Deliverable

D1.4 Data base of standardized field plots

PathFinder Project

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I. DOCUMENT CONTROL

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PU	Public, fully open access
RE	Restricted to a group specified by the PathFinder Consortium (including the Commission Services)
CO	Confidential, only for members of the PathFinder Consortium (including the Commission Services)

II. DOCUMENT HISTORY

Version	Date	Author	Change
0.1	17th December 2024	Jiří Fejfar	Initial version
0.2	21st January 2025	Jiří Fejfar	First comments from I. Alberdi processed
0.3	22nd January 2025	Jiří Fejfar	Rewrite, content added
0.4	10th February 2025	Jiří Fejfar	Processing comments from Mitja Skudnik
0.5	19th June 2025	Jiří Fejfar	Removing the misleading term “harmonized” from the document

III. Abbreviations

NIBIO	Norwegian Institute of Bioeconomy Research
ALU	Albert-Ludwigs University Freiburg
IGN	National Institute of Geographic and Forest Information
VUA	Vrije Universiteit Amsterdam
TI	Thünen Institute of Forest Ecosystems
CFRI	Croatian Forest Research Institute
LUKE	Natural Resources Institute Finland
BFW	Federal Research and Training Center for Forests, Natural Hazards and Landscape
GIS	Slovenian Forestry Institute
UHUL	Czech Forest Management Institute
VTT	Technical Research Centre of Finland Ltd.
CSIC	Consejo Superior de Investigaciones Científicas
CICERO	Center for International Climate Research
UGOE	University of Göttingen
UH	University of Helsinki
TM	TreeMetrics
EVINBO	Eigen Vermogen van het Instituut voor Natuur- en Bosonderzoek
ELO	European Landowners Organisation
IEFC	Institut Européen de la Forêt Cultivée
FMI	Finnish Meteorological Institute
WSL	Swiss Federal Research Institute for Forests Snow and Landscape Research
UB	University of Bristol
JRC	Joint Research Center
EEA	Environmental Agency

1. Contents

Summary

This deliverable (D1.4, “Data base of standardized field plots”) is part of Work Package 1 (WP1) of the Horizon Pathfinder project, which aims to establish a consistent EU field survey for effectively monitoring carbon stocks and biodiversity by integrating forest inventory field data with remote sensing products. This report details the technical solution and its implementation; the survey design was developed as part of Task 1.1.

The deliverable D1.4 encompasses a database of standardized forest inventory field plots, comprising data collected during a field survey conducted as part of the project.

A scalable, secure, and user-friendly data management system has been used, leveraging open-source technologies such as Linux, PostgreSQL, and PostGIS for spatial data handling.

At the end of the project the standardized plots database will contain data from up to 250 field plots across up to 25 countries, gathered using the Open Foris Arena platform. The data structure, includes information on:

- Plots (country, field team, ID, coordinates, forest structure)
- Slope angles
- Quadrants (stocking, forest type)
- Trees (distance, azimuth, condition, DBH, species, detectability, etc.)
- Regeneration
- Ground vegetation
- Deadwood
- Additional species

Technical challenges were addressed and discussed.

1. Introduction

This report presents the dataset developed as part of WP1: a comprehensive database of 250 standardized plots surveyed during this project, which will be publicly accessible in CSV format.

A total of 250 plots will be surveyed across the following countries: Andorra, Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Hungary, Ireland, Iceland, Italy, Lithuania, Latvia, Netherlands, Norway, Poland, Portugal, Serbia, Sweden, Slovenia, and Slovakia.

The deliverable tackles challenges related to collecting of the data on the field, data quality check and consistency of the data collected by different countries. Furthermore, used data management system ensures these complex and diverse records are managed efficiently, securely, and at scale. This report outlines the creation process, structure, and content of the forest inventory standardized dataset.

2. Results

2.1 Database of Standardized Plots (Field Data)

2.1.1 Purpose

The standardized plots dataset serves as a pilot for a consistent EU field survey, testing the possibilities to design national forest inventory plots into the directions which enable efficient monitoring of carbon

stocks and biodiversity by integrating field data with remote sensing products. The dataset was collected within the project and will be made publicly available.

2.1.2 Dataset definition

The structure of the dataset was developed in Task 1.1 and is described in full detail in the document "Inventory Guidelines and Field Protocol for PathFinder Pilot Study."

The *machine-readable* definition of the Open Foris Arena project is attached[1] and version-controlled in the Git repository[2]. Arena uses a ZIP archive containing files from the repository. To conduct a new survey with the same structure and constraints, follow these steps:

1. Download all files from the Git repository.
2. Create a ZIP archive.
3. Import the ZIP archive to the Arena server via the web interface.

The reverse process is also possible and valuable for tracking changes introduced in the web application:

1. Export and download the survey structure.
2. Unzip the files.
3. Commit the new version to the Git repository.

By utilizing the Git repository, it is possible to track all changes throughout the project's lifecycle. For example, early in the project, the option to input tree azimuth in either degrees or gons was added.

2.1.3 Dataset content

Collected records from the Arena server can be exported in CSV format (ZIP attached[3]), which includes the following files: 01_plot.csv, 02_quadrants.csv, 03_tree.csv, 04_regeneration.csv, 05_groundveg.csv, 06_deadwood.csv, 07_additional_species.csv, 08_tree_damage.csv.

2.1.4 Accessibility

The standardized dataset will be made publicly accessible to promote open research and inform policy development. Additionally, a data paper detailing the dataset's metadata is in preparation.

2.1.5 Example -- analysis of tree data

The following table can be generated by running an SQL query[4] using the open-source DuckDB[5] analytical database engine.

This table summarizes content from 198 plots out of 250 along with a brief analysis. Explanation of columns:

- n_plots: Number of surveyed plots
- avg_n_trees_pp: Average number of trees per plot
- avg_p_alive_pp: Average percentage of standing alive trees per plot
- n_trees_pc: Number of surveyed trees per country
- avg_tree_d_pc: Average tree diameter per country
- avg_d_tree_s_pp: Average number of distinct tree species per plot

[1] file arena_survey_survey_pathfinder_2025-01-22_16-42-21.zip
[2] https://gitlab.com/pathfinder_project/field_survey/-/tree/main/arena_project/arena_survey_pathfinder
[3] file survey_pathfinder_(cycle-1)_DataExport_2025-01-20_21-27-49_NOFOTO.zip with no photos to reduce size
[4] https://gitlab.com/pathfinder_project/field_survey/-/issues/20#note_2310458416
[5] https://duckdb.org/docs/installation/

country	n_plots	avg_n_trees_pp	avg_p_alive_pp	n_trees_pc	avg_tree_diameter_pc	avg_d_tree_spec_pp
Austria	17	75.0	0.71	1275.0	31.9	2.9
Belgium	6	30.33	0.99	182.0	33.6	3.8
Czechia	17	77.82	0.66	1323.0	31.1	3.3
Finland	22	34.0	0.98	748.0	19.0	3.0
France	23	61.26	0.71	1409.0	32.4	4.2
Germany	23	58.57	0.58	1347.0	36.0	4.7
Greece	2	55.5	0.79	111.0	30.1	3.0
Hungary	8	50.75	0.76	406.0	28.9	4.1
Ireland	6	55.5	1.0	333.0	20.7	1.7
Island	2	36.0	0.95	71.0	13.8	1.0
Italy	11	46.0	0.9	506.0	31.5	3.0
Latvia	1	51.0	0.9	51.0	33.5	7.0
Lithuania	1	36.0	0.81	36.0	39.1	5.0
Norway	9	55.67	0.88	501.0	25.9	5.1
Republic of Serbia	1	41.0	1.0	41.0	44.9	1.0
Slovakia	8	64.38	0.97	515.0	29.0	4.6
Slovenia	7	55.71	0.79	390.0	35.0	4.6
Spain	22	41.27	0.85	908.0	30.2	1.4
Sweden	10	41.0	0.96	410.0	18.1	2.6

2.1.6 Field Data Collection

The standardized plots were collected using the Open Foris Arena platform, which comprises a server with a web app and a mobile app (both official Arena Mobile and Arena Mobile Experiments).

The mobile app effectively guided users through plot surveys in the field, even without an Internet connection—a critical feature. The app includes a comprehensive set of checks on the field, ensuring data accuracy during collection. Once an Internet connection is available, the collected data can be uploaded to a central database. Users can then review and validate the uploaded data conveniently from an office computer using the web app, where adjustments and corrections can also be made as needed.

2.1.7 Infrastructure

The infrastructure for the standardized plots database includes a Linux server hosting the Open Foris Arena software for data collection and management. While Arena can be hosted on dedicated infrastructure, we utilized the openforis-arena.org[6] server after verifying its data policies. This setup

[6] https://www.openforis-arena.org/

provides a robust and scalable system that facilitates efficient management and analysis of standardized plot data. Additionally, custom analyses can be effectively performed using the DuckDB analytical engine on exported CSV files.

3. Discussion

Challenges and limitations:

- Decision-making: Selecting appropriate software:
    - Collect Mobile[7] (old, unmaintained, but proven effective)
    - Arena[8] (modern, actively maintained, but faced issues with its official mobile app)
    - ODK[9] (+ XLS form, less widely known, easy for implementation)
    - Field-Map[10] (not available in all countries, high subscription costs)
- Fieldwork implementation: Addressing issues with the official Arena mobile app. Performance degradation was observed after inserting data for 50 trees, an issue not identified during testing due to smaller datasets. While partially resolved in updates to the official app, the initial technical limitations posed challenges. Transitioning to the Arena Mobile Experiments (AME) app provided significant improvements, informed by field team feedback.
- Project definition evolution: Changes such as the addition of azimuth input options were introduced, but some teams continued using outdated project definitions.

Prospects include expanding the database to encompass additional plots and countries, as well as implementing centralized, enhanced quality checks.

4. Conclusion

The standardized plots databases are the key outputs of D1.4. Furthermore, a high-performance, scalable, secure, and user-friendly data management system has been used to ensure efficient handling of complex and versatile data records. By utilizing open-source technologies such as Linux, PostgreSQL, and PostGIS, the system supports spatial data management, long-term performance, and maintainability.

The infrastructure for the standardized dataset includes a Linux server hosting the Open Foris Arena platform for data collection and DuckDB for scalable and efficient data analysis. This combination provides robust support for field surveys and subsequent data analysis.

When finalized, the standardized forest inventory plots dataset (250 plots) will be publicly accessible, promoting transparency and fostering open research.

[7] https://openforis.org/solutions/collect-mobileold/
[8] https://openforis.org/solutions/arena/
[9] https://getodk.org/
[10] https://www.fieldmap.cz/