



European long-term ecosystem, critical zone and socio-ecological systems research infrastructure  
PLUS

## **eLTER network representativeness towards biodiversity pressures and trends**

### **Deliverable D9.1**

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## Summary

Global biodiversity has changed tremendously over the past 50 years due to the impact of anthropogenic drivers such as land use change, direct exploitation, pollution, climate change and invasive species. The eLTER network's biodiversity surveys provide a unique opportunity to investigate these changes and to assess their impacts. The present report has two main objectives. First, it will investigate whether eLTER data are suitable for analysing long-term biodiversity change at the European scale and whether these changes can be linked to potential drivers. The second aim is to evaluate eLTER workflows and services that benefit the scientific community and to provide recommendations for the further development of the eLTER Research Infrastructure. To address the first objective, we conducted a case study in which we analysed changes in the species composition of plant communities at eLTER sites. The experiences gained from this work were used to address the second objective.

Changes in species composition within local communities are among the most pronounced components of biodiversity change. Colonisations, extinctions and shifts in abundances can lead to a homogenisation or heterogenisation of communities. By using eLTER vegetation time series covering the period from 1995 to 2018 we investigated the relative importance of these processes by applying two different approaches. First, we partitioned temporal changes in spatial  $\beta$ -diversity into colonisation and extinction events and explored to what extent both processes have contributed to the homogenization or heterogenisation of local plant communities. Second, we analysed temporal  $\beta$ -diversity to identify sites that have extraordinarily changed.

Spatial differentiation among plant communities increased over time. This change was influenced more by extinctions than by colonisations. Extinctions resulting in a heterogenisation of plant communities is an indication of a stronger reduction of widespread species as compared to rare species. The analysis of temporal  $\beta$ -diversity likewise showed that extinctions had a more pronounced effect on community composition than colonisations. Further analysis indicated that species losses and gains over time may be related to changing precipitation patterns at eLTER sites.

The case study showed that eLTER biodiversity data are principally well suited to answer questions concerning biodiversity change at the continental scale. However, the study also points at limitations resulting from restricted spatial representativity, low sampling frequencies and various types of heterogeneity in the data. Recommendations are made to increase representativeness and to specify existing eLTER Standard Observations. Further considerations concern the development of IT services, with a focus on the documentation of metadata, data acquisition, quality control, harmonisation of variables and networking with other initiatives.

## 1 Background and aims of the deliverable

The European Long-Term Ecosystem, critical zone and socio-ecological systems Research Infrastructure (eLTER RI) has been identified by the European Strategy Forum on Research Infrastructures (ESFRI) as a major component to fill current gaps in the European RI landscape which prevent a holistic approach to understanding, managing and securing ecosystem functions and services under global change. The main objective of the HORIZON 2020 funded Research and innovation action eLTER PLUS is to support the further development of the emerging eLTER RI and to assess its performance. The project eLTER PLUS is guided by four research challenges: (i) Biodiversity loss (BDL), (ii) Biogeochemical controls of ecosystem functions (BGC), Climate-water-food nexus (CWF) and Socio-ecological systems (SES). The present deliverable addresses the first research challenge aiming at detecting trends in biodiversity at the European scale and attributing them to multiple drivers. This work is further intended to optimize the existing site network, improve standardization and harmonisation of measurements, and support the further development of services for the wider scientific community.

Work within eLTER PLUS is largely based on the network of more than 500 Long Term Ecological Research (LTER) sites and 50 Long Term Socio-Ecological Research (LTSER) platforms distributed across Europe. Many of these sites have a long history of data collection. The resulting biodiversity time series comprise a large number of different taxonomic groups, covering the terrestrial, freshwater and marine realms and in cases span periods over 30. These time series provide great potential for investigating recent changes in biodiversity and their drivers. A growing number of studies are making use of these data (Haase et al. 2023, Haubrock et al. 2023, Pilotto et al. 2020).

The individual research platforms of the LTER network have developed in a decentralized, often idiosyncratic manner. They have been established to work on a range of different research questions following different data collection protocols. Thus, there is considerable heterogeneity regarding the measured variables as well as methods and standards for data acquisition, handling and storage. The resulting data sets are heterogeneous and present a challenge for analyses across large spatial- and long temporal extent. One major aim of eLTER is to overcome these limitations by developing a set of Standard Observations (Zacharias et al. 2022) and providing services which would allow for multiple uses of the heterogeneous legacy data (Peterseil et al. 2022).

The current deliverable has two main aims. First, it will test whether eLTER data are suitable for analysing long-term biodiversity change at the European scale and whether these changes can be linked to potential drivers. For this purpose, a case study analysing species turnover in European plant communities was conducted. The second aim is to test workflows and services from data delivery to the provision of data products from eLTER sites that benefit the scientific community. The experiences gained during the preparation of data for the two case studies were used to suggest improvements in the entire data handling process within eLTER and for the further development of eLTER Standard Observations.

## 2 Case study: An analysis of $\beta$ -diversity of plant communities across Europe

### 2.1 Introduction

Global biodiversity has changed tremendously over the past 50 years due to the impact of anthropogenic drivers such as land use change, direct exploitation, pollution, climate change and invasive species (IPBES 2019). The direction and magnitude of changes vary across regions, realms and taxonomic groups (Pilotto et al. 2020), and depend on the spatial scale. Quantifying the magnitude of biodiversity change is, therefore, not a straightforward task, which is particularly true for local

biodiversity. Several studies have attempted to analyse trends in local biodiversity at a global or continental scale. Yet, the results are heterogeneous and depend on factors such as the ecosystem type, taxonomic group, biodiversity metrics and the spatial scale (Dornelas et al. 2014, Vellend et al. 2013, van Klink et al. 2020).

The eLTER network's biodiversity surveys, some of which have been running for more than 30 years, provide a unique opportunity to investigate changes in local biodiversity and to attribute them to common drivers. A first study was conducted by Pilotto et al. (2020) which showed more increasing than decreasing trends in species richness, diversity and species turnover in the network timeseries. However, it also revealed differences in these metrics between biogeographic regions, realms and taxonomic groups. The significant increase in turnover, which could be mainly attributed to changes in plant communities, was one of the most notable findings of the study. This is consistent with other studies emphasizing that changes in community composition represent one of the most pronounced components of biodiversity change (Dornelas et al. 2023b, Blowes et al. 2019). Therefore, an in-depth study of changes in species communities is necessary to get a deeper understanding of the mechanisms of local biodiversity changes as well as their causes and impacts.

Local changes in community composition arise from colonisations, extinctions and shifts in abundances. Depending on the context, these processes can lead to homogenisation or heterogenisation (i.e., differentiation) of local communities (Socolar et al. 2016). Homogenisation, i.e. a decrease in spatial dissimilarity may occur if rare and locally restricted species go extinct but may also be the result of colonisation of multiple sites across regions by the same taxa, i.e. during biological invasions (Olden and Poff 2003). Heterogenisation may arise from single colonisation events within a region or the extinction of widespread species. These processes may often be interdependent or mask each other, e.g. during disturbance events (Tatsumi et al. 2020). To cover patterns of homogenization and heterogenisation across space and time, we use two different approaches: one for space and one for time: For the first, we use the approach by Tatsumi et al. (2021) to partition temporal changes in spatial  $\beta$ -diversity into colonisation and extinction events and explore to what extent both processes have contributed to the homogenization or heterogenisation of local communities. We further investigate, whether some species have a particular effect on the observed patterns.

Local communities may not only be separated in space but also in time (Magurran et al. 2019). This temporal variation is commonly called temporal  $\beta$ -diversity (Legendre and Gauthier 2014, Shimadzu et al. 2015). Here we use a method by Legendre (2019) to examine temporal changes in community composition at multiple sites. The aim is to identify sites which have changed extraordinarily and to relate these changes to potential drivers.

## 2.2 Methods

### 2.2.1 Preparation of data

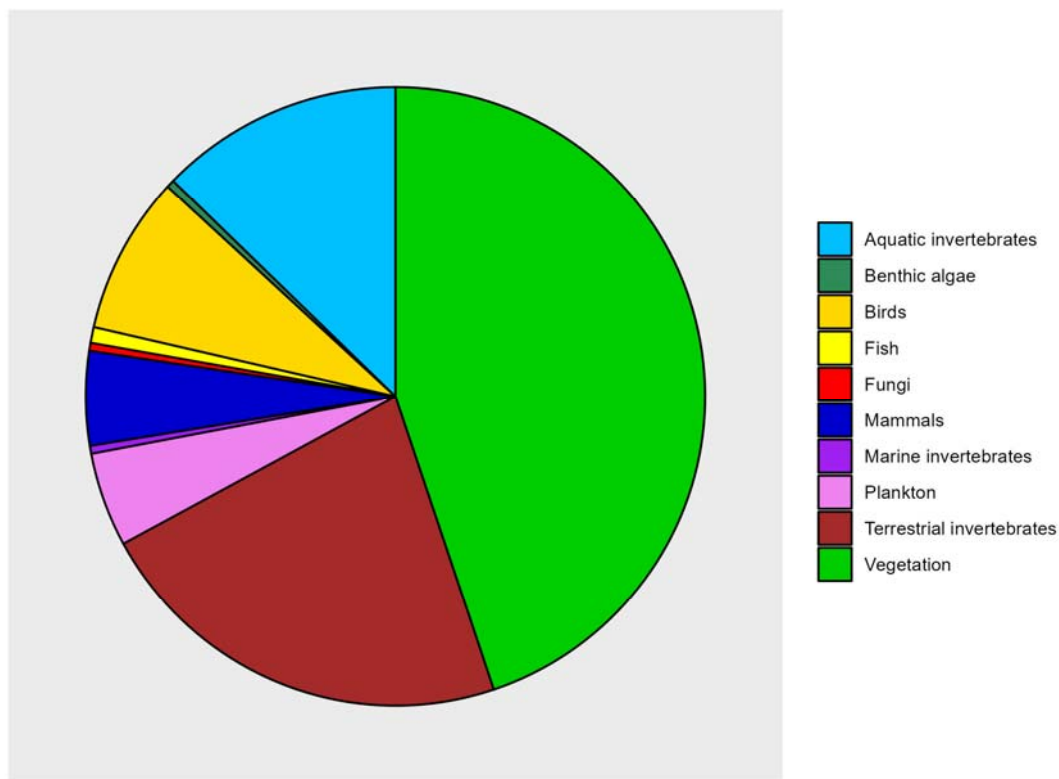
#### *Overview of biodiversity data*

Biodiversity data were collected for the scientific case studies in eLTER PLUS. Data and metadata were compiled using predefined templates provided by work package 10 (Peterseil and Geiger 2020). The aim was to obtain biodiversity time series spanning at least 10 years, which cover multiple taxonomic groups and the most important biogeographical zones in Europe.

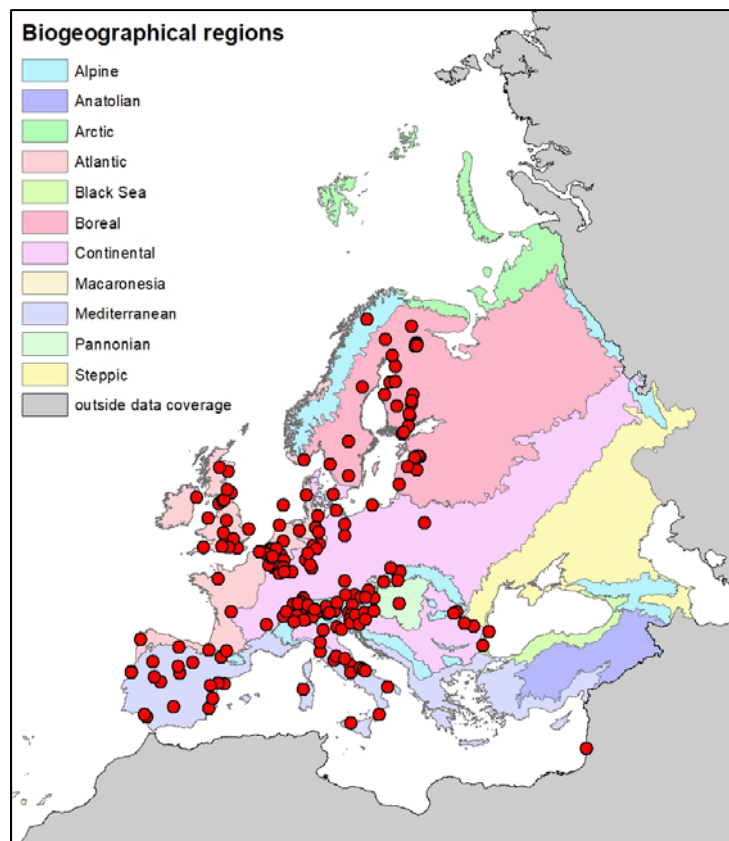
The file-based data series were submitted by the site managers or partner networks such as ICP forests (<http://icp-forests.net/>) and Environmental Change Network (<https://ecn.ac.uk>, Sier and Monteith 2016) were stored in a project-internal b2drop data repository. Additional data were obtained from the publicly accessible repository b2share (<https://b2share.eudat.eu/>). These data also originate from LTER-sites and had been collected within the preceding project eLTER H2020 or released by the data owners independently. Another source to supplement the data set for the present work was the publication of Pilotto et al. (2020).

If not already done by the data providers data from all the sources were first converted into the eLTER standard format for data reporting defined by Peterseil and Geiger (2020). The formatted data were then subjected to a general overview analysis. This included an evaluation of the length of time series (temporal extent), spatial coverage and the taxonomic group. In total 241 time series spanning at least 10 years were obtained. They could be assigned to 10 taxonomic groups (Figure 1). Vegetation time series formed the largest group providing approximately 40 % of all data. The remaining time series included birds, mammals, terrestrial invertebrates, aquatic invertebrates, marine invertebrates, plankton, fungi and benthic algae. The data originated from all over Europe and covered nearly all biogeographical zones (Figure 2). Nevertheless, the spatial distribution of the datasets differed considerably between the individual groups (

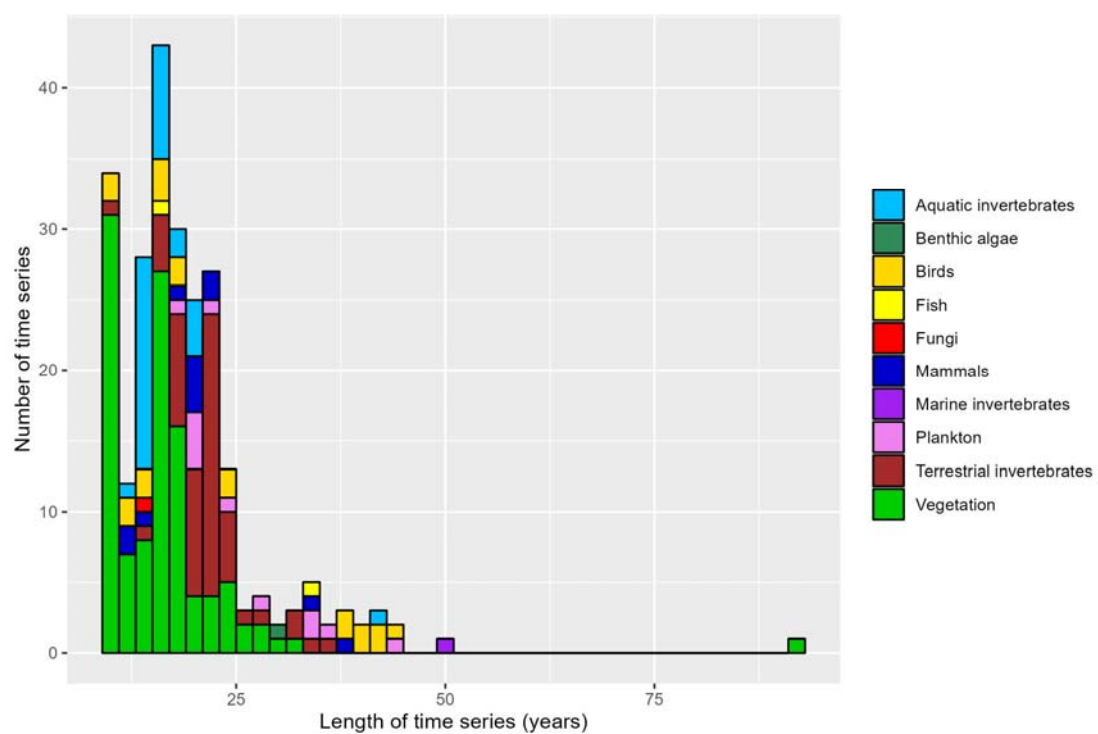
Figure 16 - Figure 24 and Table 2 in the Appendix). The time period covered by the datasets was also highly variable (Figure 3). On average, a period of 19,7 years was covered. The longest time series covered a period of 92 years. The overview analysis showed that only the vegetation data were suitable for the intended analysis of beta diversity, both in terms of the number of sites and the spatial and temporal coverage (Figure 4, Table 3 in the appendix). Therefore, the case study was restricted to vegetation data.



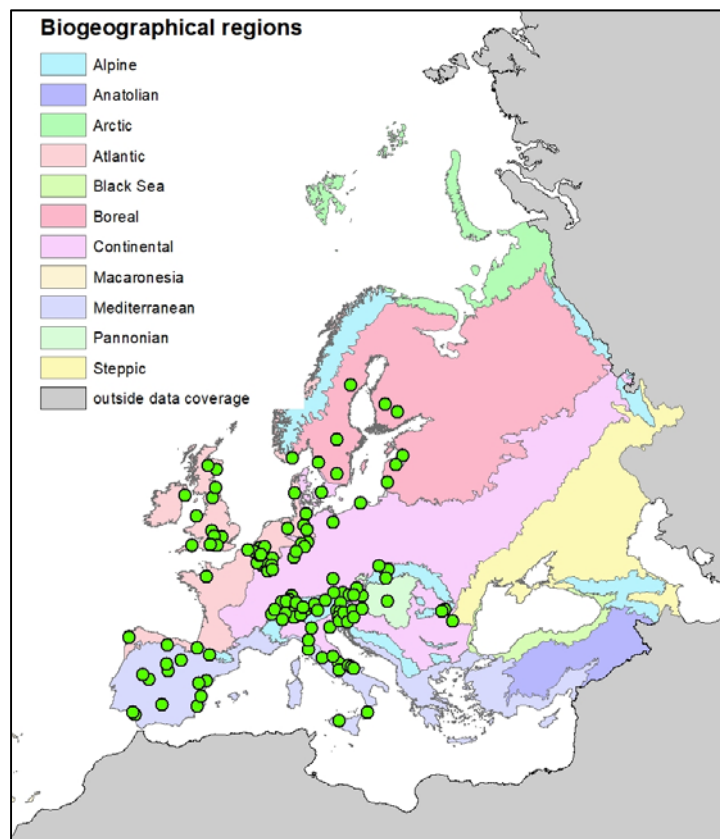
**Figure 1 Overview of the share of the main taxonomic groups in the data**



**Figure 2** Distribution of biodiversity data sets from the LTER- network across Europe. Biogeographical regions were obtained from EEA (2017).



**Figure 3** Frequency of the length of time series



**Figure 4 Distribution of vegetation time series across Europe.**

#### ***Preparation of vegetation data***

After the conversion of vegetation data into a common format, species names were harmonised using the GBIF backbone taxonomy (GBIF Secretariat 2023). For this purpose, an R script developed by UFZ was used. Species names and their synonyms which could not be automatically assigned to a GBIF taxon with high confidence were manually checked. If the proportion of species that could not be assigned to a GBIF-taxon was above 10%, the entire dataset was excluded from subsequent analyses. Further, all non-vascular plants like mosses as well as lichens were removed from the dataset as these groups have only been selectively recorded at certain sites. Coordinates of plots were re-projected to a WGS84 geographic coordinate system. Missing plot-related geographic information was supplemented by using central site coordinates from the metadata repository DEIMS (Wohner et al. 2019). From the harmonised data, species lists per site and year were generated. The availability of data across space and time was investigated and visualized, which was used in the selection of time periods. This screening of spatio-temporal patterns revealed considerable variation in recording intensity and asynchrony between eLTER- sites (Figure 5). As the intended analytical approaches require complete site  $\times$  time matrices vegetation data had to be aggregated into larger time periods. To investigate the resulting trade-off between temporal resolution and spatial extent analysis of spatial  $\beta$ -diversity was conducted based on three alternative temporal aggregations (two periods, three periods, four periods, see Table 1, Figure 6, Figure 7). The analysis of temporal  $\beta$ -diversity was based on the temporal aggregation of data into two periods only. After defining time periods and data aggregation complete species  $\times$  site matrices were generated for each studied time period.

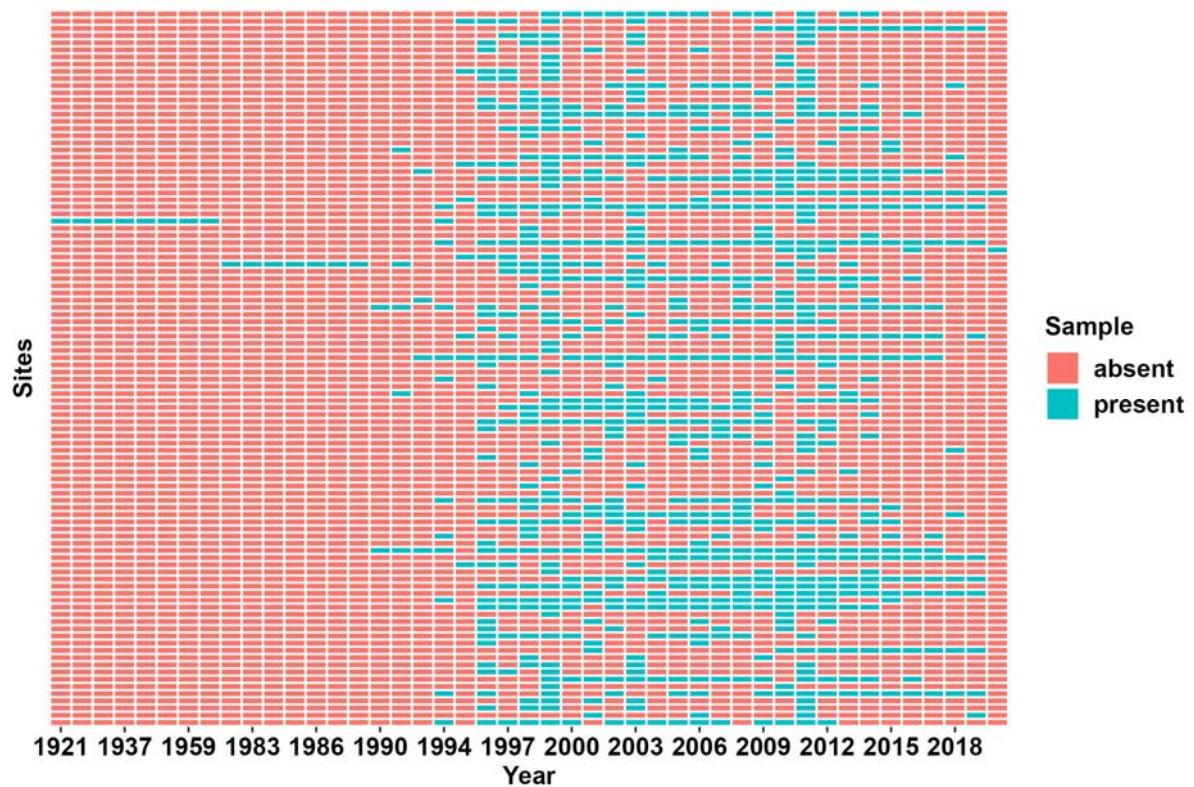
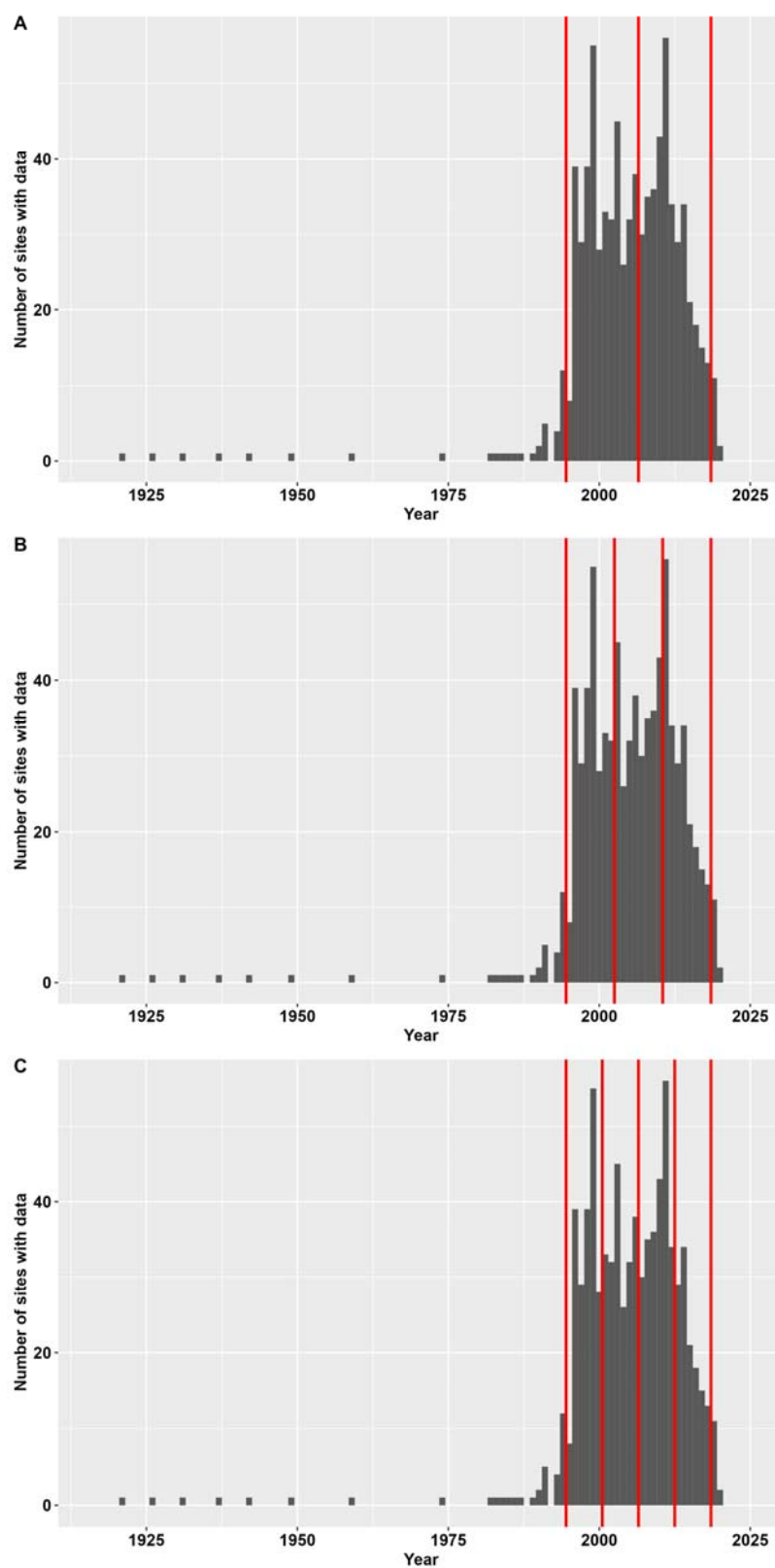


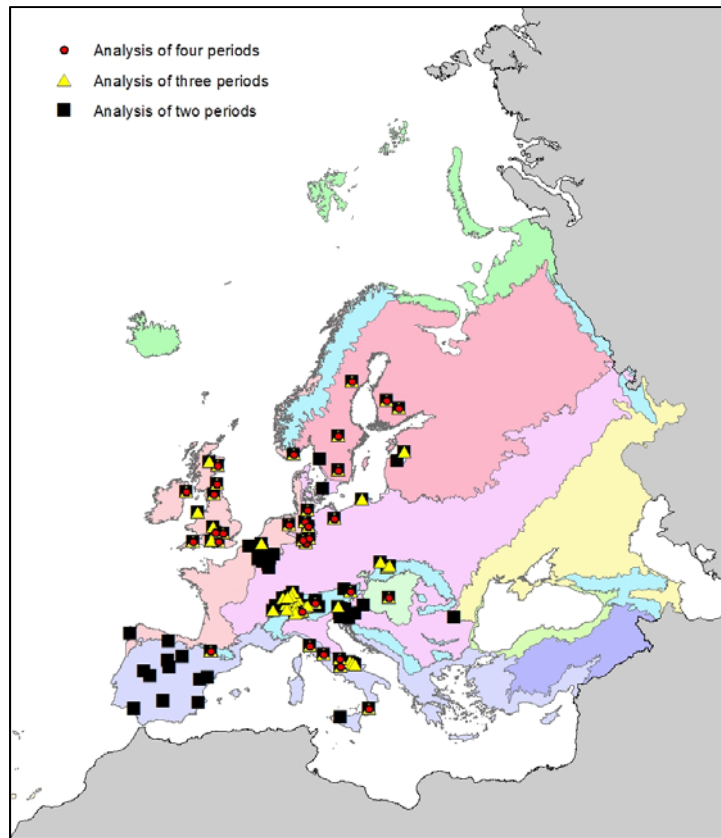
Figure 5 Temporal and spatial extent of vegetation time series

Table 1 Overview of the three versions of the analysis of spatial  $\beta$ -diversity

No of time periods	No of years aggregated per period	Time span of periods	No of sites included
2	12	Period 1: 1995-2006	100
		Period 2: 2007-2018	
3	8	Period 1: 1995-2002	61
		Period 2: 2003-2010	
		Period 3: 2011-2018	
4	6	Period 1: 1995-2000	32
		Period 2: 2001-2006	
		Period 3: 2007-2012	
		Period 4: 2013-2018	



**Figure 6** Data availability in the time periods under study for three versions of analysis (A - two periods, B - three periods, C - four periods)



**Figure 7** Distribution of vegetation time series used in the three versions of the analysis of spatial  $\beta$ -diversity. Biogeographical regions are indicated by similar colours as in Figure 2.

### *Climate data*

The E-OBS daily gridded observational datasets for precipitation and temperature (Cornes et al. 2018) at a spatial resolution of  $0.25^\circ \times 0.25^\circ$  were retrieved from the Copernicus Climate Change Service (Copernicus Climate Change Service, Climate Data Store, 2020). These data sets were intersected with eLTER site coordinates and the corresponding climate data series were retrieved. For each site mean annual temperature and total annual precipitation were calculated. Mean values for both climatic variables were then calculated for the time periods of interest. Changes in mean values between time periods were calculated to relate them to temporal  $\beta$ -diversity at the site level.

### 2.2.2 Analysis

#### *Changes in spatial $\beta$ -diversity*

Spatial differentiation of plant communities among eLTER sites was first quantified by calculating the dissimilarity index Whittakers' beta (Whittaker 1960) which accounts for species co-occurrences among multiple sites. The index was calculated for each time period. Next, the partitioning approach by Tatsumi et al. (2021) was applied to partition changes in spatial dissimilarity between time periods into a colonisation- and extinction component. Colonisation and extinction related changes were then further partitioned to quantify the contribution of both components to homogenisation and heterogenisation among plant communities, respectively. A further partition step was undertaken to measure the impact of single species on colonisation and extinction related changes in  $\beta$ -diversity.

These species scores can be used in subsequent analyses, e.g. trait analyses. Analyses were performed using the R-script provided by Tatsumi et al. (2021).

### ***Temporal $\beta$ -diversity***

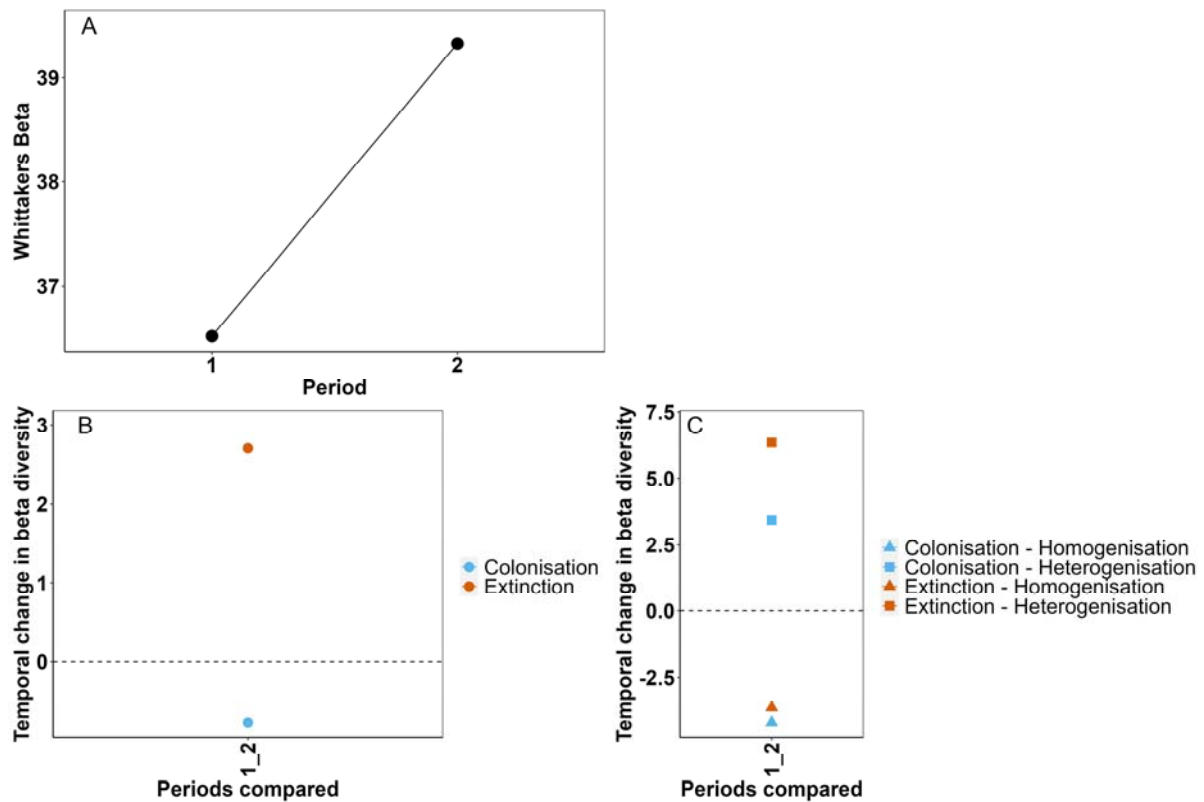
Changes in community composition at eLTER vegetation plots across time was analysed by measuring temporal  $\beta$ -diversity. For this purpose, the temporal  $\beta$ -diversity index (TBI) by Legendre (2019) was calculated between the time periods of interest for each site. TBI calculation was based on percentage difference dissimilarity metrics (Odum 1950). Indices were tested for significance using a permutation method described by Legendre (2019). Dissimilarities were then partitioned into species losses (B) and gains (C) components. All calculations were done using the *TBI.R* function implemented in the R package *adespatial* (Dray et al. 2023). Linear regression models were used to investigate the relationship between changes in climatic variables and species losses and gains components derived from the TBI calculation.

## **2.3 Results**

### ***Changes in spatial $\beta$ -diversity***

Version 1: Aggregation of data into two periods (1995-2006 and 2007-2018)

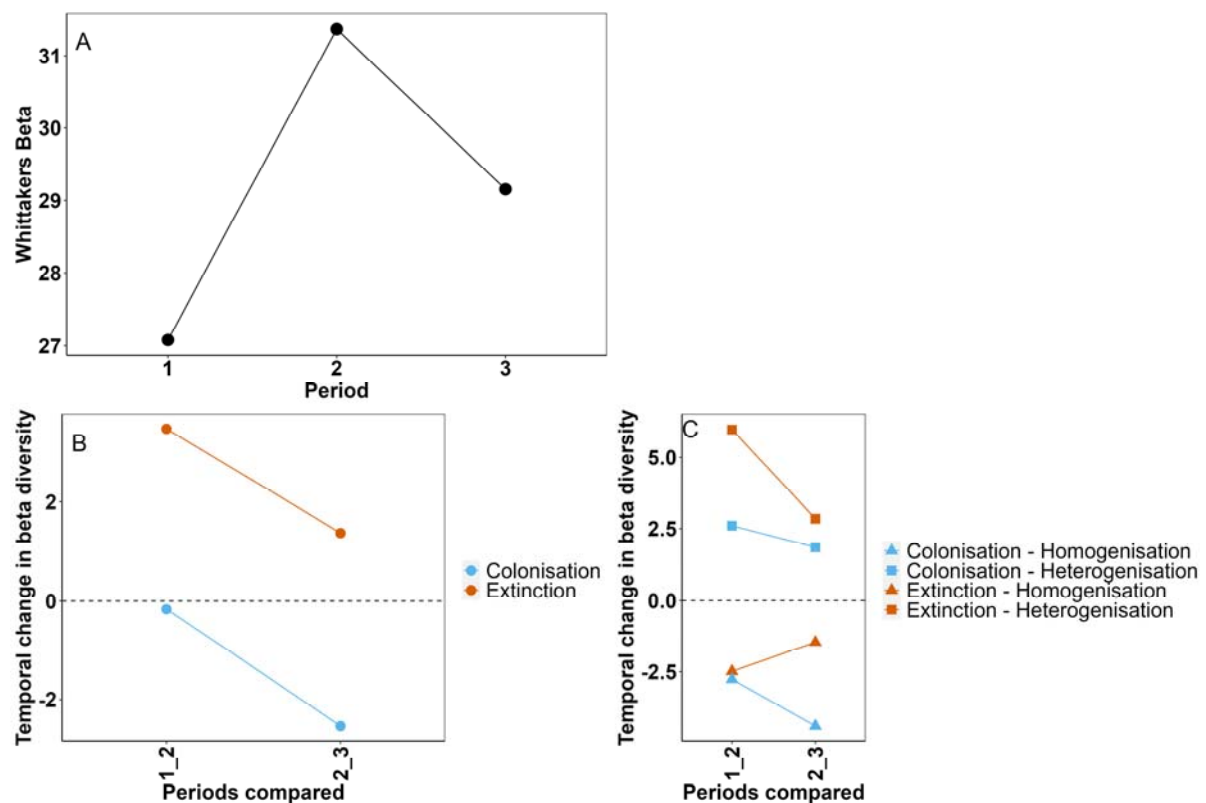
There was an overall increase in spatial differentiation among plant communities when aggregating vegetation plot data into two time periods (Whittaker's beta, Figure 8A). Partitioning of the temporal change in  $\beta$ -diversity revealed that extinction processes had more strongly contributed to spatial differentiation than colonisations (Figure 8B). This effect was emphasized by further partitioning showing that the contribution of extinctions to heterogenisation was much higher than the contributions of colonisation to homogenisation and heterogenisation, and the contribution of extinctions to homogenisation, respectively (Figure 8C).



**Figure 8 Analysis of changes in spatial  $\beta$ -diversity between two study periods. Spatial  $\beta$ -diversity (A), the contribution of colonisation and extinction to changes in spatial  $\beta$ -diversity (B), and colonisation and extinction resultant homogenisation and heterogenisation, respectively (C).**

Version 2: Aggregation of data into three periods (1995-2002, 2003-2010, 2011-2018)

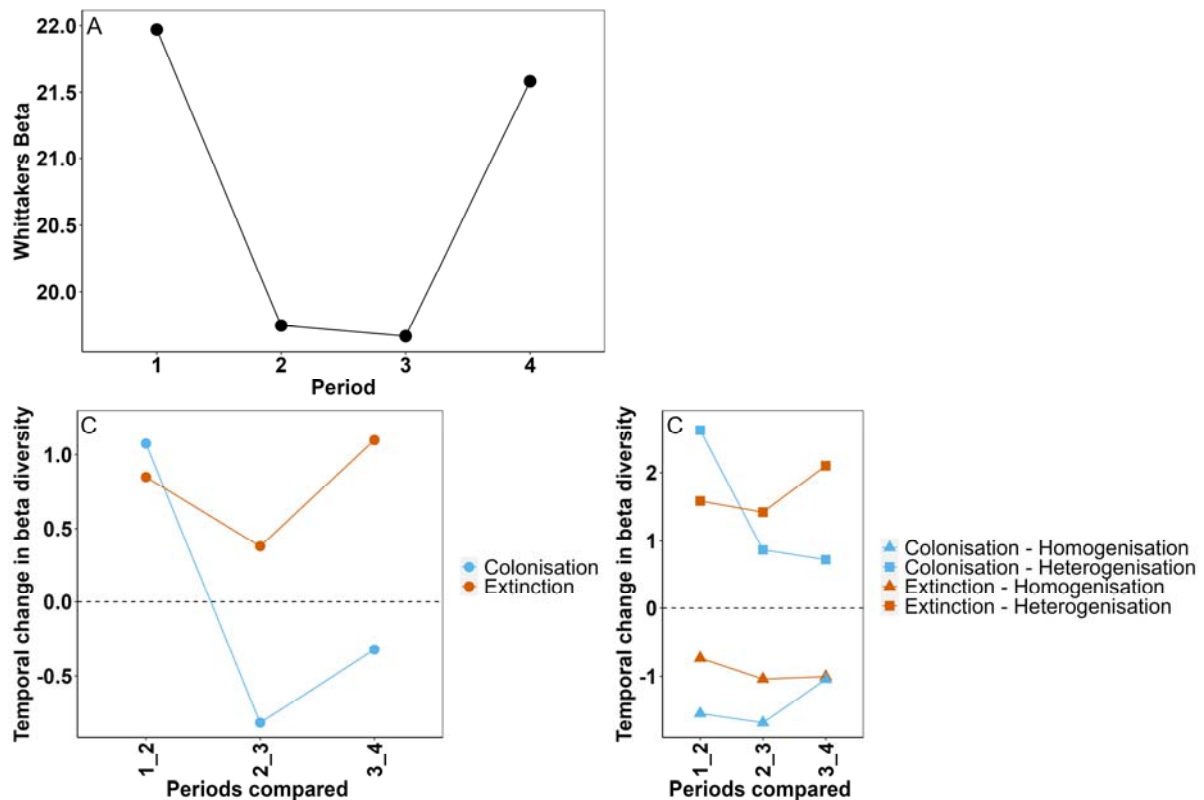
The aggregation of vegetation data into three periods considerably reduced the sample size (Table 1). Spatial differentiation between plant communities from 61 sites initially increased and then decreased again (Figure 9A). Changes between period 1 and 2 were more strongly determined by extinctions whereas colonisations dominated changes in community composition between periods 2 and 3 (Figure 9B). Extinctions contributed more strongly to heterogenisation than homogenisation between periods 1 and 2 and to a lesser extent between periods 2 and 3 (Figure 9C). The contribution of colonisations to homogenisation and heterogenisation was almost similar between periods 1 and 2 but strongly shifted towards homogenisation between periods 2 and 3.



**Figure 9 Analysis of changes in spatial  $\beta$ -diversity between three study periods. Spatial  $\beta$ -diversity (A), the contribution of colonisation and extinction to changes in spatial  $\beta$ -diversity (B), and colonisation and extinction resultant homogenisation and heterogenisation, respectively (C).**

Version 3: Aggregation of data into four periods (1995-2000, 2001-2006, 2007-2012, 2013-2018)

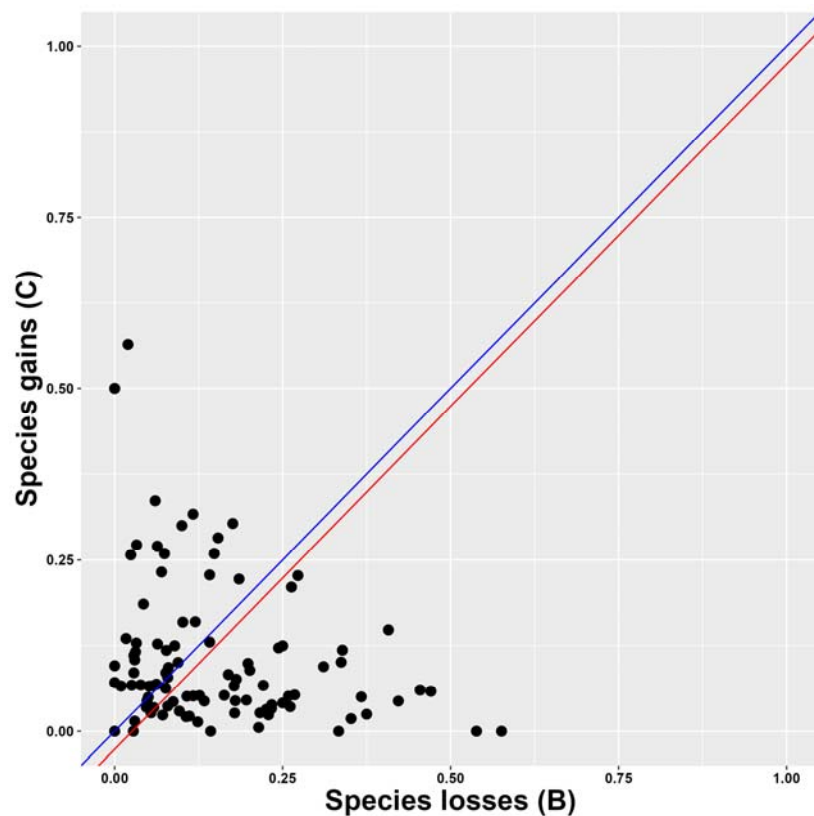
Aggregation of vegetation data into four periods showed more complex patterns in temporal change. Spatial differentiation between 32 plant communities first decreased between periods 1 and 2, remained constant between periods 2 and 3, and increased again between periods 3 and 4 (Figure 10A). Partition of changes showed that the importance of colonisations and extinctions considerably fluctuated over time whereby these fluctuations were more pronounced in colonisations (Figure 10B). While extinctions generally contributed strongly to the heterogenisation of plant communities than to homogenisation, the role of colonisations in these processes varied over time (Figure 10C).



**Figure 10** Analysis of changes in spatial  $\beta$ -diversity between four study periods. Spatial  $\beta$ -diversity (A), the contribution of colonisation and extinction to changes in spatial  $\beta$ -diversity (B), and colonisation and extinction resultant homogenisation and heterogenisation, respectively (C).

### *Temporal $\beta$ -diversity*

Dissimilarity in community composition between period 1 and 2 was separated in its species loss and gains component. Species losses contributed 58.2% to temporal dissimilarity and species gains 41.8%. There was considerable variation between sites with significantly more sites showing species losses than species gains (Figure 11,  $p < 0.05$ , paired t-test).



**Figure 11 B-C plot showing species losses and gains when comparing plant communities between period 1 and period 2. Species losses equal species gains at the blue line. The red line represents the centroid of all points. Its position below the blue line indicates that, on average, species losses dominate species gains.**

#### ***Relationship between temporal $\beta$ -diversity and environmental factors***

Species gains and losses between period 1 (1995-2006) and period 2 (2007-2018) were not related to changes in mean temperature at sites (Figure 12). Figure 13 indicates that sites with larger temperature change characterised both, species losses and gains to a similar extent. T

The species loss component was not related to changes in annual precipitation at sites between period 1 and period 2 ( $p=0.19$ , Figure 14A). However, the effect was not significant ( $p=0.19$ ). In contrast species gains were positively associated with increasing precipitation ( $p<0.05$ , Figure 14B). Figure 15 illustrates species losses and gains and their relationship to changes in precipitation.

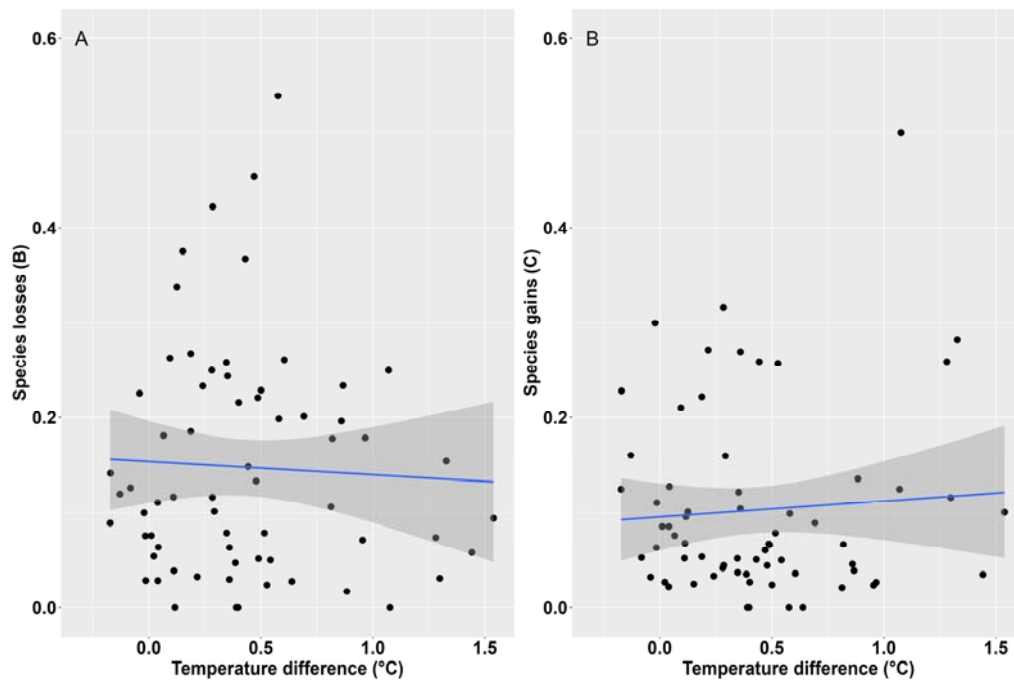


Figure 12 Relationship between temperature difference between period 1 and period 2 and species losses (A), and species gains (B), respectively. None of the relationships was statistically significant.

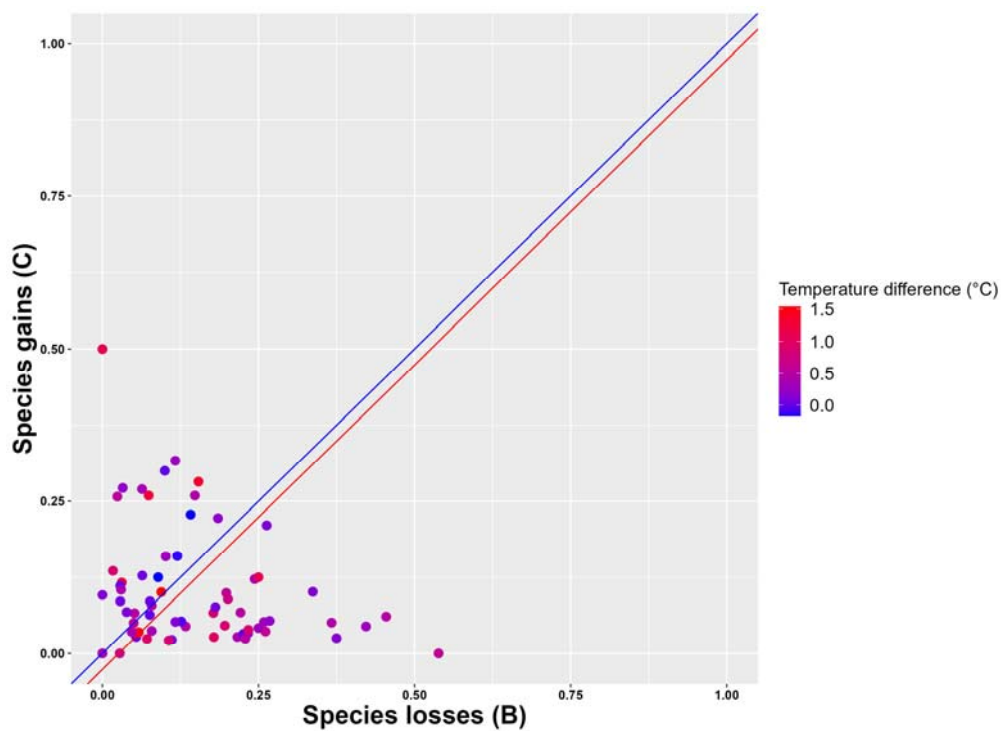
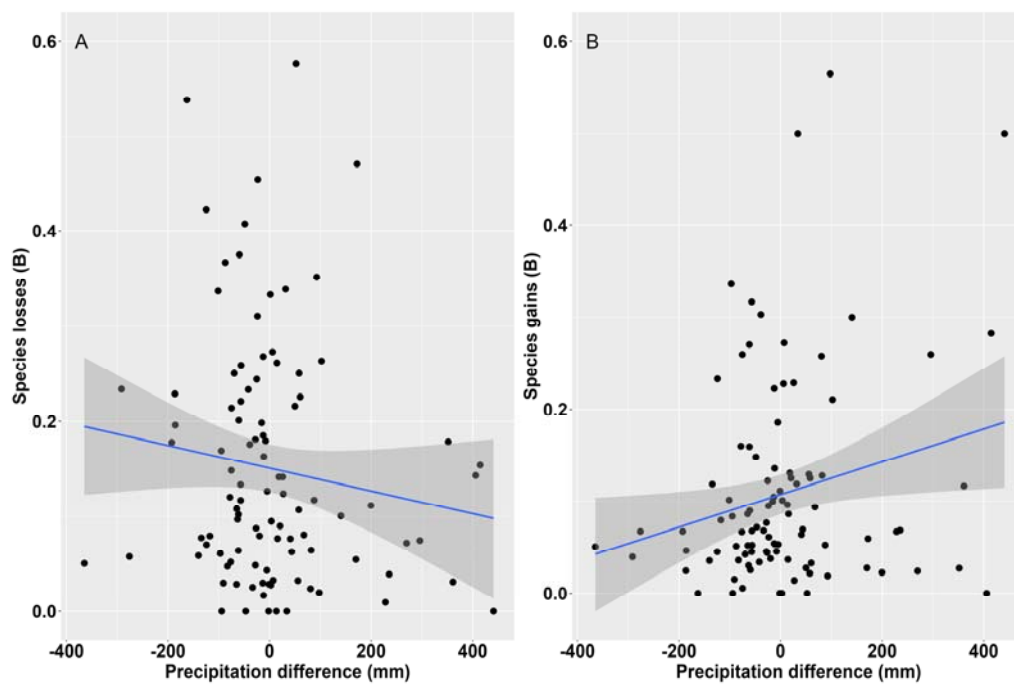
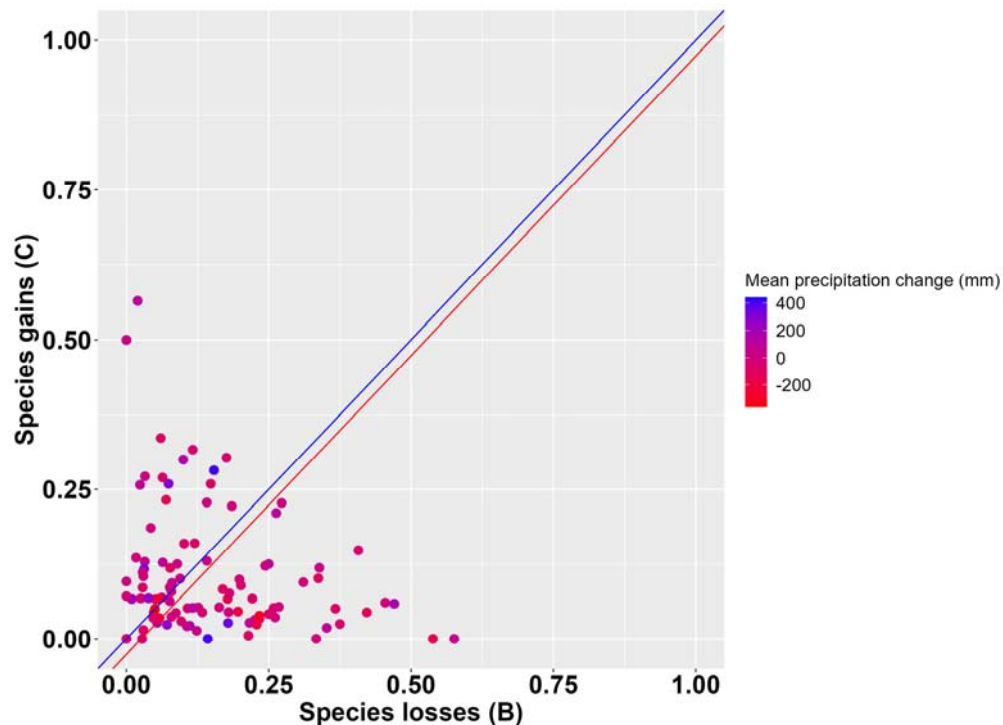


Figure 13 B/C plot illustrating the species losses and gains, and differences in mean temperature between period 1 and period 2. Sites showing the strongest increases in temperature are indicated in red.



**Figure 14** Relationship between precipitation difference between period 1 and period 2 and species losses (A), and species gains (B), respectively. Higher species losses were associated with decreasing precipitation and species gains were positively related to increasing precipitation among study periods ( $p < 0.05$ , linear models).



**Figure 15** B/C plot illustrating species losses and gains, and differences in annual precipitation between period 1 and period 2. Sites showing reductions in precipitation are indicated in red whereas sites where precipitation has increased are shown in blue.

## 2.4 Discussion and outlook

Changes in the composition of local communities are among the most pronounced components of biodiversity change (Dornelas et al. 2023). Here we investigated changes in community composition across time by analysing spatial and temporal  $\beta$ -diversity. We found an increase in spatial differentiation between plant communities over a time period of 24 years (1995-2018). This change in spatial differentiation was mainly driven by extinction and to a lesser extent by colonisations. The fact that extinctions resulted in a heterogenisation of plant communities is an indication of a stronger reduction of widespread species as compared to rare species (Tatsumi et al. 2021).

Species losses were also more dominant than species gains in shaping community differentiation over time. Preliminary analysis showed that changes in precipitation patterns between the periods 1995-2006 and 2007-2018 may be related to temporal changes in community composition. Both results show that so far, extinctions of species had a more pronounced effect on plant species composition than colonisations (incl. biological invasions).

The present case study is preliminary and has a number of limitations. For example, we had to aggregate the data into coarse time periods to keep the largest sample size possible. Increasing the temporal resolution resulted in considerably smaller datasets. Therefore, the results of the three versions of the analysis of spatial  $\beta$ -diversity cannot directly be compared. However, the results of versions 2 and 3 demonstrate that temporal changes in plant community composition and the underlying processes may occur within short time periods. Other limitations relate to differences in spatial study designs, habitats and methods. However, there are several options to further develop both types of analysis, depending on whether additional data will become available:

- Shifts in abundance are expected to become visible much faster than changes in species presence or absence. Both methods allow for the inclusion of species abundances (Legendre 2019, Tatsumi et al. 2022), potentially resulting in clearer temporal patterns. As abundances were only available for some of the vegetation data sets, we did not perform such an analysis.
- Changes in spatial  $\beta$ -diversity could be further partitioned into species components, i.e. species contributions to colonisation and extinction processes. By relating these species scores to biological traits, one could conclude possible causes and drivers of change.
- In the present analysis, we related site-specific scores for species gains and losses derived from the temporal  $\beta$ -diversity analysis to changes in mean annual temperature and annual precipitation. This type of analysis could be extended to other potential drivers known to influence plant community composition, e.g. maximum and minimum temperature, soil moisture and nitrogen inputs. By using in situ abiotic measurements from the sites, the explanatory power may be higher than compared to interpolated data sets with comparably low spatial accuracy.
- It would be beneficial to investigate differences in temporal changes in community composition between different habitat types. Accelerated changes may be expected in habitats susceptible to recurring natural or anthropogenic disturbances.
- The present analysis was carried out at the site level without considering spatial substructures of data collection. By including information on subplots in analyses of  $\beta$ -diversity it may be possible to account for the likely scale dependence of temporal patterns of community change.

### 3 Further development of the eLTER RI to benefit research on biodiversity change

One aim of the case study was to demonstrate the added value of harmonised time series for in-depth analyses of biodiversity change. This chapter summarises the experience of working with data from eLTER and provides suggestions on how to improve representativeness, data sampling procedures and data flows.

#### 3.1 Representativeness

Biodiversity time series that met the criteria for the inclusion in the present study cover 7 of the 11 main biogeographical zones in Europe. There are currently no time series from the Anatolian, Arctic, Steppic and Macaronesian biogeographical zones that are at least 10 years long. The number of sites within the individual zones varies considerably, as majority of data originates from the Atlantic and Alpine biogeographical zones (Table 2 in the appendix). In contrast, gaps are particularly apparent in the Continental biogeographical zone. Parts of the eastern Mediterranean zone and the Pannonian zone are also underrepresented.

The biodiversity surveys cover a wide taxonomic range. However, the representativeness of individual taxa is very limited. Only vegetation data are sufficiently represented in all relevant biogeographical zones (Figure 4). In contrast, other groups are scattered (e.g. fish) or concentrated in particular regions (e.g. mammals). Thus, the possibility to conduct large-scale and multi-taxa analyses is currently very limited. Conclusions on individual taxonomic groups can only be drawn for individual regions.

The temporal coverage of time series has only been evaluated in detail for vegetation. The majority covers a period of 20-30 years and is therefore, well suited to analyze recent biodiversity changes. However, many data sets are incomplete or have a low survey frequency. These gaps limit the choice of possible methods. For example, the case study on  $\beta$ -diversity requires data input for each site and time period. Such complete time  $\times$  site combinations can only be obtained by temporal aggregation of the data. There is a trade-off between the number of samples (and thus the spatial representativeness) and the temporal resolution. Studies that require a high sampling frequency, e.g. studying the impacts of extreme events, can only be conducted on a limited number of sites. Extending the spatial coverage is only possible at the cost of a low temporal resolution, and thus, only long-term and gradual changes can be analyzed at the European scale.

#### 3.2 Reflection on eLTER Standard Observations

Plot-based vegetation surveys have been proposed as an eLTER Standard Observation (SOBIO\_004 – Vegetation composition – plot scale, see Zacharias et al. 2022). However, the exact method is still under discussion. For forests, the adoption of the ICP forests protocol (Canullo et al. 2020) has been discussed as a possible option. This would insure interoperability with a large network. The fact that many LTER sites are already part of the ICP-forests program would be an additional argument for using this protocol. When using alternative protocols attention should be focused on interoperability. It might, though, be better to allow several protocols for collecting vegetation data and ensure that consistent protocols allow post-hoc standardisation. In particular the preferred scales for abundance measurements should be convertible into other commonly used cover/abundance scales. Some legacy data sets used in the present study only contain presence/ absence data. To be able to detect more subtle vegetation changes, abundance measurements should be mandatory.

For ICP forests Level II plots a sampling frequency of 5 years is prescribed. However, a yearly assessment is recommended to better separate short-term fluctuations from long-term trends. Ecosystem processes are increasingly influenced by extreme events and the occurrence of such events

is likely to increase in the future (Rahmsdorf and Coumou 2011, Mahecha et al. 2022). High sampling frequencies are required to fully capture their impacts. Therefore, intensive sampling should be carried out at least at highly equipped eLTER sites that are intended to enable the Whole Systems Approach. Increasing sampling frequency would also minimize the problem of lack of synchrony between time series that was encountered in the present case study.

As shown in chapter 2.2 not all main biogeographical zones are sufficiently covered by vegetation surveys. Likewise, there is a bias towards forested sites whereas other habitat types are underrepresented. To increase representativity and to be able to perform analyses both on the continental and regional scales, the above-mentioned gaps should be filled. This could be achieved by either setting up new surveys at eLTER sites or by establishing partnerships with other networks (co-location, co-design of sites).

### 3.3 IT services

#### 3.3.1 Metadata

The site and dataset registry DEIMS (<https://deims.org/>) provides a tool for obtaining general information on datasets available from eLTER sites. By using the keyword search or the R package ReLTER (Oggioni et al. 2023) this information can be queried and accessed. However, much of the metadata information is still hidden in the datasets or must be retrieved from verbal descriptions. Metadata should be further standardized and expanded to enable more specific queries, e.g. filtering time periods. For many datasets, essential metadata are missing, e.g. explanations of spatial plot structures, species reference lists and habitats. Future data collections from the LTER- network should not only provide templates but also tools that enable site managers to check the completeness of information before submitting datasets to central eLTER data services.

#### 3.3.2 Data acquisition

Data collection for the eLTER Biodiversity loss science case was largely file-based. To standardize the data acquisition process templates were provided by the eLTER PLUS project (Peterseil and Geiger 2020). Despite these efforts the submitted data sets were very heterogeneous and, in some cases, could only be made usable for the analysis with large effort. Future data acquisition should take the following aspects into account:

- Templates should be further developed to facilitate their use by site managers. A protocol needs to be developed on how to handle essential dataset-specific information that is currently not covered by the eLTER data specification, e. g. information on experimental treatments within the survey plots.
- An upload system for file-based data with integrated quality checks (structure, missing information, formats of variables) would secure data quality and facilitate subsequent data storage and handling.
- Versioning: datasets will be updated in the future or maybe changed for other reasons. To ensure repeatability of science it is necessary to trace which data have been used for a particular analysis.
- Interfaces: data transfers from other networks such as ICP forests should not be file-based but implemented using interfaces. In this way, the query and use of the latest data versions by end users will be secured.
- Databases: From a user's perspective file-based data compilations are complex and require additional work before they can be used for analysis. Storing data in databases and making them searchable and accessible via user interfaces would facilitate multiple uses of data by the scientific community. Data bases would also provide possibilities to develop data entry

systems, e.g. through mobile apps. Such systems would benefit sites with limited capacities to develop their own infrastructures for data management.

There are already tools that have been developed to facilitate the compilation of biodiversity data from heterogeneous sources (e.g. O'Brien et al. 2021). It should be evaluated whether such existing tools can be used or adapted to solve problems related to data compilation within eLTER.

### 3.3.3 Quality control

Quality issues related to the data submission process and possible solutions have already been discussed in chapter 3.3.2. While working with the eLTER biodiversity data various types of errors were encountered:

- Incorrect coordinates for sites and plots
- Incorrect time
- Typing errors in species names and other entries
- Double data entries

Not all of the errors can be identified by automatic procedures during data entry or beyond, but become apparent during data handling and analysis by the end users. For these types of errors, a workflow and tools for providing feedback should be developed. Ideally, data owners would receive structured reports on data issues. On this basis issues in the basic data could be solved and corrected versions of datasets could be provided to the central eLTER data services.

### 3.3.4 Harmonisation of variables

For the present case study, taxonomic harmonisation of species names was performed based on the GBIF backbone taxonomy and by using an internally developed R-script. There are also alternative tools available (Grenié et al. 2022). Ideally, taxonomic harmonisation procedures should be implemented in the central eLTER data services. Other variables that may be harmonised before they are made available to end users, e.g. abundances measures and coding of layers in vegetation time series.

### 3.3.5 Links to other data sources

Analysing the causes and impacts of biodiversity change requires the collection and preparation of data from multiple sources, e.g. climate data, landcover data and other remote sensing products, and trait data. This time-consuming process could be facilitated by providing tools to targeted queries and download the necessary data. Ideally, central eLTER data services would provide interfaces to retrieve site-specific data from external large-scale data sets, e.g. the E-OBS daily gridded observational datasets for precipitation and temperature (Cornes et al. 2018) used in the present case study. Respective solutions should be implemented into tools for data integration such as the eLTER cookie cutter.

## 4 Acknowledgements

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## 6 Appendix: Information on available biodiversity time series

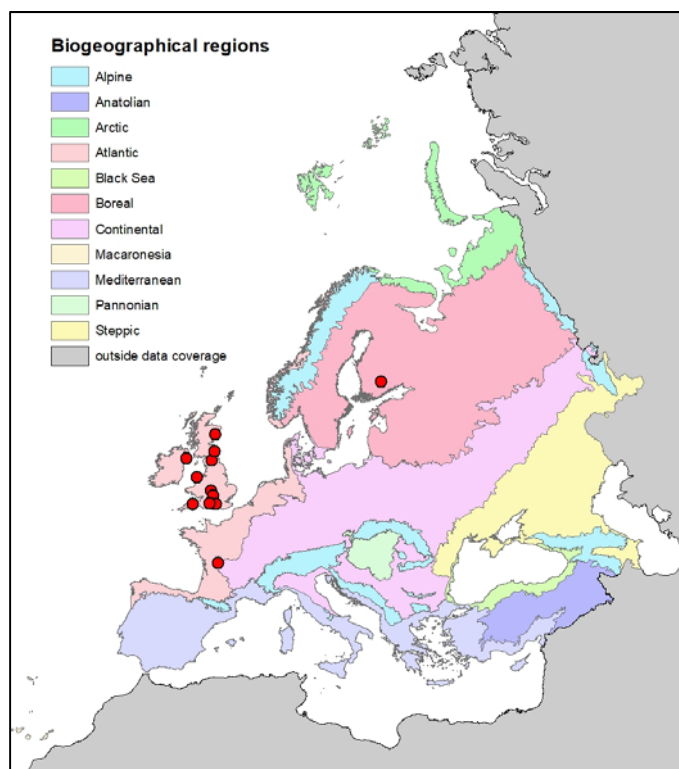


Figure 16 Distribution of mammal time series across Europe.

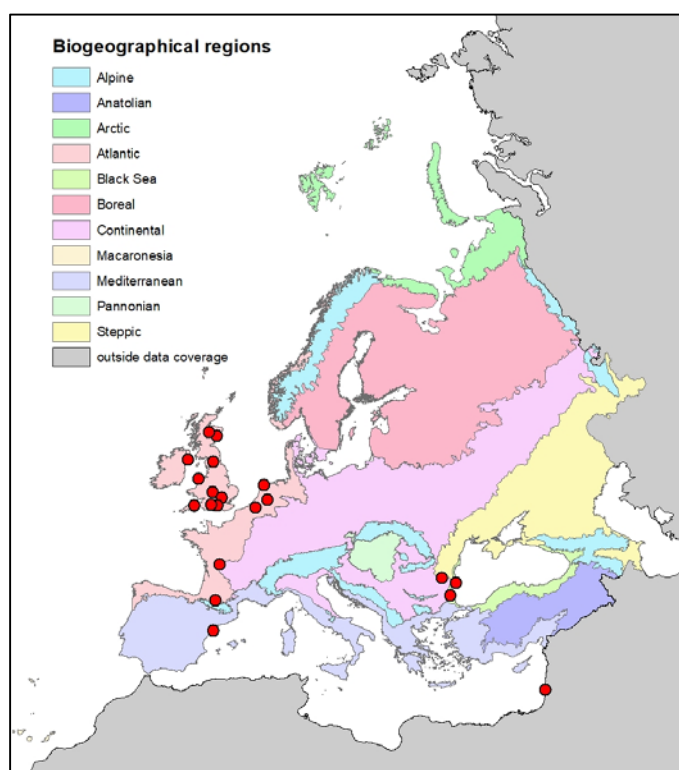


Figure 17 Distribution of bird time series across Europe.

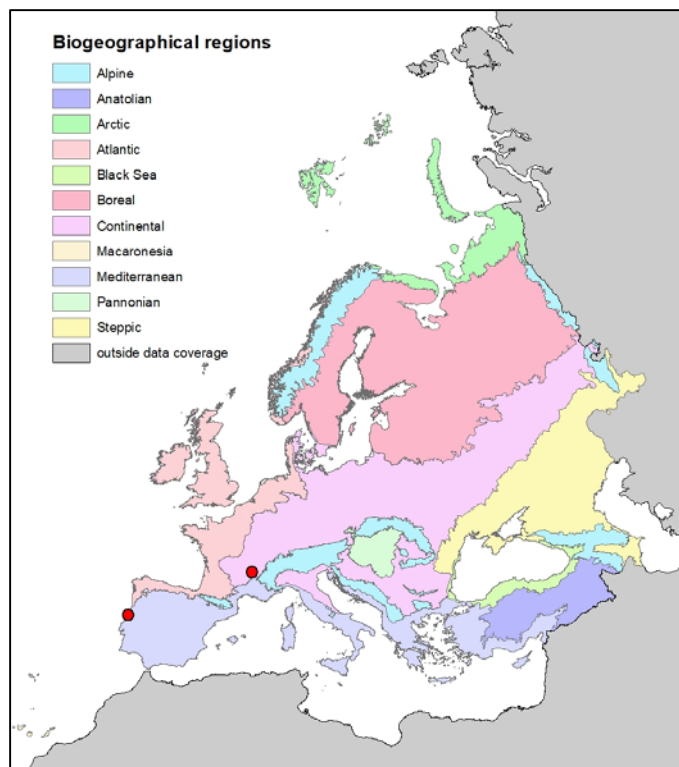


Figure 18 Distribution of fish time series across Europe.

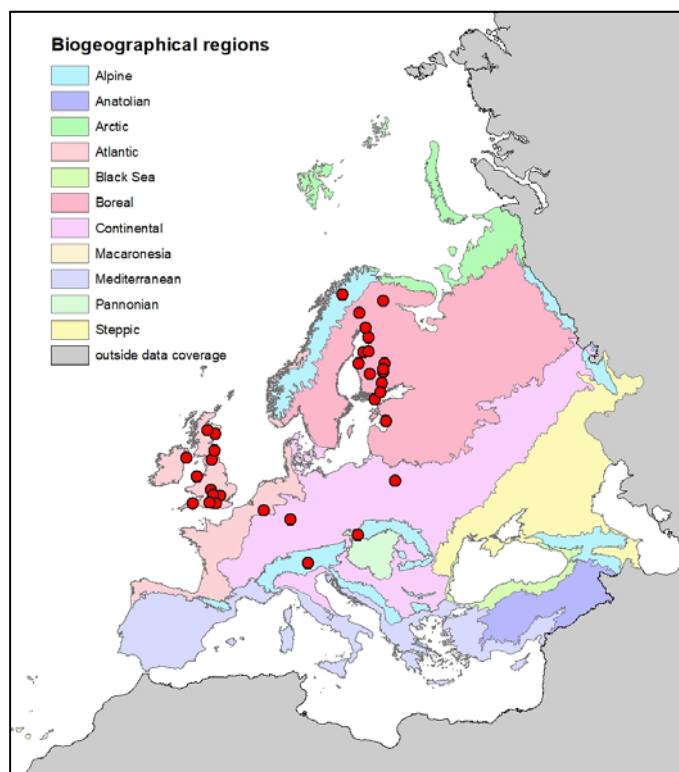


Figure 19 Distribution of terrestrial invertebrates time series across Europe.

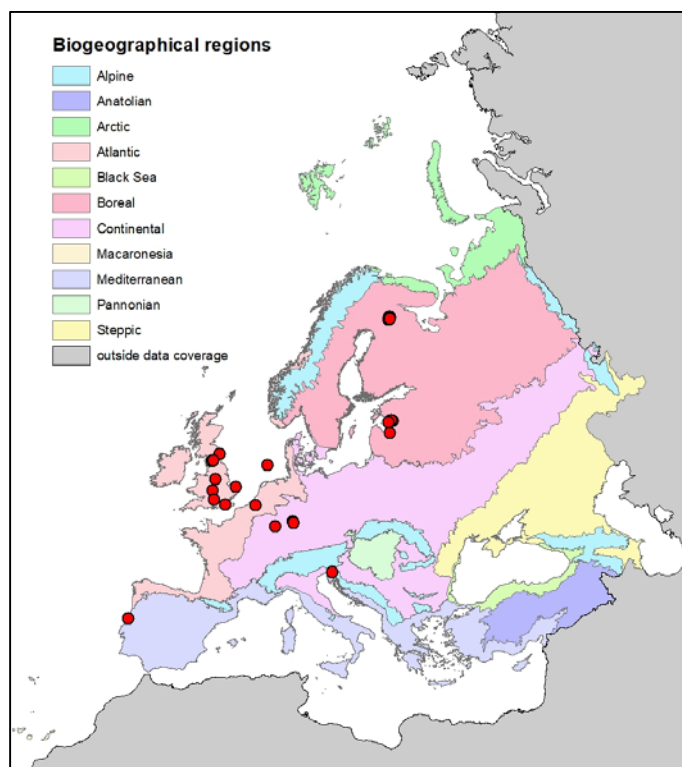


Figure 20 Distribution of aquatic invertebrates time series across Europe

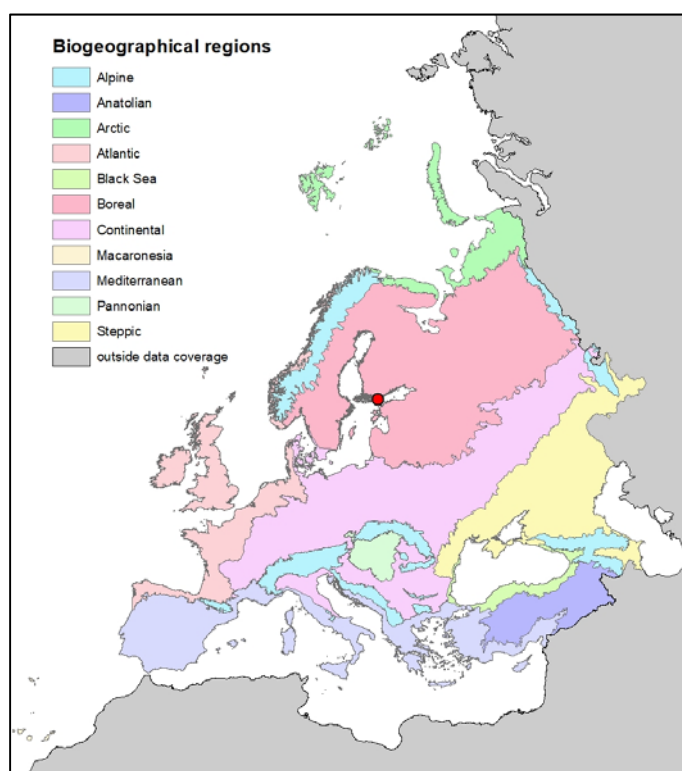


Figure 21 Distribution of marine invertebrates time series across Europe.

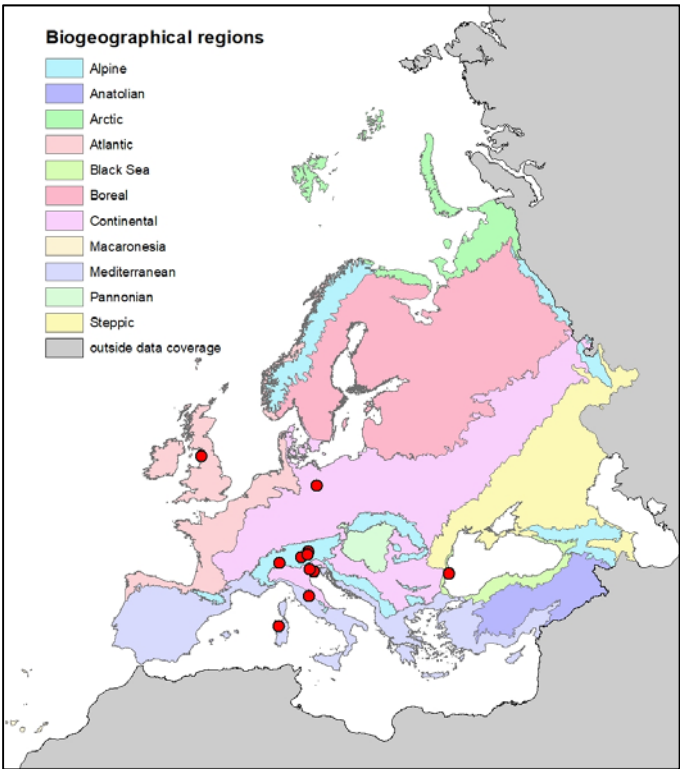


Figure 22 Distribution of plankton time series across Europe.

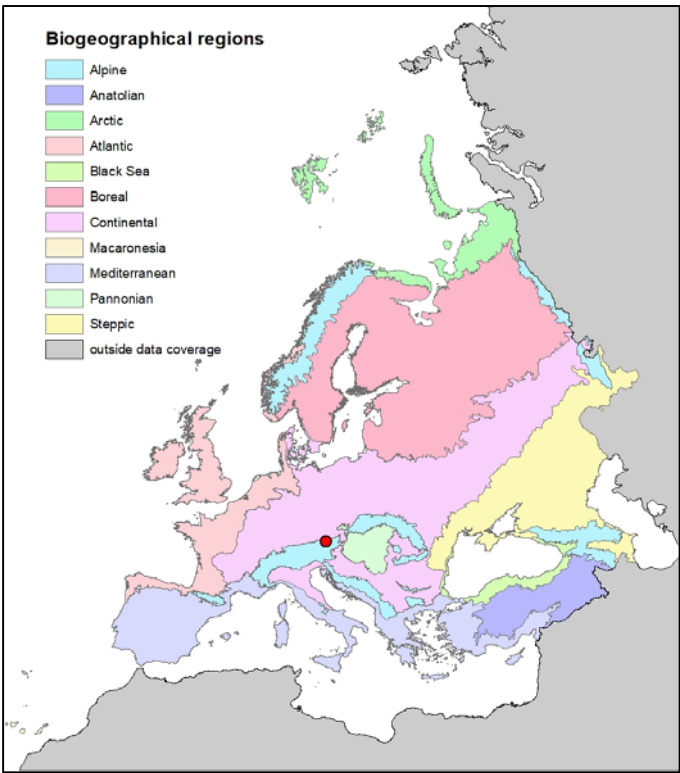
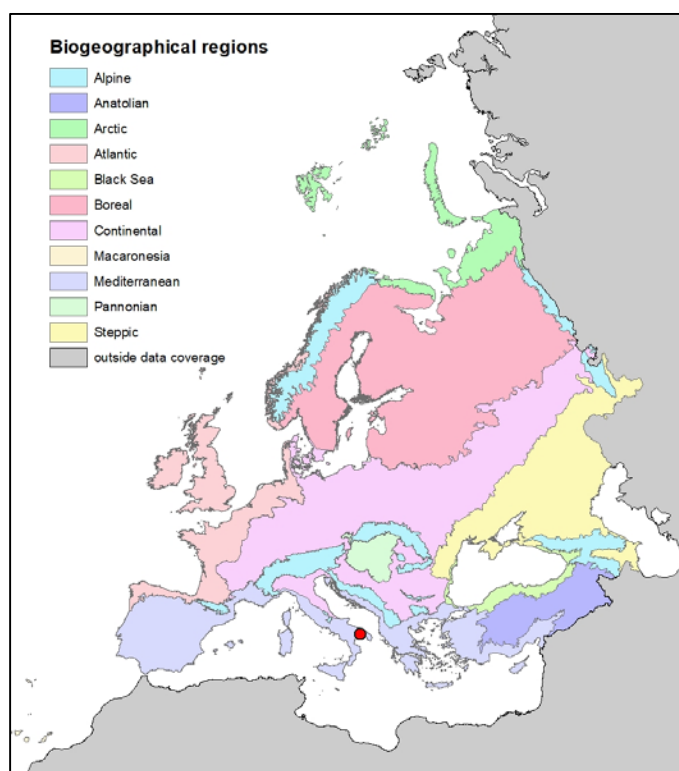


Figure 23 Distribution of fungi time series across Europe.



**Figure 24 Distribution of benthic algae time series across Europe.**

**Table 2 Availability of time series >10 years per Biogeographical region.**

Biogeographical region	ALL	MM	BI	FI	TI	AI	MI	PT	FU	BA	VE
Alpine	36				3	1		4	1		27
Anatolian											
Arctic											
Atlantic	97	11	15		34	11		1			25
Black Sea	3		2					1			
Boreal	40	1			15	14					10
Continental	42		1	1	2	4		4			30
Macaronesia											
Mediterranean	21		1	1		1		2		1	15
Pannonian	1										1
Steppic											
Outside	1		1								

Abbreviations: ALL – all biodiversity data sets, MM – mammals, BI – birds, FI – fish, TI – terrestrial invertebrates, AI – aquatic invertebrates, MI – marine invertebrates, PT – plankton, FU, BA – benthic algae, VE – vegetation

**Table 3 Overview on vegetation datasets**

ID	Country code	Site code	Site DEIMS ID
166	AT	<a href="https://deims.org/3de1057c-a364-44f2-8a2a-350d21b58ea0">https://deims.org/3de1057c-a364-44f2-8a2a-350d21b58ea0</a>	Obergurgl - Austria
220	AT	<a href="https://deims.org/8eda49e9-1f4e-4f3e-b58e-e0bb25dc32a6">https://deims.org/8eda49e9-1f4e-4f3e-b58e-e0bb25dc32a6</a>	LTER Zöbelboden - Austria
232	AT	<a href="https://deims.org/4ac03ec3-39d9-4ca1-a925-b6c1ae80c90d">https://deims.org/4ac03ec3-39d9-4ca1-a925-b6c1ae80c90d</a>	Hochschwab (AT-HSW) GLORIA - Austria
233	AT	<a href="https://deims.org/6ae2f712-9924-4d9c-b7e1-3ddffb30b8f1">https://deims.org/6ae2f712-9924-4d9c-b7e1-3ddffb30b8f1</a>	GLORIA Master Site Schrankogel (AT-SCH), Stubaier Alpen - Austria
58	BE	<a href="https://deims.org/68e6a8e5-d6d2-4c8c-91c4-10e7f87ac556">https://deims.org/68e6a8e5-d6d2-4c8c-91c4-10e7f87ac556</a>	Brasschaat - De Inslag - Belgium
59	BE	<a href="https://deims.org/0fa0d44f-5314-405f-a647-a7dda423031f">https://deims.org/0fa0d44f-5314-405f-a647-a7dda423031f</a>	Sonian Forest - Belgium
283	BE	<a href="https://deims.org/de287b65-5e6c-46ce-87da-ce0c14651fe1">https://deims.org/de287b65-5e6c-46ce-87da-ce0c14651fe1</a>	Willerzie - Belgium
284	BE	<a href="https://deims.org/528b643b-c189-4947-9e3f-f474a9159d68">https://deims.org/528b643b-c189-4947-9e3f-f474a9159d68</a>	Dochamps - Belgium
285	BE	<a href="https://deims.org/c9cf7c25-b4fa-4756-b731-da85a9f00e28">https://deims.org/c9cf7c25-b4fa-4756-b731-da85a9f00e28</a>	Mellier - Belgium
286	BE	<a href="https://deims.org/5322912e-bd69-4cda-91b7-e7a9e45c782a">https://deims.org/5322912e-bd69-4cda-91b7-e7a9e45c782a</a>	Baelen - Belgium
287	BE	<a href="https://deims.org/b2c68241-ba08-48df-809a-c6aa15af85b1">https://deims.org/b2c68241-ba08-48df-809a-c6aa15af85b1</a>	Tellin - Belgium
288	BE	<a href="https://deims.org/06e97a1e-2eb7-4ab1-8cc9-321aebf125d2">https://deims.org/06e97a1e-2eb7-4ab1-8cc9-321aebf125d2</a>	Ruette - Belgium
289	BE	<a href="https://deims.org/3405b268-4c07-42d1-af5d-f10df316cbd8">https://deims.org/3405b268-4c07-42d1-af5d-f10df316cbd8</a>	Chimay - Belgium
290	BE	<a href="https://deims.org/42ae4e04-c4de-4727-a96d-264bafc729d7">https://deims.org/42ae4e04-c4de-4727-a96d-264bafc729d7</a>	Louvain-la-Neuve - Belgium
291	BE	<a href="https://deims.org/5cdc558b-a0bc-4150-b8d1-8dd55870c7e8">https://deims.org/5cdc558b-a0bc-4150-b8d1-8dd55870c7e8</a>	Ichtegem - Wijnendale Forest - Belgium
292	BE	<a href="https://deims.org/7629b584-b8dd-4da5-a4ba-4175bb985673">https://deims.org/7629b584-b8dd-4da5-a4ba-4175bb985673</a>	Dijleland - Belgium
72	CH	<a href="https://deims.org/9e1c8ec8-a407-426a-8410-05180b96e75a">https://deims.org/9e1c8ec8-a407-426a-8410-05180b96e75a</a>	LWF Alptal - Switzerland
73	CH	<a href="https://deims.org/f6a6b3e0-9a39-4fe3-8ae5-24d833b8ad26">https://deims.org/f6a6b3e0-9a39-4fe3-8ae5-24d833b8ad26</a>	LWF Beatenberg - Switzerland
74	CH	<a href="https://deims.org/c30ed2e5-41b0-4f2b-992c-2bd96b3cdba1">https://deims.org/c30ed2e5-41b0-4f2b-992c-2bd96b3cdba1</a>	LWF Bettlachstock - Switzerland
75	CH	<a href="https://deims.org/8cb52b19-4720-4212-90f0-599375219c5b">https://deims.org/8cb52b19-4720-4212-90f0-599375219c5b</a>	LWF Celerina - Switzerland
76	CH	<a href="https://deims.org/b8c789be-5fa5-42cc-b280-6e1a2b73639b">https://deims.org/b8c789be-5fa5-42cc-b280-6e1a2b73639b</a>	LWF Chironico - Switzerland
77	CH	<a href="https://deims.org/06af0bf1-7ddf-40c8-b4b8-d3602c1f9599">https://deims.org/06af0bf1-7ddf-40c8-b4b8-d3602c1f9599</a>	LWF Isona - Switzerland
78	CH	<a href="https://deims.org/fa36576a-6409-41d4-96ae-67f2a3d7e085">https://deims.org/fa36576a-6409-41d4-96ae-67f2a3d7e085</a>	LWF Jussy - Switzerland
79	CH	<a href="https://deims.org/e60f9991-daf7-448c-9b78-44b00be86f6d">https://deims.org/e60f9991-daf7-448c-9b78-44b00be86f6d</a>	LWF Lausanne - Switzerland
80	CH	<a href="https://deims.org/dda5ccfa-3fd3-447c-bf61-08a02a3d8374">https://deims.org/dda5ccfa-3fd3-447c-bf61-08a02a3d8374</a>	LWF Lens - Switzerland

ID	Country code	Site code	Site DEIMS ID
81	CH	<a href="https://deims.org/02ebdc77-d35c-4e19-ad7b-31a65885e7df">https://deims.org/02ebdc77-d35c-4e19-ad7b-31a65885e7df</a>	LWF Nationalpark - Switzerland
82	CH	<a href="https://deims.org/e7c82a90-eee2-4e42-b90d-c0531a59e306">https://deims.org/e7c82a90-eee2-4e42-b90d-c0531a59e306</a>	LWF Neunkirch - Switzerland
83	CH	<a href="https://deims.org/27988972-7e28-4fc2-a5e0-8d30d0f5dabd">https://deims.org/27988972-7e28-4fc2-a5e0-8d30d0f5dabd</a>	LWF Novaggio - Switzerland
84	CH	<a href="https://deims.org/9d082cc6-3282-4469-8d7b-05fa3e13489a">https://deims.org/9d082cc6-3282-4469-8d7b-05fa3e13489a</a>	LWF Othmarsingen - Switzerland
85	CH	<a href="https://deims.org/f5f1ceef-2fda-40a0-8e00-4ed9ea002f0f">https://deims.org/f5f1ceef-2fda-40a0-8e00-4ed9ea002f0f</a>	LWF Visp - Switzerland
86	CH	<a href="https://deims.org/064c3ef6-5aa5-4c91-bfb5-e3e07fa17059">https://deims.org/064c3ef6-5aa5-4c91-bfb5-e3e07fa17059</a>	LWF Vordemwald - Switzerland
167	CH	<a href="https://deims.org/049de4d9-d7db-4b2c-ace5-de8873f5d277">https://deims.org/049de4d9-d7db-4b2c-ace5-de8873f5d277</a>	Schaenis - Switzerland
88	DE	<a href="https://deims.org/8e24d4f8-d6f6-4463-83e9-73cac2fd3f38">https://deims.org/8e24d4f8-d6f6-4463-83e9-73cac2fd3f38</a>	Lange Bramke - Germany
89	DE	<a href="https://deims.org/2d55b484-2a89-4023-be00-49829ab327f9">https://deims.org/2d55b484-2a89-4023-be00-49829ab327f9</a>	Solling - Germany
171	DE	<a href="https://deims.org/270a41c4-33a8-4da6-9258-2ab10916f262">https://deims.org/270a41c4-33a8-4da6-9258-2ab10916f262</a>	AgroScapeLab Quillow (ZALF) - Germany
172	DE	<a href="https://deims.org/bb3f045e-33fe-48ca-9142-1d6b94fb8f9a">https://deims.org/bb3f045e-33fe-48ca-9142-1d6b94fb8f9a</a>	Augustendorf intensive forest monitoring site - Germany
173	DE	<a href="https://deims.org/2aedc444-7007-4d07-877c-0abf528b0ecd">https://deims.org/2aedc444-7007-4d07-877c-0abf528b0ecd</a>	Bornhoeved Lake District - Germany
176	DE	<a href="https://deims.org/8849988d-762f-475b-98d6-ab08b29645ab">https://deims.org/8849988d-762f-475b-98d6-ab08b29645ab</a>	Ehrhorn intensive monitoring site - Germany
177	DE	<a href="https://deims.org/a4294831-1a8e-4f0a-9d3b-e0305ec6fe42">https://deims.org/a4294831-1a8e-4f0a-9d3b-e0305ec6fe42</a>	Göttinger Wald intensive forest monitoring site - Germany
179	DE	<a href="https://deims.org/050e88fa-06e7-43e5-8dcc-6b75a549cb09">https://deims.org/050e88fa-06e7-43e5-8dcc-6b75a549cb09</a>	Luess intensive monitoring site - Germany
298	DK	<a href="https://deims.org/c9736cb4-7276-48db-86e4-23cf8dcba6bf">https://deims.org/c9736cb4-7276-48db-86e4-23cf8dcba6bf</a>	Vestskoven - Denmark
91	ES	<a href="https://deims.org/829a2bcc-79d6-462f-ae2c-13653124359d">https://deims.org/829a2bcc-79d6-462f-ae2c-13653124359d</a>	Ordesa y Monte Perdido / Huesca ES - Spain
300	ES	<a href="https://deims.org/6b5ea4b7-c31d-4418-9dd5-233188df1114">https://deims.org/6b5ea4b7-c31d-4418-9dd5-233188df1114</a>	Spanish ICP-Forests Level II Plots Network (Plot code 05 Ps) - Spain
301	ES	<a href="https://deims.org/8f6ff47e-046b-468b-b4b9-472f5fd025d4">https://deims.org/8f6ff47e-046b-468b-b4b9-472f5fd025d4</a>	Spanish ICP-Forests Level II Plots Network (Plot code 06 Qi) - Spain
302	ES	<a href="https://deims.org/f1f781c4-0745-4086-86ee-0bb122f59637">https://deims.org/f1f781c4-0745-4086-86ee-0bb122f59637</a>	Spanish ICP-Forests Level II Plots Network (Plot code 07 Qi) - Spain
303	ES	<a href="https://deims.org/52cc849a-2fd1-491d-a298-9bf3db884b88">https://deims.org/52cc849a-2fd1-491d-a298-9bf3db884b88</a>	Spanish ICP-Forests Level II Plots Network (Plot code 10 Ppa) - Spain
304	ES	<a href="https://deims.org/82a80c17-91b2-4e0d-8250-af97bcc20261">https://deims.org/82a80c17-91b2-4e0d-8250-af97bcc20261</a>	Spanish ICP-Forests Level II Plots Network (Plot code 11 Qs) - Spain
305	ES	<a href="https://deims.org/ce3205f5-c3ed-4828-a279-ca0ccac5182">https://deims.org/ce3205f5-c3ed-4828-a279-ca0ccac5182</a>	Spanish ICP-Forests Level II Plots Network (Plot code 22 Pn) - Spain
306	ES	<a href="https://deims.org/846d8978-bd67-43db-843e-c3568c40b088">https://deims.org/846d8978-bd67-43db-843e-c3568c40b088</a>	Spanish ICP-Forests Level II Plots Network (Plot code 25 Ph) - Spain
307	ES	<a href="https://deims.org/101534e3-569e-43db-867c-6dd3689f6975">https://deims.org/101534e3-569e-43db-867c-6dd3689f6975</a>	Spanish ICP-Forests Level II Plots Network (Plot code 26 Qi) - Spain
308	ES	<a href="https://deims.org/0534178f-c40e-4247-9e34-fd174c6709f8">https://deims.org/0534178f-c40e-4247-9e34-fd174c6709f8</a>	Spanish ICP-Forests Level II Plots Network (Plot code 30 Ps) - Spain
309	ES	<a href="https://deims.org/bce69205-cc4d-4428-be30-c47274eee024">https://deims.org/bce69205-cc4d-4428-be30-c47274eee024</a>	Spanish ICP-Forests Level II Plots Network (Plot code 33 Qpe) - Spain

ID	Country code	Site code	Site DEIMS ID
310	ES	<a href="https://deims.org/edc104bd-a710-42dc-902e-2f8401004d95">https://deims.org/edc104bd-a710-42dc-902e-2f8401004d95</a>	Spanish ICP-Forests Level II Plots Network (Plot code 37 Ppr) - Spain
312	ES	<a href="https://deims.org/50374ba1-d524-4396-bd2f-a6270e7d9af8">https://deims.org/50374ba1-d524-4396-bd2f-a6270e7d9af8</a>	Spanish ICP-Forests Level II Plots Network (Plot code 102 Ppr) - Spain
236	FI	<a href="https://deims.org/663dac80-211d-4c19-a356-04ee0da0f0eb">https://deims.org/663dac80-211d-4c19-a356-04ee0da0f0eb</a>	Hyytiälä SMEAR II LTER - Finland
237	FI	<a href="https://deims.org/a43d31c8-6219-4ab8-ac41-6088cb56b12b">https://deims.org/a43d31c8-6219-4ab8-ac41-6088cb56b12b</a>	Lammi LTER - Finland
111	HU	<a href="https://deims.org/c7a1d72c-7296-49e7-813a-890a11cf0ae9">https://deims.org/c7a1d72c-7296-49e7-813a-890a11cf0ae9</a>	Kiskun Restoration Experiments, KISKUN LTER - Hungary
113	IT	<a href="https://deims.org/c0738b00-854c-418f-8d4f-69b03486e9fd">https://deims.org/c0738b00-854c-418f-8d4f-69b03486e9fd</a>	Appennino centrale: Gran Sasso d'Italia - Italy
114	IT	<a href="https://deims.org/68a5673c-9172-48cc-88e5-b9408b203309">https://deims.org/68a5673c-9172-48cc-88e5-b9408b203309</a>	Val Masino LOM1 - Italy
115	IT	<a href="https://deims.org/9b1d144a-dc37-4b0e-8cda-1dda1d7667da">https://deims.org/9b1d144a-dc37-4b0e-8cda-1dda1d7667da</a>	Collelongo-Selva Piana ABR1 - Italy
116	IT	<a href="https://deims.org/d35d5417-d167-4137-97d1-c62ae4bc580b">https://deims.org/d35d5417-d167-4137-97d1-c62ae4bc580b</a>	Piano Limina CAL1 - Italy
117	IT	<a href="https://deims.org/05e96829-e64a-48d3-a96d-de2aa4cde146">https://deims.org/05e96829-e64a-48d3-a96d-de2aa4cde146</a>	Monte Rufeno LAZ1 - Italy
118	IT	<a href="https://deims.org/fdd9b462-d2a9-441a-80a1-f4e8947f5577">https://deims.org/fdd9b462-d2a9-441a-80a1-f4e8947f5577</a>	Colognole TOS1 - Italy
189	IT	<a href="https://deims.org/c85fc568-df0c-4cbc-bd1e-02606a36c2bb">https://deims.org/c85fc568-df0c-4cbc-bd1e-02606a36c2bb</a>	Appennino centro-meridionale: Majella-Matese - Italy
192	IT	<a href="https://deims.org/1835cda2-b56d-400a-b413-ab5c74086dc5">https://deims.org/1835cda2-b56d-400a-b413-ab5c74086dc5</a>	Foce Trigno-Marina di Petacciato (Campobasso) - Italy
281	IT	<a href="https://deims.org/088fe3af-c5bb-4cc8-b479-fe1ea6d5be80">https://deims.org/088fe3af-c5bb-4cc8-b479-fe1ea6d5be80</a>	Foce Saccione-Bonifica Ramitelli (Campobasso) - Italy
293	IT	<a href="https://deims.org/5907d0b6-7b4d-4260-a669-4bc0f61d1696">https://deims.org/5907d0b6-7b4d-4260-a669-4bc0f61d1696</a>	Tarvisio FRI2 - Italy
294	IT	<a href="https://deims.org/ec2bba9a-365f-45d8-9e0d-229de0f41332">https://deims.org/ec2bba9a-365f-45d8-9e0d-229de0f41332</a>	Ficuzza SIC1 - Italy
296	IT	<a href="https://deims.org/5d32cbf8-ab7c-4acb-b29f-600fec830a1d">https://deims.org/5d32cbf8-ab7c-4acb-b29f-600fec830a1d</a>	Renon BOL1 - Italy
242	LV	<a href="https://deims.org/61c188bc-8915-4488-8d92-6d38483406c0">https://deims.org/61c188bc-8915-4488-8d92-6d38483406c0</a>	Randu meadows - Latvia
243	LV	<a href="https://deims.org/66431807-ebf1-477f-aa52-3716542f3378">https://deims.org/66431807-ebf1-477f-aa52-3716542f3378</a>	LTSE Engure - Latvia
244	NO	<a href="https://deims.org/68af6e55-e241-4afe-a3a6-32e79eef12fb">https://deims.org/68af6e55-e241-4afe-a3a6-32e79eef12fb</a>	Birkenes - Norway
198	PL	<a href="https://deims.org/0ff5485d-4436-4153-b6fb-d6eac9c9dd23">https://deims.org/0ff5485d-4436-4153-b6fb-d6eac9c9dd23</a>	Brenna - Poland
199	PL	<a href="https://deims.org/588940f5-ce9f-4248-82bb-c9ce1c39ec31">https://deims.org/588940f5-ce9f-4248-82bb-c9ce1c39ec31</a>	Slowinski National Park - Poland
200	PL	<a href="https://deims.org/017a10e1-a31a-4a0a-b714-3e8ac3cd60de">https://deims.org/017a10e1-a31a-4a0a-b714-3e8ac3cd60de</a>	Tatranski National Park - Poland
324	RO	<a href="https://deims.org/5311dc45-04db-4358-b5fa-9ba59c044e61">https://deims.org/5311dc45-04db-4358-b5fa-9ba59c044e61</a>	Stefanesti-oak - Romania
124	SE	<a href="https://deims.org/27415652-8de8-40e7-92c1-f82526116a2d">https://deims.org/27415652-8de8-40e7-92c1-f82526116a2d</a>	Gammtratten, IM-site SE16 - Sweden
125	SE	<a href="https://deims.org/9aa88bb6-b4a9-4569-8520-3d26643e6de9">https://deims.org/9aa88bb6-b4a9-4569-8520-3d26643e6de9</a>	Kindla, IM-site SE15 - Sweden

ID	Country code	Site code	Site DEIMS ID
126	SE	<a href="https://deims.org/c7f490fb-76a4-4d6c-ba3e-2fd2f33822ec">https://deims.org/c7f490fb-76a4-4d6c-ba3e-2fd2f33822ec</a>	Gårdsjön, IM-site SE04 - Sweden
245	SE	<a href="https://deims.org/9dd45aa6-ed7a-49d2-bea4-7750351c55d0">https://deims.org/9dd45aa6-ed7a-49d2-bea4-7750351c55d0</a>	Aneboda, IM-site SE14 - Sweden
330	SI	<a href="https://deims.org/0d3e7231-2414-429f-80bb-71f1e1fc3d17">https://deims.org/0d3e7231-2414-429f-80bb-71f1e1fc3d17</a>	Pokljuka - Slovenia
331	SI	<a href="https://deims.org/96adc9f8-190b-4a7c-be68-e51747d872a0">https://deims.org/96adc9f8-190b-4a7c-be68-e51747d872a0</a>	Fondek - Slovenia
332	SI	<a href="https://deims.org/a9a6346a-cfdd-4642-944c-7a5f55d5e447">https://deims.org/a9a6346a-cfdd-4642-944c-7a5f55d5e447</a>	Gropajski bori - Slovenia
333	SI	<a href="https://deims.org/7e3d1406-6c22-43eb-bf85-e704e3c5a70b">https://deims.org/7e3d1406-6c22-43eb-bf85-e704e3c5a70b</a>	Brdo - Slovenia
334	SI	<a href="https://deims.org/d5544ca4-8400-4553-b7f8-9728c358f03a">https://deims.org/d5544ca4-8400-4553-b7f8-9728c358f03a</a>	Borovec - Slovenia
336	SI	<a href="https://deims.org/deaa845b-dbd9-42a4-a9a5-d9db2a86d4c2">https://deims.org/deaa845b-dbd9-42a4-a9a5-d9db2a86d4c2</a>	Krakovski gozd - Slovenia
337	SI	<a href="https://deims.org/8c280ddb-c31c-45d8-a4eb-77dac64848b3">https://deims.org/8c280ddb-c31c-45d8-a4eb-77dac64848b3</a>	Murska šuma - Slovenia
123	SK	<a href="https://deims.org/e13f1146-b97a-4bc5-9bc5-65322379a567">https://deims.org/e13f1146-b97a-4bc5-9bc5-65322379a567</a>	Jalovecka dolina - Slovakia
247	UK	<a href="https://deims.org/00eb83ef-c965-462d-8022-7f7ff75ccd14">https://deims.org/00eb83ef-c965-462d-8022-7f7ff75ccd14</a>	Drayton
248	UK	<a href="https://deims.org/1c4d454d-0c00-49f9-a7fe-3a3e596c3648">https://deims.org/1c4d454d-0c00-49f9-a7fe-3a3e596c3648</a>	Glensaugh
249	UK	<a href="https://deims.org/371c5259-6f38-4aa7-9517-c56f608c62cc">https://deims.org/371c5259-6f38-4aa7-9517-c56f608c62cc</a>	Hillsborough
250	UK	<a href="https://deims.org/bf78c96f-0763-4b31-b1a6-6eccef19edd1">https://deims.org/bf78c96f-0763-4b31-b1a6-6eccef19edd1</a>	Moor House – Upper Teesdale
251	UK	<a href="https://deims.org/4fbe4bf9-e342-4412-8f0c-c75aff08a8ca">https://deims.org/4fbe4bf9-e342-4412-8f0c-c75aff08a8ca</a>	North Wyke
252	UK	<a href="https://deims.org/cb340d4c-e6e5-465a-b0cb-d6c613fa5541">https://deims.org/cb340d4c-e6e5-465a-b0cb-d6c613fa5541</a>	Rothamsted
253	UK	<a href="https://deims.org/125d4667-0fae-418d-88ff-7d9930809d12">https://deims.org/125d4667-0fae-418d-88ff-7d9930809d12</a>	Sourhope
254	UK	<a href="https://deims.org/16dcd0c3-a114-412c-9f01-8c1af292ba69">https://deims.org/16dcd0c3-a114-412c-9f01-8c1af292ba69</a>	Wytham
255	UK	<a href="https://deims.org/d47ec839-5d20-4315-9f88-1e9edbab22e8">https://deims.org/d47ec839-5d20-4315-9f88-1e9edbab22e8</a>	Alice Holt
256	UK	<a href="https://deims.org/0f05a86f-0f7a-4b81-8268-6818a6064428">https://deims.org/0f05a86f-0f7a-4b81-8268-6818a6064428</a>	Porton Down
257	UK	<a href="https://deims.org/8b5da977-eed8-459f-b663-f3835aa0b356">https://deims.org/8b5da977-eed8-459f-b663-f3835aa0b356</a>	Y Wyddfa – Snowdon
258	UK	<a href="https://deims.org/5a04fee1-42aa-47e9-abfc-043a3eda12ac">https://deims.org/5a04fee1-42aa-47e9-abfc-043a3eda12ac</a>	Cairngorms