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REPORT

AgriWeedClim database: A repository of vegetation plot data from Central European arable habitats over 100 years

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Abstract

Aims: Arable habitats (i.e. fields, orchards, vineyards, and their fallows) were created by humans and have been essential elements in Central European landscapes for several millennia. In recent decades, these habitats have been drastically altered by changes in land use as well as agricultural practices and, more recently, by climate change. These changes have precipitated substantial changes in vegetation and their spatial and temporal trajectories have not yet been exhaustively studied. Here, we present the AgriWeedClim database — a new resource of vegetation plot (relevé) data of arable habitats in Central Europe.

Location: Germany, Czech Republic, Slovakia, Switzerland, Liechtenstein, Austria, Hungary, Northern Italy, Slovenia, Croatia.

Methods: Vegetation plot data were obtained from large repositories (e.g. European Vegetation Archive), specialized regional databases, colleagues and the literature. Data were then checked for completeness and standardized (e.g. taxonomy, nomenclature, crop types). Species were assigned native, archaeophyte (i.e. alien species introduced before c. 1492 CE) or neophyte (i.e. alien species introduced after c. 1492 CE) status.

Results: The AgriWeedClim database version 1.0 contains georeferenced data from 32,889 vegetation plots sampled from 1916 to 2019.

Conclusions: We provide an overview of this new resource and present example analyses to show its content and possible applications. We outline potential research questions including analysis of patterns and causes of vegetation changes in arable habitats from the early 20th century to the present.

KEYWORDS

agriculture, biodiversity, biological invasions, climate change, data repository, land-use change, segetal flora, vegetation plots, weeds

1 | INTRODUCTION

Arable habitats — here defined as fields, orchards, vineyards and their fallows — were first created in Central Europe by human activities several thousands of years ago with the spread of agricultural land use from southeastern Europe (Poschlod, 2015). Since then, they have been essential and often dominant elements in Central European landscapes. They are pivotal for agricultural production, and for generating income in rural areas, but they are also essential habitats for many species (e.g. Storkey & Cussans, 2007).

Arable habitats are shaped by human activities such as tilling, planting or sowing one (or few) crop species, crop rotation, fertilization and weed management. In recent decades, arable land has been heavily transformed by various processes triggered by the Great Agricultural Revolution including widespread mechanization, increasing application of fertilizers and pesticides, the abandonment of marginally profitable land, and the segregation and specialization of farmers in one or a few agricultural products (Bruckmüller et al., 2002; Poschlod, 2015). Combined, these changes led to an intensification of land use, increases in field size, and a loss of heterogeneity and of unused or extensively used habitats such as hedgerows and wetlands within agricultural landscapes. This ultimately resulted in the dominance of nutrient-rich habitats, which had pronounced negative effects on many species (Kienast, 1993; Plieninger et al., 2015; Mupepele et al., 2021).

While changes in land-use type and intensity have substantially affected the biota of arable habitats (Storkey et al., 2012) there is growing evidence that species are increasingly responding to climate change (Parmesan & Yohe, 2003; Chen et al., 2011). As climate change will continue in the coming decades (IPCC, 2022), the resulting impacts on arable habitats and their biota will become more pronounced (Ziska, 2016; Vilá et al., 2021). In addition, arable habitats in Central Europe show high levels of invasion by alien plant species introduced both a long time ago (i.e. archaeophytes) and more recently (i.e. neophytes). The introduction and spread of neophytes is increasing worldwide (Seebens et al., 2017), and this is also the case for neophytes in fields, with some emerging as new weeds (Follak et al., 2017).

In recent decades, technical advances have facilitated the mobilization and subsequent integration of large amounts of biodiversity data, which in turn has allowed the development of large data repositories. For vegetation plot data in Europe, the European Vegetation Archive (EVA) has emerged as an integrated database of nearly two million vegetation plots of all habitats (Chytrý et al., 2016). In the case of arable habitats, data pertaining to the crop are essential because crop species define farming practices (e.g., weed management, fertilization, tillage frequency, etc.) and these shape habitat conditions. This information is not readily available in large repositories, or is only available in unstandardized form, which would require an unmanageable effort to filter data from different data sources and remove irrelevant information. Thus, more specific databases are needed to fill these information gaps and facilitate analyses. Vegetation plot data for arable habitats in (Central) Europe, have recently been compiled in two such databases: (i) the “European Weed Vegetation Database” (Küzmič et al., 2020) and (ii) the “Arable Weeds and Management in Europe” database (Bürger et al., 2020). The former includes vegetation plots from fields as well as ruderal habitats and its geographic focus is mainly on southeastern Europe with less than 25% (ca. 6000) of its vegetation plots located in Central Europe, while the latter contains only data from arable fields from the 1990s onwards; its geographic scope is all of Europe, and <30% (ca. 14,000) of its vegetation plots are from Central Europe.

Here we present the AgriWeedClim database version 1.0, the first exhaustive repository of vegetation plot data from the 1910s onward from arable habitats in Central Europe. Specifically, we (i) describe the approach and scope, (ii) provide an overview of the content of this new resource, and (iii) outline possible applications.

2 | MATERIALS AND METHODS

2.1 | Study area

The AgriWeedClim database geographically covers most of Central Europe — Germany, Czech Republic, Slovakia, Switzerland, Liechtenstein, Austria, Hungary, Northern Italy (Valle d'Aosta, Piemonte, Lombardia, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Liguria, Emilia-Romagna), Slovenia and Croatia (Figure 1). The c. 900,000 km^2 large study area mostly belongs to the Continental Biogeographic Region, but smaller parts belong to the Atlantic, Alpine, Pannonian, and marginally to the Mediterranean Biogeographic Region (European Environment Agency, 2002). The climate of the study area is predominantly cool-temperate and humid in the lowlands with a gradient from more oceanic climates in the northwest to a more continental climate in the east. Average annual temperatures increase from north to south, and the southernmost parts of the study region – the coastal areas of northern Italy and Croatia – have a Mediterranean climate with mild, humid winters and hot, dry summers. Several mountain ranges (e.g. the European Alps, western Carpathians, Dinaric Mountains, northern Apennines, Bohemian Massif and German low mountains) are part of the study area — there, arable fields are mostly restricted to valleys and low-lying peripheral parts of the mountain ranges.

The total human population of the study area is c. 165 million, and the national population sizes vary between 83.2 million (Germany) and 2.1 million (Slovenia; European Commission, 2021) with a mean density of 177 people per km^2 (Goldewijk et al., 2017). All countries are highly industrialized and economically prosperous, albeit countries in former Eastern Europe and successor countries of former Yugoslavia (Slovenia, Croatia) somewhat less so. Historically, agriculture throughout the study was dominated by small-scale family farms, with some large-scale farms owned by the aristocracy or the Catholic Church (Bruckmüller et al., 2002). However, there are noteworthy differences in agricultural practices that were shaped by the differing socioeconomic systems adopted by the countries in the study area between 1945 and 1990 (Figure Error! Reference source not found.a). After World War II, Europe was divided into two parts with opposing political and economic systems. In the West, agriculture continued to be based on private land and farm ownership and a market economy. The economy recovered quickly and agricultural mechanization had been adopted earlier (Voigtländer et al., 2001). In the East, socialist political systems were introduced based on state-run, planned economies. In the 1940s and 1950s, some landowners were expropriated, and other landowners forced to pool their land in large cooperative farms. Economic resources were scarce at times, leading to a later onset of mechanization (Voigtländer et al., 2001). Countries in the West cooperated economically and politically in the predecessors of the European Union, countries in the East within the framework of the Comecon (Council for Mutual Economic Assistance). In this period, Yugoslavia presents a special case as a socialist country not part of Comecon and retaining private ownership of small-scale farms. After the political change in the East around 1990, agriculture was (re)privatized, but the large-scale land-use structures established under socialism were retained. Throughout the study area farm and field size have increased steadily in concert

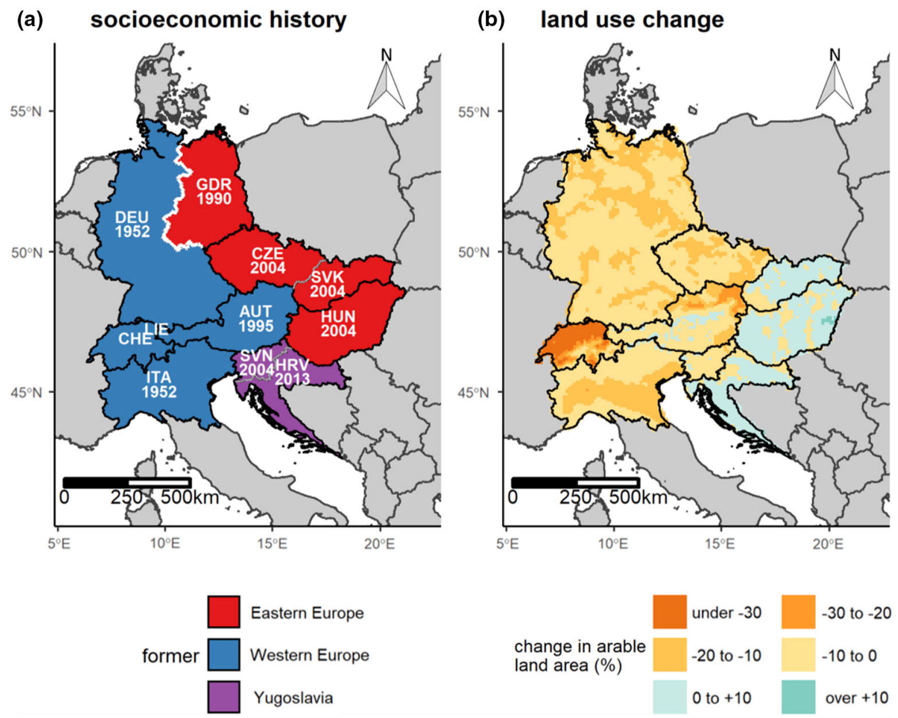

FIGURE 1 Study area (colored) of the AgriWeedClim database, with Europe (gray) for context. (a) Countries with divergent political and economic systems influencing agricultural land use in the second half of the 20th century. Border colors correspond to current borders of countries and the study area (black), borders that were dropped (white) and borders of larger countries now split into smaller ones (gray). The years of accession to the European Union or its respective predecessor organizations are shown below the country code. (b) Change in arable land in percentage of grid cells between 1910 and 2010 (Goldewijk et al., 2011)

with mechanization and land use, albeit at different rates due to the afore-mentioned divide (Poschlod, 2016). All countries in the study area (except Switzerland and Liechtenstein) are now members of the European Union and thus subject to its Common Agricultural Policy.

The total area of arable land in the AgriWeedClim study area is currently about 182,000 km^2, which corresponds to 20% of the study area ("cropland" *sensu* Goldewijk et al., 2017; Figure 1b) and represents a 24% loss in area used as arable land from about 239,000 km^2 in 1910. Large losses of arable land occurred in most countries of the study area, being most pronounced in Switzerland (decline by c. 82%) and of the three countries (Slovakia, Hungary, Croatia) showing moderate increases, the largest can be found in Hungary (7.6%).

2.2 | Thematic scope and data sources

In AgriWeedClim, we include vegetation plot data that can be assigned to arable habitats either by context (e.g., land-use type or header data mentioning crops) or species list (e.g. containing crop species). As a first step, vegetation plot data from arable habitats were requested from the European Vegetation Archive (EVA), the largest repository of vegetation plot data for Europe (Chytrý et al., 2016) based on syntaxonomic class (*Chenopodietea*, *Papaveretea rhoeadis*, *Sisymbrietea*, and *Digitario sanguinalis-Eragrostietea minoris sensu* Mucina et al., 2016) and EUNIS habitat types corresponding to our definition of arable land. On September 15, 2020, a total of 39,072 vegetation plots were received from EVA including 3184 vegetation plots from the "European Weed Vegetation database" (Küzmič et al., 2020), which is integrated in EVA. Further data requests distributed among colleagues resulted in 18,471 additional vegetation plots received — including plot data sampled using other methods than Braun-Blanquet (1964) such as 4224 vegetation plots received from the database "Arable Weeds and Management in Europe" (Bürger et al., 2020), which used absolute counts of individuals as measure of abundance. Additional efforts were focused on digitizing historical data to close remaining gaps, resulting in 1207 vegetation plots from 10 publications being digitized and integrated into the AgriWeedClim database. In total, 59,931 vegetation plots were collected for further processing as outlined below.

2.3 | Data mobilization, integration and standardization

All plot data were extracted in their original format from the different data sources (e.g. Turboveg [Hennekens & Schaminée, 2001]; Microsoft Access; Microsoft Excel), and transformed into a common data format with R Version 4.1.0 (R Core Team, 2021) using the packages *tidyverse* (Wickham, 2021), *dbplyr* (Wickham et al., 2021), *odbc* (Hester & Wickham, 2021), *raster* (Hijmans et al., 2021), *sp* (Pebesma et al., 2021) and *TaxonStand* (Cayuela et al., 2012, 2019). Data were then recompiled into a Microsoft Access database (see Figure 2).

Vegetation plot data were standardized by removing non-target species groups (i.e. non-vascular plant species). Species taxonomy and nomenclature of the species were then standardized according to The Plant List (The Plant List, 2013) while retaining the original species name. Infraspecific ranks (e.g. subspecies, varieties) were discarded after standardization because they were not used consistently in the data. Species' original abundance values, i.e., rank on the over 30 cover scales or in some cases absolute counts, as well as author-reported cover percentages, were preserved. For species lists for which only scale values were given, the corresponding percentages were obtained by contacting the authors, and when this was unsuccessful, the cover percentages were added from similar scales used in other data.

Header data (i.e. the metadata of the vegetation plots, "header" for short), completeness and content varied widely between datasets and thus could only be partially standardized. Coordinates were transformed to a common coordinate system (EPSG:42310) and geographic uncertainty of vegetation plot location was standardized to meters based on the information given in the source. If available, the size of the vegetation plot was included. The date of records (as accurately as possible) was standardized and for missing cases the year of publication was used as a proxy instead. Literature references to published vegetation plots were also standardized and included.

Information on crop species was assessed as accurately as possible. For this purpose, crop data were divided into three hierarchical crop type (CT) levels (CT1, CT2, CT3). The highest level, CT1, represents the coarsest grouping into fields, orchards, vineyards and their fallows. The second hierarchical crop type level (CT2) differentiates between major crop groups (i.e., cereals, root crops, vegetables, oil crops, shrub and tree orchards). Finally, the finest hierarchical crop type level (CT3) provides information on the crop species if this information was available. For vineyards, no differentiation at the two lower crop type levels was done as there is only one crop species. For the vegetation plot data received from EVA, crop types had to be identified from the plot data because the crop type was not received with the header. This was done by iteratively creating a list of possible crop species and then screening the plot data for these crops. For vegetation plots with crop species known to occur only very rarely outside of cultivation, the crop with the maximum cover was identified as CT3. If more than one potential crop species with identical cover percentages was present in a vegetation plot, this was interpreted as a vegetation plot including two adjacent crops or located in mixed cultivation. For potential crop species that also occur regularly in the wild or show persistence after cultivation, a conservative minimum threshold of 25% cover was used for accepting a species as crop at the CT3-level ("maxthresh" in Table S1). Finally, to identify fodder and fertilizer crops potentially grown in mixed cultivation, the sum of the cover values of all potential fodder and fertilizer crops was compared to the 25% cover threshold ("sumthresh" in Table S1). As fallows do not necessarily contain a crop species, we used the EUNIS habitat type "V15 — bare tilled fallow

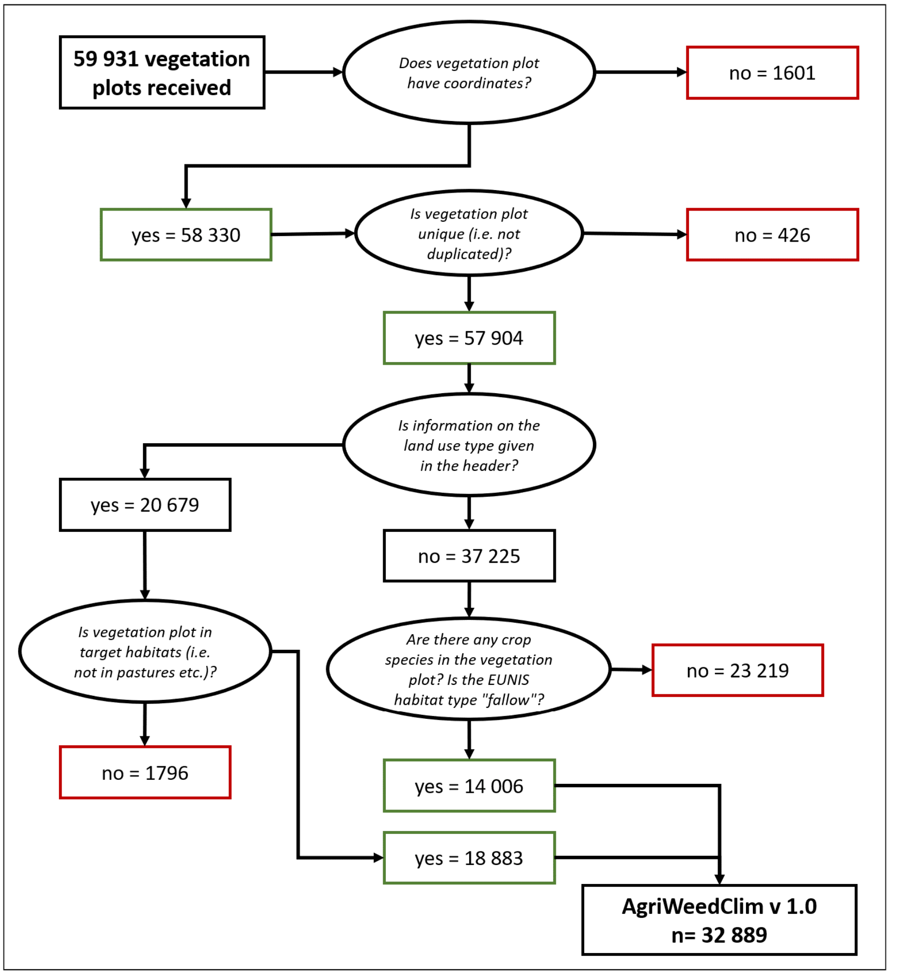

FIGURE 2 Workflow of data mobilization, standardization and integration for the AgriWeedClim database (from top left to bottom right). Ovals denote processing steps, red boxes show the number of vegetation plots that were discarded, green those that were retained at each step. Duplicated vegetation plots were defined as exact matches of coordinates and species list including cover scale value and were manually checked for plausibility

or recently abandoned agricultural land" ("EUNIS code" in Table S1; sensu Chytrý et al., 2020) as provided by EVA to identify fallows within the vegetation plots received from EVA. In some cases of vegetation plots with documented crop species, these were not included in the vegetation plots' species lists and were only mentioned in the headers. These species were added from the header to the respective plots with their cover values where available to ensure consistent species numbers per plot.

Ellenberg Indicator Values provide information on the ecological preferences of vascular plant species in Central Europe with respect to important environmental conditions (e.g. nutrients, moisture, temperature) on a nine-level scale (Ellenberg, 1974). We included all Ellenberg Indicator Values in the AgriWeedClim database taken from Ellenberg values for Central Europe (Ellenberg et al., 2001) and filled the gaps in this list with values from Hungary (Borhidi, 1995) and Italy (Pignatti, 2005). To do so, we standardized species names given there to the same taxonomic concept as used in the AgriWeedClim database. In cases where infraspecific taxa had different Ellenberg Indicator Values, the values were denoted as "z", comparable to the indicator value "x" used for indifference to a given environmental variable.

We classified species into natives, archaeophytes (i.e. alien species introduced to Central Europe before c. 1492) and neophytes (i.e. alien species introduced after that date, see Pyšek et al., 2004 for details on the terminology). We note that the differentiation between natives and archaeophytes is often challenging for weeds, as reconstructing the native ranges of archaeophytes is difficult (Willcox, 2011). Native range data were requested for all species in the AgriWeedClim database from the GloNAF-database (van Kleunen et al., 2019) which contains data from two sources, the World Checklist of Selected Plant Families (WCSP, http://apps.kew.org/wcsp/) and the Germplasm Resources Information Network (GRIN, http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl). If a species was listed as native in the two TDWG-2 regions "Middle Europe" and "Southeastern Europe" ("World Geographical Scheme for Recording Plant Distributions Edition 2", 2001) in either of the above sources, we accepted the species as native in the AgriWeedClim database. Conversely, if a species' native range did not overlap with the TDWG-1-region "Europe" or one of the TDWG-2-regions listed above, it was accepted as alien. For remaining data gaps, we screened country-level species lists containing information on species' biogeographic status

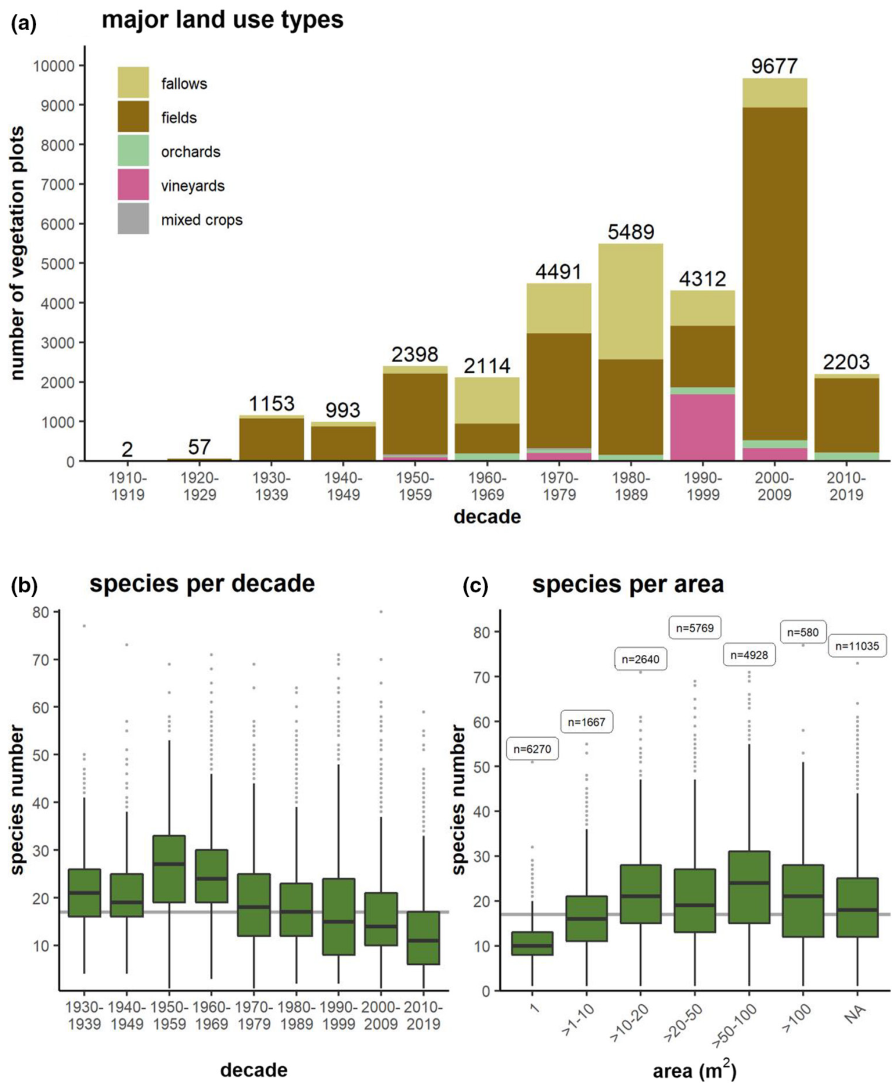

FIGURE 3 Overview of key database attributes: (a): number of vegetation plots in the AgriWeedClim database per decade and coarsest crop type category (CT1); the total number of vegetation plots per decade is shown above the bars. (b) Recorded species numbers per vegetation plot per decade; the thick black line indicates the median, the box the 25th and 75th percentiles and whiskers indicate 1.5 times interquartile range, Gray points are outliers. Gray line indicates overall median species number (17). (c) Recorded species number grouped by vegetation plot size classes; boxplot follows the same logic as in (b) and the sample size is indicated above the top whisker. For other key attributes see Appendix S1: Table S1

for Austria (Gilli et al., 2019), Switzerland (Info Flora, 2021) and Germany (Bundesamt für Naturschutz, 2021) to manually check if these species were recorded as native in these countries. Once native species had been identified this way, we used these species lists supplemented by archaeophyte checklists from several countries of the study region — the Czech Republic (Pyšek et al., 2012), Slovenia (Jogan et al., 2012), Germany (Bundesamt für Naturschutz, 2021), Slovakia (Medvecká et al., 2012) and Switzerland (Info Flora, 2021); and an unpublished archaeophyte checklist for Croatia (Nikolić, 2022) — to differentiate archaeophytes from neophytes; if an alien species was listed as archaeophyte in any of these countries, it was accepted as archaeophyte for our entire study area, otherwise it was considered a neophyte. Finally, these assignments were checked by the authors. To make the AgriWeedClim database accessible to a wider public it was registered with the global index of vegetation databases (ID: EU-00-035, https://www.givd.info) and the data that had not yet been included in EVA were contributed there as a separate database.

3 | RESULTS

3.1 | Spatial, temporal and thematic coverage of the AgriWeedClim database

A total of 59,931 vegetation plots were received from the different data sources. Of these, 27,042 vegetation plots had to be discarded for various reasons such as missing coordinates, duplicate vegetation plots, vegetation plots outside of arable habitats, or absence of crop species in the species list and header for non-fallows (Figure 2). This resulted in 32,889 vegetation plots included in the AgriWeedClim database version 1.0. About two thirds of these (21,854 vegetation plots) contained information on the vegetation plot size, with a mean of c. 42 m^2 (minimum: 1 m^2, maximum: 2500 m^2; see Figure 3c). The mean geographic uncertainty of plot location was 2683 m, although this information was missing for 42% of vegetation plots. In contrast, almost all (31,894, i.e. >96%) had information on the sampling year, while for the remaining 995 (<4%) the publication year was used as a proxy

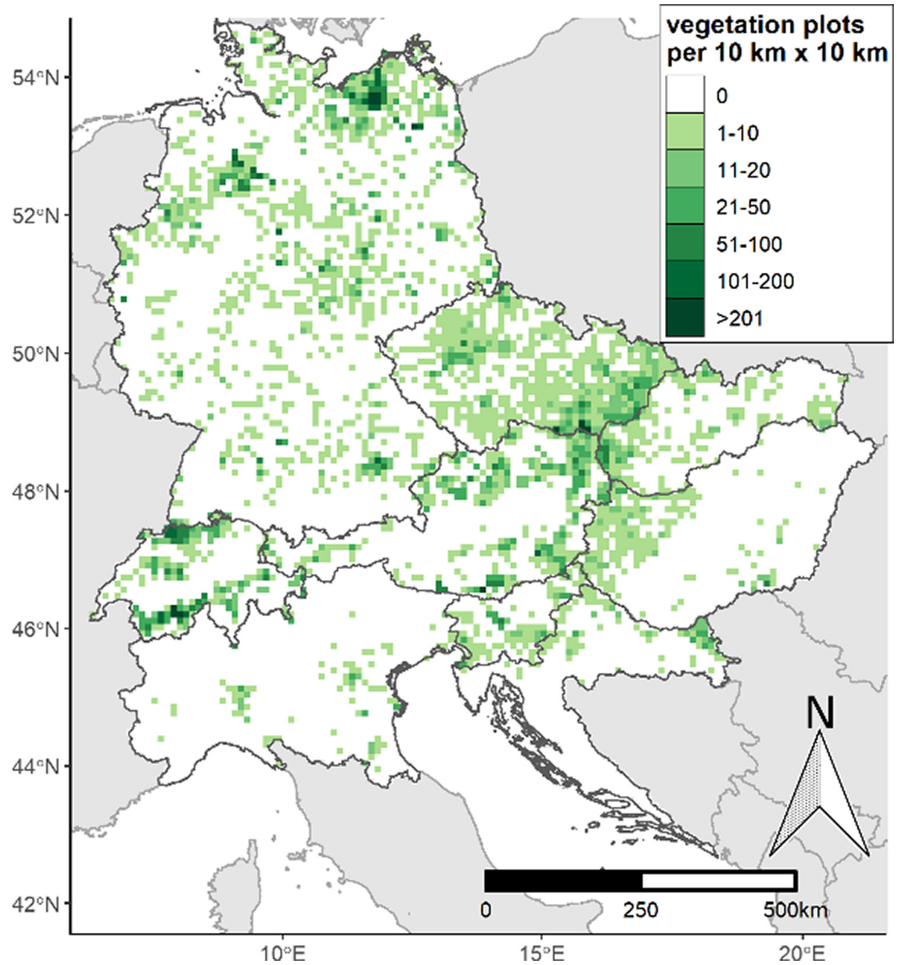

FIGURE 4 Vegetation plot density in the AgriWeedClim database on a 10 km × 10 km grid; areas outside the study area are shown in gray. For an overview of plots sampled per decade see Appendix S1: Figure S1

instead. The oldest vegetation plot was sampled in 1916, and 59 vegetation plots were sampled before 1930 (Figure 3a). From the 1930s onwards, the number of records grows steadily, peaking in the 2000s, then declining in the last decade (2010–2019). It also varies substantially across space (see Appendix S1: Figure S1) with well-sampled regions being the Czech Republic, western Hungary, the lowlands of Austria and Switzerland, western Slovakia, north-eastern Germany and parts of Slovenia (Figure 4). Most vegetation plot data were collected in fields (21,955 plots), followed by fallows (7484 plots), vineyards (2358 plots) and orchards (975 plots; Figure 3a). For a summary of the main AgriWeedClim database header data see Appendix S1: Table S1.

Of the 3964 original taxon entries in the data sources, taxonomic standardization resulted in 1911 accepted species. Only 45 taxon names (ca. 2%, corresponding to ca. 0.2% of species list entries) could not be unambiguously assigned in the process of taxonomic standardization and therefore remain unresolved.

3.2 | First insights into changes in arable species occurrence over time

Median species numbers per vegetation plot were rather stable around 24 species until the 1950s. Later, the median number of species recorded per vegetation plot declined from its peak of 27 in the 1950s to 10 in the 2010s (Figure 3a). We note that this analysis of temporal changes of species numbers per vegetation plot is based on raw data not corrected for sampling effort per decade or for vegetation plot size as well as differences in data sources (i.e. studies focusing on biodiversity versus studies focusing on agriculture and weed management) that may influence the number of species per plot (Bürger et al., 2022).

The most common species in the AgriWeedClim database, *Stellaria media*, occurs in about half of all vegetation plots. Species' commonness declines rapidly, with only 42 species documented in more than 10% of all vegetation plots and noteworthy changes in relative occurrences (i.e., percentage of plots where species occur) over time (Table 1).

Between the three groups of biogeographic origin — natives, archaeophytes and neophytes — different trends in their occurrences can be observed over time (Figure 5). Neophytes tend to become more common over time and some of them only appear in the data set in recent decades (e.g. *Ambrosia artemisiifolia*). In contrast many once-common archaeophytes (e.g. *Agrostemma githago*) show marked declines over time, while native species show a wide range of trends in occurrence.

A predominant factor in land-use change has been the cessation of cultivation in marginally profitable settings (i.e. soils unfavorable

TABLE 1 Top ten most common species in the AgriWeedClim database based on relative total occurrences (i.e. percentage of plots in which species occurs) per decade. For the 100 most common species, see Appendix S2: Table S2

Species	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s	Relative total occurrences (%)
Stellaria media	50	26.3	34.9	36.8	54.8	58.4	37.4	65.5	54	55	20.7	50.8
Viola arvensis	100	61.4	50.2	52	43.7	56.1	43	65.3	34.4	53.8	31.1	49.4
Chenopodium album	100	38.6	51.5	59	65.7	59.2	49.7	46.5	39.3	33.2	36	44.1
Capsella bursa-pastoris	0	29.8	36	35.1	48.3	50.3	37.2	48	41.1	47.3	16.3	42.6
Polygonum aviculare	50	28.1	55.2	47.1	58.1	50.9	33.5	42.8	33.4	38.6	31.4	40.5
Fallopia convolvulus	100	1.8	26.5	32.6	34.7	58.3	32.4	49.7	28.6	42.4	34	39.4
Cirsium arvense	100	26.3	30.4	39.4	43.6	51.1	36.5	30.5	38.5	34.8	19.3	35.4
Elymus repens	50	19.3	30.7	38	39.3	43.8	24	40.9	35.7	35.8	29.7	35.3
Convolvulus arvensis	100	29.8	47.3	44.9	47.7	22.6	42.8	28.1	57.1	27.6	11.9	34.9
Galium aparine	90	19.3	40.5	33.8	36.3	19.3	22.3	36.1	25.9	40	28.9	32.5

to agriculture, steep slopes; Bruckmüller et al., 2002). These land-use changes have contributed to the decline of habitat specialists while widespread intensification of land use (e.g. increased application of fertilizers and herbicides) has benefited a few generalists capable of growing under these new conditions (e.g. Meyer et al., 2013; see Figure 6 for an example comparison).

4 | DISCUSSION

The AgriWeedClim database version 1.0 is a valuable resource for addressing a wide range of questions related to plant diversity changes in Central European arable habitats based on the integration of a wealth of data collected by hundreds of colleagues over the course of a century. Because large data repositories have only recently become widely available and are continuously growing, there may still be several untapped sources of vegetation plot data, such as private, non-integrated data or non-digitized data in physical archives at research institutions. Thus, we encourage colleagues who are aware of or have access to additional data to make them available to the AgriWeedClim database. Similarly, we encourage colleagues interested in using or expanding the database for specific purposes to contact the first or senior author of this article.

4.1 | Limits and biases

In this article, we have provided an overview of the content of the AgriWeedClim database. As with any large biodiversity dataset based on the integration of a wide range of data with different sampling schemes compiled opportunistically, there are inherent biases and limitations that must be acknowledged and taken into account for analyses (Chytrý et al., 2014). For the database presented here, two main sources of bias are (i) spatio-temporal sampling bias between regions (Appendix S1: Figure S1) and crop types (Figure 3a) and (ii) bias due to differences in site selection (e.g. exclusion of certain vegetation types, sampling at the field margin versus field center) between different studies. Therefore we advise tailoring the available methods for bias correction (e.g., Jandt et al., 2011; Outhwaite et al., 2018) as well as methods to deal with data gaps (e.g., missing plot sizes) to individual research questions.

4.2 | Potential research questions

The AgriWeedClim database offers a wide range of potential applications for analyzing the patterns and underlying processes of changes in plant diversity, composition and abundance on arable habitats of a large European region. Answering such research questions will be of high relevance for both science and environmental management and policy.

Although it has become evident that there have been severe biodiversity declines in arable habitats of Central Europe in recent

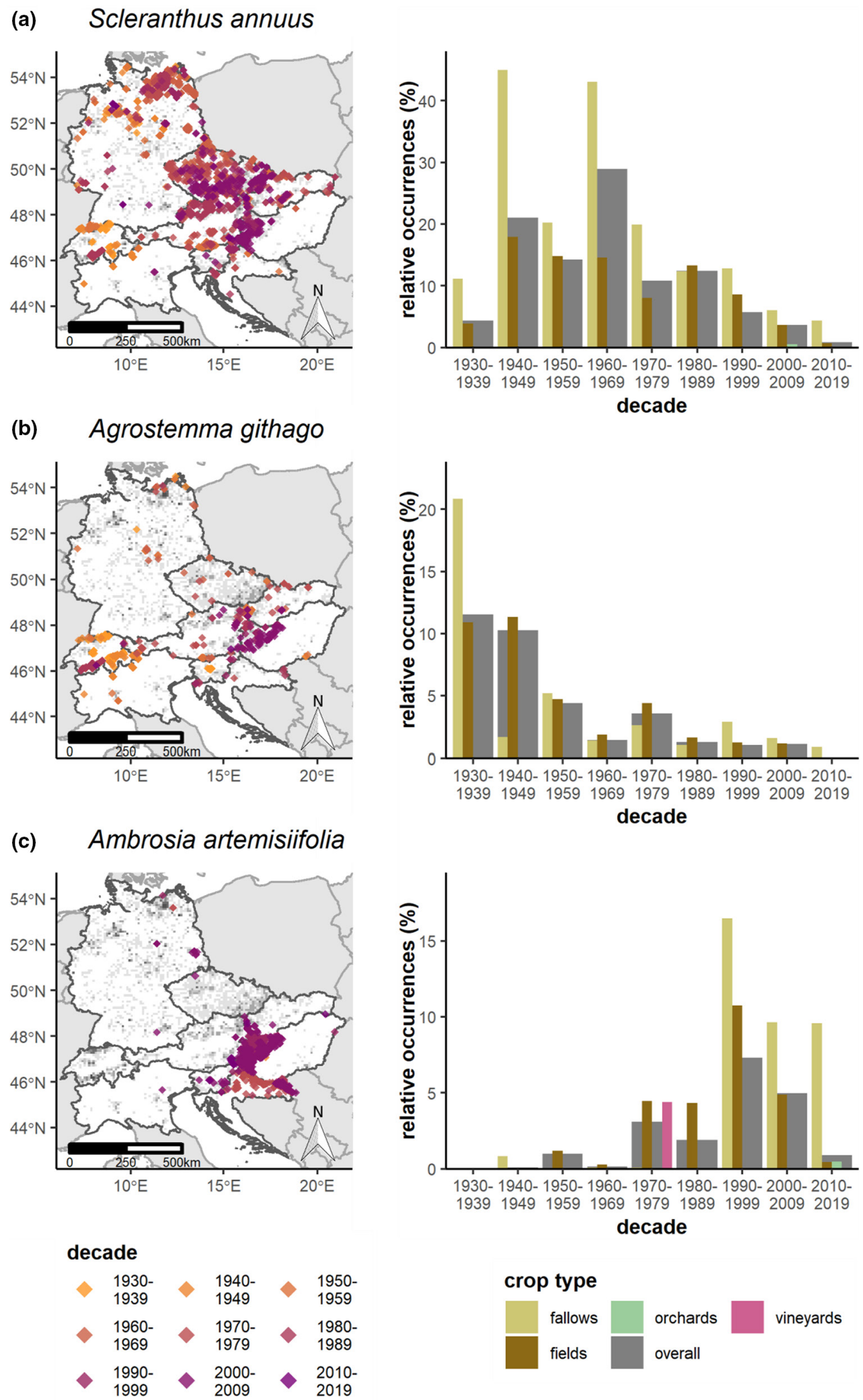

FIGURE 5 Example species data from the AgriWeedClim database. Left: Species distribution; point color corresponds to decade; gray background indicates the density of vegetation plots in the database given in Figure 2. Right: Percentage of occurrences in plots per decade by crop type (CT1, narrow colored bars) and overall (wide gray bar in background). Species differ in biogeographic origin: (a) is native, (b) is an archaeophyte and (c) is a neophyte. Note that values are not corrected for spatial sampling bias and scaling of the y axes differs between species

decades (Czech Republic: Pyšek et al., 2005; Central Germany: Meyer et al., 2013; Europe: Richner et al., 2015) the specific trajectories, causes and patterns of these processes are still insufficiently understood. For instance, it is unknown which spatio-temporal patterns characterize the changes in arable habitats vegetation, and how these changes have been driven by changes in land use and other environmental drivers. Furthermore, biodiversity in arable habitats provides important services for human society such as pollination or regulating the outbreaks of agricultural pest species (Swinton et al., 2007). More generally, many ecosystem functions and services have been shown to be provided in higher quantities by more species-rich ecosystems (Cardinale et al., 2012). The AgriWeedClim database provides a resource to address questions of ecosystem services provision, and the interaction with biodiversity conservation in highly modified habitats. Currently, the European Union is spending a large part of its budget on the Common Agricultural Policy, but despite increasing emphasis on greening the EU agricultural policy (European Commission, 2019), there are still major

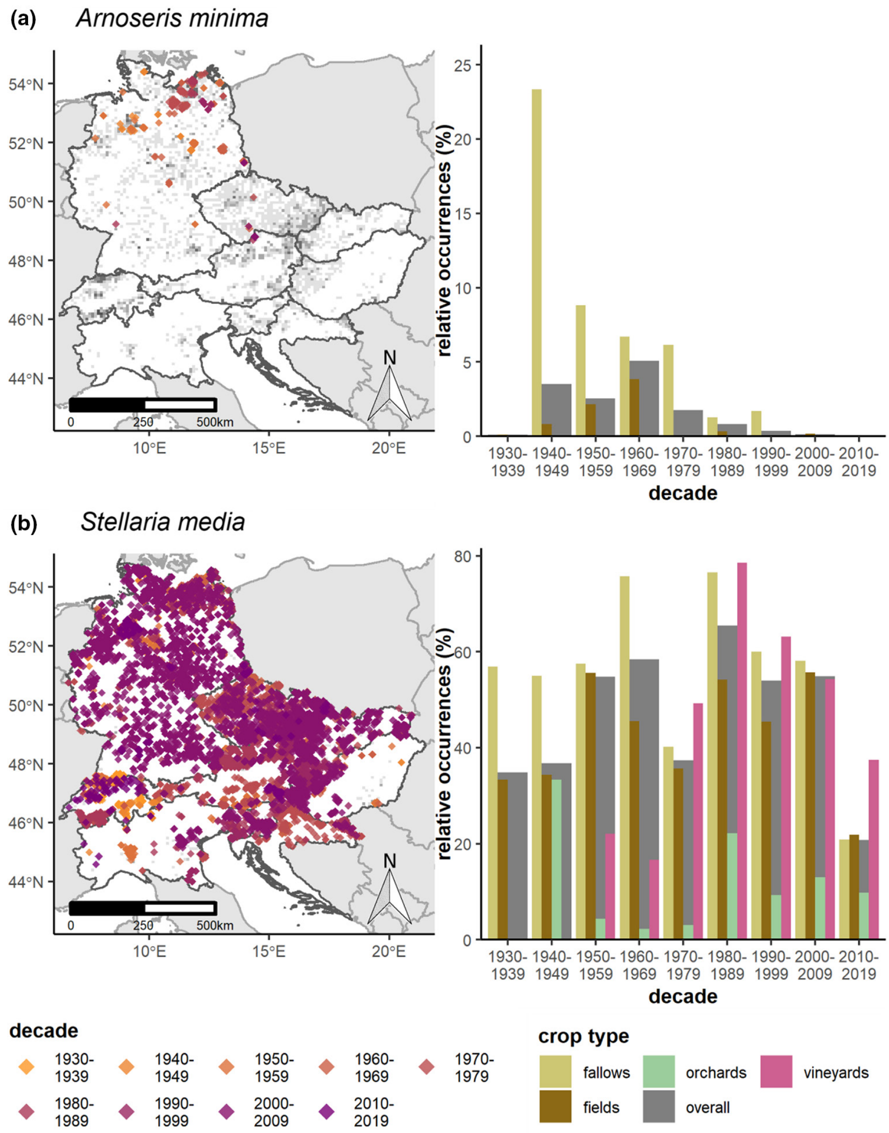

FIGURE 6 Example data of species with different arable habitat preferences from the AgriWeedClim database. Left: Occurrences of example species, point color corresponds to decade. Right: percentage of occurrences in plots per decade by crop type (narrow colored bars) and overall (wide gray bar in background). Species differ in habitat preference: (a) habitat specialist for acidic, nutrient-poor, sandy soils; (b) an abundant generalist. Note that the values are not corrected for spatial sampling bias and the scaling of the y axes differs between species.

concerns about its effectiveness (Pe'er et al., 2019). In this context, the AgriWeedClim database can facilitate retrospective analyses of the impacts of agricultural policies on plant diversity, composition and abundance in arable habitats as well as comparing the efficacy of different modes of implementation these policies had across countries and, given its large temporal coverage, differences in baseline conditions between countries. Finally, the AgriWeedClim database can be used to answer questions about how climate, land-use change, biological invasions and other factors interact with changes in the species composition of arable habitats. This may include, but is not limited to, the identification of emerging weeds — i.e. newly occurring and/or spreading plants that can cause damage to crops, livestock or humans (Groves, 2006) — and providing insight regarding e.g., habitat preference, potential impacts and high-risk areas of future emerging weeds.

AUTHOR CONTRIBUTIONS

Michael Glaser and Franz Essl conceived the idea and led the writing of the manuscript. Michael Glaser handled data requests, carried out data mobilization, integration and standardization with support from Franz Essl, Dietmar Moser and Stefan Dullinger. Christian Berg, Jana Bürger, Franz Essl, Swen Follak, Filip Küzmič, Zdeňka Lososová and Urban Šilc participated in the development of the AgriWeedClim database. Christian Berg, Serge Buholzer, Jana Bürger, Milan Chytrý, Franz Essl, Swen Follak, Filip Küzmič, Zdeňka Lososová, Stefan Meyer, Petr Pyšek, Nina Richner, Urban Šilc and Alexander Wietzke contributed vegetation plot data and Pavel Dřevojan, Alessandro Chiarucci and Fabrizio Buldrini digitized data to fill important gaps. All authors discussed and revised the manuscript.

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DATA AVAILABILITY STATEMENT

Vegetation plot data in the AgriWeedClim database are owned by the contributors. The lead author has data use rights for the purpose of the AgriWeedClim project. Any data requests should be directed to the lead author and will be communicated to the data contributors by the first or senior authors.

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REFERENCES

Borhidi, A.L. (1995) Social behaviour types of the Hungarian flora, its naturalness and relative ecological indicator values of the higher plants in the Hungarian Flora. *Acta Botanica Hungarica*, 39(1–2), 97–181.

Braun-Blanquet, J. (1964) *Pflanzensoziologie, Grundzüge der Vegetationskunde*, 3rd edition. Vienna: Springer Verlag.

Bruckmüller, E., Hanisch, E., Sandgruber, R. & Weigl, N. (2002) *Geschichte der Land- und Forstwirtschaft im 20. Jahrhundert. Band 1: Politik. Gesellschaft. Wirtschaft*. Vienna: Carl Ueberreuter Verlag.

Bundesamt für Naturschutz. (2021) *FloraWeb - Daten und Informationen zu den Wildpflanzen Deutschlands*. Available from: www.floraweb.de [Accessed 20 September 2021].

Bürger, J., Metcalfe, H., von Redwitz, C., Cirujeda, A., Fogliatto, S., Fried, G. et al. (2020) Arable weeds and Management in Europe. *Vegetation Classification and Survey*, 1, 169–170. https://doi.org/10.3897/vcs/2020/61419

Bürger, J., Küzmič, F., Šilc, U., Jansen, F., Bergmeier, E., Chytrý, M. et al. (2022) Two sides of one medal: arable weed vegetation of Europe in phytosociological data compared to agronomical weed surveys. *Applied Vegetation Science*, 25(1), e12460. https://doi.org/10.1111/avsc.12460

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P. et al. (2012) Biodiversity loss and its impact on humanity. *Nature*, 486, 59–67. https://doi.org/10.1038/nature11148

Cayuela, L., Granzow-de la Cerda, Í., Albuquerque, F.S. & Golicher, D.J. (2012) Taxonstand: an R package for species names standardisation in vegetation databases. *Methods in Ecology and Evolution*, 3(6), 1078–1083. https://doi.org/10.1111/j.2041-210X.2012.00232.x

Cayuela, L., Macarro, I., Stein, A. & Oksanen, J. (2019) *Package "Taxonstand" (2.2)*. Available from: https://cran.r-project.org/web/packages/Taxonstand/index.html [Accessed 17 October 2019].

Chen, I., Hill, J.K., Ohlemüller, R., Roy, D.B. & Thomas, C.D. (2011) Rapid range shifts of species. *Science*, 333(6045), 1024–1026. https://doi.org/10.1126/science.1206432

Chytrý, M., Tichý, L., Hennekens, S.M. & Schaminée, J.H.J. (2014) Assessing vegetation change using vegetation-plot databases: a risky business. *Applied Vegetation Science*, 17(1), 32–41. https://doi.org/10.1111/avsc.12050

Chytrý, M., Hennekens, S.M., Jiménez-Alfaro, B., Knollová, I., Dengler, J., Jansen, F. et al. (2016) European Vegetation Archive (EVA): an integrated database of European vegetation plots. *Applied Vegetation Science*, 19(1), 173–180. https://doi.org/10.1111/avsc.12191

Chytrý, M., Tichý, L., Hennekens, S.M., Knollová, I., Janssen, J.A.M., Rodwell, J.S. et al. (2020) EUNIS habitat classification: expert system, characteristic species combinations and distribution maps of European habitats. *Applied Vegetation Science*, 23(4), 648–675. https://doi.org/10.1111/avsc.12519

Ellenberg, H. (1974) Indicator values of plants in Central Europe (in German). *Scripta Geobotanica*, 9, 1–97.

Ellenberg, H., Weber, H.E., Düll, R., Wirth, V., Werner, W. & Paulißen, D. (2001) Indicator values of plants in Central Europe (in German). *Scripta Geobotanica*, 18(1), 1–262.

European Commission. (2019) *The post-2020 common agricultural policy: environmental benefits what the future CAP will bring to the table*. Available from: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/cap-post-2020-environ-benefits-simplification_en.pdf [Accessed 17 September 2021].

European Commission. (2021) *EuroStat - population*. Available from: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tps00001%5Cnhttp://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&language=en&pcode=tps00001&tableSelection=1&footnotes=yes&labeling=labels&plugin=1 [Accessed 21 January 2021].

European Environment Agency. (2002) *EEA report no 1/2002 Europe's biodiversity biogeographical regions and seas - introduction*. Available from: https://www.eea.europa.eu/data-and-maps/figures/european-biogeographical-regions-and-seas [Accessed 21 January 2021].

Info Flora. (2021) *Info flora*. Available from: https://www.infoflora.ch/de/flora/art-abfragen/art-abfragen.html [Accessed 20 September 2021].

Follak, S., Schleicher, C., Schwarz, M. & Essl, F. (2017) Major emerging alien plants in Austrian crop fields. *Weed Research*, 57(6), 406–416. https://doi.org/10.1111/wre.12272

Gilli, C., Gutermann, W. & Billensteiner, A. (2019) *Liste der Gefäßpflanzen Österreichs: Vol. 1.0*. Available from: https://plantbiogeography.univie.ac.at/fileadmin/user_upload/p_plantbiogeography/documents/taxaliste_oe_v1.0.pdf [Accessed 20 September 2021].

Goldewijk, K.K., Beusen, A., Van Drecht, G. & Vos, M.D. (2011) The HYDE 3.1 spatially explicit database of human-induced global land-use change over the past 12,000 years. *Global Ecology and Biogeography*, 20(1), 73–86. https://doi.org/10.1111/j.1466-8238.2010.00587.x

Goldewijk, K.K., Beusen, A., Doelman, J. & Stehfest, E. (2017) Anthropogenic land use estimates for the Holocene - HYDE 3.2. *Earth System Science Data*, 9(2), 927–953. https://doi.org/10.5194/essd-9-927-2017

Groves, R.H. (2006) Are some weeds sleeping? Some concepts and reasons. *Euphytica*, 148, 111–120. https://doi.org/10.1007/s10681-006-5945-5

Hennekens, S.M. & Schaminée, J.H.J. (2001) TURBOVEG, a comprehensive data base management system for vegetation data. *Journal of Vegetation Science*, 12(4), 589–591. https://doi.org/10.2307/3237010

Hester, J. & Wickham, H. (2021) *Package "odbc"* (1.3.2). Available from: https://github.com/r-dbi/odbc [Accessed 11 March 2021].

Hijmans, R. J., Van Etten, J., Sumner, M., Cheng, J., Baston, D, Bevan, A. et al. (2021) *Package "raster"* (3.5-2). Available from: https://rspatial.org/raster [Accessed 11 March 2021].

IPCC. (2022) Climate Change 2022 - Impacts, adaptation and vulnerability - Summary for policymakers. In: Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. et al. (Eds.) *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press, p. 37. Available from: https://www.ipcc.ch/report/ar6/wg2/ [Accessed 5 March 2022].

Jandt, U., von Wehrden, H. & Bruelheide, H. (2011) Exploring large vegetation databases to detect temporal trends in species occurrences. *Journal of Vegetation Science*, 22, 957–972. https://doi.org/10.1111/j.1654-1103.2011.01318.x

Jogan, N., Baćić, M. & Strgulc-Krajšek, S. (2012) Invasive alien species in Slovenia and the impact on biodiversity conservation and sustainable use of resources (Slovenian). In: Jogan, N., Baćić, M. & Strgulc-Krajšek, S. (Eds.) *Neobiota of Slovenia, final project report*. Ljubljana, Slovenia: University of Ljubljana, pp. 170-171.

Kienast, F. (1993) Analysis of historic landscape patterns with a geographical information system - a methodological outline. *Landscape Ecology*, 8(2), 103–118. https://doi.org/10.1007/BF00141590

Küzmič, F., Šilc, U., Lososová, Z., Mucina, L., Chytrý, M., Knollová, I. et al. (2020) European weed vegetation database – a gap-focused vegetation-plot database. *Phytocoenologia*, 50(1), 93–100. https://doi.org/10.1127/phyto/2019/0337

Medvecká, J., Kliment, J., Májeková, J., Halada, L., Zaliberová, M., Gojdičová, E. et al. (2012) Inventory of the alien flora of Slovakia. *Preslia*, 84(2), 257–309.

Meyer, S., Wesche, K., Krause, B. & Leuschner, C. (2013) Dramatic losses of specialist arable plants in Central Germany since the 1950s/60s - a cross-regional analysis. *Diversity and Distributions*, 19(9), 1175–1187. https://doi.org/10.1111/ddi.12102

Mucina, L., Bültmann, H., Dierßen, K., Theurillat, J., Raus, T., Čarni, A., et al. (2016) Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science*, 19(S1), 3–264. https://doi.org/10.1111/avsc.12257

Mupepele, A.C., Bruelheide, H., Brühl, C., Dauber, J., Fenske, M., Freibauer, A. et al. (2021) Biodiversity in European agricultural landscapes: transformative societal changes needed. *Trends in Ecology and Evolution*, 36, 1067–1070. https://doi.org/10.1016/j.tree.2021.08.014

Nikolić, T. (2022) Flora Croatica database. Available from: https://hirc.botanic.hr/fcd/Search.aspx

Outhwaite, C.L., Chandler, R.E., Powney, G.D., Collen, B., Gregory, R.D. & Isaac, N.J.B. (2018) Prior specification in Bayesian occupancy modelling improves analysis of species occurrence data. *Ecological Indicators*, 93, 333–343. https://doi.org/10.1016/j.ecolind.2018.05.010

Parmesan, C. & Yohe, G. (2003) A globally coherent fingerprint of climate change impacts across natural systems. *Nature*, 421, 37–42. https://doi.org/10.1038/nature01286

Pebesma, E., Bivand, R., Rowlingson, B., Hijmans, R., Sumner, M., Macqueen, D. et al. (2021) *Package "sp"* (1.4-6). Available from: https://github.com/edzer/sp/ [Accessed 11 March 2021].

Pe'er, G., Zinngrebe, Y., Moreira, F., Sirami, C., Schindler, S., Müller, R. et al. (2019) A greener path for the EU common agricultural policy. *Science*, 365(6452), 449–451. https://doi.org/10.1126/science.aax3146

Pignatti, S. (2005) Bioindication values of vascular plants of the flora of Italy (in Italian). *Braun-Blanquetia*, 39, 3–37.

Plieninger, T., Levers, C., Mantel, M., Costa, A., Schaich, H. & Kuemmerle, T. (2015) Patterns and drivers of scattered tree loss in agricultural landscapes: orchard meadows in Germany (1968-2009). *PLoS One*, 10(5), 1–19. https://doi.org/10.1371/journal.pone.0126178

Poschlod, P. (2015) The origin and development of the central European man-made landscape, habitat and species diversity as affected by climate and its changes – a review. *Interdisciplinaria Archaeologica Natural Sciences in Archaeology*, VI(2), 197–221.

Poschlod, P. (2016) *History of the cultivated landscape (in German)*, 2nd edition. Stuttgat: Eugen Ulmer.

Pyšek, P., Richardson, D.M., Rejmánek, M., Webster, G.L., Williamson, M. & Kirschner, J. (2004) Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. *Taxon*, 53(1), 131–143. https://doi.org/10.2307/4135498

Pyšek, P., Jarošík, V., Kropáč, Z., Chytrý, M., Wild, J. & Tichý, L. (2005) Effects of abiotic factors on species richness and cover in central European weed communities. *Agriculture, Ecosystems and Environment*, 109(1–2), 1–8. https://doi.org/10.1016/j.agee.2005.02.018

Pyšek, P., Danihelka, J., Sádlo, J., Chrtek, J. Jr., Chytrý, M., Jarošík, V. et al. (2012) Catalogue of alien plants of the Czech Republic (2nd edition): checklist update, taxonomic diversity and invasion patterns. *Preslia*, 84(2), 155–255.

R Core Team. (2021) *R: a language and environment for statistical computing R Foundation for Statistical Computing, Vienna, Austria (4.1.0)*. Vienna, Austria: R Foundation for Statistical Computing. Available from:. https://www.r-project.org/

Richner, N., Holderegger, R., Linder, H.P. & Walter, T. (2015) Reviewing change in the arable flora of Europe: a meta-analysis. *Weed Research*, 55(1), 1–13. https://doi.org/10.1111/wre.12123

Seebens, H., Blackburn, T.M., Dyer, E.E., Genovesi, P., Hulme, P.E., Jeschke, J.M. et al. (2017) No saturation in the accumulation of alien species worldwide. *Nature Communications*, 8, 14435. https://doi.org/10.1038/ncomms14435

Storkey, J. & Cussans, J.W. (2007) Reconciling the conservation of in-field biodiversity with crop production using a simulation model of weed growth and competition. *Agriculture, Ecosystems and Environment*, 122(2), 173–182. https://doi.org/10.1016/j.agee.2006.12.031

Storkey, J., Meyer, S., Still, K.S. & Leuschner, C. (2012) The impact of agricultural intensification and land-use change on the European arable flora. *Proceedings of the Royal Society B: Biological Sciences*, 279(1732), 1421–1429. https://doi.org/10.1098/rspb.2011.1686

Swinton, S.M., Lupi, F., Robertson, G.P. & Hamilton, S.K. (2007) Ecosystem services and agriculture: cultivating agricultural ecosystems for diverse benefits. *Ecological Economics*, 64(2), 245–252. https://doi.org/10.1016/j.ecolecon.2007.09.020

The Plant List. (2013) *The Plant List*. Available from: http://www.theplantlist.org/ (1.1) www.theplantlist.org [Accessed 21 June 2021].

van Kleunen, M., Pyšek, P., Dawson, W., Essl, F., Kreft, H., Pergl, J. et al. (2019) The global naturalized alien flora (GloNAF) database. *Ecology*, 100(1), 1–2. https://doi.org/10.1002/ecy.2542

Vilá, M., Beaury, E.M., Blumenthal, D.M., Bradley, B.A., Early, R., Laginha, B.B. et al. (2021) Understanding the combined impacts of weeds and climate change on crops. *Environmental Research Letters*, 16, 034043.

Voigtländer, U., Scheller, W. & Martin, C. (2001) *Applied landscape ecology (issue 40): reasons for the differences in biological inventory of the agricultural landscape in east- and West Germany (in German)*, 1st edition. Bonn: Bundesamt für Naturschutz.

Wickham, H. (2021) *Package "tidyverse"* (1.3.1). Available from: https://tidyverse.tidyverse.org [Accessed 11 March 2021].

Wickham, H., Girlich, M. & Ruiz, E. (2021) *Package "dbplyr"* (2.1.1). Available from: https://dbplyr.tidyverse.org/ [Accessed 11 March 2021].

Willcox, G. (2011) Searching for the origins of arable weeds in the Near East. *Vegetation History and Archaeobotany*, 21(2), 163–167. https://doi.org/10.1007/s00334-011-0307-1

World Geographical Scheme for Recording Plant Distributions Edition 2. (2001) *Group (issue august)*. Pittsburgh: Hunt Institute for Botanical Documentation Carnegie Mellon University. Available from:. http://www.tdwg.org/geo2.htm [Accessed 11 March 2021].

Ziska, L.H. (2016) The role of climate change and increasing atmospheric carbon dioxide on weed management: herbicide efficacy. *Agriculture, Ecosystems and Environment*, 231, 304–309. https://doi.org/10.1016/j.agee.2016.07.014

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. Additional information on the database.
Appendix S2. The 100 most common species per decade.

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