, 2002).

(IV) The efficacy of database platforms strongly depends on the completeness of species inventories and the survey coverage across space and the environment (Hortal et al., 2008; Troia & McManamay, 2016), therefore it is necessary to continue surveys in undersampled areas (Beck et al., 2012; Engemann et al., 2015). Here, results of the DMC analyses can be used to identify these undersampled areas and help focus search efforts for data information in relevant literature or further databases. This would be possible by selecting undersampled parts of the niche and translate them back to the geographical space. Furthermore, the results of DMC analyses can be used to guide future botanical explorations and practical fieldwork, to make new sampling in geographical and climate spaces cost-efficient.

(V) Including both the DMC metrics as covariates in any model with species as the observational unit may help to account for potential confounding effects due to the varying sampling coverage of the sampled species distribution within both the climatic and geographic space. Since DMC values are species-specific, they can be included as weights in macroecological analyses and models, where well-represented species might be weighted higher than less-well represented species. Nevertheless, it might be necessary to apply re-sampling methods (e.g. Lengyel, Chytrý, & Tichý, 2011) to prevent spatial autocorrelation in model residuals.

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Author contributions

EW and MS developed the DMC concept, with considerable input by GS and HB. MS wrote the first draft of the manuscript, with considerable input by EW, HB, PK and UJ. MS and GS harmonized data retrieved from EVA and CDH. GS wrote R code for DMC calculation. PK wrote R code for the null model application for DMC calculations. MS carried out statistical analyses and produced the graphs. All other authors contributed data. All authors contributed to writing the manuscript.

Data accessibility

The R code for DMC calculation with an application example is available from Figshare Digital Repository: <https://doi.org/10.6084/m9.figshare.7924934.v2>.

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Figures

Figure 1 Distribution of the 808,794 vegetation plots (green dots) extracted from EVA (European Vegetation Archive). Only plots with at least one of the 564 study species are shown. The study species merged distributions based on CDH are represented by grey cells. White areas (large water bodies, glaciers, and deserts) represent regions where none of the studied species occurs. (a) Distribution of vegetation plots in the geographic space. (b) Distribution of vegetation plots in climatic space represented by its first two PCA axes (74.1% and 13.9% variance explained by PC1 and PC2, respectively), where PC1 and PC2 were negatively and positively related to temperature and precipitation, respectively.

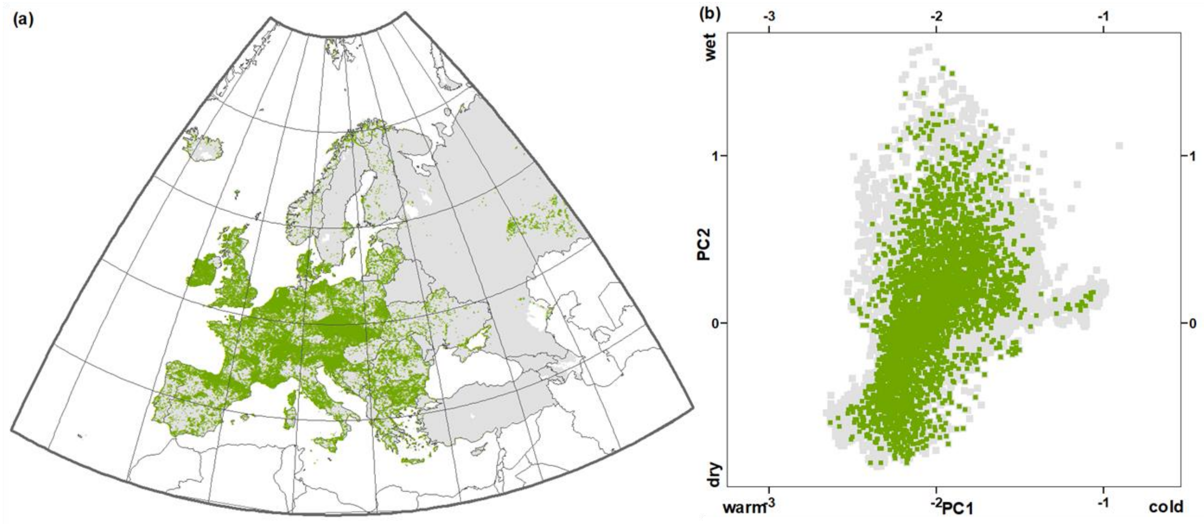


Figure 2 Study species data density in the geographic and climatic space. (a) Data density on species geographic ranges of 564 vascular plant species included in this study in 2.5-min resolution raster. White areas (large water bodies, glaciers, and deserts) represent regions where none of the studied species occurs. (b) Data density on climatic niches of 564 species in the respective common climatic space represented by its first two PCA axes (74.1% and 13.9% variance explained by PC1 and PC2, respectively), where PC1 and PC2 were negatively and positively related to temperature and precipitation, respectively.

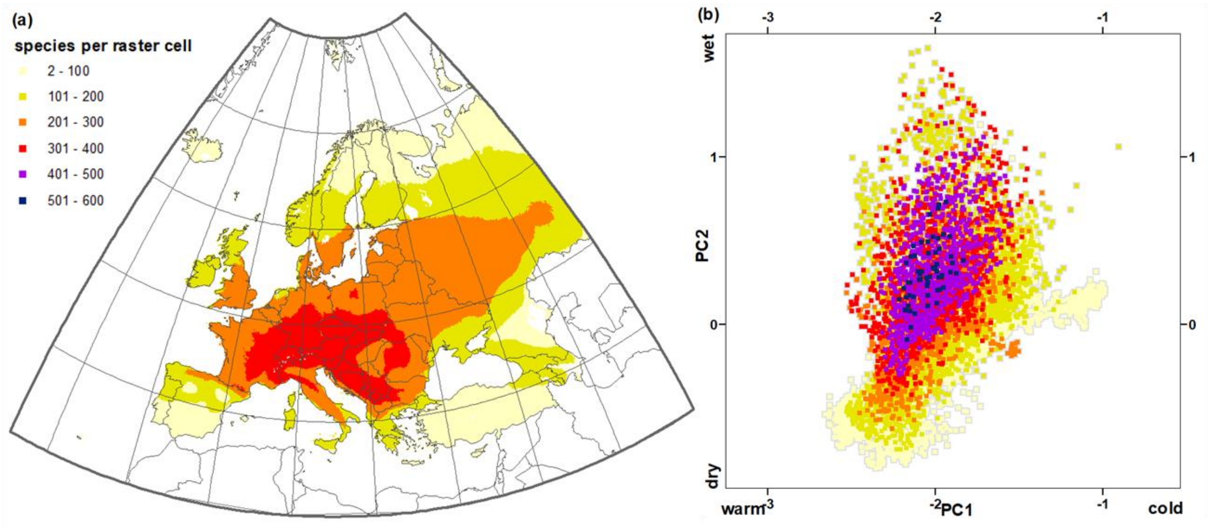


Figure 3 Dynamic Match Coefficient (DMC) calculated for two example species X and Y with different plot distributions but similar ranges and climatic niches. DMC measures sampling coverage from fine resolution to coarse resolution as the area under the curve (AUC). Scaling for species X, with clumped plots (10 red dots) in the species range or climatic niche (grey background), results in a low DMC value. Scaling for species Y, with more regularly distributed plots (10 blue dots) in the species range or climatic niche (grey background), results in a high DMC value.

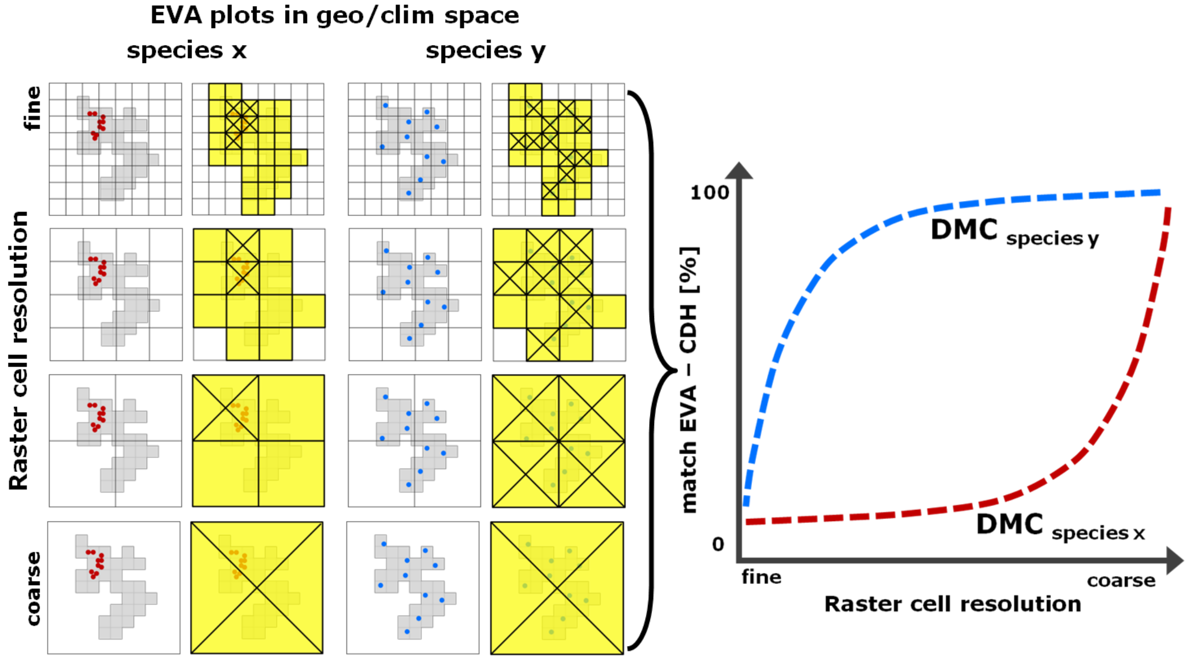


Figure 4 The DMC scaling approach applied to the distribution of EVA vegetation plots inside species ranges in geographic space and inside species niches in climatic space (grey cells). (a) The distribution of EVA plots containing *Hieracium murorum* (left, red) and *Calluna vulgaris* (right, blue). (b) Four selected scaling steps from fine to coarse raster-cell resolution in geographic space (left-hand four panels in each set) and climatic space (right-hand four panels in each set). (c) The resulting DMC curves along 20 scaling steps, where the cell match ratio is the percentage of grey raster cells (species range or climatic niche) matched by a vegetation plot containing the species. In all cases, the maximum achievable DMC is 1 (100% cell match in all scaling steps). DMC values reached 0.42 and 0.58 for the geographic (DMC_{GEO}) and climatic (DMC_{CLIM}) space for *Hieracium murorum* and 0.74 for both the geographic (DMC_{GEO}) and climatic (DMC_{CLIM}) space for *Calluna vulgaris*.

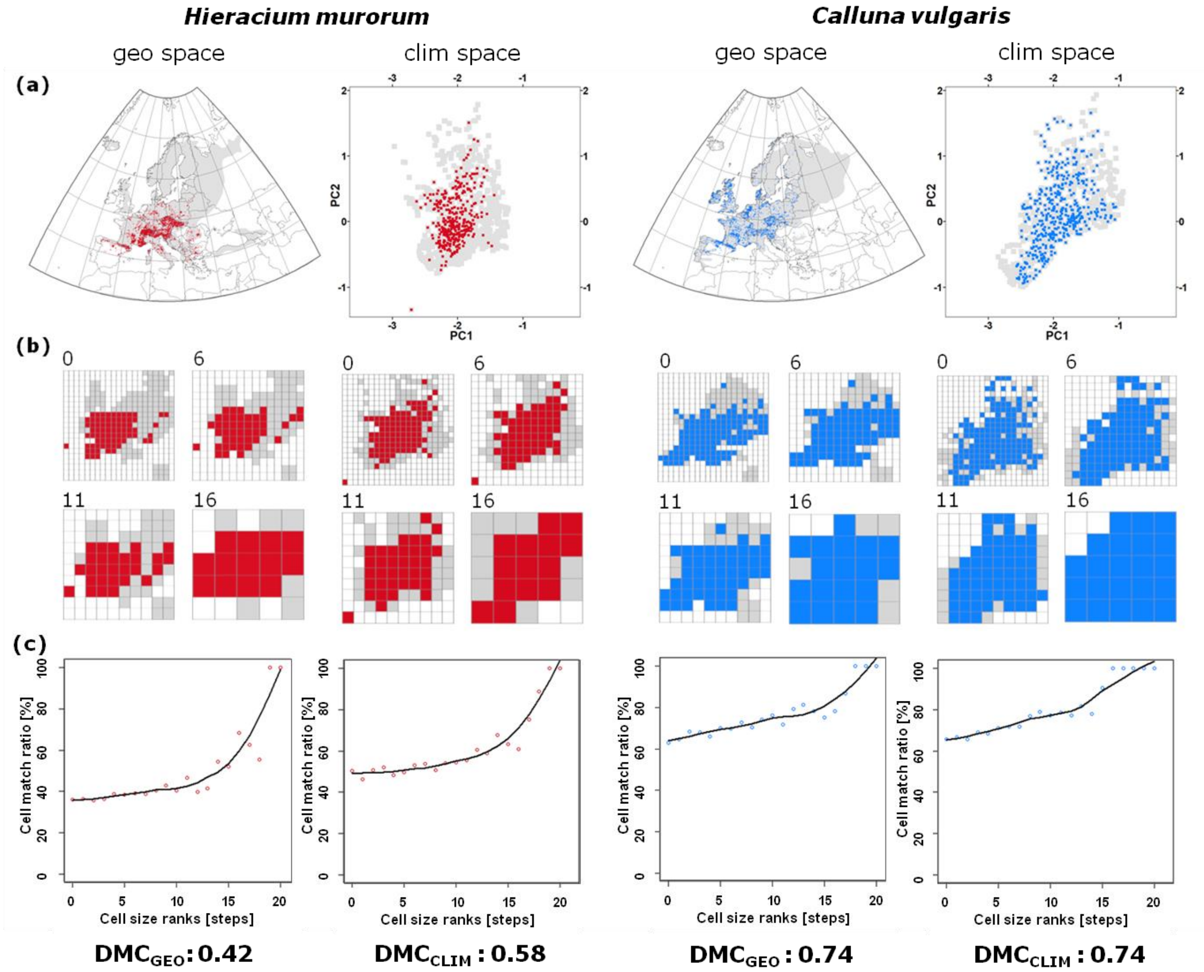


Figure 5 Scatterplot and Spearman correlation coefficients (rho) of the relationship between DMC values in geographic space (DMC_{GEO}) and DMC values in climatic space (DMC_{CLIM}) for 564 plant species. Low DMC values indicate an underdispersed (more clumped) distribution of species occurrences in EVA vegetation plots, while high DMC values indicate a homogenous distribution in EVA vegetation plots, in the geographic range or realized climatic niche of a species.

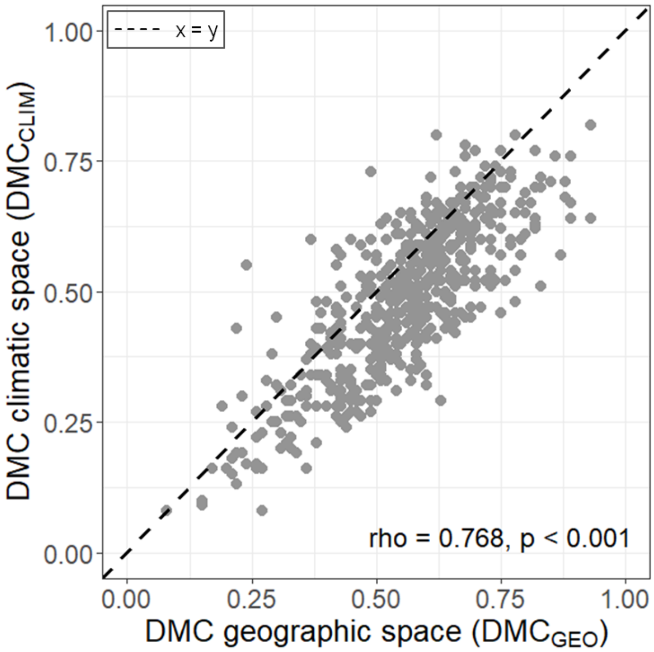


Figure 6 Scatterplots and Spearman correlation coefficients (rho) of the relationships between the observed DMC and expected DMC derived by null models for (a) geographic space and (b) climatic space. Dots are medians; lines are inter-quartile ranges of the simulations from the null model. Colour gradient represents the percentage match of a species range by EVA vegetation plots in the geographic space (match at 2.5-min raster cell resolution) or climate space (ratio of PCA cells matched by EVA plots to all species-specific raster cells matched by the geographic range data in the PCA space).

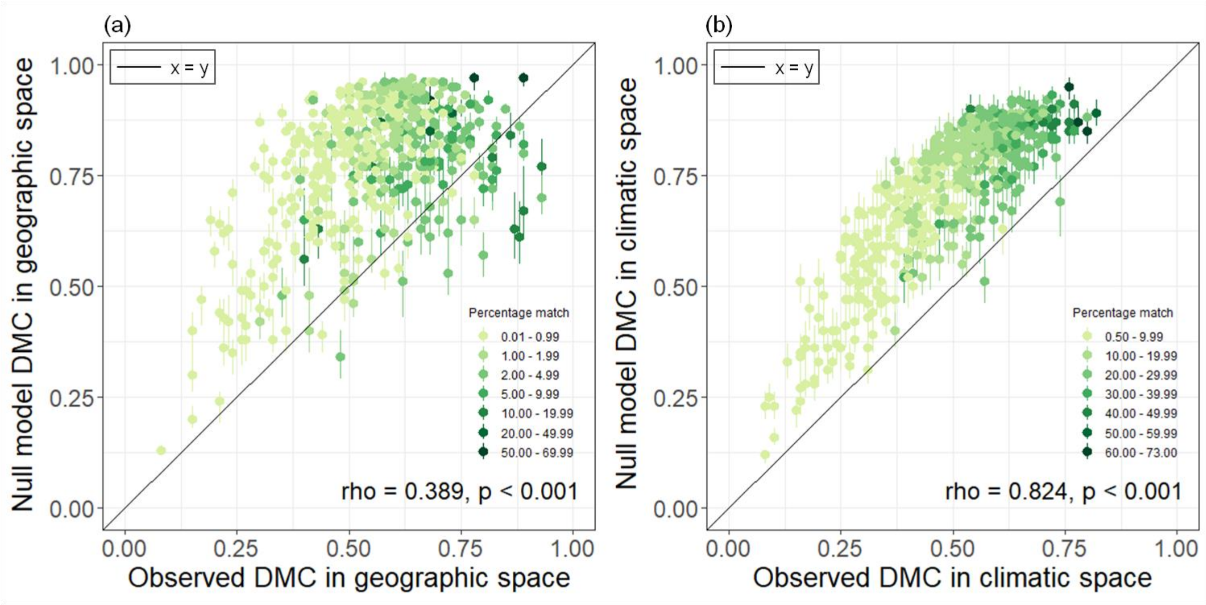


Figure 7 Scatterplot and Spearman correlation coefficients (rho) of the relationship between the deviation of the observed DMC values from null model DMC values in the geographic space (DEV_{GEO}) and in climatic space (DEV_{CLIM}). Low deviation of the observed DMC values from the null expectation indicates a more regular distribution of occurrences for a given species across its reference range or realized climatic niche, a high deviation indicates an underdispersed (more clumped) distribution.

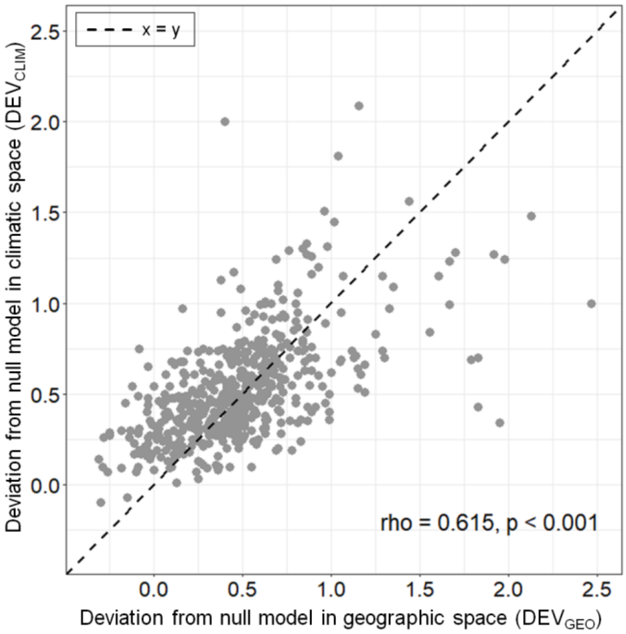
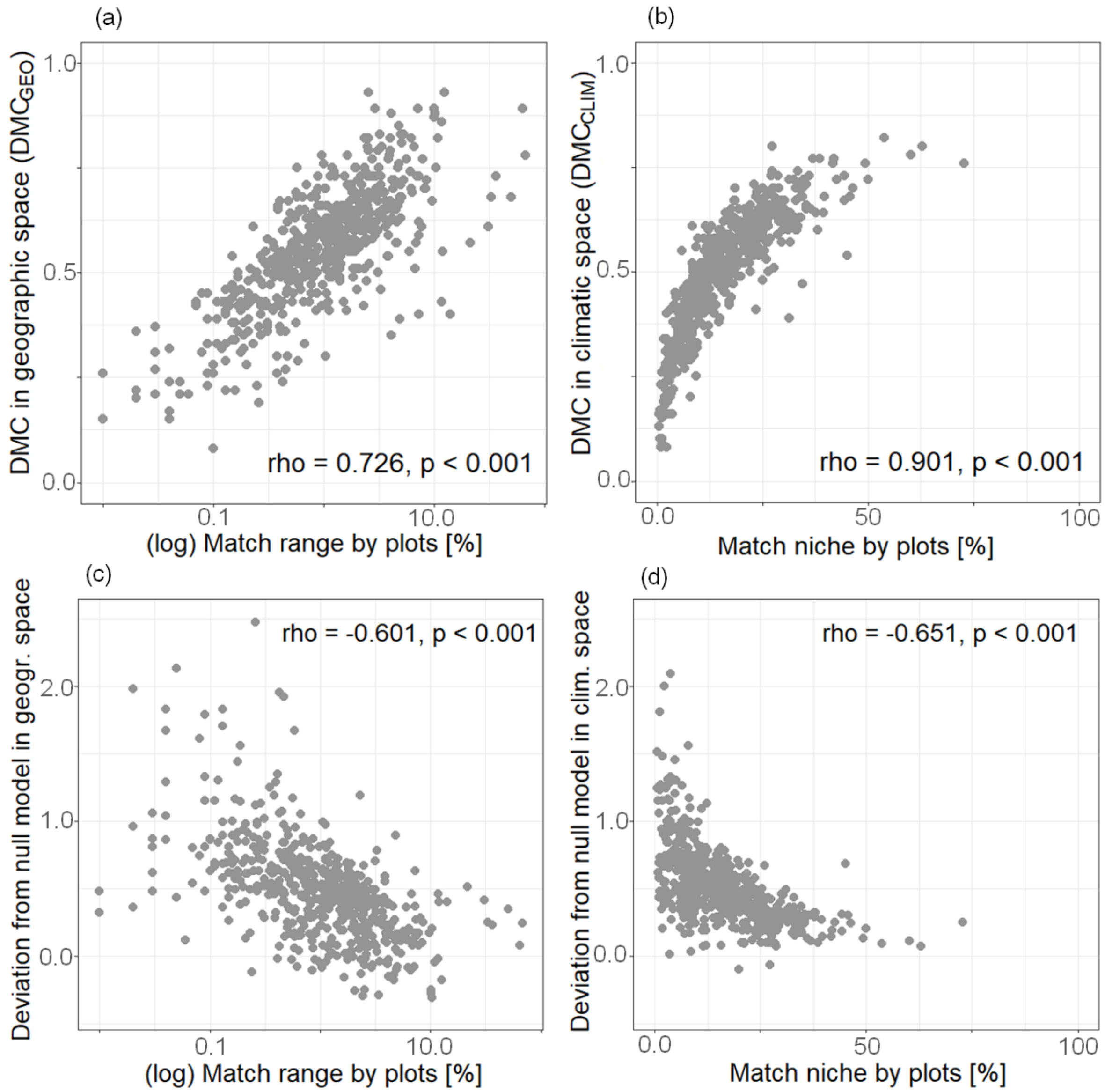


Figure 8 Scatterplots and Spearman correlation coefficients (rho) of the relationships between percentage match of species ranges by EVA vegetation plots and (a) observed DMC in geographic space (DMC_{GEO}); (b) observed DMC in climatic space (DMC_{CLIM}); (c) deviation of observed DMC values from null model DMC values in geographic space (DEV_{GEO}); (d) deviation of observed DMC values from null model DMC values in climatic space (DEV_{CLIM}).



Supporting Information

Appendix S1 Climatic resampling procedure and background PCA niche space of the study area.

Appendix S2 Information on the 564 species included in this study.

Appendix S3 Information on the 59 databases that provided vegetation plots included in this study.

Appendix S4 Information on initial grain size in DMC calculations; correlation between percentage match of species ranges by EVA vegetation plots in geographic vs. climatic space; correlation between species range sizes and niche sizes.

Supporting information to the paper

Sporbert, M. et al. Assessing sampling coverage of species distribution in biodiversity databases. *Journal of Vegetation Science.*

Appendix S1 Climatic resampling procedure and background PCA niche space of the study area

Multivariate approaches such as PCA or clustering algorithms are sensitive to the frequency distribution of the (e.g. climatic) values and more average conditions might be lumped in the presence of extreme values. To minimize the spatial autocorrelation between species occurrences in terms of climatic data, it is desirable to sample climatic conditions equally.

Climatic resampling procedure

We developed a stratification based on a climatic resampling procedure as follows:

1. We used global layers with monthly mean values of temperature and precipitation at 2.5-min raster cell resolution (hemisphere-adjusted). All precipitation values were log-transformed to take into account the decreasing ecological importance of differences with increasing precipitation. Monthly mean values of temperature and (log) precipitation were separately standardized (0-1).

2. After standardization (0-1), 10 classes (class width 0.1) per variable (cf. temperature and (log) precipitation) were derived and labelled “A” to “J” (see Figure S1.1a).

3. The cells of a unique climate class are defined by an identical string of class labels (= climate class ID) containing of 12 “A” to “J” combinations, one for each month.

All 2.5-min raster cells of one climatically homogenous region are labelled by an identical climate class ID. In total, 2,144 unique climate class ID where built in EVA space by the applied climatic resampling procedure. One climatically homogenous region may be represented by one to many geographical patches of different size (see Figure S1.1b). The smallest climatically homogenous region consists of only one 2.5-min raster cell while the largest climatically homogenous region consists of 38,577 2.5-min raster cells.

Based on this spatial pre-partitioning, any climatic data extracted at species occurrences can be subsampled evenly from differently sized, yet climatically homogenous regions.

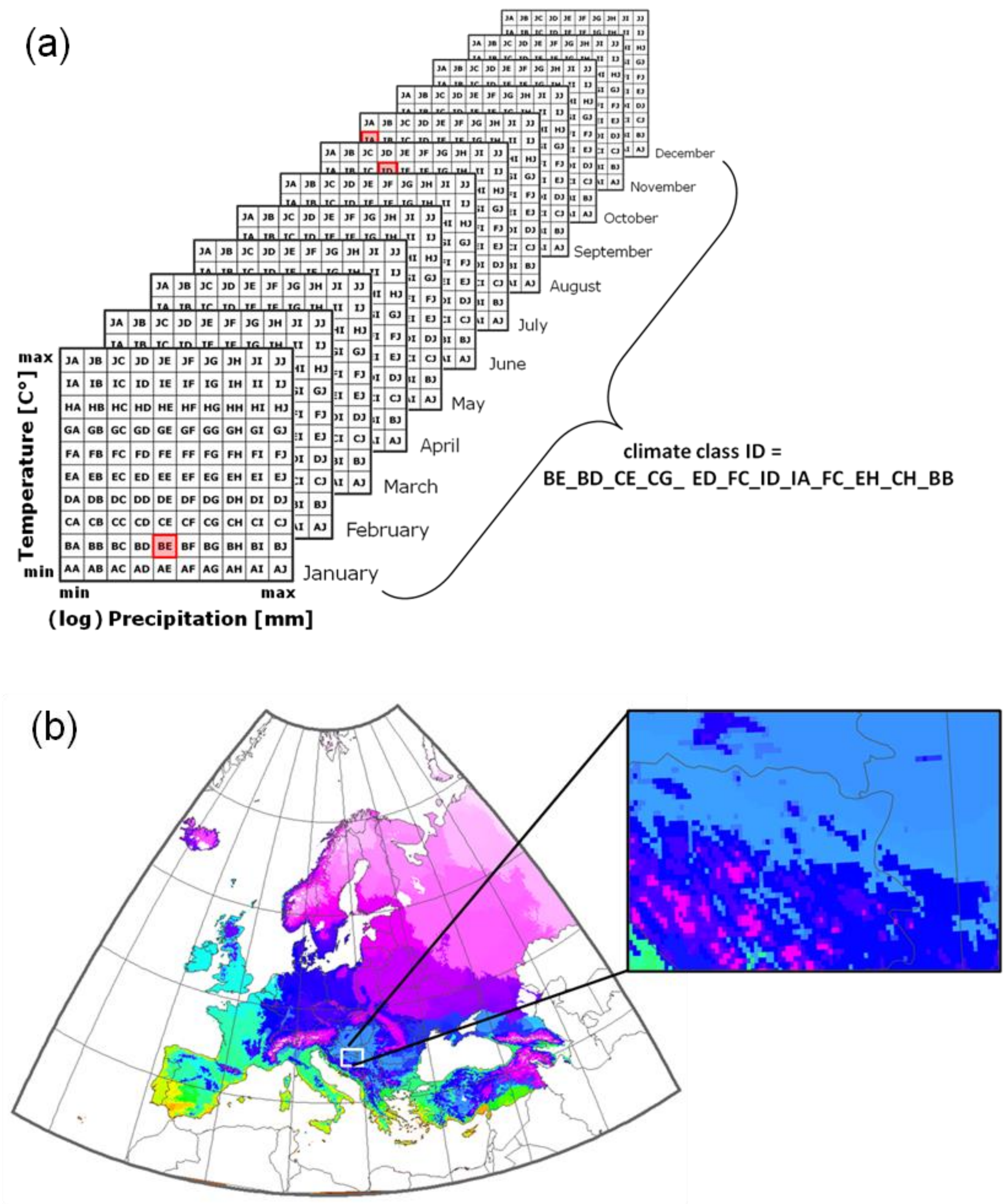


Figure S1.1 Illustration of the climatic resampling procedure. (a) Monthly mean values of temperature and (log) precipitation were separately standardized (0-1). 10 classes (class width 0.1) per variable were derived and labelled “A” to “J”. Cells of a unique climate class are labelled by a unique climate class ID. (b) All cells of one climatically homogenous region are represented by identical colour. Black lines represent the country borders on the continent.

Background PCA niche space of the study area

Per homogenous climatic region (identical climate class ID from climatic resampling) we aggregated mean values for each of the 19 bioclimatic variables from Worldclim with 2.5-min raster cell resolution (Hijmans et al., 2005). The multi-dimensional climatic space (or climatic niche) was determined by principal components analysis (PCA). The common European climatic space is well represented by the first two PCA axes which explain 88.0% of the data variance. Accordingly, unique PCA space locations are representing unique climate classes and were considered (and counted as) niche cells. Results of Pearson correlations between the 19 bioclimatic variables (BIO 01 – BIO 19) and the first two axes of the principal component analysis (PC1 and PC2) are given in Table S1.3.

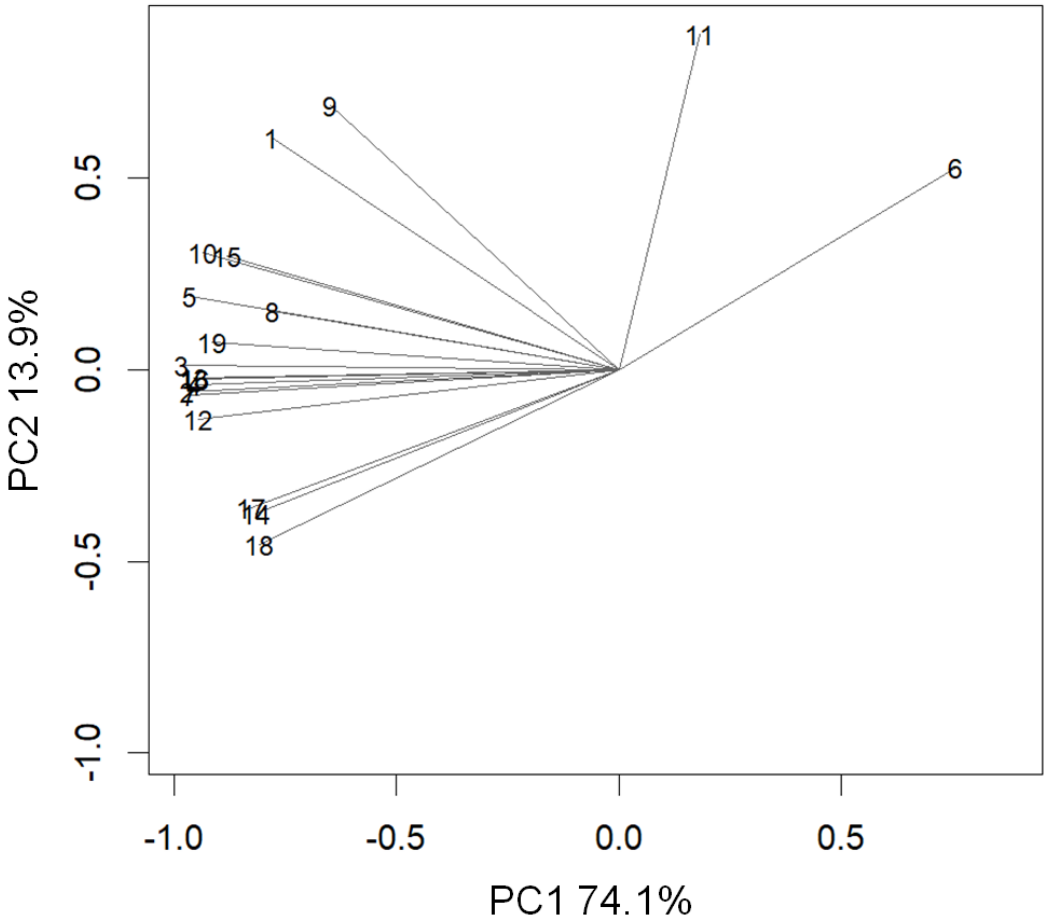


Figure S1.2 Biplot of the principal component analysis (PCA) for bioclimatic variables in the European study space. The two principal components (PC1 and PC2) explained 88.0% of total variation in bioclimatic data. PC1 was negatively related to temperature and PC2 was positively related to precipitation.

Table S1.3 Results of Pearson correlation between the 19 bioclimatic variables (BIO 01 – BIO 19) and the first two axes of the principal component analysis (PC1 and PC2).

Bioclim variable	PC1	PC2
BIO1 = Annual Mean Temperature	-0.650	-0.064
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))	-0.583	0.065
BIO3 = Isothermality (BIO2/BIO7) (* 100)	-0.526	0.071
BIO4 = Temperature Seasonality (standard deviation *100)	-0.436	0.014
BIO5 = Max Temperature of Warmest Month	-0.611	-0.067
BIO6 = Min Temperature of Coldest Month	-0.526	-0.051
BIO7 = Temperature Annual Range (BIO5-BIO6)	-0.495	0.048
BIO8 = Mean Temperature of Wettest Quarter	-0.565	0.016
BIO9 = Mean Temperature of Driest Quarter	-0.641	-0.098
BIO10 = Mean Temperature of Warmest Quarter	-0.628	-0.074
BIO11 = Mean Temperature of Coldest Quarter	-0.574	-0.048
BIO12 = Annual Precipitation	-0.210	0.115
BIO13 = Precipitation of Wettest Month	-0.255	0.085
BIO14 = Precipitation of Driest Month	-0.192	0.176
BIO15 = Precipitation Seasonality (Coefficient of Variation)	-0.348	-0.129
BIO16 = Precipitation of Wettest Quarter	-0.248	0.085
BIO17 = Precipitation of Driest Quarter	-0.197	0.175
BIO18 = Precipitation of Warmest Quarter	-0.177	0.166
BIO19 = Precipitation of Coldest Quarter	-0.224	0.057

Supporting information to the paper: Sporbert, M. et al. Assessing sampling coverage of species distribution in biodiversity da

Appendix S1 Information on the 564 species included in this study.
Information on species range/niche size: (occupied raster cells at 2.5-min raster cell resolution) in geographical/climatic space
EVA sample geo/clim: number of EVA plots at 2.5-min raster cell resolution including the focal species in geographic/climatic s
DMC geo/clim: results of DMC calculations in geographical/climatic space;
DMC geo Null/clim Null: results of Null model DMC calculations in geographical/climatic space;
ratio geo = (DMC geo Null - DMC geo) / DMC geo; ratio clim = (DMC clim Null - DMC clim) / DMC clim;
range percent: percentage of a species range matched by EVA vegetation plots at 2.5min raster cell resolution;
niche percent: percentage of a species niche matched by EVA vegetation plots (= ratio of PCA cells matched by EVA plots to a
starting grain size [km2] in DMC calculations, bandwidth of scaling steps were calculated species specific according to the spe

Species name
Achillea atrata
Achillea clavennae
Achillea crithmifolia
Achillea nobilis
Actaea spicata
Adenostyles alliariae
Adonis vernalis
Adoxa moschatellina
Aegopodium podagraria
Agrimonia eupatoria
Agrostis castellana
Ajuga chamaepitys
Ajuga genevensis
Ajuga reptans
Alliaria petiolata
Allium senescens
Alopecurus pratensis
Anchusa arvensis
Androsace chamaejasme
Androsace obtusifolia
Anemone baldensis
Anemone nemorosa
Angelica archangelica
Angelica palustris
Angelica sylvestris
Antennaria dioica
Anthemis tinctoria
Anthericum ramosum
Anthoxanthum odoratum
Anthriscus sylvestris
Anthyllis vulneraria
Apium repens
Aquilegia vulgaris
Arabis alpina
Arabis hirsuta
Arnica montana

Artemisia alba
Artemisia campestris
Artemisia pontica
Artemisia scoparia
Artemisia vulgaris
Aruncus dioicus
Asperula arvensis
Asperula tinctoria
Aster bellidiastrum
Aster tripolium
Astragalus frigidus
Astragalus glycyphyllos
Astrantia major
Asyneuma canescens
Athyrium filix-femina
Atriplex portulacoides
Atriplex tatarica
Atropa bella-donna
Barbarea vulgaris
Bartsia alpina
Bellis perennis
Bellis sylvestris
Berteroa incana
Betonica officinalis
Betula nana
Bifora radians
Bistorta officinalis
Brachypodium phoenicoides
Brachypodium pinnatum
Brachypodium sylvaticum
Brassica nigra
Briza media
Bromus erectus
Bromus hordeaceus
Bromus squarrosus
Bromus sterilis
Bromus tectorum
Buphthalmum salicifolium
Bupleurum falcatum
Bupleurum ranunculoides
Bupleurum rotundifolium
Cakile maritima
Calamagrostis villosa
Calluna vulgaris
Calystegia sepium
Campanula alpina
Campanula glomerata
Campanula patula
Campanula persicifolia

Campanula ramosissima
Campanula rapunculoides
Campanula rapunculus
Campanula rotundifolia
Campanula sibirica
Campanula trachelium
Cardamine enneaphyllos
Cardamine pratensis
Cardaminopsis arenosa
Cardaria draba
Carduus acanthoides
Carduus defloratus
Carduus micropterus
Carduus pycnocephalus
Carduus thoermeri
Carex alba
Carex arenaria
Carex brizoides
Carex caryophyllea
Carex distans
Carex echinata
Carex elongata
Carex ericetorum
Carex firma
Carex hostiana
Carex panicea
Carex pilosa
Carex pilulifera
Carex pulicaris
Carex remota
Carex rostrata
Carex sempervirens
Carex umbrosa
Carlina acanthifolia
Carlina acaulis
Carlina corymbosa
Carlina vulgaris
Carthamus lanatus
Carum carvi
Centaurea alba
Centaurea calcitrapa
Centaurea cyanus
Centaurea deustiformis
Centaurea jacea
Centaurea maculosa
Centaurea phrygia
Cerastium arvense
Cerastium semidecandrum
Ceratocapnos claviculata

Chaerophyllum aureum
Chaerophyllum temulum
Chamaespartium sagittale
Chimaphila umbellata
Chrysanthemum segetum
Cichorium intybus
Cichorium spinosum
Circaea lutetiana
Cirsium acaule
Cirsium erisithales
Cirsium ligulare
Cirsium montanum
Cirsium oleraceum
Cirsium rivulare
Cirsium vulgare
Clematis recta
Clinopodium vulgare
Coeloglossum viride
Conium maculatum
Consolida ajacis
Convallaria majalis
Coronilla coronata
Coronilla vaginalis
Cortusa matthioli
Corydalis cava
Corydalis solida
Corynephorus canescens
Crepis biennis
Crepis capillaris
Crepis praemorsa
Crepis tectorum
Crepis vesicaria
Cruciata laevipes
Crupina crupinastrum
Crupina vulgaris
Cyclamen hederifolium
Cymbalaria muralis
Cynosurus cristatus
Cynosurus elegans
Cytisus multiflorus
Dactylorhiza fuchsii
Dactylorhiza sambucina
Daucus carota
Deschampsia flexuosa
Dianthus armeria
Dianthus carthusianorum
Dianthus deltoides
Dianthus seguieri
Dianthus superbus

Dictamnus albus
Digitalis ferruginea
Digitalis grandiflora
Digitalis lanata
Digitalis lutea
Digitalis purpurea
Digitalis viridiflora
Dryas octopetala
Dryopteris oreades
Echinops ritro
Echium vulgare
Empetrum nigrum
Epilobium hirsutum
Epipactis atrorubens
Erica cinerea
Erigeron glabratus
Eriophorum latifolium
Eriophorum scheuchzeri
Eriophorum vaginatum
Erodium cicutarium
Eryngium campestre
Eryngium maritimum
Erysimum cheiranthoides
Eupatorium cannabinum
Euphorbia amygdaloides
Euphorbia cyparissias
Euphorbia helioscopia
Euphrasia officinalis
Festuca altissima
Festuca amethystina
Festuca gigantea
Festuca heterophylla
Festuca pratensis
Filago pyramidata
Filipendula ulmaria
Filipendula vulgaris
Fragaria vesca
Fragaria viridis
Galeopsis bifida
Galeopsis segetum
Galeopsis speciosa
Galium anisophyllon
Galium aparine
Galium aristatum
Galium boreale
Galium glaucum
Galium heldreichii
Galium laevigatum
Galium octonarium

Galium pinetorum
Galium rotundifolium
Galium scabrum
Galium spurium
Galium timeroyi
Galium triflorum
Galium uliginosum
Galium verum
Gaudinia fragilis
Genista anglica
Gentiana acaulis
Gentiana asclepiadea
Gentiana clusii
Gentiana cruciata
Gentiana lutea
Gentiana pannonica
Gentiana utriculosa
Gentiana verna
Gentianella aspera
Gentianella ciliata
Geranium columbinum
Geranium dissectum
Geranium palustre
Geranium pratense
Geranium robertianum
Geranium sanguineum
Geranium sylvaticum
Geum rivale
Gladiolus imbricatus
Glechoma hederacea
Globularia punctata
Gratiola officinalis
Gymnadenia conopsea
Hedysarum hedysaroides
Helichrysum arenarium
Helictotrichon pubescens
Helleborus foetidus
Heracleum sphondylium
Herniaria glabra
Hieracium aurantiacum
Hieracium bifidum
Hieracium glaucum
Hieracium murorum
Hieracium piliferum
Hieracium pilosella
Hieracium umbellatum
Hierochloe odorata
Hippocrepis comosa
Hippocrepis emerus

Holcus lanatus
Homogyne alpina
Hordelymus europaeus
Hypericum maculatum
Hypericum pulchrum
Hypochaeris maculata
Inula britannica
Inula conyzae
Inula ensifolia
Inula germanica
Iris germanica
Iris sibirica
Jasione montana
Juniperus sabina
Knautia arvensis
Koeleria macrantha
Koeleria pyramidata
Krascheninnikovia ceratoides
Lactuca perennis
Lactuca serriola
Lactuca tatarica
Lactuca tenerrima
Lamium album
Lamium maculatum
Lamium purpureum
Laserpitium latifolium
Lathraea clandestina
Lathyrus linifolius
Lathyrus nissolia
Lathyrus pratensis
Lathyrus sphaericus
Lathyrus tuberosus
Lathyrus vernus
Legousia speculum-veneris
Leontodon autumnalis
Leontodon crispus
Leontodon hirtus
Leontodon hispidus
Leontodon incanus
Leontodon tuberosus
Lepidium ruderale
Ligustrum vulgare
Linaria vulgaris
Linum catharticum
Linum hirsutum
Linum tenuifolium
Lithospermum officinale
Loiseleuria procumbens
Lonicera alpigena

Lonicera etrusca
Lonicera periclymenum
Lonicera xylosteum
Lotus pedunculatus
Luzula luzuloides
Luzula nivea
Luzula pilosa
Lycopus europaeus
Lysimachia nummularia
Malva pusilla
Marrubium vulgare
Medicago lupulina
Melampyrum sylvaticum
Melica nutans
Melica uniflora
Melilotus officinalis
Mentha arvensis
Milium effusum
Moehringia trinervia
Myosotis arvensis
Myosotis stricta
Myosurus minimus
Nardus stricta
Neslia paniculata
Oenanthe fistulosa
Ononis arvensis
Ononis repens
Onopordum acanthium
Ophrys insectifera
Ophrys speculum
Orchis militaris
Orchis ustulata
Origanum vulgare
Orobanche caryophyllacea
Oxalis acetosella
Papaver rhoeas
Papaver somniferum
Paris quadrifolia
Pastinaca hirsuta
Pastinaca sativa
Pedicularis kerneri
Pedicularis oederi
Pedicularis palustris
Pedicularis recutita
Pedicularis sceptrum-carolinum
Pentaglottis sempervirens
Petasites albus
Peucedanum cervaria
Peucedanum oreoselinum

Phyteuma globulariifolium
Phyteuma orbiculare
Phyteuma tenerum
Pimpinella major
Pimpinella peregrina
Pimpinella saxifraga
Plantago alpina
Plantago lanceolata
Plantago major
Plantago media
Platanthera bifolia
Platanthera chlorantha
Poa alpina
Poa bulbosa
Poa chaixii
Poa glauca
Poa hybrida
Poa laxa
Poa nemoralis
Polemonium caeruleum
Polygala amara
Polygala amarella
Polygala chamaebuxus
Polygala comosa
Polygala nicaeensis
Polygonatum multiflorum
Potentilla alba
Potentilla anglica
Potentilla anserina
Potentilla argentea
Potentilla erecta
Potentilla micrantha
Potentilla palustris
Potentilla patula
Potentilla recta
Potentilla reptans
Potentilla rupestris
Potentilla sterilis
Potentilla tabernaemontani
Primula farinosa
Primula veris
Primula vulgaris
Pritzelago alpina
Prunella vulgaris
Pseudofumaria alba
Pulicaria dysenterica
Pulmonaria officinalis
Pulmonaria rubra
Pulsatilla vulgaris

Pyrola chlorantha
Ranunculus acris
Ranunculus cassubicus
Ranunculus ficaria
Ranunculus flammula
Ranunculus kochii
Ranunculus lanuginosus
Ranunculus neapolitanus
Ranunculus peltatus
Ranunculus polyanthemos
Ranunculus repens
Ranunculus reptans
Reseda lutea
Rhinanthus alectorolophus
Rhinanthus groenlandicus
Rhinanthus minor
Ribes alpinum
Rubus caesius
Rubus chamaemorus
Rubus saxatilis
Rumex acetosella
Rumex alpinus
Rumex hydrolapathum
Rumex tuberosus
Salix reticulata
Salvia aethiopis
Salvia pratensis
Sambucus nigra
Sambucus racemosa
Sanguisorba minor
Sanguisorba officinalis
Sanicula europaea
Saxifraga aizoides
Scabiosa canescens
Scabiosa columbaria
Scabiosa graminifolia
Scabiosa lucida
Scabiosa ochroleuca
Scabiosa triandra
Scorzonera humilis
Scorzonera parviflora
Scrophularia nodosa
Securigera varia
Sedum acre
Sedum album
Sedum telephium
Selinum carvifolia
Senecio adonidifolius
Senecio aquaticus

Senecio jacobaea
Senecio paludosus
Senecio papposus
Senecio subalpinus
Senecio viscosus
Senecio vulgaris
Sesleria caerulea
Silaum silaus
Silene coronaria
Silene dioica
Silene flos-cuculi
Silene latifolia
Silene noctiflora
Silene nutans
Sium latifolium
Solanum dulcamara
Solanum nigrum
Solidago virgaurea
Sonchus arvensis
Stachys palustris
Stachys recta
Stachys sylvatica
Stellaria graminea
Stellaria holostea
Stellaria media
Stipa calamagrostis
Stipa capillata
Succisa pratensis
Symphytum officinale
Tanacetum corymbosum
Tanacetum macrophyllum
Tanacetum vulgare
Teesdalia nudicaulis
Tephroseris helenitis
Teucrium botrys
Teucrium chamaedrys
Teucrium flavum
Teucrium montanum
Teucrium scorodonia
Thalictrum aquilegiifolium
Thlaspi arvense
Thlaspi perfoliatum
Thymus vulgaris
Tragopogon dubius
Tragopogon pratensis
Trientalis europaea
Trifolium alpestre
Trifolium arvense
Trifolium fragiferum

Trifolium hybridum
Trifolium medium
Trifolium montanum
Trifolium pratense
Trifolium repens
Trifolium spadiceum
Turgenia latifolia
Tussilago farfara
Vaccinium myrtillus
Vaccinium oxycoccos
Vaccinium vitis-idaea
Valeriana officinalis
Valeriana saxatilis
Valeriana tuberosa
Valerianella carinata
Valerianella locusta
Verbascum thapsus
Veronica alpina
Veronica arvensis
Veronica montana
Veronica officinalis
Veronica serpyllifolia
Viburnum lantana
Viburnum opulus
Vicia cracca
Vicia lathyroides
Vicia sepium
Vicia tetrasperma
Vicia villosa
Vinca major
Vinca minor
Viola arvensis
Viola biflora
Viola lutea
Viola odorata
Viola palustris
Viola rupestris
Xeranthemum annuum

range size	niche size	EVA sample geo	EVA sample clim	DMC geo	DMC geo Null	DMC clim
3 217	426	145	82	0.65	0.74	0.49
3 410	513	166	88	0.39	0.74	0.43
4 427	384	324	96	0.4	0.65	0.48
242 396	5 039	571	198	0.49	0.84	0.29
355 510	3 199	3 998	665	0.43	0.84	0.57
33 302	1 691	1 614	469	0.76	0.85	0.7
3 244	385	699	152	0.57	0.87	0.64
497 713	2 631	2 892	502	0.55	0.92	0.53
518 745	3 649	9 467	776	0.55	0.91	0.57
566 800	7 949	6 201	793	0.66	0.95	0.46
30 295	1 788	692	317	0.65	0.69	0.52
283 332	7 033	602	224	0.44	0.86	0.26
314 205	4 476	1 671	318	0.45	0.77	0.35
410 733	3 735	12 873	1 092	0.6	0.89	0.65
351 315	4 384	4 919	632	0.54	0.85	0.49
100 151	2 192	916	265	0.61	0.72	0.43
668 369	4 853	9 630	570	0.56	0.95	0.47
364 066	3 357	978	126	0.43	0.77	0.28
4 389	446	114	67	0.52	0.6	0.39
4 799	597	68	48	0.48	0.59	0.32
3 006	488	60	41	0.51	0.51	0.35
332 673	3 262	10 660	989	0.64	0.88	0.61
242 346	1 549	356	98	0.47	0.59	0.4
497	83	70	26	0.4	0.56	0.39
659 229	5 315	11 147	973	0.65	0.95	0.63
614 133	4 916	2 147	630	0.57	0.92	0.61
537 251	6 380	1 086	300	0.43	0.82	0.3
189 874	1 909	2 915	420	0.6	0.83	0.52
708 879	6 449	21 930	1 781	0.67	0.96	0.7
624 495	5 162	8 023	685	0.63	0.92	0.55
440 152	6 988	6 315	1 111	0.59	0.87	0.62
994	203	41	19	0.35	0.48	0.25
289 311	2 836	2 134	593	0.57	0.89	0.65
170 278	6 098	726	363	0.24	0.71	0.55
571 772	6 412	2 169	569	0.42	0.93	0.47
63 192	1 488	1 298	381	0.64	0.79	0.63

25 925	1 391		462	201	0.71	0.69	0.47
415 620	3 388	3 236		461	0.63	0.83	0.52
104 317		770	192	65	0.31	0.58	0.31
226 158	4 108		57	38	0.27	0.49	0.16
699 793	6 098	6 085		442	0.5	0.94	0.41
79 104	2 744	1 887		436	0.58	0.82	0.51
180 870	5 535		81	44	0.24	0.55	0.17
91 201		519	658	149	0.56	0.68	0.59
19 702	1 168	1 610		431	0.7	0.9	0.77
125 172	1 892	1 294		185	0.54	0.7	0.48
75 801	1 406		69	54	0.23	0.63	0.3
401 640	4 800	2 967		525	0.59	0.93	0.44
58 881	1 906	1 656		466	0.68	0.85	0.62
11 581		674	121	64	0.51	0.46	0.33
672 148	6 338	11 891	1 251		0.65	0.95	0.62
52 662	2 330		583	118	0.58	0.82	0.37
220 760	3 338		283	85	0.46	0.62	0.27
114 494	2 136		547	228	0.67	0.76	0.46
584 686	6 590		756	207	0.4	0.76	0.28
108 843	2 421		938	385	0.63	0.66	0.57
245 784	4 261	9 013		971	0.61	0.81	0.6
44 194	2 346		297	175	0.65	0.74	0.43
460 231	4 044	1 413		194	0.42	0.86	0.26
422 318	4 361	7 860		996	0.63	0.9	0.56
15 029		892	596	215	0.66	0.63	0.65
80 437	3 493		79	48	0.26	0.49	0.17
486 062	5 230	3 850		561	0.57	0.92	0.45
40 170	1 746	1 548		376	0.54	0.85	0.63
468 084	5 100	8 886	1 064		0.58	0.94	0.58
497 144	6 097	13 527	1 663		0.62	0.96	0.8
230 302	2 297		221	63	0.28	0.53	0.33
427 231	5 525	12 486	1 165		0.59	0.88	0.55
151 123	2 518	6 251		858	0.88	0.86	0.71
95 835	1 910	8 118		860	0.7	0.77	0.54
241 571	6 518	1 116		319	0.45	0.84	0.29
253 048	6 020	2 567		625	0.76	0.93	0.52
426 209	7 312	1 447		339	0.53	0.79	0.37
19 046	1 033	1 486		390	0.61	0.72	0.64
186 550	2 408	2 243		375	0.61	0.9	0.53
11 896		906	414	199	0.63	0.6	0.6
220 969	5 334		74	59	0.31	0.5	0.23
74 867	2 541		888	245	0.75	0.79	0.46
24 957	1 082	1 958		391	0.77	0.83	0.73
492 948	3 786	11 826	1 263		0.74	0.95	0.74
571 808	7 733	6 048		612	0.63	0.95	0.46
2 076		351	153	81	0.59	0.74	0.54
499 660	4 139	2 959		637	0.52	0.84	0.51
404 238	2 389	4 556		552	0.49	0.89	0.6
391 658	2 631	4 369		654	0.62	0.93	0.67

8 046	768	20	19	0.23	0.42	0.19
380 282	3 756	3 733	502	0.47	0.85	0.49
160 400	4 062	1 363	468	0.69	0.77	0.45
598 686	3 690	7 900	946	0.66	0.93	0.63
139 659	1 101	823	171	0.56	0.85	0.47
373 121	3 045	6 127	919	0.65	0.89	0.67
24 035	994	1 456	363	0.74	0.86	0.65
636 060	4 242	11 340	752	0.7	0.93	0.65
172 726	1 400	1 325	240	0.47	0.8	0.53
116 286	1 231	722	181	0.58	0.53	0.38
249 820	3 210	1 342	236	0.6	0.69	0.34
10 677	763	1 339	410	0.93	0.77	0.82
13 867	737	13	13	0.26	0.38	0.16
95 397	5 116	326	167	0.52	0.75	0.41
314 907	4 248	167	79	0.21	0.64	0.18
38 196	1 529	1 758	389	0.57	0.71	0.55
2 709	216	1 832	136	0.78	0.97	0.8
4 364	455	2 196	274	0.68	0.92	0.78
378 303	3 518	6 012	952	0.66	0.86	0.73
266 471	5 226	1 499	383	0.69	0.85	0.47
582 336	5 651	4 604	849	0.63	0.95	0.6
439 621	2 835	1 292	142	0.42	0.89	0.38
346 941	1 797	517	157	0.44	0.8	0.49
12 564	887	375	164	0.62	0.79	0.57
207 218	2 771	1 218	325	0.64	0.85	0.56
421 876	4 614	9 219	893	0.73	0.88	0.65
225 899	1 626	2 160	302	0.6	0.91	0.51
237 595	2 885	6 053	719	0.68	0.8	0.63
37 299	1 103	1 519	364	0.82	0.77	0.7
341 046	4 005	4 294	587	0.63	0.93	0.54
685 506	5 394	5 335	686	0.68	0.96	0.56
32 416	1 676	1 246	418	0.59	0.91	0.59
112 373	1 965	677	198	0.54	0.73	0.41
21 367	1 374	779	249	0.61	0.75	0.52
77 722	1 780	3 333	566	0.7	0.84	0.62
1 905	700	1 221	509	0.89	0.97	0.76
165 721	3 789	4 385	730	0.73	0.8	0.54
190 403	6 525	481	222	0.5	0.81	0.29
557 758	5 016	2 680	487	0.48	0.88	0.44
28 423	1 545	188	129	0.58	0.68	0.43
142 764	3 451	262	128	0.41	0.66	0.32
586 120	4 133	2 332	220	0.37	0.86	0.4
2 986	325	3	3	0.08	0.13	0.08
378 031	3 028	10 363	764	0.62	0.85	0.58
2 485	187	116	44	0.62	0.51	0.41
158 851	459	489	152	0.37	0.67	0.6
514 405	4 439	4 086	643	0.49	0.9	0.51
283 327	3 718	2 535	411	0.7	0.82	0.52
7 916	359	942	100	0.55	0.77	0.51

40 089	2 538			645		284	0.41	0.48	0.4
275 711	3 304		2 124			380	0.58	0.78	0.48
68 330	1 766		1 746			416	0.69	0.86	0.6
223 185		813		258		57	0.32	0.74	0.29
129 726	2 759			241		66	0.38	0.59	0.34
647 909	8 378		3 579			541	0.57	0.94	0.35
4 410		553		20		13	0.27	0.38	0.08
309 820	4 489		6 310			735	0.62	0.92	0.5
109 423	1 660		3 229			496	0.89	0.8	0.64
17 168		953	1 061			316	0.7	0.78	0.7
13 342		833		223		95	0.55	0.56	0.5
6 884		593		26		23	0.26	0.43	0.22
344 237	1 584		5 381			447	0.6	0.89	0.67
75 419		952	1 793			255	0.75	0.83	0.65
630 010	6 394		4 952			599	0.54	0.93	0.46
196 855	2 158			531		188	0.4	0.8	0.33
533 191	6 868		7 353		1 280		0.57	0.92	0.57
599 766	4 264			659		303	0.39	0.85	0.46
589 507	7 826			503		217	0.45	0.82	0.32
25 137	1 645			61		37	0.44	0.39	0.24
454 950	3 986		5 980			659	0.61	0.91	0.47
22 677	1 268			175		83	0.45	0.66	0.27
12 936		778		336		171	0.68	0.68	0.54
33 784		401		127		64	0.3	0.45	0.45
141 018	2 187		1 296			360	0.62	0.72	0.5
341 891	2 888			658		214	0.38	0.82	0.39
136 565	1 398		1 730			205	0.73	0.82	0.6
235 059	2 233		3 857			426	0.62	0.79	0.52
209 972	4 082		2 720			435	0.57	0.79	0.42
200 485	1 212			285		136	0.42	0.7	0.55
473 203	2 071			611		109	0.43	0.72	0.34
105 382	2 524			942		350	0.73	0.71	0.51
255 626	5 188		2 583			620	0.59	0.9	0.46
68 734	4 589			136		111	0.42	0.63	0.4
90 297	3 448			681		286	0.51	0.78	0.46
32 291	2 084			892		388	0.58	0.72	0.62
210 654	3 669			337		155	0.45	0.76	0.33
332 132	4 179		10 300			991	0.64	0.88	0.56
27 429	1 673			196		142	0.55	0.69	0.61
10 128		465		213		76	0.57	0.8	0.45
215 317	1 950			918		300	0.43	0.76	0.46
1 947		571		644		282	0.68	0.85	0.76
450 341	7 451		10 510		1 049		0.62	0.87	0.52
546 715	5 222		13 780		1 453		0.67	0.93	0.68
116 918	2 428			500		207	0.52	0.56	0.42
54 326	1 147		2 715			396	0.83	0.76	0.7
360 594	2 302		1 882			318	0.57	0.77	0.54
2 435		408		245		121	0.87	0.63	0.57
423 390	2 310			394		153	0.39	0.84	0.43

88 597	2 848			560		185	0.46	0.74	0.31
43 113	2 455			92		62	0.43	0.6	0.31
120 342	1 752		1 881			424	0.56	0.79	0.58
22 969		885		323		133	0.49	0.53	0.5
17 407	1 080		1 203			383	0.57	0.62	0.65
39 526	1 152		2 124			527	0.72	0.81	0.68
6 216		510		146		80	0.51	0.69	0.53
142 706	3 852			794		320	0.38	0.83	0.48
9 895		848		63		52	0.49	0.51	0.35
147 083	1 494			860		299	0.55	0.72	0.61
422 371	4 379		3 822			608	0.56	0.8	0.52
264 836	1 557		1 730			399	0.68	0.78	0.68
555 114	7 898		4 693			563	0.59	0.94	0.45
348 838	3 783		2 106			576	0.47	0.85	0.59
57 182	1 077		2 225			350	0.77	0.86	0.72
16 051	1 332			118		88	0.43	0.71	0.4
607 547	4 860		1 895			509	0.58	0.91	0.51
196 506	2 431			144		113	0.43	0.67	0.41
666 444	4 970		2 574			592	0.65	0.94	0.54
668 594	8 806		3 507			591	0.55	0.93	0.4
247 853	4 588		6 181			818	0.68	0.89	0.54
29 572	1 676			965		268	0.83	0.86	0.51
587 189	3 133		1 094			101	0.35	0.89	0.3
426 947	4 819		5 519			724	0.6	0.91	0.56
142 951	3 376		7 383		1 110		0.81	0.92	0.67
186 725	2 315		9 026			819	0.85	0.9	0.71
471 060	7 005		2 533			376	0.5	0.9	0.38
279 204	2 015		2 964			585	0.55	0.82	0.65
91 356	2 258		2 499			538	0.6	0.71	0.56
16 027		843		170		89	0.58	0.63	0.4
402 004	3 898		4 854			566	0.59	0.93	0.47
142 812	2 157		4 569			906	0.75	0.8	0.77
582 960	5 140		12 124			819	0.56	0.9	0.47
158 103	5 845			594		272	0.54	0.82	0.44
707 727	5 761		13 042			895	0.69	0.96	0.59
410 902	4 817		4 257			697	0.7	0.93	0.51
693 388	6 830		15 021		1 535		0.6	0.96	0.59
422 233	4 739		3 705			391	0.59	0.94	0.36
570 718	3 892		2 021			201	0.41	0.92	0.38
49 142		604		150		53	0.36	0.64	0.3
483 358	3 065		1 987			340	0.36	0.85	0.37
21 553	1 426			937		346	0.72	0.83	0.64
583 465	7 102		14 483		1 199		0.62	0.95	0.56
3 287		465		338		184	0.88	0.61	0.68
596 277	3 209		2 824			420	0.62	0.9	0.56
42 530		904		910		156	0.66	0.77	0.42
2 554		343		29		24	0.41	0.4	0.31
7 286		608		331		125	0.57	0.77	0.59
97 578		813		176		64	0.31	0.75	0.2

7 173		471		273		124	0.54	0.77	0.61
60 580	2 397		2 241			612	0.65	0.84	0.65
2 975		290		125		79	0.72	0.62	0.74
565 727	4 238			504		129	0.33	0.78	0.29
3 986		197		48		24	0.49	0.49	0.37
119 114		813		7		6	0.15	0.2	0.1
630 730	3 309		6 106			522	0.66	0.94	0.59
651 266	8 295		12 532		1 235		0.63	0.94	0.52
2 763		700	1 003			266	0.73	0.89	0.6
55 674		895	1 069			218	0.75	0.78	0.67
7 079		862		515		218	0.62	0.72	0.64
32 874	2 062		2 381			508	0.62	0.85	0.65
7 303		689		368		180	0.63	0.73	0.62
289 774	3 164			637		243	0.51	0.83	0.4
26 247	1 795		1 096			330	0.63	0.77	0.54
2 491		323		167		85	0.51	0.75	0.5
15 126	1 191			147		104	0.42	0.64	0.46
38 291	1 783			972		370	0.65	0.69	0.65
3 711		315		39		30	0.3	0.42	0.32
62 272	1 696			637		202	0.58	0.72	0.41
238 288	4 407		1 111			370	0.52	0.78	0.45
343 304	7 716		2 455			474	0.56	0.87	0.41
398 787	1 970		1 047			148	0.37	0.8	0.38
424 629	2 221		1 982			242	0.5	0.85	0.47
536 916	8 327		12 672		1 421		0.6	0.95	0.57
313 009	3 866		2 692			659	0.68	0.88	0.52
551 689	5 137		2 953			767	0.6	0.92	0.58
667 193	5 460		4 530			677	0.65	0.94	0.58
182 444	2 421			319		90	0.36	0.78	0.16
570 188	4 194		11 345			717	0.62	0.94	0.5
89 548	2 628		1 988			473	0.69	0.78	0.47
306 938	3 307			816		186	0.54	0.82	0.31
608 455	5 627		2 992			667	0.53	0.92	0.52
72 877	3 006			186		110	0.19	0.65	0.28
238 436	1 030			873		94	0.51	0.82	0.37
412 473	4 452		5 354			537	0.58	0.94	0.44
70 342	1 835		2 765			555	0.78	0.91	0.65
616 113	4 639		11 840		1 011		0.55	0.92	0.56
493 621	6 075			826		249	0.5	0.86	0.42
51 584	1 650			269		122	0.43	0.67	0.31
144 069	3 386			848		346	0.29	0.77	0.38
10 218		846		88		69	0.41	0.61	0.41
473 445	5 361		10 866		1 232		0.42	0.92	0.58
8 404		765		174		88	0.72	0.53	0.52
548 419	5 195		13 395		1 271		0.63	0.94	0.61
689 495	5 298		3 957			517	0.53	0.96	0.46
578 198	3 544			192		57	0.37	0.7	0.34
103 537	2 556		4 159			743	0.79	0.9	0.67
73 842	3 507		2 361			626	0.64	0.85	0.63

351 172	4 071	20 003	1 264	0.77	0.91	0.6
22 347	1 371	2 627	572	0.86	0.84	0.76
6 522	897	2 013	448	0.61	0.86	0.72
426 209	2 888	4 870	645	0.55	0.9	0.56
94 479	1 322	2 227	342	0.67	0.81	0.57
367 057	2 819	1 332	425	0.56	0.87	0.51
462 086	4 865	1 274	185	0.47	0.87	0.26
151 307	2 989	1 914	422	0.74	0.81	0.52
45 215	1 065	636	150	0.51	0.51	0.42
122 604	2 364	188	80	0.38	0.68	0.21
52 769	2 346	26	21	0.24	0.35	0.17
317 575	2 232	367	113	0.43	0.8	0.33
300 705	2 621	3 458	580	0.73	0.87	0.63
1 202	572	142	101	0.43	0.63	0.44
594 525	4 705	8 599	740	0.58	0.92	0.46
186 748	1 751	3 463	462	0.51	0.78	0.63
136 107	1 873	3 209	590	0.82	0.72	0.64
50 153	1 011	18	13	0.15	0.3	0.09
32 016	1 447	894	302	0.73	0.79	0.52
478 965	7 469	2 206	389	0.5	0.81	0.35
115 612	1 607	217	50	0.32	0.44	0.21
12 847	701	27	24	0.36	0.4	0.31
468 648	4 635	2 005	221	0.4	0.83	0.34
332 015	3 433	3 634	633	0.61	0.9	0.55
480 896	4 175	3 213	356	0.49	0.82	0.43
127 481	2 270	1 918	519	0.58	0.77	0.59
15 031	410	195	87	0.58	0.63	0.56
169 813	2 832	3 168	629	0.62	0.91	0.5
100 278	2 330	310	135	0.5	0.64	0.34
712 125	6 478	12 531	1 047	0.56	0.94	0.52
71 563	3 017	193	138	0.42	0.62	0.31
359 977	4 129	1 280	202	0.49	0.82	0.37
460 534	3 195	5 147	683	0.53	0.91	0.55
106 967	3 051	227	101	0.45	0.72	0.32
628 275	4 255	9 162	779	0.66	0.95	0.67
97 223	4 500	1 284	420	0.54	0.8	0.4
14 035	680	330	126	0.67	0.65	0.52
392 367	4 413	10 237	1 061	0.61	0.88	0.63
7 608	576	504	192	0.8	0.72	0.61
60 463	2 804	287	174	0.51	0.71	0.41
353 519	3 998	541	113	0.34	0.56	0.26
176 769	4 147	8 389	850	0.66	0.84	0.59
546 119	3 206	3 495	345	0.54	0.91	0.51
425 100	4 187	7 455	919	0.57	0.89	0.61
53 021	1 705	161	66	0.43	0.65	0.29
120 282	4 292	1 434	374	0.6	0.84	0.41
454 563	5 862	380	171	0.45	0.78	0.3
99 839	2 495	388	217	0.52	0.77	0.5
21 547	1 238	1 579	430	0.73	0.84	0.72

73 881	3 426	1 847		530	0.66	0.87	0.53
120 436	1 939	7 712		639	0.69	0.82	0.6
409 245	3 008	6 966		900	0.58	0.92	0.63
150 423	1 926	7 531		664	0.71	0.73	0.68
85 467	1 486	6 138		659	0.89	0.82	0.67
20 040	957	1 707		444	0.72	0.9	0.7
597 428	4 483	6 450		770	0.63	0.96	0.58
580 107	6 749	8 212		672	0.64	0.97	0.46
428 151	2 393	8 319		501	0.6	0.86	0.59
329 321	1 463		102	45	0.21	0.44	0.24
418 812	7 635		278	158	0.42	0.75	0.28
523 077	6 783	10 045	1 045		0.64	0.88	0.5
349 019	3 002	2 197		578	0.52	0.88	0.6
569 049	4 331	5 902		663	0.58	0.95	0.53
220 655	3 968	6 668	1 029		0.73	0.92	0.53
597 137	6 514	1 490		330	0.49	0.89	0.35
614 194	3 654	5 264		435	0.55	0.92	0.46
648 436	4 989	6 939		862	0.61	0.92	0.57
548 141	6 526	6 732		818	0.5	0.93	0.46
673 636	6 253	4 660		495	0.5	0.92	0.42
427 436	3 350	1 636		244	0.5	0.8	0.42
520 092	3 281		427	63	0.31	0.81	0.2
490 456	4 970	6 948	1 096		0.63	0.9	0.66
470 741	3 865		614	133	0.29	0.77	0.25
157 810	2 792	1 285		166	0.64	0.82	0.45
286 160	3 094		940	203	0.47	0.89	0.29
134 352	2 636	2 042		325	0.66	0.78	0.51
336 278	5 333		366	147	0.43	0.72	0.25
80 627	1 513		474	152	0.59	0.67	0.41
20 038	972		12	12	0.21	0.24	0.15
271 959	2 446		495	137	0.43	0.81	0.35
271 203	2 730		578	258	0.48	0.82	0.5
513 921	6 968	5 220	1 007		0.61	0.92	0.58
155 493	2 853		266	113	0.42	0.63	0.31
498 856	4 619	13 169	1 272		0.64	0.94	0.65
397 710	7 966	2 756		428	0.5	0.82	0.38
643 275	8 257		103	42	0.2	0.58	0.16
540 336	4 031	6 298		821	0.59	0.9	0.55
8 864	518		134	61	0.43	0.67	0.43
497 005	3 779	2 765		376	0.48	0.84	0.51
4 207	620		88	51	0.51	0.74	0.37
13 885	820		93	60	0.33	0.67	0.32
572 533	3 092	1 324		344	0.61	0.9	0.58
6 115	521		49	32	0.49	0.56	0.32
357 634	1 219		36	23	0.26	0.38	0.27
1 926	210		47	42	0.48	0.34	0.57
49 567	2 004	2 452		507	0.67	0.77	0.6
159 907	2 018	1 907		349	0.65	0.89	0.59
261 695	2 388	2 003		392	0.6	0.91	0.47

4 947		620		163		75	0.46	0.82	0.47
56 734	1 531		1 862			543	0.73	0.76	0.66
27 761		645		182		52	0.43	0.75	0.29
195 844	2 442		4 035			587	0.57	0.74	0.61
31 713	2 118			64		56	0.28	0.48	0.28
597 853	5 533		10 415			904	0.56	0.94	0.5
3 998		673		435		194	0.82	0.79	0.62
581 554	8 303		24 321		1 601		0.65	0.9	0.58
773 711	9 318		11 413			989	0.58	0.95	0.49
610 231	4 574		8 272			920	0.55	0.93	0.52
522 765	3 832		3 182			675	0.52	0.89	0.54
218 735	4 048		1 090			364	0.64	0.8	0.43
250 333	4 804		1 699			587	0.52	0.75	0.6
416 199	7 806		3 249			819	0.59	0.9	0.49
49 361	1 243		1 270			329	0.79	0.77	0.57
112 001	2 502			29		24	0.27	0.41	0.23
21 482		982		144		95	0.51	0.65	0.38
16 105		884		142		80	0.45	0.7	0.4
580 595	4 339		12 307		1 365		0.61	0.91	0.72
321 909	1 968			126		57	0.32	0.6	0.26
13 653		702		460		176	0.8	0.57	0.65
263 592	1 461			730		202	0.42	0.73	0.55
14 858		905	1 538			401	0.75	0.9	0.73
385 280	2 780		1 835			359	0.55	0.89	0.5
41 083	1 868			293		186	0.54	0.78	0.5
378 117	3 923		7 932			717	0.62	0.96	0.53
115 216	1 062			697		144	0.54	0.82	0.4
44 468		432		379		103	0.61	0.54	0.56
576 379	3 860		7 623			380	0.63	0.9	0.58
551 711	5 584		4 012			462	0.51	0.87	0.34
469 358	4 879		15 471		1 412		0.71	0.89	0.66
51 442	2 451		1 543			542	0.68	0.77	0.62
568 549	3 319		3 982			505	0.71	0.89	0.6
98 250		612		39		17	0.17	0.47	0.16
310 320	5 395		1 296			370	0.54	0.84	0.37
439 890	5 726		7 328			829	0.65	0.88	0.52
45 714	1 658			229		137	0.52	0.63	0.43
78 643	1 238		1 506			362	0.68	0.74	0.67
152 945	2 282		3 668			508	0.57	0.83	0.57
40 292	1 037			745		296	0.49	0.63	0.73
362 334	3 307		6 319			906	0.67	0.89	0.64
114 901	3 453		3 200			758	0.77	0.82	0.59
9 503		914		383		193	0.67	0.74	0.64
754 885	9 081		15 019		1 468		0.62	0.96	0.59
8 361		623		34		25	0.49	0.47	0.27
227 645	5 628		1 618			373	0.63	0.91	0.46
348 878	1 803		3 693			538	0.45	0.89	0.6
3 749		339		186		97	0.68	0.61	0.63
30 162		437		901		148	0.7	0.65	0.63

318 116	2 555		510	221	0.38	0.76	0.43
712 893	5 034	17 772	1 162		0.73	0.95	0.71
286 291	641		376	86	0.41	0.82	0.42
464 024	4 926	6 226		708	0.56	0.87	0.53
423 071	2 692	6 728		590	0.57	0.86	0.61
620 310	3 846	4 070		392	0.53	0.91	0.44
153 574	2 389	3 005		599	0.75	0.9	0.7
19 861	1 350		197	115	0.47	0.63	0.43
272 360	3 414		559	157	0.39	0.71	0.34
476 865	3 738	2 077		315	0.51	0.89	0.36
566 117	5 681	20 260	1 187		0.69	0.87	0.61
417 481	2 306		63	50	0.36	0.49	0.31
390 835	7 749	1 179		290	0.52	0.89	0.33
62 813	1 349	1 594		423	0.93	0.7	0.64
41 002	981		18	12	0.15	0.4	0.1
611 460	4 463	5 479		828	0.66	0.94	0.67
193 219	3 002	1 998		462	0.59	0.9	0.55
499 866	6 068	7 488		799	0.65	0.94	0.53
365 232	2 136		555	206	0.54	0.81	0.48
639 655	4 705	2 722		637	0.6	0.93	0.57
733 807	5 821	10 055	1 035		0.62	0.95	0.61
19 299	1 835		386	200	0.46	0.66	0.4
378 565	1 819	2 212		157	0.58	0.86	0.51
63 040	4 254		81	52	0.33	0.52	0.26
86 431	2 427		412	207	0.51	0.82	0.49
91 430	2 771		143	45	0.34	0.59	0.19
246 910	3 023	4 072		517	0.65	0.9	0.52
329 230	5 030	9 617		920	0.62	0.86	0.53
319 145	2 564	3 595		539	0.5	0.9	0.56
418 495	7 452	10 492	1 313		0.62	0.93	0.58
511 771	3 787	4 674		535	0.53	0.9	0.48
369 149	5 949	6 540	1 089		0.63	0.95	0.58
95 600	2 683		753	344	0.49	0.8	0.53
10 509	162		419	56	0.62	0.77	0.47
61 280	2 462	4 324		711	0.73	0.83	0.7
4 746	652		61	58	0.51	0.52	0.4
16 840	1 119		860	299	0.68	0.78	0.66
174 801	1 366	1 981		257	0.57	0.8	0.51
33 371	1 514		438	183	0.53	0.77	0.48
189 210	1 626	2 049		334	0.61	0.87	0.55
86 500	1 431		94	29	0.33	0.55	0.22
520 653	4 231	6 666		637	0.53	0.93	0.49
327 990	5 252	4 709		511	0.54	0.9	0.38
589 247	5 847	3 849		595	0.58	0.92	0.49
205 568	5 876	2 482		682	0.63	0.86	0.61
539 508	4 960		875	275	0.46	0.88	0.39
345 218	2 401	1 936		227	0.56	0.94	0.44
10 208	601		320	134	0.5	0.85	0.57
99 634	1 266	2 508		330	0.8	0.75	0.69

457 606	3 975	5 499		544	0.61	0.83	0.56
209 660	1 100	372		75	0.46	0.75	0.4
14 113	759	23		19	0.22	0.36	0.19
4 245	361	255		87	0.55	0.74	0.54
209 510	2 569	793		159	0.44	0.71	0.34
635 356	6 503	3 042		475	0.5	0.89	0.45
39 852	1 410	2 506		544	0.82	0.74	0.77
79 350	1 187	1 317		198	0.78	0.65	0.48
46 171	1 391	505		163	0.57	0.74	0.47
276 924	3 306	4 024		668	0.52	0.81	0.6
590 661	4 603	10 253		729	0.55	0.93	0.49
662 285	5 247	3 832		617	0.56	0.91	0.52
284 879	1 464	764		79	0.35	0.69	0.34
280 659	2 412	4 458		821	0.6	0.76	0.68
455 498	2 558	1 233		114	0.48	0.86	0.45
583 534	7 038	6 288		636	0.52	0.95	0.43
456 676	4 628	1 700		282	0.5	0.73	0.39
714 829	6 099	11 734	1 427		0.71	0.95	0.68
676 579	4 929	3 472		317	0.5	0.95	0.46
614 216	4 956	4 370		320	0.5	0.94	0.42
228 288	2 446	3 532		657	0.73	0.92	0.58
511 568	4 939	7 262		845	0.57	0.95	0.49
673 894	4 469	9 422		798	0.57	0.94	0.54
519 514	4 338	7 465		817	0.63	0.94	0.54
782 025	8 283	9 448		868	0.6	0.93	0.49
30 351	1 795	557		263	0.61	0.85	0.57
69 780	819	1 336		267	0.6	0.62	0.61
461 261	3 616	7 717		805	0.66	0.92	0.64
435 063	2 841	4 563		320	0.53	0.87	0.44
251 708	3 758	3 858		743	0.64	0.91	0.49
13 904	817	32		26	0.33	0.38	0.2
711 463	5 046	3 318		302	0.46	0.9	0.39
113 442	1 569	1 334		189	0.6	0.82	0.42
24 466	583	76		36	0.38	0.58	0.28
84 595	1 993	410		148	0.55	0.79	0.36
229 477	6 489	8 389	1 173		0.67	0.93	0.56
20 396	1 465	415		202	0.65	0.82	0.48
88 296	2 643	2 748		635	0.79	0.87	0.6
111 379	2 060	5 977		877	0.83	0.84	0.72
252 896	2 514	1 866		618	0.61	0.88	0.64
543 757	5 267	2 423		181	0.36	0.75	0.28
334 891	7 459	951		289	0.53	0.87	0.38
17 154	879	1 737		331	0.89	0.67	0.64
254 899	3 481	987		301	0.66	0.85	0.44
251 538	2 693	4 888		635	0.69	0.82	0.62
470 853	2 183	1 899		377	0.67	0.89	0.62
258 641	2 959	2 771		526	0.57	0.92	0.5
600 686	7 134	4 716		722	0.6	0.92	0.45
401 603	6 989	1 750		349	0.6	0.89	0.32

329 303	2 977	2 702	367	0.58	0.8	0.35
532 318	4 433	4 598	691	0.59	0.9	0.51
383 854	2 687	4 121	680	0.66	0.94	0.67
757 079	7 735	18 692	1 548	0.58	0.96	0.59
596 271	6 181	20 340	1 511	0.65	0.92	0.63
254 579	1 791	326	140	0.22	0.62	0.43
232 025	6 716	44	36	0.22	0.43	0.13
717 047	7 227	4 275	691	0.48	0.94	0.51
589 715	4 543	13 142	1 471	0.71	0.96	0.72
370 558	2 376	2 157	440	0.75	0.79	0.62
536 543	3 732	5 503	886	0.7	0.93	0.69
608 094	5 074	5 239	684	0.6	0.93	0.58
2 978	367	289	125	0.67	0.78	0.63
53 125	1 657	219	123	0.42	0.69	0.43
144 525	3 612	223	100	0.46	0.66	0.29
245 347	4 003	745	199	0.55	0.71	0.36
432 069	4 089	715	240	0.49	0.77	0.4
77 220	2 492	391	208	0.56	0.76	0.52
550 227	6 428	6 154	709	0.54	0.93	0.43
106 293	1 726	2 736	564	0.82	0.81	0.63
625 453	5 495	9 309	1 218	0.6	0.95	0.59
672 317	5 342	3 360	579	0.48	0.93	0.52
162 800	3 917	5 489	758	0.69	0.87	0.58
536 009	4 511	6 416	597	0.55	0.93	0.49
613 465	4 605	12 606	956	0.67	0.92	0.61
150 489	2 908	870	237	0.68	0.8	0.45
617 385	5 430	8 471	924	0.61	0.95	0.55
408 674	4 183	2 953	344	0.57	0.83	0.33
289 994	3 615	1 222	340	0.55	0.81	0.56
16 447	1 096	91	62	0.63	0.61	0.29
151 835	2 157	1 466	377	0.78	0.75	0.54
618 787	5 473	5 027	383	0.52	0.93	0.38
142 116	3 316	1 853	538	0.52	0.84	0.64
6 420	397	301	125	0.75	0.65	0.57
275 846	3 148	1 689	421	0.65	0.75	0.44
515 979	3 578	4 457	666	0.69	0.91	0.7
417 577	3 296	921	292	0.43	0.83	0.51
151 616	4 433	712	142	0.3	0.87	0.25

DMC clim Null	ratio geo	ratio clim	range percent	niche percent	starting grain size [km2]
0.59	0.15	0.2	4.51	19.25	3 030
0.6	0.89	0.4	4.87	17.15	3 356
0.64	0.63	0.32	7.32	25	11 624
0.6	0.7	1.07	0.24	3.93	24 509
0.82	0.97	0.45	1.12	20.79	33 113
0.8	0.11	0.14	4.85	27.74	10 719
0.81	0.51	0.27	21.55	39.48	25 425
0.83	0.66	0.56	0.58	19.08	32 083
0.89	0.64	0.56	1.82	21.27	37 190
0.79	0.43	0.71	1.09	9.98	45 669
0.75	0.05	0.44	2.28	17.73	29 609
0.6	0.98	1.31	0.21	3.18	26 899
0.71	0.73	1.02	0.53	7.1	29 742
0.87	0.49	0.34	3.13	29.24	34 448
0.81	0.57	0.66	1.4	14.42	38 824
0.69	0.18	0.6	0.91	12.09	26 252
0.82	0.72	0.76	1.44	11.75	39 217
0.55	0.8	1	0.27	3.75	34 442
0.53	0.15	0.37	2.6	15.02	2 648
0.44	0.23	0.39	1.42	8.04	3 981
0.42	-0.01	0.17	2	8.4	11 892
0.88	0.38	0.45	3.2	30.32	33 215
0.58	0.26	0.43	0.15	6.33	29 241
0.52	0.4	0.34	14.08	31.33	19 417
0.89	0.45	0.43	1.69	18.31	42 584
0.83	0.63	0.36	0.35	12.82	33 872
0.66	0.93	1.2	0.2	4.7	41 580
0.77	0.39	0.49	1.54	22	19 373
0.9	0.43	0.28	3.09	27.62	49 479
0.83	0.45	0.51	1.28	13.27	42 479
0.84	0.48	0.34	1.43	15.9	40 279
0.36	0.38	0.43	4.12	9.36	14 373
0.81	0.56	0.24	0.74	20.91	30 753
0.73	1.95	0.34	0.43	5.95	53 056
0.77	1.19	0.66	0.38	8.87	39 013
0.79	0.23	0.25	2.05	25.6	16 757

0.7	-0.03	0.48	1.78	14.45	10 364
0.75	0.31	0.45	0.78	13.61	35 098
0.51	0.85	0.68	0.18	8.44	14 903
0.34	0.81	1.06	0.03	0.93	21 107
0.78	0.87	0.91	0.87	7.25	41 908
0.79	0.41	0.56	2.39	15.89	17 271
0.36	1.29	1.15	0.04	0.79	19 692
0.74	0.22	0.25	0.72	28.71	19 431
0.86	0.28	0.11	8.17	36.9	4 986
0.68	0.29	0.43	1.03	9.78	36 968
0.51	1.79	0.69	0.09	3.84	23 932
0.77	0.58	0.76	0.74	10.94	29 785
0.8	0.25	0.29	2.81	24.45	12 489
0.49	-0.09	0.49	1.04	9.5	5 431
0.86	0.47	0.39	1.77	19.74	49 787
0.55	0.41	0.49	1.11	5.06	28 995
0.47	0.36	0.74	0.13	2.55	27 168
0.68	0.14	0.48	0.48	10.67	17 466
0.61	0.89	1.16	0.13	3.14	46 386
0.79	0.06	0.39	0.86	15.9	35 377
0.88	0.33	0.46	3.67	22.79	42 087
0.61	0.15	0.42	0.67	7.46	13 683
0.65	1.02	1.45	0.31	4.8	29 049
0.87	0.41	0.55	1.86	22.84	33 291
0.77	-0.05	0.19	3.97	24.1	33 982
0.38	0.86	1.27	0.1	1.37	19 162
0.79	0.62	0.77	0.79	10.73	36 782
0.79	0.59	0.25	3.85	21.53	13 607
0.85	0.61	0.47	1.9	20.86	35 839
0.88	0.55	0.1	2.72	27.28	35 796
0.48	0.87	0.43	0.1	2.74	38 513
0.87	0.49	0.59	2.92	21.09	35 001
0.88	-0.03	0.23	4.14	34.07	17 245
0.9	0.1	0.68	8.47	45.03	40 356
0.67	0.84	1.3	0.46	4.89	26 009
0.8	0.22	0.52	1.01	10.38	27 318
0.66	0.51	0.79	0.34	4.64	37 071
0.85	0.17	0.32	7.8	37.75	10 832
0.73	0.47	0.36	1.2	15.57	21 620
0.72	-0.04	0.19	3.48	21.96	9 088
0.4	0.62	0.73	0.03	1.11	27 755
0.68	0.06	0.5	1.19	9.64	31 360
0.83	0.08	0.13	7.85	36.14	7 841
0.91	0.28	0.23	2.4	33.36	43 845
0.75	0.5	0.63	1.06	7.91	44 450
0.61	0.27	0.12	7.37	23.08	3 357
0.81	0.62	0.58	0.59	15.39	33 560
0.87	0.8	0.45	1.13	23.11	33 717
0.89	0.51	0.33	1.12	24.86	27 679

0.29	0.88	0.55	0.25	2.47	4 470
0.79	0.81	0.6	0.98	13.37	35 835
0.76	0.11	0.67	0.85	11.52	23 845
0.91	0.4	0.44	1.32	25.64	44 256
0.72	0.52	0.54	0.59	15.53	16 237
0.85	0.37	0.27	1.64	30.18	31 856
0.85	0.16	0.3	6.06	36.52	6 056
0.89	0.34	0.37	1.78	17.73	43 324
0.74	0.71	0.4	0.77	17.14	22 886
0.67	-0.08	0.75	0.62	14.7	27 009
0.66	0.16	0.97	0.54	7.35	28 574
0.89	-0.18	0.09	12.54	53.74	9 050
0.24	0.48	0.45	0.09	1.76	6 586
0.6	0.45	0.44	0.34	3.26	30 925
0.45	2.13	1.48	0.05	1.86	28 392
0.82	0.25	0.5	4.6	25.44	25 515
0.85	0.24	0.07	67.63	62.96	22 526
0.87	0.35	0.11	50.32	60.22	13 744
0.9	0.31	0.23	1.59	27.06	34 678
0.7	0.24	0.5	0.56	7.33	36 276
0.87	0.51	0.44	0.79	15.02	41 493
0.65	1.13	0.7	0.29	5.01	29 689
0.67	0.81	0.34	0.15	8.74	27 830
0.69	0.28	0.21	2.98	18.49	4 381
0.76	0.33	0.37	0.59	11.73	25 076
0.86	0.21	0.33	2.19	19.35	39 834
0.76	0.52	0.48	0.96	18.57	18 878
0.86	0.16	0.38	2.55	24.92	37 186
0.83	-0.06	0.19	4.07	33	25 253
0.81	0.49	0.49	1.26	14.66	29 012
0.85	0.41	0.53	0.78	12.72	38 627
0.81	0.55	0.37	3.84	24.94	8 999
0.65	0.35	0.59	0.6	10.08	19 957
0.76	0.23	0.45	3.65	18.12	9 555
0.84	0.21	0.36	4.29	31.8	13 067
0.95	0.08	0.25	64.09	72.71	11 449
0.84	0.09	0.54	2.65	19.27	34 821
0.59	0.63	1.01	0.25	3.4	28 924
0.77	0.84	0.74	0.48	9.71	39 579
0.63	0.18	0.47	0.66	8.35	7 729
0.56	0.6	0.74	0.18	3.71	29 318
0.69	1.29	0.74	0.4	5.32	38 174
0.12	0.63	0.58	0.1	0.92	1 039
0.85	0.37	0.45	2.74	25.23	36 945
0.53	-0.18	0.3	4.67	23.53	3 938
0.74	0.83	0.24	0.31	33.12	22 781
0.84	0.85	0.63	0.79	14.49	46 044
0.73	0.17	0.39	0.89	11.05	32 749
0.65	0.4	0.28	11.9	27.86	14 019

0.7	0.19	0.74	1.61	11.19	30 421
0.73	0.34	0.52	0.77	11.5	30 320
0.8	0.25	0.34	2.56	23.56	11 883
0.48	1.3	0.7	0.12	7.01	17 302
0.48	0.56	0.39	0.19	2.39	35 939
0.71	0.66	1	0.55	6.46	47 842
0.23	0.4	2	0.45	2.35	3 644
0.82	0.49	0.63	2.04	16.37	31 149
0.82	-0.09	0.28	2.95	29.88	25 722
0.8	0.12	0.15	6.18	33.16	9 125
0.59	0.02	0.19	1.67	11.4	8 028
0.31	0.63	0.38	0.38	3.88	2 372
0.84	0.47	0.25	1.56	28.22	24 545
0.78	0.11	0.21	2.38	26.79	13 770
0.77	0.71	0.66	0.79	9.37	38 712
0.62	0.97	0.89	0.27	8.71	23 578
0.85	0.61	0.49	1.38	18.64	37 186
0.76	1.15	0.64	0.11	7.11	37 894
0.59	0.81	0.87	0.09	2.77	47 812
0.37	-0.12	0.54	0.24	2.25	16 725
0.84	0.49	0.78	1.31	16.53	34 358
0.51	0.47	0.87	0.77	6.55	15 546
0.72	0.01	0.32	2.6	21.98	5 730
0.56	0.49	0.25	0.38	15.96	23 584
0.73	0.16	0.44	0.92	16.46	24 675
0.68	1.14	0.71	0.19	7.41	31 915
0.73	0.13	0.22	1.27	14.66	19 834
0.77	0.28	0.5	1.64	19.08	22 924
0.74	0.39	0.75	1.3	10.66	32 488
0.65	0.69	0.19	0.14	11.22	22 876
0.56	0.68	0.63	0.13	5.26	36 362
0.73	-0.03	0.44	0.89	13.87	28 286
0.79	0.51	0.71	1.01	11.95	24 693
0.55	0.51	0.38	0.2	2.42	12 616
0.7	0.52	0.54	0.75	8.29	15 369
0.81	0.23	0.31	2.76	18.62	15 864
0.58	0.68	0.74	0.16	4.22	30 287
0.88	0.37	0.58	3.1	23.71	28 798
0.63	0.25	0.03	0.71	8.49	9 566
0.6	0.41	0.34	2.1	16.34	6 167
0.81	0.77	0.76	0.43	15.38	30 301
0.85	0.25	0.13	33.08	49.39	17 485
0.81	0.41	0.56	2.33	14.08	40 548
0.9	0.39	0.33	2.52	27.82	43 203
0.67	0.07	0.61	0.43	8.53	25 630
0.84	-0.08	0.19	5	34.52	16 035
0.78	0.35	0.45	0.52	13.81	34 856
0.71	-0.28	0.26	10.06	29.66	6 483
0.66	1.15	0.53	0.09	6.62	27 312

0.62	0.63	1	0.63	6.5	22 085
0.46	0.4	0.49	0.21	2.53	10 127
0.8	0.41	0.37	1.56	24.2	21 571
0.63	0.08	0.28	1.41	15.03	11 041
0.82	0.08	0.26	6.91	35.46	13 925
0.88	0.11	0.3	5.37	45.75	20 144
0.57	0.36	0.08	2.35	15.69	1 163
0.77	1.17	0.61	0.56	8.31	42 543
0.47	0.04	0.34	0.64	6.13	21 014
0.81	0.32	0.32	0.58	20.01	27 427
0.8	0.42	0.54	0.9	13.88	40 040
0.84	0.15	0.25	0.65	25.63	38 095
0.73	0.61	0.64	0.85	7.13	35 321
0.81	0.83	0.36	0.6	15.23	38 049
0.83	0.11	0.17	3.89	32.5	20 999
0.52	0.63	0.31	0.74	6.61	7 392
0.79	0.57	0.56	0.31	10.47	37 048
0.63	0.54	0.54	0.07	4.65	44 294
0.83	0.46	0.55	0.39	11.91	38 370
0.73	0.69	0.83	0.52	6.71	49 531
0.84	0.32	0.54	2.49	17.83	27 966
0.74	0.03	0.46	3.26	15.99	26 167
0.55	1.56	0.84	0.19	3.22	35 516
0.81	0.52	0.44	1.29	15.02	33 034
0.91	0.13	0.36	5.16	32.88	19 065
0.87	0.05	0.24	4.83	35.38	16 981
0.7	0.79	0.85	0.54	5.37	46 522
0.86	0.49	0.32	1.06	29.03	27 843
0.83	0.19	0.49	2.74	23.83	32 666
0.56	0.08	0.4	1.06	10.56	12 235
0.81	0.58	0.71	1.21	14.52	29 668
0.91	0.07	0.19	3.2	42	19 528
0.84	0.59	0.78	2.08	15.93	41 826
0.64	0.5	0.47	0.38	4.65	35 326
0.86	0.38	0.45	1.84	15.54	40 192
0.8	0.34	0.57	1.04	14.47	31 302
0.89	0.6	0.5	2.17	22.47	41 440
0.72	0.6	0.99	0.88	8.25	29 782
0.7	1.25	0.83	0.35	5.16	33 565
0.47	0.78	0.55	0.31	8.77	9 642
0.78	1.35	1.09	0.41	11.09	35 379
0.78	0.16	0.21	4.35	24.26	7 561
0.84	0.52	0.51	2.48	16.88	51 165
0.77	-0.31	0.14	10.28	39.57	5 169
0.83	0.45	0.48	0.47	13.09	39 631
0.68	0.17	0.62	2.14	17.26	8 995
0.36	-0.04	0.16	1.14	7	1 807
0.65	0.37	0.1	4.54	20.56	6 364
0.51	1.44	1.56	0.18	7.87	10 875

0.68	0.43	0.1	3.81	26.33	4 057
0.85	0.29	0.31	3.7	25.53	25 631
0.69	-0.15	-0.07	4.2	27.24	10 557
0.57	1.33	0.97	0.09	3.04	38 911
0.4	0	0.08	1.2	12.18	4 552
0.16	0.32	0.62	0.01	0.74	18 988
0.87	0.42	0.47	0.97	15.78	34 499
0.84	0.49	0.6	1.92	14.89	43 534
0.8	0.23	0.32	36.3	38	15 752
0.77	0.04	0.15	1.92	24.36	14 297
0.75	0.17	0.18	7.28	25.29	5 642
0.82	0.37	0.27	7.24	24.64	13 733
0.73	0.16	0.19	5.04	26.12	4 129
0.71	0.61	0.77	0.22	7.68	25 474
0.73	0.21	0.35	4.18	18.38	11 144
0.64	0.46	0.26	6.7	26.32	2 669
0.61	0.51	0.32	0.97	8.73	4 723
0.78	0.07	0.19	2.54	20.75	16 752
0.39	0.39	0.24	1.05	9.52	3 092
0.66	0.23	0.61	1.02	11.91	11 159
0.76	0.48	0.68	0.47	8.4	32 064
0.73	0.55	0.77	0.72	6.14	44 713
0.66	1.12	0.74	0.26	7.51	32 129
0.75	0.71	0.59	0.47	10.9	31 075
0.84	0.59	0.48	2.36	17.06	49 626
0.82	0.29	0.57	0.86	17.05	31 891
0.88	0.53	0.5	0.54	14.93	41 202
0.84	0.44	0.45	0.68	12.4	43 563
0.51	1.16	2.09	0.17	3.72	23 039
0.85	0.52	0.69	1.99	17.1	35 365
0.78	0.12	0.66	2.22	18	21 629
0.61	0.52	0.96	0.27	5.62	27 727
0.82	0.74	0.58	0.49	11.85	38 483
0.56	2.47	1	0.26	3.66	34 894
0.59	0.61	0.59	0.37	9.13	21 246
0.79	0.62	0.8	1.3	12.06	33 732
0.86	0.17	0.32	3.93	30.25	12 589
0.9	0.68	0.61	1.92	21.79	37 265
0.61	0.71	0.46	0.17	4.1	36 373
0.61	0.57	0.94	0.52	7.39	24 519
0.76	1.67	0.99	0.59	10.22	39 638
0.5	0.48	0.22	0.86	8.16	3 372
0.88	1.19	0.51	2.3	22.98	40 597
0.55	-0.26	0.07	2.07	11.5	8 300
0.89	0.48	0.46	2.44	24.47	36 295
0.8	0.81	0.74	0.57	9.76	36 600
0.46	0.87	0.35	0.03	1.61	41 960
0.86	0.14	0.28	4.02	29.07	13 911
0.84	0.33	0.32	3.2	17.85	20 491

0.89	0.18	0.49	5.7	31.05	39 318
0.87	-0.02	0.14	11.76	41.72	8 139
0.86	0.41	0.2	30.86	49.94	24 443
0.85	0.63	0.51	1.14	22.33	33 128
0.8	0.21	0.4	2.36	25.87	18 768
0.8	0.54	0.56	0.36	15.08	28 189
0.61	0.86	1.33	0.28	3.8	31 224
0.76	0.1	0.48	1.26	14.12	21 231
0.64	0	0.54	1.41	14.08	16 555
0.48	0.76	1.29	0.15	3.38	20 135
0.28	0.43	0.69	0.05	0.9	14 627
0.57	0.84	0.74	0.12	5.06	24 609
0.83	0.2	0.32	1.15	22.13	35 903
0.6	0.46	0.37	11.81	17.66	22 874
0.83	0.59	0.8	1.45	15.73	40 258
0.82	0.55	0.3	1.85	26.38	31 462
0.83	-0.13	0.3	2.36	31.5	30 550
0.25	1.04	1.81	0.04	1.29	23 317
0.77	0.07	0.49	2.79	20.87	11 406
0.68	0.62	0.93	0.46	5.21	42 756
0.4	0.38	0.95	0.19	3.11	29 208
0.31	0.13	0.01	0.21	3.42	6 484
0.67	1.06	0.95	0.43	4.77	37 188
0.83	0.48	0.5	1.09	18.44	29 609
0.71	0.69	0.66	0.67	8.53	49 302
0.81	0.34	0.38	1.5	22.86	20 495
0.61	0.09	0.09	1.3	21.22	8 644
0.85	0.47	0.69	1.87	22.21	25 032
0.59	0.28	0.75	0.31	5.79	22 600
0.86	0.68	0.66	1.76	16.16	43 074
0.55	0.48	0.78	0.27	4.57	32 591
0.64	0.67	0.74	0.36	4.89	29 512
0.86	0.72	0.58	1.12	21.38	30 266
0.53	0.61	0.65	0.21	3.31	17 997
0.88	0.45	0.32	1.46	18.31	42 584
0.74	0.47	0.87	1.32	9.33	15 183
0.65	-0.03	0.26	2.35	18.53	8 415
0.87	0.44	0.4	2.61	24.04	31 911
0.76	-0.11	0.23	6.62	33.33	4 292
0.61	0.41	0.46	0.47	6.21	12 746
0.52	0.62	1	0.15	2.83	46 637
0.84	0.27	0.44	4.75	20.5	27 915
0.78	0.67	0.54	0.64	10.76	30 604
0.86	0.57	0.41	1.75	21.95	40 192
0.5	0.52	0.73	0.3	3.87	10 526
0.71	0.41	0.71	1.19	8.71	17 451
0.58	0.74	0.93	0.08	2.92	36 238
0.73	0.48	0.45	0.39	8.7	34 250
0.84	0.14	0.17	7.33	34.73	7 050

0.78	0.32	0.47	2.5	15.47	22 364
0.86	0.2	0.43	6.4	32.96	21 532
0.92	0.59	0.46	1.7	29.92	32 820
0.86	0.03	0.27	5.01	34.48	37 622
0.87	-0.08	0.31	7.18	44.35	11 279
0.87	0.25	0.24	8.52	46.39	4 451
0.85	0.51	0.46	1.08	17.18	33 871
0.8	0.5	0.72	1.42	9.96	34 288
0.82	0.43	0.4	1.94	20.94	31 154
0.4	1.06	0.69	0.03	3.08	41 067
0.53	0.8	0.9	0.07	2.07	39 074
0.82	0.37	0.66	1.92	15.41	45 273
0.85	0.7	0.41	0.63	19.25	35 646
0.85	0.63	0.59	1.04	15.31	32 210
0.88	0.26	0.67	3.02	25.93	28 312
0.68	0.81	0.95	0.25	5.07	37 649
0.8	0.66	0.75	0.86	11.9	33 939
0.86	0.51	0.51	1.07	17.28	45 464
0.82	0.84	0.78	1.23	12.53	37 484
0.76	0.84	0.8	0.69	7.92	48 852
0.68	0.62	0.6	0.38	7.28	43 596
0.43	1.61	1.15	0.08	1.92	33 017
0.88	0.45	0.34	1.42	22.05	42 463
0.57	1.7	1.28	0.13	3.44	35 624
0.63	0.28	0.39	0.81	5.95	24 154
0.66	0.89	1.26	0.33	6.56	24 384
0.73	0.19	0.45	1.52	12.33	23 064
0.56	0.69	1.24	0.11	2.76	31 825
0.62	0.14	0.49	0.59	10.05	23 516
0.22	0.12	0.48	0.06	1.23	7 438
0.59	0.91	0.7	0.18	5.6	24 948
0.67	0.72	0.34	0.21	9.45	24 441
0.82	0.51	0.42	1.02	14.45	37 178
0.54	0.49	0.77	0.17	3.96	22 621
0.92	0.48	0.42	2.64	27.54	36 119
0.7	0.63	0.85	0.69	5.37	48 151
0.35	1.98	1.24	0.02	0.51	39 550
0.86	0.52	0.58	1.17	20.37	38 764
0.52	0.58	0.22	1.51	11.78	1 300
0.77	0.73	0.51	0.56	9.95	36 163
0.47	0.46	0.28	2.09	8.23	3 248
0.53	1.05	0.68	0.67	7.32	24 901
0.8	0.49	0.39	0.23	11.13	30 442
0.39	0.16	0.21	0.8	6.14	3 112
0.32	0.48	0.2	0.01	1.89	19 184
0.51	-0.3	-0.1	2.44	20	11 190
0.84	0.16	0.38	4.95	25.3	19 291
0.76	0.38	0.3	1.19	17.29	17 161
0.75	0.52	0.61	0.77	16.42	24 511

0.56	0.78	0.19	3.29	12.1	3 243
0.86	0.03	0.31	3.28	35.47	11 502
0.47	0.73	0.64	0.66	8.06	8 171
0.82	0.31	0.34	2.06	24.04	28 687
0.42	0.69	0.48	0.2	2.64	11 434
0.84	0.69	0.68	1.74	16.34	36 203
0.75	-0.05	0.21	10.88	28.83	6 207
0.85	0.39	0.46	4.18	19.28	49 073
0.8	0.62	0.63	1.48	10.61	57 578
0.87	0.68	0.67	1.36	20.11	38 836
0.84	0.71	0.54	0.61	17.61	36 435
0.75	0.25	0.73	0.5	8.99	31 192
0.8	0.45	0.34	0.68	12.22	46 677
0.78	0.52	0.59	0.78	10.49	44 199
0.77	-0.02	0.35	2.57	26.47	12 769
0.33	0.48	0.43	0.03	0.96	43 771
0.58	0.27	0.53	0.67	9.67	6 526
0.52	0.55	0.3	0.88	9.05	6 888
0.9	0.5	0.25	2.12	31.46	41 749
0.47	0.86	0.84	0.04	2.9	29 315
0.72	-0.29	0.1	3.37	25.07	8 439
0.71	0.72	0.28	0.28	13.83	26 220
0.87	0.2	0.18	10.35	44.31	4 824
0.78	0.61	0.56	0.48	12.91	29 531
0.68	0.43	0.38	0.71	9.96	7 577
0.83	0.54	0.58	2.1	18.28	28 845
0.65	0.52	0.61	0.6	13.56	14 651
0.65	-0.11	0.17	0.85	23.84	26 336
0.78	0.44	0.36	1.32	9.84	42 863
0.72	0.7	1.1	0.73	8.27	36 065
0.91	0.25	0.37	3.3	28.94	43 204
0.83	0.14	0.34	3	22.11	16 116
0.85	0.26	0.42	0.7	15.22	40 011
0.27	1.83	0.7	0.04	2.78	12 071
0.69	0.54	0.9	0.42	6.86	28 375
0.82	0.36	0.58	1.67	14.48	42 042
0.57	0.21	0.33	0.5	8.26	17 580
0.81	0.09	0.22	1.91	29.24	19 803
0.79	0.46	0.38	2.4	22.26	20 709
0.79	0.3	0.09	1.85	28.54	21 732
0.85	0.33	0.33	1.74	27.4	36 855
0.86	0.07	0.46	2.79	21.95	30 548
0.71	0.1	0.1	4.03	21.12	13 296
0.85	0.54	0.44	1.99	16.17	54 535
0.34	-0.02	0.27	0.41	4.01	10 028
0.73	0.44	0.58	0.71	6.63	26 226
0.84	0.99	0.4	1.06	29.84	29 307
0.67	-0.1	0.07	4.96	28.61	3 611
0.74	-0.07	0.17	2.99	33.87	11 752

0.69	1	0.62	0.16	8.65	32	963
0.92	0.31	0.29	2.49	23.08	43	002
0.57	0.99	0.36	0.13	13.42	18	387
0.82	0.53	0.55	1.34	14.37	38	815
0.88	0.52	0.44	1.59	21.92	42	724
0.8	0.72	0.82	0.66	10.19	35	870
0.84	0.21	0.21	1.96	25.07	15	703
0.61	0.34	0.4	0.99	8.52	7	065
0.59	0.85	0.75	0.21	4.6	34	245
0.7	0.74	0.92	0.44	8.43	27	707
0.87	0.27	0.42	3.58	20.89	49	786
0.43	0.36	0.39	0.02	2.17	34	019
0.63	0.71	0.92	0.3	3.74	38	735
0.82	-0.25	0.27	2.54	31.36	17	271
0.23	1.67	1.23	0.04	1.22	11	259
0.88	0.42	0.32	0.9	18.55	39	906
0.78	0.53	0.43	1.03	15.39	23	300
0.8	0.44	0.51	1.5	13.17	35	100
0.77	0.5	0.59	0.15	9.64	23	803
0.85	0.56	0.48	0.43	13.54	41	822
0.87	0.52	0.42	1.37	17.78	48	983
0.67	0.44	0.66	2	10.9	27	141
0.66	0.48	0.28	0.58	8.63	28	028
0.41	0.58	0.58	0.13	1.22	14	149
0.73	0.62	0.47	0.48	8.53	31	024
0.36	0.73	0.94	0.16	1.62	16	502
0.76	0.38	0.47	1.65	17.1	23	064
0.85	0.39	0.58	2.92	18.29	36	434
0.84	0.8	0.48	1.13	21.02	25	234
0.84	0.5	0.45	2.51	17.62	41	640
0.79	0.67	0.65	0.91	14.13	40	305
0.86	0.52	0.49	1.77	18.31	32	895
0.8	0.64	0.5	0.79	12.82	37	163
0.64	0.23	0.37	3.99	34.57	7	100
0.83	0.13	0.19	7.06	28.88	24	705
0.52	0.02	0.29	1.29	8.9	6	047
0.78	0.16	0.18	5.11	26.72	6	493
0.75	0.41	0.48	1.13	18.81	22	915
0.7	0.44	0.47	1.31	12.09	9	013
0.76	0.43	0.37	1.08	20.54	26	013
0.36	0.66	0.66	0.11	2.03	22	158
0.86	0.75	0.78	1.28	15.06	36	736
0.74	0.67	0.91	1.44	9.73	27	612
0.81	0.6	0.65	0.65	10.18	46	049
0.78	0.35	0.27	1.21	11.61	31	139
0.68	0.89	0.76	0.16	5.54	33	355
0.74	0.67	0.68	0.56	9.45	25	964
0.69	0.7	0.2	3.13	22.3	5	924
0.82	-0.07	0.19	2.52	26.07	18	318

0.79	0.36	0.4	1.2	13.69	35 802
0.52	0.63	0.28	0.18	6.82	26 333
0.28	0.61	0.46	0.16	2.5	3 745
0.63	0.36	0.16	6.01	24.1	3 864
0.59	0.63	0.71	0.38	6.19	30 663
0.76	0.77	0.7	0.48	7.3	53 912
0.85	-0.09	0.1	6.29	38.58	23 632
0.69	-0.16	0.45	1.66	16.68	17 974
0.67	0.29	0.42	1.09	11.72	13 099
0.83	0.58	0.39	1.45	20.21	38 148
0.82	0.69	0.7	1.74	15.84	43 205
0.79	0.64	0.51	0.58	11.76	38 090
0.51	0.99	0.5	0.27	5.4	37 902
0.89	0.26	0.31	1.59	34.04	36 523
0.6	0.77	0.35	0.27	4.46	31 478
0.75	0.82	0.74	1.08	9.04	35 618
0.68	0.46	0.74	0.37	6.09	45 086
0.91	0.35	0.33	1.64	23.4	37 618
0.74	0.89	0.63	0.51	6.43	35 692
0.72	0.88	0.7	0.71	6.46	37 719
0.83	0.27	0.43	1.55	26.86	18 850
0.85	0.66	0.72	1.42	17.11	35 848
0.88	0.66	0.62	1.4	17.86	39 298
0.86	0.5	0.6	1.44	18.83	32 637
0.78	0.55	0.6	1.21	10.48	52 940
0.73	0.37	0.29	1.84	14.65	7 032
0.81	0.02	0.31	1.91	32.6	25 871
0.88	0.4	0.36	1.67	22.26	41 385
0.76	0.64	0.73	1.05	11.26	32 101
0.83	0.42	0.71	1.53	19.77	28 311
0.33	0.17	0.68	0.23	3.18	5 422
0.74	0.97	0.89	0.47	5.98	40 901
0.68	0.37	0.61	1.18	12.05	16 997
0.38	0.52	0.36	0.31	6.17	7 241
0.61	0.46	0.71	0.48	7.43	11 466
0.84	0.39	0.5	3.66	18.08	22 273
0.69	0.25	0.44	2.03	13.79	7 744
0.83	0.09	0.38	3.11	24.03	13 204
0.9	0.02	0.25	5.37	42.57	17 316
0.8	0.46	0.24	0.74	24.58	29 644
0.6	1.07	1.15	0.45	3.44	52 010
0.64	0.63	0.68	0.28	3.87	30 038
0.82	-0.25	0.29	10.13	37.66	11 639
0.72	0.28	0.63	0.39	8.65	25 018
0.83	0.2	0.33	1.94	23.58	33 707
0.84	0.32	0.35	0.4	17.27	27 734
0.8	0.61	0.62	1.07	17.78	22 331
0.78	0.53	0.73	0.79	10.12	49 738
0.67	0.49	1.08	0.44	4.99	43 720

0.73	0.38	1.13	0.82	12.33	31 766
0.84	0.53	0.67	0.86	15.59	34 765
0.85	0.44	0.28	1.07	25.31	28 733
0.86	0.67	0.45	2.47	20.01	43 435
0.88	0.42	0.39	3.41	24.45	47 648
0.62	1.83	0.43	0.13	7.82	31 580
0.33	0.96	1.51	0.02	0.54	34 879
0.79	0.95	0.54	0.6	9.56	44 999
0.93	0.36	0.29	2.23	32.38	39 476
0.85	0.06	0.36	0.58	18.52	30 565
0.88	0.33	0.28	1.03	23.74	33 001
0.84	0.54	0.46	0.86	13.48	40 429
0.74	0.17	0.17	9.7	34.06	3 666
0.59	0.64	0.36	0.41	7.42	24 526
0.51	0.43	0.74	0.15	2.77	23 174
0.63	0.31	0.74	0.3	4.97	38 760
0.69	0.57	0.7	0.17	5.87	34 597
0.68	0.37	0.3	0.51	8.35	42 565
0.78	0.71	0.81	1.12	11.03	44 745
0.84	-0.01	0.33	2.57	32.68	20 519
0.9	0.59	0.54	1.49	22.17	41 442
0.84	0.93	0.6	0.5	10.84	42 237
0.83	0.26	0.45	3.37	19.35	23 257
0.82	0.69	0.69	1.2	13.23	33 561
0.87	0.38	0.42	2.05	20.76	42 741
0.7	0.17	0.56	0.58	8.15	24 383
0.87	0.56	0.58	1.37	17.02	40 506
0.72	0.45	1.17	0.72	8.22	34 330
0.73	0.49	0.32	0.42	9.41	34 525
0.48	-0.03	0.65	0.55	5.66	14 151
0.76	-0.04	0.4	0.97	17.48	21 664
0.73	0.8	0.9	0.81	7	50 425
0.84	0.62	0.31	1.3	16.22	34 689
0.73	-0.14	0.26	4.69	31.49	16 776
0.74	0.15	0.68	0.61	13.37	31 177
0.89	0.31	0.27	0.86	18.61	43 002
0.72	0.91	0.43	0.22	8.86	32 698
0.57	1.92	1.27	0.47	3.2	14 970

Supporting information to the paper

Sporbert, M. et al. Assessing sampling coverage of species distribution in biodiversity databases. *Journal of Vegetation Science.*

Appendix S3 Information on the 59 databases that provide vegetation plots included in this project. Official database name, Databases code in Global Index of Vegetation-Plot Database (GIVD), Name of the database custodians the dataset used in this study is component of, total number of vegetation plot samples included in the dataset [data access: October 2015], number of vegetation plot samples included in this study, proportional contribution of the datasets plot samples to this study [proportion = (Count Dataset Sporbert et al. *100) / 808794].

Database name	**GIVD Code**	**Custodian name**	**Count Dataset total (10/2015)**	**Count Dataset Sporbert et al.**	**Proportion [%]**
Vegetation Database of Albania	EU-AL-001	Michele De Sanctis	290	193	0.024
Mediterranean Ammophiletea database	EU-00–016	Corrado Marcenò	6 835	4 843	0.599
Austrian Vegetation Database	EU-AT-001	Wolfgang Willner	30 659	23 941	2.960
Balkan Dry Grasslands Database	EU-00–013	Kiril Vassilev	8 152	4 769	0.590
Balkan Vegetation Database	EU-00–019	Kiril Vassilev	9 579	7 092	0.877
Vegetation-Plot Database of the University of the Basque Country (BIOVEG)	EU-00–011	Idoia Biurrun	18 429	16 405	2.028
INBOVEG	EU-BE-002	Els De Bie	13 541	8 204	1.014
UK National Vegetation Classification Database	EU-GB-001	John S. Rodwell	25 485	24 104	2.980
Bulgarian Vegetation Database	EU-BG-001	Iva Apostolova	5 235	1 935	0.239
Croatian Vegetation Database	EU-HR-002	Željko Škvorc	8 517	8 249	1.020
Czech National Phytosociological Database	EU-CZ-001	Milan Chytrý	110 534	97 650	12.074
NATURDATA.DK	EU-DK-002	Jesper Erenskjold Moeslund	24 264	23 994	2.967
Vegetation Database of Eurasian Tundra	00–00–004	Risto Virtanen	1 132	294	0.036
European Coastal Vegetation Database	EU-00–017	John Janssen	4 311	2 251	0.278
European Mire Vegetation Database	EU-00–022	Tomáš Peterka	10 099	9 047	1.119

SOPHY	EU-FR-003	Henry Brisse	155 275	143 323	17.721
GVRD Vegetation Reference Database Halle	EU-DE-014	Ute Jandt	29 797	28 418	3.514
VegetWeb	EU-DE-013	Jörg Ewald	22 363	21 525	2.661
VegMV	EU-DE-001	Florian Jansen	49 631	44 410	5.491
Hellenic Woodland Database + Hellenic Beech Forests Database (Hell-Beech-DB)	EU-GR-006 + EU-GR-007	Ioannis Tsiripidis	3 199	636	0.079
Hellenic Natura 2000 database (HelNatVeg)	EU-GR-005	Panayotis Dimopoulos	4 857	4 295	0.531
CoenoDat Hungarian Phytosociological Database	EU-HU-003	János Csiky	5 104	812	0.100
Irish Vegetation Database	EU-IE-001	Úna Fitzpatrick	26 687	25 010	3.092
Italian National Vegetation Database (BVN/ISPRA)	EU-IT-010	Laura Casella	3 562	3 496	0.432
Georeferenced Vegetation Database - Sapienza University of Roma	EU-IT-011	Emiliano Agrillo	12 665	10 981	1.358
Semi-natural Grassland Vegetation Database of Latvia	EU-LV-001	Solvita Rūsiņa	5 594	5 581	0.690
Lithuanian Vegetation Database	EU-LT-001	Valerijus Rašomavičius	2 206	1 842	0.228
Vegetation Database of the Republic of Macedonia	EU-MK-001	Renata Ćušterevska	1 269	370	0.046
Dutch National Vegetation Database	EU-NL-001	Joop H.J. Schaminée	93 812	83 968	10.382
The Nordic Vegetation Database	EU-00–018	Jonathan Lenoir	7 718	7 144	0.883
Nordic-Baltic Grassland Vegetation Database	EU-00–002	Jürgen Dengler	6 062	6 056	0.749
Polish Vegetation Database	EU-PL-001	Zygmunt Kącki	56 989	53 381	6.600
Romanian Grassland Database	EU-RO-008	Eszter Ruprecht	4 962	4 718	0.583
Romanian Forest Database	EU-RO-007	Adrian Indreica	6 017	6 006	0.743
Vegetation Database Forest of Southern Ural	00-RU-001	Vassiliy Martynenko	997	222	0.027
Lower Volga Valley Phytosociological Database	EU-RU-002	Valentin Golub	11 846	5 320	0.658
Database Meadows and Steppes of Southern Ural + Database of South Ural Order Galietalia veri + Database of South Ural Order Arrhenatheretalia	00-RU-003 + 00-RU-004 + 00-RU-005	Sergey Yamalov	2 034	1 093	0.135
SE Europe Forest Database	EU-00–021	Andraž Čarni	3 659	3 656	0.452
Vegetation Database Grassland Vegetation of Serbia	EU-RS-002	Svetlana Aćić	5 587	5 364	0.663
Database of Forest Vegetation in Republic of Serbia + Vegetation Database of Northern Part of Serbia (AP Vojvodina)	EU-RS-003 + EU-RS-004	Mirjana Krstivojević Ćuk	1 131	1 131	0.140
Slovak Vegetation Database	EU-SK-001	Milan Valachovič	36 266	33 320	4.120
Vegetation Database of Slovenia	EU-SI-001	Urban Šilc	10 986	10 750	1.329

Iberian and Macaronesian Vegetation Information System (SIVIM)	EU-00–004	Xavier Font	3 496	3 091	0.382
Iberian and Macaronesian Vegetation Information System (SIVIM) - Catalonia	EU-00–004	Xavier Font	3 875	3 512	0.434
Iberian and Macaronesian Vegetation Information System (SIVIM)	EU-00–023	Juan Antonio Campos	6 630	6 286	0.777
Iberian and Macaronesian Vegetation Information System (SIVIM) – Grasslands	EU-00–004	Maria Pilar Rodríguez-Rojo	7 331	7 199	0.890
Iberian and Macaronesian Vegetation Information System (SIVIM) – Sclerophyllous forests	EU-00–004	Federico Fernández-González	3 799	3 170	0.392
Iberian and Macaronesian Vegetation Information System (SIVIM) - Shrublands	EU-00–004	Xavier Font	3 007	2 386	0.295
Iberian and Macaronesian Vegetation Information System (SIVIM) - Wetlands	EU-ES–001	Aaron Pérez-Haase	6 539	4 507	0.557
Swiss Forest Vegetation Database	EU-CH-005	Thomas Wohlgemuth	14 193	14 182	1.753
Vegetation Database of Tatarstan	EU-RU-011	Vadim Prokhorov	7 426	2 301	0.284
Forest Vegetation Database of Turkey – FVDT	00-TR-001	Ali Kavgacı	144	127	0.016
Vegetation Database of the Grassland Communities in Anatolia	AS-TR-001	Deniz Işık Gürsoy	20	6	0.001
Vegetation Database of Oak Communities in Turkey	AS-TR-002	Emin Uğurlu	68	61	0.008
Ukrainian Grassland Database	EU-UA-001	Anna Kuzemko	4 043	3 954	0.489
Halophytic and coastal vegetation database of Ukraine	EU-UA-005	Tetiana Dziuba	4 399	13	0.002
Vegetation database of Ukraine and adjacent parts of Russia	EU-UA-006	Viktor Onyshchenko	3 325	3 192	0.395
VegItaly	EU-IT-001	Roberto Venanzoni	15 332	8 957	1.107
WetVegEurope	EU-00–020	Flavia Landucci	1 994	6	0.001

Supporting information to the paper

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Appendix S4 Distribution of initial grain size (in km²) in DMC calculations (Figure S4.1). Scatterplots and Spearman correlation coefficients (rho) of the relationship between species range sizes and niche sizes (Figure S4.2). Scatterplots and Spearman correlation coefficients (rho) of the relationship between percentage match of species ranges by EVA vegetation plots and percentage match of species niches by EVA vegetation plots (Figure S4.3).

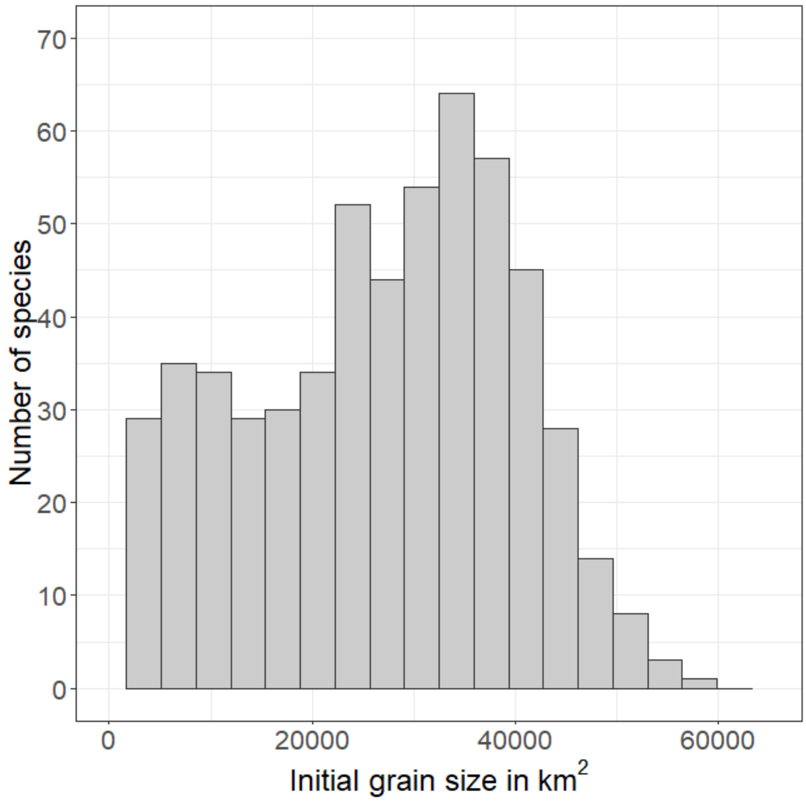

Figure S4.1 Distribution of initial grain size (in km²) in DMC calculations. Bandwidth of scaling steps were calculated species specific according to the species range sizes at 2.5-min raster cell resolution in geographic space.

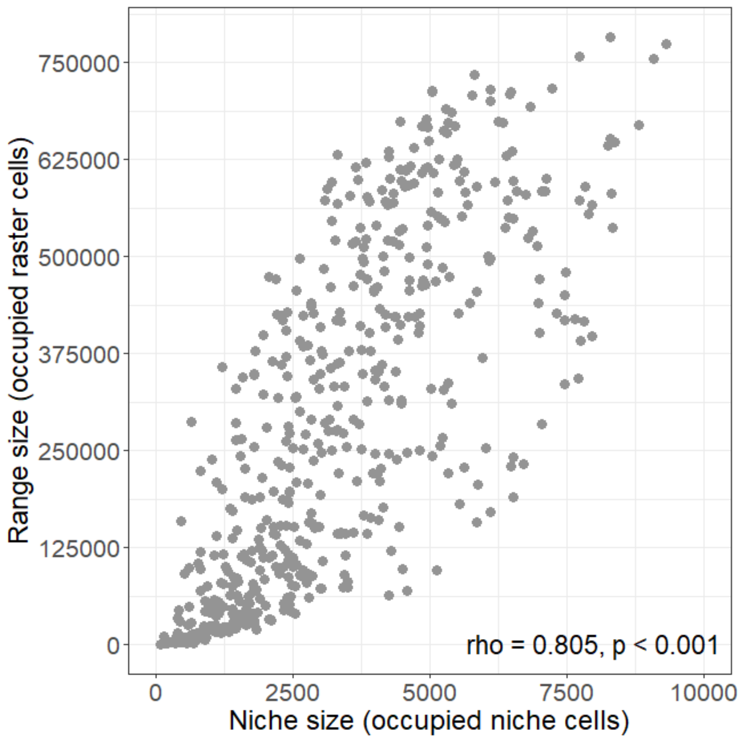

Figure S4.2 Scatterplots and Spearman correlation coefficients (rho) of the relationship between species range sizes (occupied raster cells at 2.5-min raster cell resolution) in geographic space and niche sizes (occupied niche cells) in climatic space.

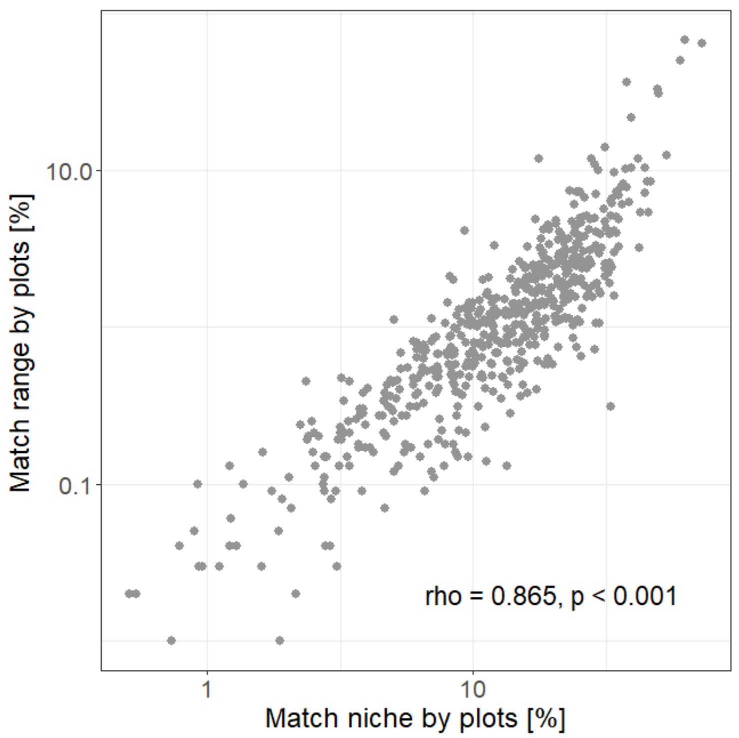

Figure S4.3 Scatterplots and Spearman correlation coefficients (rho) of the relationship between percentage match of species ranges by EVA vegetation plots and percentage match of species niches by EVA vegetation plots. X axis and y axis are log-transformed.