

# REPORT DELIVERABLE 1.3.2

Transnational database on drivers of forest degradation and management recommendations



Version 1.1  
11 2025





## Summary

The Harmonized Database (Deliverable DT1.3.2) represents a compiled and standardized transnational collection of spatial data layers. It provides the common geospatial foundation for all subsequent modelling and mapping activities within the RE-ENFORCE project. The database integrates harmonized map files in the form of shapefiles, GeoTIFF rasters, and tabular metadata, jointly contributed by the project partners and aligned to a unified coordinate system.

Its main purpose is to support all RE-ENFORCE modelling groups by providing a consistent spatial lattice across Central Europe for analyzing forest degradation, modelling future risks, and estimating restoration potential. The database ensures that all partners work on the same spatial framework and data standards, enabling comparability of model outputs, reproducibility of analyses, and integration of results into the web-based Decision Support System.

The database contains key environmental and forest parameters, including climate variables, topography, land cover, soils, and forest stands characteristics such as biomass, canopy height, species distribution and composition. In addition, validation layers depicting observed disturbance levels (e.g., bark beetle) are included to support model calibration and evaluation. Each dataset is supplemented with complete metadata, source reference, and license information to ensure transparency, traceability, and proper attribution.

Within WP2, the database serves as the baseline for DT2.1.2 Mapping provision of Ecosystem services under the current climate and climate change, and DT2.2.1 Transnational delineation of priority areas for forest restoration. These deliverables rely on the same harmonized layers to perform cross-border analyses and generate comparable outputs under current and future climate conditions. In WP3, they provide the geospatial backbone for DT3.1.2, an Integrated Web-based DSS with a Handbook for Decision-Making. This will enable forest managers, planners, and policymakers to visualise, query, and combine data layers to explore site-specific Nature-based Solutions.

The database is freely accessible to all users via **Zenodo** (DOI: [10.5281/zenodo.17191513](https://doi.org/10.5281/zenodo.17191513)) and is maintained through a continuously updated **GitHub repository** (<https://github.com/JCepl/RE-ENFORCE-Harmonized-Database>), which hosts metadata, processing scripts, and documentation.

By aligning diverse datasets into a coherent and transparent structure, the Harmonized Database reinforces the consistency of RE-ENFORCE outputs across WPs and directly supports the project's main objective—to develop transnational, evidence-based forest restoration strategies applicable across Central Europe. The data are freely available for research, allowing external users, future projects, and national authorities to capitalize on the compiled information.



## Introduction

The Harmonized Database (Deliverable DT1.3.2) was developed within Work Package 1: *Identifying challenges, learning from past, and harmonizing data and knowledge* of the RE-ENFORCE project. Its purpose is to compile and standardize spatial datasets required for modelling and mapping forest degradation, ecosystem services, and restoration potential across Central Europe.

This deliverable establishes the link between Work Package 1, where datasets from all partners and external sources were collected and harmonized, and Work Package 2 (Mapping and Modelling), where these layers serve as inputs for transnational analyses and model development. It also provides the geospatial foundation for Work Package 3 (Decision Support System), ensuring that all project outputs are based on a common spatial framework.

The database includes environmental and forest-related variables most relevant for modelling, such as climate, topography, land cover, soils, and forest attributes, together with layers representing disturbance drivers (drought, bark beetle outbreaks). All datasets were harmonized in coordinate system, resolution, and extent, converted into a unified structure, and documented with metadata detailing their source, projection, and license terms and conditions.

By providing a consistent geospatial basis for all analytical work, the Harmonized Database enables modelling teams to apply identical environmental predictors and validation layers, ensuring that outputs from different regions and model types remain comparable and can be integrated into the project's Decision Support System.

While this deliverable focuses on harmonizing national and transnational datasets describing the drivers of forest degradation, the database has been designed as an expandable framework. In later project stages, it will be extended to include management recommendations and restoration strategies derived from the modelling and scenario analyses of subsequent deliverables. This structure ensures that the Harmonized Database can evolve into a comprehensive reference resource, linking degradation drivers with adaptive forest management solutions across Central Europe and fueling the Decision Support System development.



## Database Hosting, Access, and Versioning

The Harmonized Database was compiled through a coordinated effort of all RE-ENFORCE partners under Work Package 1. The process focused on collecting, cleaning, and aligning spatial datasets required for modelling risks of forest degradation and restoration potential across Central Europe.

The database is hosted on Zenodo as a single dataset package under the RE-ENFORCE community:

DOI: [10.5281/zenodo.17191513](https://doi.org/10.5281/zenodo.17191513)

All accompanying scripts, processing workflows, and extended documentation are maintained in the GitHub repository:

<https://github.com/JCepl/RE-ENFORCE-Harmonized-Database>

This GitHub repository serves as a working environment for updates, providing reproducible examples, R and Python code snippets, and metadata templates.

The compiled database structure, metadata, and scripts are released under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence, while each individual dataset retains the licence conditions of its original provider.

The current release (Version 1.0.0; 25<sup>th</sup> November 2025) includes all input datasets necessary for modelling activities in Work Package 2. As model outputs are generated in subsequent project stages, these will be integrated under the same framework, expanding the database to include derived indicators and management recommendations.

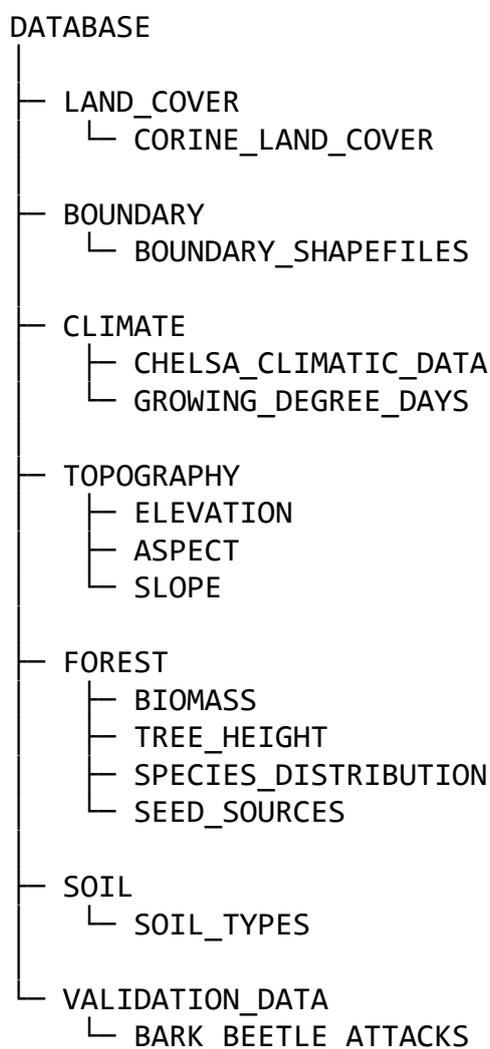
Version control will be applied to document all updates and reflect the evolving state of the database. Any revisions or newly added layers will be uploaded as incremental Zenodo versions, along with updates to this document, and mirrored in the GitHub repository to ensure full transparency and reproducibility.



## Database structure

The database is organized into several subdirectories, each corresponding to a specific thematic layer to facilitate intuitive navigation. The main subdirectories include LAND\_COVER, BOUNDARY, CLIMATE, TOPOGRAPHY, FOREST, SOIL, and VALIDATION\_DATA.

Each of these directories contains datasets related to its respective theme. A detailed description of the individual layers within each directory is provided in the section “Database Detailed Content.”





## Database detailed content

All spatial layers were aligned to a unified grid with the following parameters:

Projection: WGS84 geographic coordinates (longitude-latitude, EPSG:4326)

Resolution: 30 arc seconds ( $\sim 0.008333^\circ$ , approximately 1 km)

Extent: longitude  $-10.7^\circ$  to  $38.6^\circ$ , latitude  $34.5^\circ$  to  $71.6^\circ$

The processing was done in R, using packages raster (v3.6-26) and terra (v1.7-78), including its dependencies; in QGIS 3.34 or in Python 3.13.

### References:

R Core Team (2024). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.  
Available at: <https://www.R-project.org/>

Hijmans, R.J. (2023). raster: Geographic Data Analysis and Modeling. R package version 3.6-26.  
Available at: <https://CRAN.R-project.org/package=raster>

Hijmans, R.J. (2024). terra: Spatial Data Analysis. R package version 1.7-78.  
Available at: <https://CRAN.R-project.org/package=terra>

QGIS Development Team (2024). QGIS Geographic Information System (Version 3.34). Open Source Geospatial Foundation.  
Available at: <https://www.qgis.org/>

Python Software Foundation (2024). Python: A Programming Language (Version 3.13).  
Available at: <https://www.python.org/>



## Land Cover - CORINE Land Cover

Source	European Environment Agency (EEA), Copernicus Land Monitoring Service
URL	<a href="https://land.copernicus.eu/">https://land.copernicus.eu/</a>
Licence	Copernicus Data and Information Policy - free and open access, © European Union, Copernicus Land Monitoring Service, European Environment Agency (EEA). Use, redistribution and modification permitted with appropriate attribution.
Citation	European Environment Agency (EEA), Copernicus Land Monitoring Service. (2020). <i>CORINE Land Cover 2018 (Raster 100 m), Europe, 6-yearly - version 2020_20u1</i> [Dataset]. DOI: <a href="https://doi.org/10.2909/960998c1-1870-4e82-8051-6485205ebbac">10.2909/960998c1-1870-4e82-8051-6485205ebbac</a> .
Original projection	ETRS89 / LAEA Europe (EPSG: 3035)
Original resolution	100 m × 100 m grid
Processing	Extracted relevant thematic layers (e.g. forest and land-cover classes) Reprojected to EPSG 4326, upscaled to 30" (~1 km) grid, clipped to Central European extent
Use	Provides harmonised land-cover composition for modelling tasks.
Form	.zip file with 3 GeoTIFFs
Size	4.42 GB
Note	Three different spatial expansions: <ul style="list-style-type: none"><li>● Interreg-CE</li><li>● Interreg-CE Countries (includes whole Germany and Italy)</li><li>● Europe</li></ul> Three zone types with defined CORINE land cover classes: <ul style="list-style-type: none"><li>● Forest zone<ul style="list-style-type: none"><li>○ 3.1.1 = Broad-leaved forest</li><li>○ 3.1.2 = Coniferous forest</li><li>○ 3.1.3 = Mixed forest</li></ul></li><li>● Buffer zone<ul style="list-style-type: none"><li>○ 3.2.2 = Moors and heathland</li><li>○ 3.2.3 = Sclerophyllous vegetation</li><li>○ 3.2.4 = Transitional woodland/shrub</li></ul></li><li>● Fire zone (land classes for modelling fire)<ul style="list-style-type: none"><li>○ 2.3.1 = Pastures</li><li>○ 3.2.1 = Natural grassland</li></ul></li></ul> For the Interreg-CE files, information on the country, zone type, and CORINE land cover class is available. For Europe as a whole, only information on the zone type and CORINE land cover class is included.



## Climate - CHELSA

Source	World Data Center for Climate (WDCC), WSL - <i>Climatologies at High Resolution for the Earth's Land Surface Areas (CHELSA) v2.1</i>
URL	<a href="https://chelsa-climate.org/">https://chelsa-climate.org/</a>
Licence	Creative Commons Attribution 4.0 International (CC BY 4.0) Karger, D.N., Conrad, O., Böhner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E., Linder, H.P., Kessler, M. (2021). <i>Climatologies at high resolution for the earth's land surface areas (CHELSA V2.1)</i> .
Citation	Climate of the Past, 17(2): 525-550. <a href="https://doi.org/10.1038/sdata.2017.122">https://doi.org/10.1038/sdata.2017.122</a>  Karger, D.N., Schmatz, D.R., Dettling, G. et al. <i>High-resolution monthly precipitation and temperature time series from 2006 to 2100</i> . Sci Data 7, 248 (2020). <a href="https://doi.org/10.1038/s41597-020-00587-y">https://doi.org/10.1038/s41597-020-00587-y</a>
Original projection	WGS 84 geographic coordinates (EPSG: 4326)
Original resolution	30 arc-seconds (~0.008333°, approx. 1 km)
Processing	Monthly mean temperature and precipitation rasters from CHELSA v2.1 were used directly at native 30" resolution, clipped to the Europe extent. Potential evapotranspiration (PET) was calculated with the Penman-Monteith equation.
Use	Provides harmonised climatic variables and derived thermal indices for modelling drought stress, bark-beetle activity, and forest regeneration potential across Central Europe.
Form	4 ZIP archives (1981-2010, 2011-2040, 2041-2070, 2071-2100) containing GeoTIFF rasters of temperature and precipitation.
Size	16.68 GB
Notes	Monthly mean temperature (mean, maximum, minimum) and total precipitation rasters were extracted for the baseline (1981-2010) and three future periods (2011-2040, 2041-2070, 2071-2100). Future data correspond to five GCMs (GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0, UKESM1-0-LL) under SSP585. Each ZIP archive contains 12 GeoTIFFs per variable for the baseline or 5 × 12 files per variable for future periods. All data were clipped to the European extent. Future projections were averaged across the five GCMs (SSP585). Each dataset includes complete metadata, units, and period-specific subfolders.



## Climate - Growing Degree Days

Source	World Data Center for Climate (WDCC), WSL - <i>Climatologies at High Resolution for the Earth's Land Surface Areas (CHELSA) v2.1</i>
URL	<a href="https://chelsa-climate.org/">https://chelsa-climate.org/</a>
Licence	Creative Commons Attribution 4.0 International (CC BY 4.0) Karger, D.N., Conrad, O., Böhrner, J., Kawohl, T., Kreft, H., Soria-Auza, R.W., Zimmermann, N.E., Linder, H.P., Kessler, M. (2021). <i>Climatologies at high resolution for the earth's land surface areas (CHELSA V2.1)</i> . <i>Climate of the Past</i> , 17(2): 525-550.
Citation	<a href="https://doi.org/10.1038/sdata.2017.122">https://doi.org/10.1038/sdata.2017.122</a>  Karger, D.N., Schmatz, D.R., Dettling, G. et al. <i>High-resolution monthly precipitation and temperature time series from 2006 to 2100</i> . <i>Sci Data</i> 7, 248 (2020). <a href="https://doi.org/10.1038/s41597-020-00587-y">https://doi.org/10.1038/s41597-020-00587-y</a>
Original projection	WGS 84 geographic coordinates (EPSG: 4326)
Original resolution	30 arc-seconds ( $-0.008333^{\circ}$ , approx. 1 km)  Growing Degree Days (for <i>Ips typographus</i> ) were derived from monthly mean air temperature rasters using the following workflow:
Processing	<ul style="list-style-type: none"><li>• Base temperature (T_base) = 8.3 °C</li><li>• Maximum temperature (T_max) = 38.9 °C</li><li>• For each pixel and month: values above T_max capped, T_base subtracted, negatives set to zero, multiplied by the number of days in the month, and summed for April-October (beetle activity period).</li></ul>
Use	Provides a biologically relevant variable for modelling <i>Ips typographus</i> vulnerability and outbreak potential across Central Europe..
Form	GeoTIFF stack (annual GDD layer) representing accumulated Growing Degree Days calibrated for <i>Ips typographus</i> development.
Size	11.72 GB
Notes	



## Topography - EU-DEM Derived

Source	Copernicus Land Monitoring Service / European Environment Agency (EEA) - EU-DEM v1.1
URL	<a href="https://ec.europa.eu/eurostat/web/gisco/geodata/digital-elevation-model/eu-dem">https://ec.europa.eu/eurostat/web/gisco/geodata/digital-elevation-model/eu-dem</a>
Licence	Copernicus Data and Information Policy - free and open access, © European Union, Copernicus Land Monitoring Service, European Environment Agency (EEA). European Environment Agency (EEA), 2016. <i>EU-DEM v1.1 Digital Elevation Model</i> . Copernicus Land Monitoring Service, European Environment Agency (EEA). Available at: <a href="https://ec.europa.eu/eurostat/web/gisco/geodata/digital-elevation-model/eu-dem">https://ec.europa.eu/eurostat/web/gisco/geodata/digital-elevation-model/eu-dem</a>
Citation	
Original projection	ETRS89 / LAEA Europe (EPSG: 3035)
Original resolution	1-arc-second (~25 m)
Processing	Reprojected to WGS 84 (EPSG: 4326) Resampled to 30 arc-seconds (~1 km)
Use	Provides harmonised topographic predictors (elevation, slope, aspect) for climatic, hydrological, and disturbance-risk modelling across Central Europe.
Form	Three separate GeoTIFF rasters for Elevation, Slope and Aspect
Size	Elevation 105.38 MB Slope 105.41 MB Aspect 26.39 MB
Notes	Derived terrain attributes: <ul style="list-style-type: none"><li>• Elevation - mean elevation per 1 km cell</li><li>• Slope - gradient in degrees from horizontal</li><li>• Aspect - terrain orientation classified into 8 compass sectors (1 = N, 8 = NW)</li></ul>



## Forest – Biomass (BAWS, 2020)

Source	Avitabile, V. (2022). Map of the forest Biomass Available for Wood Supply (BAWS) of EU-27 for 2020. European Commission, Joint Research Centre (JRC).
URL	<a href="http://data.europa.eu/89h/5258cc23-7c0a-4462-af65-04500e2f0d48">http://data.europa.eu/89h/5258cc23-7c0a-4462-af65-04500e2f0d48</a>
Licence	Creative Commons Attribution 4.0 International (CC BY 4.0)
Citation	Avitabile, V. (2022). <i>Map of the forest Biomass Available for Wood Supply (BAWS) of EU27 for 2020</i> . European Commission, Joint Research Centre (JRC) [Dataset] PID: <a href="http://data.europa.eu/89h/5258cc23-7c0a-4462-af65-04500e2f0d48">http://data.europa.eu/89h/5258cc23-7c0a-4462-af65-04500e2f0d48</a>
Original projection	ETRS89 / LAEA Europe (EPSG: 3035)
Original resolution	100 m × 100 m grid
Processing	Reprojected to WGS 84 (EPSG: 4326) and resampled to 30 arc-seconds (~1 km).
Use	Provides estimates of forest biomass used in modelling of degradation drivers.
Form	Single GeoTIFF raster
Size	570.88 MB
Notes	



## Tree Height (2021)

Source	Turubanova, S., Potapov, P., Tyukavina, A., et al. (2023). Tree canopy extent and height change in Europe.
URL	<a href="https://doi.org/10.1016/j.rse.2023.113797">https://doi.org/10.1016/j.rse.2023.113797</a>
Licence	Creative Commons Attribution 4.0 International (CC BY 4.0)
Citation	Turubanova, S. et al. (2023). <i>Tree canopy extent and height change in Europe</i> . <i>Remote Sensing of Environment</i> , 298: 113797. <a href="https://doi.org/10.1016/j.rse.2023.113797">https://doi.org/10.1016/j.rse.2023.113797</a>
Original projection	WGS 84 geographic coordinates (EPSG: 4326)
Original resolution	30 m × 30 m grid
Processing	Reprojected and aggregated to 30" (~1 km) grid by averaging canopy height values per cell.
Use	Represents tree canopy height across Europe as for 2021, used in modelling of degradation drivers.
Form	Single GeoTIFF raster
Size	4.02 GB
Notes	



## Species Distribution

Source	Caudullo, G., Welk, E., San-Miguel-Ayanz, J. (2024). Chorological data for the main European woody species.
URL	<a href="https://doi.org/10.17632/hr5h2hcgg4.18">https://doi.org/10.17632/hr5h2hcgg4.18</a>
Licence	Creative Commons Attribution 4.0 International (CC BY 4.0)
Citation	Caudullo, G. et al. (2024). <i>Chorological data for the main European woody species</i> . Mendeley Data, V18. <a href="https://doi.org/10.17632/hr5h2hcgg4.18">DOI: 10.17632/hr5h2hcgg4.18</a>
Original projection	WGS 84 geographic coordinates (EPSG: 4326)
Original resolution	~30 arc-seconds (~1 km)
Processing	Boolean rasters (1 = presence, 0 = absence) for 101 tree species were standardised to the common 30" grid and aligned with other environmental predictors.
Use	Provides species-level distribution data as input for modelling.
Form	GeoTIFF stack
Size	42.41 MB
Notes	Raster dataset representing the distribution of 101 tree species across Europe. The data are boolean (1 = presence, 0 = absence), with each of the 101 layers corresponding to one species' range. Includes combined native, introduced, and naturalized distribution areas.



## Seed Sources (FOREMATIS)

<b>Source</b>	Forest Reproductive Material Information System (FOREMATIS), European Commission.
<b>URL</b>	<a href="https://ec.europa.eu/forematis/">https://ec.europa.eu/forematis/</a>
<b>Licence</b>	Publicly available; free for research and educational purposes with proper attribution to the European Commission.
<b>Citation</b>	European Commission (2024). FOREMATIS - Forest Reproductive Material Information System. Available at: <a href="https://ec.europa.eu/forematis/">https://ec.europa.eu/forematis/</a>
<b>Original projection</b>	WGS 84 geographic coordinates (EPSG: 4326)
<b>Original resolution</b>	Vector point data
<b>Processing</b>	Downloaded from FOREMATIS as GeoPackage format; cleaned and standardised attribute fields (Member State, species, category, region of provenance, latitude/longitude, altitude).
<b>Use</b>	Represents registered European seed sources, provenance trials, and basic material sites; supports analyses of genetic-resource availability and forest-restoration or assisted-migration planning.
<b>Form</b>	Single GeoPackage file containing standardized point features of registered European seed sources and provenance regions.
<b>Size</b>	14.31 MB
<b>Notes</b>	



## European Soil Database (ESDBv2)

Source	European Commission - Joint Research Centre (JRC) / European Soil Data Centre (ESDAC), ESDBv2 Raster Library
URL	<a href="https://esdac.jrc.ec.europa.eu/content/european-soil-database-v2-raster-library-10kmx10km">https://esdac.jrc.ec.europa.eu/content/european-soil-database-v2-raster-library-10kmx10km</a>
Licence	Free for research and education; © European Commission, Joint Research Centre (JRC)
Citation	Panagos, P. et al. 2022. European Soil Data Centre 2.0: Soil data and knowledge in support of the EU policies. European Journal of Soil Science, 73(6), e13315. DOI: <a href="https://doi.org/10.1111/ejss.13315">https://doi.org/10.1111/ejss.13315</a>
Original projection	ETRS89 / LAEA Europe (EPSG: 3035)
Original resolution	10 km × 10 km grid
Processing	Reprojected to WGS 84 (EPSG: 4326) Resampled to 30 arc-seconds (~1 km) Exported as harmonised GeoTIFF rasters
Use	Provides harmonised soil parameters for use as environmental predictors in modelling
Form	Compressed 7z archive containing multiple harmonised GeoTIFF rasters
Size	72.61 MB
Notes	<ul style="list-style-type: none"><li>• Soil Classification - WRB: WRB-FULL, WRB-LEV1, WRB-ADJ1, WRB-ADJ2</li><li>• Soil Classification - FAO: FAO85-FULL, FAO85-LEV1, FAO85-LEV2, FAO85-LEV3, FAO90-FULL</li><li>• Texture: TEXT-SRF-DOM, TEXT-SRF-SEC, TEXT-SUB-DOM, TEXT-SUB-SEC, TEXT-DEP-CHG</li><li>• Parent Material: PAR-MAT-DOM, PAR-MAT-SEC, PAR-MAT-DOM1, PAR-MAT-SEC1</li><li>• Land Use: USE-DOM, USE-SEC</li><li>• Limitation to Agricultural Use: AGLIM1, AGLIM2</li><li>• Obstacle to Roots / Impermeable Layers: ROO, IL</li><li>• Soil Water Regime &amp; Management: WR, WM1, WM2</li><li>• Altitude &amp; Slope: ZMIN, ZMAX, SLOPE-DOM, SLOPE-SEC</li><li>• Primary Properties: TEXT, OC_TOP, PEAT, ALT</li><li>• Chemical Properties: CEC_TOP, CEC_SUB, BS_TOP, BS_SUB, MIN_TOP, MIN_SUB</li><li>• Mechanical Properties: PD_TOP, PD_SUB, VS, DR, STR_TOP</li><li>• Hydrological Properties: AWC_TOP, AWC_SUB, EAWC_TOP, EAWC_SUB, HG</li><li>• Applications / Derived Indices: AGLIM1NNI, TEXT-CRUST, ERODIBILITY, USE, ATC</li></ul>



## Bark Beetle Disturbance (1985-2023)

<b>Source</b>	European Forest Disturbance Atlas
<b>URL</b>	<a href="https://zenodo.org/records/13333034">https://zenodo.org/records/13333034</a>
<b>Licence</b>	Copernicus Data and Information Policy - open and free to use with attribution
<b>Citation</b>	Viana-Soto, A., & Senf, C. (2024). European Forest Disturbance Atlas (Version 2.1.1.) [Data set]. Zenodo. <a href="https://doi.org/10.5281/zenodo.13333034">https://doi.org/10.5281/zenodo.13333034</a>
<b>Original projection</b>	WGS 84 geographic coordinates (EPSG: 4326)
<b>Original resolution</b>	original inputs consist of annual disturbance-detection products at ~30 m resolution
<b>Processing</b>	Annual disturbance-severity layers (1985-2023) extracted from the European Forest Disturbance Atlas Reprojected to WGS 84 (EPSG: 4326), resampled to 30 arc-seconds (~1 km) using average aggregation Compiled into a single harmonised raster covering Europe
<b>Use</b>	Provides a spatially explicit indicator of historical bark beetle disturbance for training, testing, and validation of disturbance-risk and forest-dynamics models across Europe
<b>Form</b>	GeoTIFF stack
<b>Size</b>	6.11 MB
<b>Notes</b>	Values represent relative disturbance intensity per year aggregated across the 1985-2023 period.



## Licensing

The RE-ENFORCE Harmonized Database (v1.0.0) contains raster and vector datasets that were prepared by processing and combining openly available data from several European institutions and data providers. All files represent derived products created within *Work Package 1*, they were clipped, reprojected, standardised to a common spatial grid, and in many cases further processed from the original datasets.

Each raster or vector layer retains the original licence and attribution of its source dataset (e.g. Copernicus Open Data, CC BY 4.0, or equivalent). Users are required to respect these conditions when redistributing or citing the data.

The documentation, metadata, and processing scripts developed by the RE-ENFORCE consortium are released under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence, allowing reuse and adaptation provided that proper credit is given to the RE-ENFORCE project.

Any reuse or redistribution of the harmonised database, whether in part or in full, must include:

- a reference to the *RE-ENFORCE Harmonized Database (v1.0.0)*,
- citations of all original data sources, and
- a note stating that the derived products were produced within *RE-ENFORCE Work Package 1*.

When using or redistributing the database, please cite as follows:

RE-ENFORCE Consortium (2025). Transnational Database on Drivers of Forest Degradation. Zenodo. <https://doi.org/10.5281/zenodo.17191513>



## Conclusions

The Harmonized Database (Deliverable DT1.3.2) provides the essential geospatial foundation for all analytical, modelling, and mapping tasks within the RE-ENFORCE project. By integrating climate, topography, land cover, soil, and forest datasets into a unified structure, the database ensures that every partner and modelling group operates on the same spatial reference, resolution, and data standards.

Through systematic data cleaning, reprojection, and resampling, all layers were aligned to a 30" (~1 km) WGS 84 grid covering Central Europe. This harmonisation enables cross-border comparability of results, facilitates reproducibility of model outputs, and allows seamless integration of indicators across Work Packages 2 and 3.

The database is openly accessible through Zenodo and accompanied by scripts, metadata, and documentation stored on GitHub, ensuring transparency and reusability. Its open-data structure promotes further use by researchers, forest managers, and policy stakeholders beyond the lifetime of the project, supporting future applications in forest restoration, resilience assessment, and Nature-based Solutions.

By providing a shared geospatial framework and ensuring licence compliance, the Harmonized Database directly supports RE-ENFORCE's main objective: to develop evidence-based, transnational tools for restoring degraded forests and enhancing ecosystem resilience across Central Europe.

Future versions of the database will integrate management recommendations and restoration strategies developed in subsequent deliverables, ensuring continuity between the analysis of degradation drivers and the formulation of adaptive forest-management guidance.