


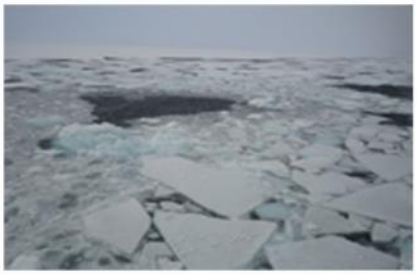


# HOLOCENE ARCTIC BIODIVERSITY DATABASE

## CHARTER Deliverable D4.2


Grant Agreement Number: 869471
Project Acronym: CHARTER
Project title: Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity
Starting Date: 01/08/2020
Project Duration: 48 months
Project Officer: Alberto Zocchi
Project Coordinator: Bruce Forbes / LAY
Leading Author: Marc Macias-Fauria / UOXF
Contributing partners: UOXF, AU, UNILIV, UH, NTNU

Co-financed by the Connecting Europe Facility of the European Union

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**Version 1.0**

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**Authors:** Marc Macias-Fauria and Andrew Martin, University of Oxford and the CHARTER WP4 team (UOXF, AU, UNILIV, UH, NTNU)
**Due Submission Date:** 31/01/2023
**Actual Submission Date:** 31/01/2023 (original submission data was month 24 (July 2023) but a 6-month postponed was agreed)

| Status | |
|---|---|
| Draft | |
| Final | x |

| Type | | |
|---|---|---|
| R | Document, report | x |
| DEM | Demonstrator, pilot, prototype | |
| DEC | Websites, patent fillings, videos, etc. | |
| OTHER | | |

| Dissemination level | | |
|---|---|---|
| PU | Public | x |
| CO | Confidential, only for members of the consortium (incl. the Commission services) | |

CHARTER

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## Revision history

| Date(s) | Lead author(s) | Comments |
|---|---|---|
| 30/07/2022 | Marc Macias-Fauria<br>Andrew C. Martin | Draft prepared in line with previous (now superseded) submission date |
| 23/01/2023 | Marc Macias-Fauria<br>Andrew C. Martin | Draft updated to include developments in public-facing database |
| 31/01/2023 | Marc Macias-Fauria<br>Andrew C. Martin | Final version, submitted |

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# 1 Introduction

WP4 is entitled ***Biodiversity Changes at Centennial Timescales*** and is led by the University of Oxford (UOXF). The objective of this report is to present the outputs of Work Package 4 (WP4) Deliverable 4.2 until January 2023 (= month 30) and to assess the progress made. Outputs (software, publications etc.) are underlined throughout the report, and listed again at the end. All software outputs are available in the CHARTER *Zenodo* community.

D4.2 ("Pan-Arctic paleo-ecological database") is part of Objective 4.1 ("Determine the variability of key biodiversity and ecosystem state variables across the terrestrial Arctic ecosystems during the Holocene"; **Figure 1**). This Objective starts with a systematic mapping exercise that identifies all possible biological data from the Holocene (last ~11.400 years; T4.1, D4.1). From this, a Pan-Arctic Palaeo-ecological database (T4.2, **D4.2, presented herein**) is built, which is the basis for extracting Key Biodiversity/Ecosystem state variables (T4.6; D4.4) and, by analysing these over the last millennia, their temporal dynamics (T4.7; D4.5). Objective 4.2 ("Study the relationships between these variables and changes in climate, cryospheric processes, and human agency"), requires first to build a dataset on Climate and the Cryosphere which spans the Holocene (T4.3, D4.3), so that the biodiversity/ecosystem state variables can be compared against coeval changes in the environment (T4.8; D4.6). Both Objectives 4.1 and 4.2 can be informed by newly collected – and existing but not yet published – palaeo-ecological data from CHARTER Focal Sites (Fennoscandia). These represent centennial and multi-centennial dendrochronological material and millennial palaeo-ecological information obtained from two newly collected peat cores (T4.4; T4.5; D4.7). Finally, Objective 4.3 ("Analyse the temporal stability of these responses, and whether they are in agreement with the more recent observational record (WPs1&2) and state-of-the-art process-understanding of the Arctic System (WP5)") represents the last stage of WP4, and consists of comparing the long-term relationships and dynamics obtained from this work package with those obtained from the observational record (WP2; D4.8) and those embedded and obtained in the modelling work package (WP5, D4.9).

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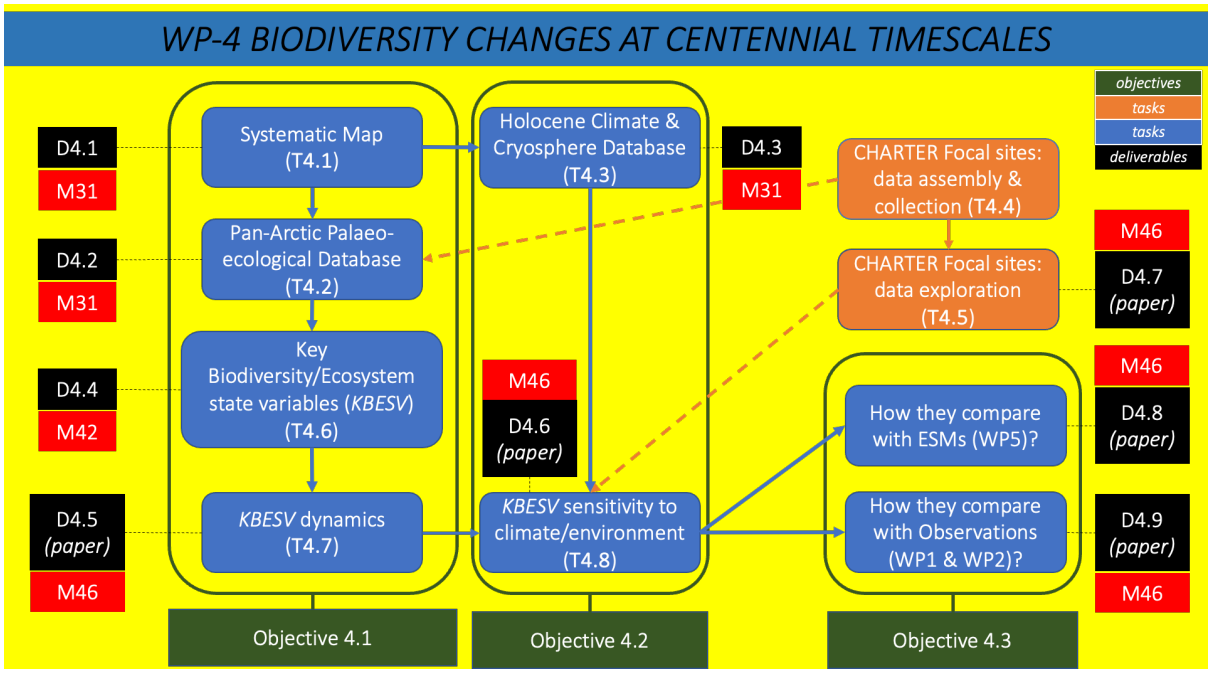


**Figure 1**. Relationships between the different components of Work Package 4 (WP4). **Blue** (existing data) or **orange** (production of new data) boxes represent *Tasks* within WP4; **black** boxes are the *Deliverables* linked to each task; **red** boxes are *Project Month* in which the *Deliverables* are planned; large boxes outlined in **green** with a green label are the *Objectives* linked to each task. Arrows connecting tasks represent the workflow of the project (see *text*).

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# 2 Progress Report

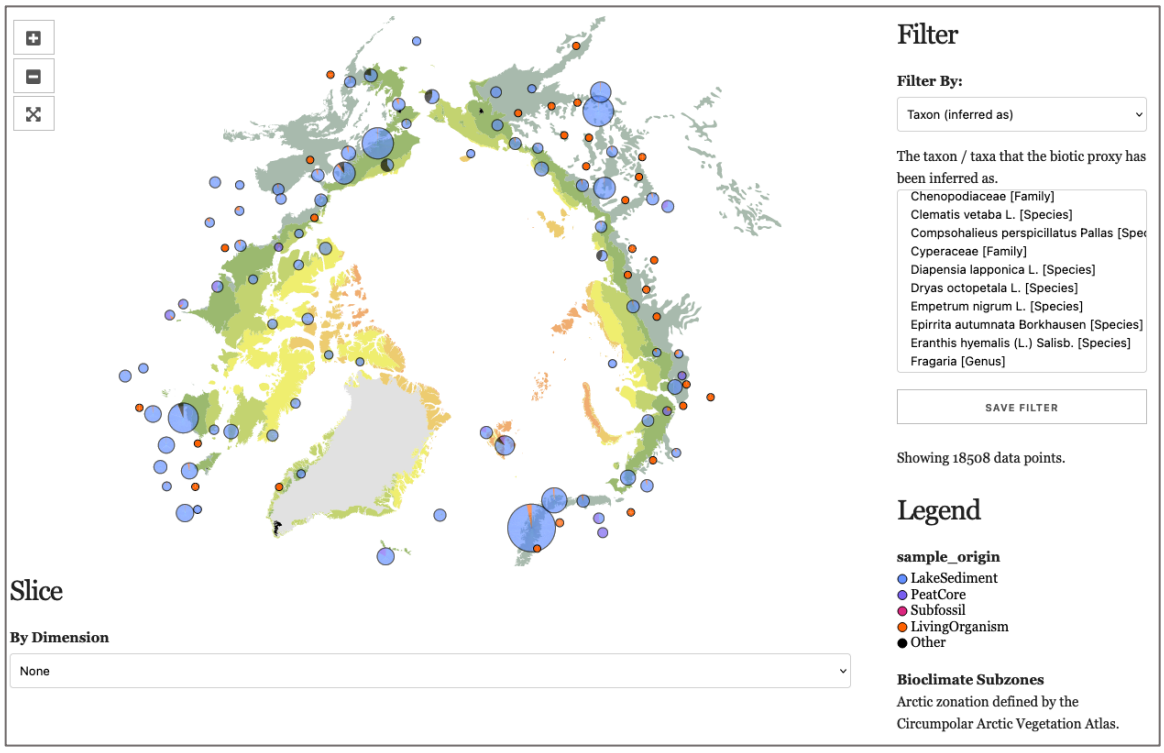


**Figure 2** Online mapping interface for the Arctic Holocene Biodiversity Database (AHBD).

The **A**rctic **H**olocene **B**iodiversity **D**atabase (AHBD) is a new database output that forms D4.2. The v1.0 of the database (doi: https://doi.org/10.5281/zenodo.7584533) currently has 18,508 individual biotic proxy records and will continue to expand during the first half of 2023. The architecture, internal structure, and licensing of the database are completed. The contents of the database – now at >18k records – are expected to grow in the coming months, and we plan to update and upgrade the database regularly in the future, resources allowing. The database has been licensed under the Open Data Commons Open Database License; any rights in individual contents of the database have been licensed under the Database Contents License.

The database's defined scope is that it only includes records that have two or more time-points at the same sampling context; these records must intersect the Holocene (11,700 – 0 cal. yr. BP) and occur within the Arctic area as defined by the Arctic Biodiversity Assessment. The resultant database has spatial coverage of all Arctic bioclimatic subzones, as well as most of the Oro-Arctic (Virtanen et al 2016).

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The database is now explorable primarily along geographical, temporal, and taxonomic axes (**Figure 2**). A website for data exploration and visualisation has been created using the *thalloo* mapping framework (Martin 2018). It is a static website hosted on GitHub Pages at https://acm.im/holocene-arctic-biodiversity-map/ahbdb/, but it is hoped that this will soon move to the charter-arctic.org domain. The website reflects the real-time contents of the database.

The cryosphere database created in D4.3 (see separate report) has been linked into the *Holocene Arctic Biodiversity Indicators Database* such that the records in the AHBD may be sliced and filtered based on temporal variability in key cryosphere metrics.

A key aim and result of the database is to capture core uncertainties when using palaeo-data to infer biodiversity change over time. The database therefore contains a data structure such that the uncertainties that arise from spatial, temporal, and taxonomic axes may be explored.

- First, on the spatial axis locations are defined on increasing levels of granularity from country-scale to site-scale.
- Second, on the temporal axis, the temporal extents as stated by study authors are included, alongside any associated measurement uncertainty. The database also contains information on dating methods applied within each temporal context and every individual date that was used to form that time series. For example, a wood ring time-series of presence-only data may be made up of cross-dated wood discs from living specimens, but then be extended backwards through time using subfossil wood. In this case, the individual date used to pin the entire temporal sequence is the collection date of the modern material (e.g., summer 2008). Alternatively, for a lake sediment sequence, many radiocarbon dates of organic material at different levels in the sediment core may be calibrated and then used in an age-depth model to form a time-sequence. As the AHBD captures all this information, it is now possible to recompute uncertainty-based age-depth models based on the latest radiocarbon calibration curve IntCal20 to harmonise dates across the database and capture temporal uncertainty. AHBD also includes other quantitative dating methods (e.g., lead-210, tephra) and qualitative dates (e.g., pollen zones).
- Third, the taxonomic uncertainty arising from the use of biotic proxies (for example, pollen morphotypes) is captured in the database using 'triples' of ***biotic proxy – inference method – taxon / taxa***. Continuing the example of pollen morphotypes, where specific keys or pollen atlases have been used to conduct pollen identification, we have input the pollen atlas as the 'inference method', alongside the botanical taxon or taxa that the pollen morphotype refers to in the interpretation employed by the study authors. The database therefore overcomes

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the problem of working in morphotypes but can work directly in real botanical taxa; this also allows integration of data types across different biotic proxies, e.g., across pollen, plant macrofossils and dendroecological samples.

To make the database more accessible and machine-readable, the database schema has been developed in line with the Dublin Core and its extensions (using DCMI metadata terms) (DCMI Usage Board 2020). Labelling of the public-facing entry points with DCMI metadata terms is continuing but when complete will allow efficient ingestion and reuse of the database.

The database, once fully populated, will add substantial complementary value to existing palaeoecological databases (e.g., Neotoma, International Tree Ring Database), as it will include all sources identified in a systematic map of changes in Arctic biodiversity during the Holocene (Martin et al 2022). The initial phase of WP4 was to identify relevant published and unpublished sources that contain evidence of changes within Holocene biodiversity indicators and combine these with the unpublished material available within the CHARTER consortium. This method to be used was defined as a systematic map in Deliverable 4.1. The systematic map has been progressed in Deliverable 4.1. Analysis of the intersect between publications and other sources identified by the systematic map in Deliverable 4.1 and publications / sources with data in the existing palaeoecological databases is very small.

# 3 Summary of Outputs

| Title | License | Location |
|---|---|---|
| The Holocene Arctic Biodiversity Indicators Database v1.0 | Open Data Commons Open Database License v1.0 | https://doi.org/10.5281/zenodo.7584532 |
| AHBD Website | Open Data Commons Open Database License v1.0 | https://acm.im/holocene-arctic-biodiversity-map/ahbdb/ |

# References

DCMI Usage Board 2020. DCMI Metadata Terms. https://www.dublincore.org/specifications/dublin-core/dcmi-terms/

Martin AC. 2018. thalloo: a framework for web visualisation of geographical evidence maps.

Martin, AC, Assmann, J. J., Bradshaw, R. H. W., Kuoppamaa, M., Kuosmanen, N. I., Normand, S., . . . Macias-Fauria, M. (2022). What evidence exists for temporal variability in Arctic terrestrial and freshwater biodiversity throughout the Holocene? A systematic map protocol. *Environmental Evidence, 11*(1), 13. doi:10.1186/s13750-022-00267-x

Virtanen R, Oksanen L, Oksanen T, Cohen J, Forbes BC, Johansen B, Käyhkö J, Olofsson J, Pulliainen J, Tømmervik H. 2016. Where do the treeless tundra areas of northern highlands fit in the global biome

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system: toward an ecologically natural subdivision of the tundra biome. Ecology and evolution 6: 143–158.