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Evaluation of BioSoil Demonstration Project

Preliminary Data Analysis

Roland Hiederer and Tracy Durrant

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European Commission
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Institute for Environment and Sustainability

Contact information

R. Hiederer
European Commission
Joint Research Centre
Institute for Environment and Sustainability
Via Enrico Fermi, 2749 - 21027 - Ispra (VA) – Italy
E-mail: roland.hiederer@jrc.ec.europa.eu

http://ies.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

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European Commission Joint Research Centre
Institute for Environment and Sustainability
TP 261
21027 Ispra (VA)
Italy

COVER PAGE:

The cover page shows a forest in Sweden taken in May, 2005

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List of Acronyms

ACRONYM	TEXT
CV	Coefficient of Variation
DG AGRI	Directorate General Agriculture
DG ENV	Directorate General Environment
FSCC	Forest Soil Co-ordinating Centre
FSEP	Forest Soil Expert Panel
ICP Forests	International Cooperative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests
INBO	Instituut voor Natuur- en Bosonderzoek / Research Institute for Nature and Forest of the Flemish Government in Belgium
IPCC	Intergovernmental Panel on Climate Change
JRC	European Commission Joint Research Centre
NFC	National Focal Centre
OC	Organic carbon
SOC	Soil organic carbon
SD	Standard deviation
SE	Standard error
SGDBE	Soil Geographic Database of Eurasia
SOC	Soil Organic Carbon
SPADE/M	Soil Profile Analytical Database of Europe, Measured profiles

1 INTRODUCTION

The BioSoil demonstration project is one of the studies initiated in response to the stipulations of Article 6 of *Regulation (EC) No. 2152/2003* (Forest Focus) [1] to develop the monitoring scheme by means of studies, experiments, demonstration projects, testing on a pilot basis and establishment of new monitoring activities. The aim of the BioSoil project is to demonstrate how a large-scale European study can provide harmonised soil and biodiversity data and contribute to research and forest related policies. It directly supports achieving the objectives of the monitoring scheme of assessing "the requirements for and develop the monitoring of soils, carbon sequestration, climate change effects and biodiversity, as well as protective functions of forests" (Forest Focus, Article 1(1)b).

The first ideas concerning the project were suggested by experts from EU Member States. Details on the scientific and technical aspects were finalized during the 1st meeting of the BioSoil expert group held at the JRC, Ispra on 13.-14. December, 2004 (FSCC, 2004). The results of the expert meeting were discussed at the level of the Standing Forestry Committee on 22. December, 2004. The project started in November 2006 for the duration of 3 years, of which the first 2 years were allocated to conducting the ground survey and laboratory analysis and the last year specifically for data validation and system management. It was undertaken as part of an Administrative Arrangement of the European Commission Joint Research Centre (JRC) and Directorate General Environment (DG ENV).

The demonstration project comprises two main modules:

a) Soil Module;

b) Biodiversity Module.

Both modules use a common site for sampling data. The locations of the sites should make use of the existing network of sites for monitoring the forest environment under Forest Focus / ICP Forests.

1.1 Soil Module

The specific objectives of the Soil Module of the BioSoil demonstration project were defined at several stages during the preparation of the project[2]. For the evaluation task the relevant objectives of the project have been grouped according to two main aspects as:

[1] OJ L 324, 11.12.2003, p. 1-8

[2] a) Service Contract Tender Specification (2006/ S 51-052820 of 15/03/2006)

b) Report from the first meeting of the JRC "BioSoil" expert group, Ispra, 13-14.12.2004.

Note: several versions of the meeting document have been circulated.

A. Analysis of Data

1. To assess the consistency of selected constant parameters (soil and site) between data from the previous soil survey and BioSoil data.
2. To determine temporal change for soil organic carbon content and density between data from the previous soil survey data to BioSoil data.
3. To assess the spatial variability of soil organic carbon at country level.

B. Analysis of Procedures

4. To comment on the QA procedures and parameters used during data validation.
5. To review the methodologies specified in the Manual on soil sampling.

The analysis of data from the central laboratory was not included ion the evaluation due to the provisional status of the data submitted by the NFCs at the time of processing. The final version of the database on soil conditions, including all re-submissions, has been made available in December, 2010.

1.2 Biodiversity Module

The BioSoil demonstration project was taken as an opportunity to assess and demonstrate the efficacy of the Level 1 network, as a representative tool of European forests, in order to address other issues of relevance to European forestry, such as forest biodiversity, with the addition of a few assessment variables. The approach to the forest biodiversity component of BioSoil was devised following a meeting of biodiversity experts from 16 Member States in co-operation with the JRC. The goal of BioSoil/Biodiversity is to provide data to support policy, international and national, on forest biodiversity, by:

1. Conducting a demonstration study to collect harmonised information relevant to forest biodiversity at the European level and demonstrate the use of the Level 1 network in this context;
2. Presenting a European forest type classification of the Level 1 plots and give a first attempt of habitat classification of the forests of Europe
3. Testing selected, internationally recognised, robust and practical indicators of forest biodiversity on a large scale survey thereby to develop a practical methodology as a manual.
4. Establishing an improved common baseline framework to integrate other information and ongoing projects (including the soil initiative of BioSoil) on forest biodiversity to achieve maximum added value;
5. Designing a multi-scale hierarchical approach to quantify European forest biodiversity and monitor changes over time and space.

Although data were foreseen to be collected in the network of Level I points for the countries that joined the project proposal, some countries used a subset of their network and at least one country (UK) set up an entirely new network specifically for the project.

1.3 Scope of Preliminary Data Analysis

This report concerns the initial evaluation of the results obtained from both the Soil and the Biodiversity Modules. Although measurements were taken and observations were made using the same plots the results are presented separately in this report. Combining the results from both surveys has been left to a later date.

A summary of the first results of the data evaluation were presented to the public during the BioSoil Conference held in Brussels on 09. November, 2009 [3]. In the assessment of the findings it should be considered that the analysis was limited to the data available at the time of processing the data. For the more elaborate soil data the status of the database as of 30. September, 2009 was used. For the data on biodiversity some amendments sent at later dates could be included in the analysis, although at this stage it was mainly limited to summary statistics. Because of the preliminary status of the data results from the re-analysis of samples from the historic survey and BioSoil by the central laboratory were not analysed for this report.

[3] http://ec.europa.eu/environment/forests/ffocus_noticeboard.htm

2 PROJECT ORGANIZATION

The preparatory project phase involved a substantial number of national and international organizations (FCSS for ICP Forests Manual). The main partners of the implementation phase were the *National Focus Centres* (NFCs), the *European Commission Joint Research Centre* (JRC) and the service contractor.

2.1 Legal Framework

The BioSoil demonstration project is part of the schemes for protecting forests against atmospheric pollution and for monitoring the forest environment. The activities under the schemes can be divided in a period before and after 2003, when Forest Focus came into force. Provisions for the monitoring activities are made by European regulations detailing the procedures. The realization of the scheme is defined by regulations on the implementation. Technical details are specified in survey manuals. The BioSoil project is closely linked to the Soil Condition survey of Forest Focus, However, as a demonstration project BioSoil produced a specific survey manual on field sampling, analyses methods and data management. In the interest of advancing the monitoring activity the manual deviates in some aspects considerably from the Forest Focus specifications.

The foundations for the surveys on monitoring soil conditions on Level 1 and Level 2 plots are laid down by two main regulations:

- Council Regulation (EEC) No 3528/86 of 17 November 1986 on the protection of the Community's forests against atmospheric pollution[4]
- Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus)[5]

These regulations are complemented by several additional regulations laying down rules for their implementation and specifying the sampling procedures.

A summary of the documents pertaining to the implementation of the sampling of soil conditions is given in Table 1.

[4] Official Journal L 326 , 21/11/1986 P. 0002 - 0004
[5] Official Journal L 324 , 11/12/2003 P. 0001 - 0008

Table 1: Summary of Documents Related to the Implementation of Sampling Forest Soil Condition Data

Item	Monitoring		
Period	1986-2002	2003-2006	
Programme	Protection of the Community's Forests against Atmospheric Pollution	Forest Focus	
Regulation	(EEC) No 3528/86	(EC) No 2152/2003	
Implementation	(EEC) No 1696/87 (EC) No 804/94 (EC) No 1091/94	(EC) No 1737/2006	
Survey	Soil Condition	Soil Condition	BioSoil

Council Regulation (EEC) No. 3528/86 formed the basis for assessing and monitoring the effects of air pollution on forests. The monitoring scheme itself dates back further to the *International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests* (ICP Forests) of the UN/ECE *Convention on Long-range Transboundary Air Pollution* (CLRTAP).

Council Regulation (EEC) No. 3528/86 together with *Commission Regulation (EEC) No. 1696/87*[6] and *Commission Regulation (EEC) No. 1091/94*[7] define the arrangement of the monitoring activity, but specify in the implementation rules the procedures to be applied for field sampling. These specifications of procedures were modelled after the ICP Forests Manual for sampling data. They were subsequently used for the sampling, measurement and reporting rules applied to Forest Focus.

Regulation n.(EC) No. 2152/2003 or Forest Focus provided the legal framework for the continuation of the monitoring activity until 2006. Specific rules for the implementation of Forest Focus are laid down in *Commission Regulation (EC) No 1737/2006 of 7 November 2006 laying down detailed rules for the implementation of Regulation (EC) No 2152/2003 of the European Parliament and of the Council concerning monitoring of forests and environmental interactions in the Community*. The BioSoil Demonstration Project follows the provisions made under Article 6 of Forest Focus as part of developing the scheme.

According to Article 10 of Forest Focus further specifications on parameters to be collected, methods of sampling and analysis and data transmission are to be defined in monitoring manuals. Under paragraph 15 of Forest Focus the objective of establishing a data platform containing spatial data is stipulated. The Forest Focus Monitoring database includes also all Level 1 and Level 2 data from all previous monitoring campaigns, notably the data from the intensive monitoring sites formerly managed by the *Forest Intensive Monitoring Coordinating Institute* (FIMCI) under contract from

[6] OJ L 161, 22.06.1987, p.1-22
[7] OJ L 125, 18.05.1994, p1-44

DG AGRI and Level 1 Soil Condition data from the 1994/95 campaign which were managed by the *Forest Soil Co-ordinating Centre* (FSCC). The FSCC is hosted by the *Research Institute for Nature and Forest* (INBO), Belgium[8].

With the legal framework the organizations responsible for managing the data changed. Those administrative alterations impacted on the communication with NFCs, the range of data reported, the validation procedures applied and the storage arrangements of the database.

2.2 Project Participants

The management of BioSoil / Soil data was distributed between three main participants in the project:

- National Focal Centres
- European Commission Joint Research Centre
- Service Contractor

The participants had distinctly different tasks to perform.

2.2.1 National Focal Centres

NFCs were responsible for the field survey, assembling the data from all sites belonging to the responsibility of the NFC and transmitting the data according to the data format specifications to the JRC. BioSoil/Soil data on Level 1 sites were submitted by a total of 31 NFCs via a Web-application.

The coverage for soil data of the participating NFCs is given in Figure 1.

[8] http://www.inbo.be/content/page.asp?pid=EN_MON_forest_soils

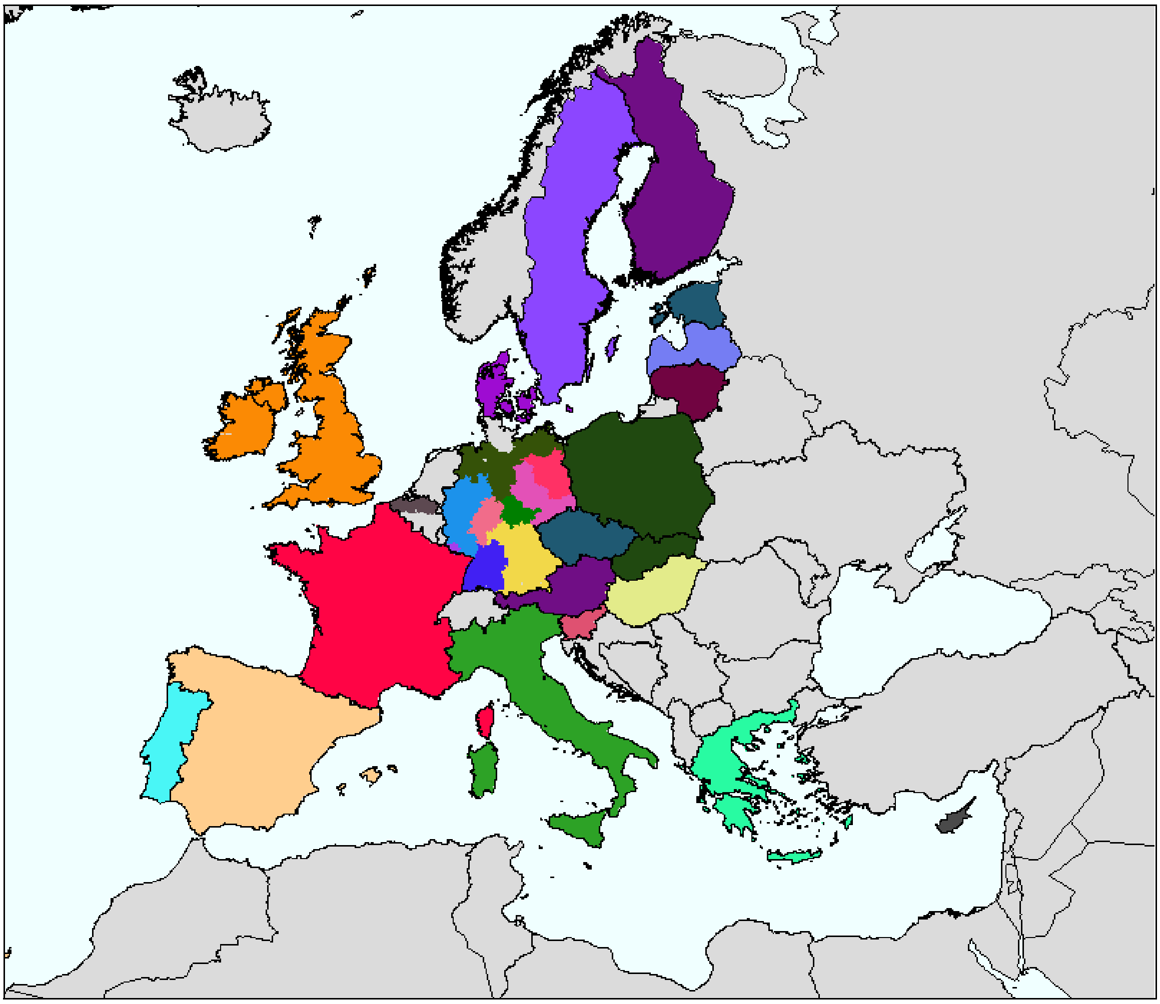


Figure 1: Coverage of NFCs Participating in BioSoil/Soil Project (Level 1 and Level 2)

The participating countries were the same as those shown in Figure 1, but excluding Portugal, Greece, Estonia and Germany (Saxony), who only participated in the soils module. Some of the participating countries assessed fewer of their BioSoil plots for biodiversity, resulting in an overall lower number of points assessed than for the soils data.

In a deviation from the reporting arrangements used in the Forest Focus monitoring activity Germany authorized NFCs by Länder instead of a central NFC managing the data. Of the 15 German Länder 10 participated in the project. Data for Level 2 sites were submitted by 22 NFCs. In total data were submitted by 32 NFCs, because Greece only submitted data for Level II sites.

2.2.2 Joint Research Centre

The role of the JRC was to ensure that suitable specifications were compiled for field and laboratory methods, to specify the database system components and validation procedure and to manage the service contract and the overall management of the project. The JRC was also the interface for communications with the NFCs for any technical questions arising from the BioSoil activity, in particular for data submission issues and queries of data quality.

The procedure for the Biodiversity module was different from that used for the soil module and data were submitted directly to the JRC by e-mail.. Because of the relative simplicity of the data (no laboratory analysis required) the entire module was managed within the JRC whose role in this case also included database design, data management and validation in addition to the project management.

2.2.3 Service Contractor

For the development of the data management system and the implementation of the validation procedure a call for tender for a service contract was issued by JRC[9]. The service contract "*Service provision for Technical support in the BioSoil study, provision of central laboratory services for soils analysis and data management 2006 – 2008 in the framework of the Forest Focus regulation EEC 2152/2003*" was awarded to a consortium consisting of the *Institute national de la recherche agronomique* (INRA) and *Inventaire forestier national* (IFN).

[9] Call for tender: 2006/ S 51-052820 of 15/03/2006, Contract n°382419 F1SC

3 ANALYSIS OF BIOSOIL / SOIL DATA

The procedure adopted for sampling soil data under BioSoil largely followed the methodology adopted to sample soil condition data under Forest Focus and ICP Forests. The monitoring scheme uses two distinctly different networks of site locations:

- Level I: network of sites for systematic forest condition monitoring
- Level II: sites for intensive forest condition monitoring

The sites, their geographic distribution and the data collected serve very different purposes. Level I sites were arranged in a regular grid of 16km x 16km with some excerptions for areas in Scandinavia. Their purpose was to serve as the basis of a statistical analysis of the extent of damage to forests from atmospheric pollution. On Level I sites monitoring on an annual basis is restricted to the Crown Condition survey.

Level II sites are intended for intensive monitoring of environmental conditions and their effects on the state of the forest ecosystem. They are selectively positioned and data are not immediately suited to provide statistics on forest conditions. However, at Level II sites data from up to 12 surveys are collected to study the interactions between environmental parameters and the state of the forest.

To distinguish between the sites used for long-term forest monitoring and those used by BioSoil the Forest Focus / ICP Forests networks are designated by capital Roman numerals (Level I, Level II), while for the BioSoil sites Arabic numerals are used (Level 1, Level 2).

3.1 Forest Soil Surveys

Data used in the evaluation originate from various sources. An overview of the data by provenance is presented in Figure 2.

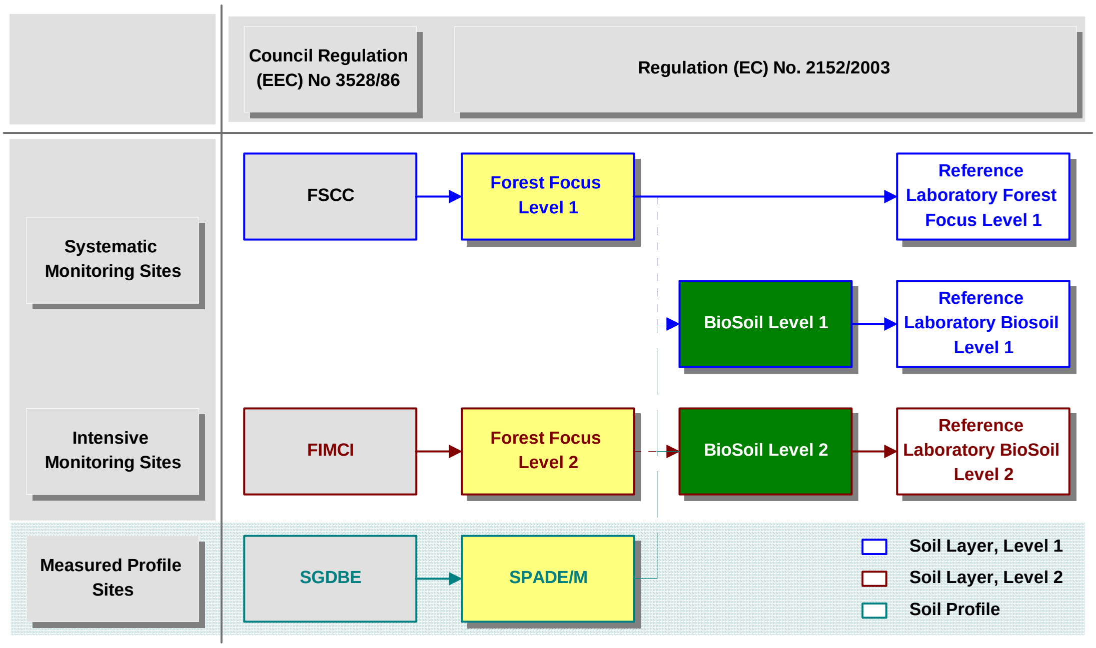


Figure 2: Provenance of Data Used in BioSoil/Soil Evaluation Task

With respect to the sources of the data one can distinguish between the legal framework, the distribution of the sample sites and the type of activity.

3.1.1 BioSoil / Soil Project Data

The data generated by the BioSoil/Soil project are:

a) Quantitative information from observations and measurements
   - from BioSoil/Soil Level 1 sample sites analyzed by national laboratories
   - from BioSoil/Soil Level 2 sample sites analyzed by national laboratories
   - from BioSoil/Soil Level 1 sample sites analyzed by reference laboratories
   - from ICP Forests Level 1 sample sites analyzed by reference laboratories

b) Qualitative information on site, sampling and laboratory procedures

The quantitative information surveyed at the sample sites forms the main component of the data collection task. All procedures and methods to be applied to the quantitative data are described in detail in the BioSoil/Soil field manual. The data are further subjected to the quality control of the data validation phase.

Having comparable data available from a soil survey conducted 10 years previously should allow estimating the consistency by comparing invariable parameters and appraising temporal changes for variable soil parameters. The results of the re-analysis of part of the data by a reference laboratory using standard methods for all samples should provide an assessment of the spatial variations introduced by variations in the analysis methods.

The qualitative information on sites and methods is reported in form of *Data Accompanying Reports* (DARs). The formal demands for the DARs are limited and free-format text files were accepted. The additional information provided in the DARs were intended to aid the validation process by highlighting site-specific conditions and exceptional circumstances, which were of influence on measuring or reporting the quantitative data and could not be recorded in the forms used to report the quantitative data.

3.1.2 Sampling by Layers and Pedological Horizons

Historic Level I and Level II data originate from surveys performed according to specifications of the ICP Forests Manual (Sub-Manual IIIa and Annex) or the specifications provided by the Regulations defining the implementation rules for the monitoring activity. These specifications and rules vary over time. The variations in the rules have a direct effect on the data collected, the measurement method applied and the arrangements for reporting observations and measurements. As a consequence, the modifications can potentially lead to intrinsic differences when comparing data from the previous Soil Condition surveys performed on Level 1 and Level 2 sites with those from the BioSoil project.

A completely independent set of soil profile data was given by the *Soil Profile Analytical Database for Europe of Measured Data* (SPADE/M) (Hiederer, *et al*., 2006). The database forms part of the *Soil Geographic Database for Eurasia* (SGDBE) and contains quantitative descriptions of profiles. The main criterion for selecting the sample sites of the profiles was to cover typical conditions for soil types to support defining pedo-transfer rules when estimating soil properties.

Data from the BioSoil project were collected according to am amended version of the ICP Forests Sub-Manual IIIa. The procedures specified therein were applicable to sampling data under the Soil Condition survey after 2006. Soil data sampled under the Forest Focus monitoring activity were thus not sampled according to the Sub-Manual IIIa of 2006, but following the specifications of version 6/2003. The procedures applied before 2003 were specified in an unmarked version of Sub-Manual IIIa. The sampling, measuring and reporting rules for the previous Level 1 Soil Condition survey of 1994/95 seems to have been performed on the basis of *Commission Regulation (EEC) No. 926/93*, Article Ia of Annex II and *Commission Regulation (EEC) No. 1091/94* Annex IV.

3.2 Data and Database

Several files are submitted by the NFS to the project using a Web-Interface. The data from the submitted files are examined and parsed from the ASCII format to the data-specific storage formats.

3.2.1 Files Submitted

The data on the soil survey are separated into five files, four submitted by NFCs and one by the Central Laboratory:

- **PLS**

  The file contains the description of the plot. Data are stored in the PLOT table.

- **SOM**

  The file contains the analysis of the samples surveyed by fixed layer depth. Results of the SOM file are stored in the LAYER_ANALYSIS_RESULT and HORIZON_ANALYSIS_RESULT tables, although some data are also found in the reference files LAYER and HORIZON.

- **PFH**

  The equivalent of the SOM file for data surveyed by pedological horizon. The data are also distributed between the reference and results table. The field CODE_POROSITY is recorded in the HORIZON table, while the values for POROSITY are stored in the HORIZON_ANALYSIS_RESULT table.

- **PRF**

  The file contains the data from the soil profile description. The format is hard-wired for reporting up to 6 WRB qualifiers and specifiers and 10 diagnostic horizons.

- **CLL**

  Data from the central laboratory is stored in the CLL file. Similarly to the data from the national laboratories the information from this file is separated and stored in the CLAB_LAYER and the CLAB_LAYER_ANALYSIS_RESULT tables. Deviating from the former data all results are stored in the results file.

3.2.2 Data Formats

Within the files the data are arranged as comma-separated values (CSV). The data types are

- **Integer**
  Values without decimal point, no distinction between short or long integer formats.
- **Numeric**
  Data of type float with decimal values.
- **String**
  Alpha-numeric format for codes, strings and coordinate data.
- **Date**
  Format for recording calendar dates.

The data are not necessarily read according to the format specifications. For example, the guidelines for the formats specifications state that a condition where a value is below the detection limit of the instrument it should be coded as "<0". This requirement necessitates the field values to be read as alpha-numeric and then translated into a numeric value.

A comma-separated format can cause problems when the field separator is also used as a decimal separator, as is the case in some European countries, such as Germany or Austria, or when descriptive text contains a comma. The example in the file documentation gives a semicolon (';') as a separator instead of a comma. Commas in descriptive text could be identified by using double quotes (") around string values. The instructions and the interpretation of the values are not consistent in dealing with the data. At times codes stored internally as characters are not requested to by recorded in double quotes (example: CODE_COUNTRY), although alpha0numeric codes are (example: LAYER_LABORATORY_CODE). The values for CODE_COUNTRY could be stored as integers, but because the leading 0 is included in the code the values form a string. This is not applicable to other codes, e.g. to record the altitude of the plot (CODE_ELEVATION).

In the database tables some inconsistencies between expected and actual field entries were encountered. The situations are summarized in Table 2.

Table 2: Data Problems in Files and Fields

Level	Table	Field	Comment
1	DAR_VARIABLES	LABORATIRY_CODE	For SUBMISSION_ID 659 field entry contains non-ASCII characters
1	PLOT	OBSERVATIONS	Numerous entries with double quotes ("")

The table contains only those situations which were came to light during the evaluation. A comprehensive analysis of all field entries was not performed since this was the aim of the validation task.

3.2.3 Data Model

The data model of the BioSoil/Soil database should be compatible with the data models of the Level 1 and Level 2 Soil Condition surveys of the Forest Focus Monitoring Database and the profile database of SPADE/M. The model actually implemented to store the BioSoil/Soil data differs significantly from the former two databases. A schematic model of the main tables of the BioSoil/soil database is presented in Figure 3.

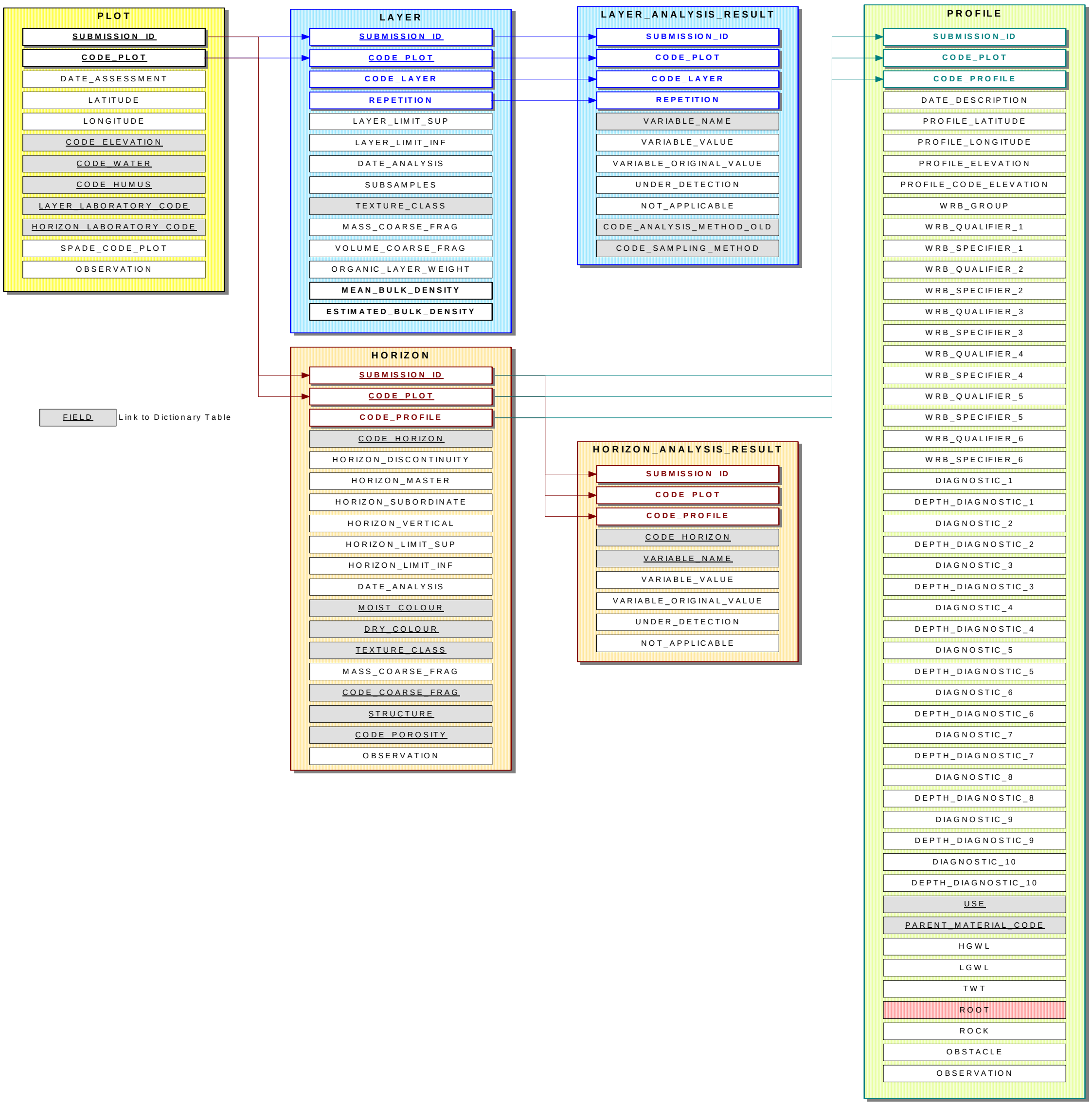


Figure 3: **Simplified Data Structure Diagram for BioSoil/Soil Data Model for Survey Data (as exported in XML file)**

The diagram shows the arrangement of data tables for the principal element of the database, the storage model for the surveyed data. Common information on the sample site (plot) is stored in a single table. Observations and measurements are separated into those related to sampling layers of fixed depth and pedological horizons. For each survey type the numeric data are stored in a single data (LAYER_ANALYSIS_RESULTS and HORIZON_ANALYSIS-RESULTS}. The separation of the reference unit (layer or horizon) and the observed or measured data is has been documented, but is not followed consistently in the implementation. The tables HORIZON and LAYER both contain also measured or observed data (MOIST_COLOUR, DRY_COLOUR, TEXTURE_CLASS, MASS_COARSE_FRAG, CODE_COARSE_FRAG, STRUCTURE, CODE_POROSITY). Since the data are pertinent to the depth section surveyed it is not immediately evident why the data are stored in the LAYER table rather than the result tables.

Not all links between the tables are complete. The situations found in the course of the evaluation are summarized in Table 3.

Table 3: Incomplete Links between Tables

Level	Table	Child	Comment
1	PLOT	LAYER	No data for 8 plots (943_1511, 943_1576, 943_1809, 1064_526, 1091_1130, 1213_1540, 1213_1714, 1214_103)

An incomplete link between tables only concerns the index field(s) and not the availability of data other than those fields. The database was not systematically tested for data integrity[10]. Only for the parameters analyzed was the existence of codes used in a data table related to the dictionary table. The checks performed concentrated on verifying the parameter values. Not generally evaluated was further the degree of normalization of the BioSoil data tables and the model. Ambiguity in links and duplication of information were assessed only as needed.

Different data models for storing soil profile data are used by other databases. Most use the same principle of separating site conditions, soil profile and dictionaries into distinct tables. However, the table structure varies significantly.

- **SPADE/M**

  The revised database for measured data of the Soil Profile Analytical Database (SPADE/M) of the Soil Geographic Database for Eurasia (SGDBE) uses a model, which is more oriented towards the arrangement of parameters in a spreadsheet (Hiederer, *et al.*, 2006). In this arrangement each parameter is

[10] Referential integrity cannot be defined for the tables within the structure exported by the RDBMS used (Paradox).

defined as a field (equivalent to a spreadsheet column) with a pre-defined field name and storage format.

- **FSCC**

  The data of the first soil survey on ICP Forests. Forest Focus Level 1 plots are stored in a database maintained by the *Forest Soil Coordinating Centre* (FSCC)[11]. The original storage environment was not formally described and the data made available to the JRC was the result of a structuring exercise performed during February – November, 2002 by FSCC. In the redesign data are stored by plot and layer or horizon. Separate tables are used for storing physical and chemical parameters. Parameter values are actually stored in an alpha-numeric field format to allow representing all parameter values. The data used in the evaluation task originate from the MS Access version of the database.

- **FIMCI**

  The *Forest Intensive Monitoring Coordinating Institute* (FIMCI) stored data from the surveys performed on Level II plots in a model akin to the forms specified to record and submit the observations and measurements. The data were made available to the JRC in form of exported ASCII files. The files were then parsed into the Forest Focus Monitoring Database. The Soil Condition data in the FIMCI Soil Condition database was integrated into the data model of the intensive monitoring database. The data model was aligned to the design of the forms of the Soil Condition survey. Plot samples were separated into mandatory and optional parameters. For storing the data individual fields were defined for each parameter analogous to a spreadsheet arrangement.

- **Forest Focus Monitoring Database**

  Data from the 1996 Level I soil Condition survey and the surveys performed on Level II plots were integrated into the *Forest Focus Monitoring Database* (FFMDb; (Hiederer, *et al*., 2008). The data model of the FFMDb is largely aligned to the forms for reporting the data from the monitoring activity. Parameters are stored in individual fields which are formatted according to the provisions made in the *Technical Specifications* documents published by the JRC.

The various data models to store data all have their merits and inconveniences. The non-normalized storage of data with parameters arranged as fields resemble the data forms and can be more readily used in a spreadsheet. However, they are inflexible with respect to any modifications of the data sampled and contain a considerable amount of redundant information. Data redundancy is to some degree caused by the provisions made in the Manual and not always the fault of the data model. The data models used by FSCC and BioSoil are more open to future modifications of the survey and data

[11] http://www.inbo.be/content/page.asp?pid=EN_MON_forest_soils

reporting requirements than the other models and use a higher level of normalization. In the adherence to design concepts the FSCC model goes further than the BioSoil model (storage of some profile parameters as separate field values in the LAYER table is inconsistent with design principles). Nonetheless, the BioSoil data model seems to be perfectly adequate to store the survey data.

3.2.4 Naming Convention

Naming conventions of fields are not fully consistent. For a number of fields containing codes the type of the data is given in the field name, usually starting the field name with the CODE_ prefix, such as CODE_COUNTRY, CODE_HUMUS. For some parameters the word CODE is added at different positions (PARENT_MATERIAL_CODE) or not used, such as STRUCTURE or USE.

The field formats of codes are mainly alpha-numeric (character string). This convention is also applied to fields which contain only numeric entries (CODE_COUNTRY, CODE_ELEVATION). Where codes are actual identifiers, as in the case of plot or profile identifiers, the field name still contains CODE, but the field format is of type integer (CODE_PLOT, CODE_PROFILE).

Some of the table fields and formats given in the document differ from those of the database. The cases are listed in Table 4.

Table 4: Field Format Changes between Documentation and Data

Field Name	Documented Type	Documented Dimension	Data Dimension
VARIABLE_NAME	CHAR	12	31
MOIST_COLOUR	CHAR	8	16
DRY_COLOUR	CHAR	8	16

During the implementation of the database the field formats have been adjusted to conform to the storage needs of the data. The field format information can be retrieved from the database. An update of the physical database model was provided to document the status of the database at the end of the project.

Fields of the database not found in the exported XML files are given in Table 5.

Table 5: Missing Fields in XML File

Table	Field Name
PROFILE	ROOT

3.2.5 Meta Data

The dictionary tables are stored in a structure referred to as meta-data. The meta-data contains a table with the verbose description of the checks performed and the messages displayed. However, the actual values used in the checks are not part of the export functionality. The meta-data table RANGE contains limits for 5 parameters (PERCENTAGE, VOLUME_PERCENTAGE, G_PER_100G, PH, BASE_SATURATION). The values for lower and upper constraints are set to the theoretical limits, not to expected ranges. The ranges of the values used to validate data Compliance are not included in the export file.

3.2.6 XML Export and Data Processing

For the evaluation the data from the XML-Export facility have been imported into a RDBMS (Microsoft Access). The XML-files are imported as alphanumeric data with 255 characters. The size of the resulting data posed a problem when converting data formats for the Level 1 LAYER_ANALYSIS_RESULTS and HORIZON_ANALYSIS_RESULTS tables. The problem is not so much caused by the amount of the data but rather the storage format. Options of solving the problem of file size are to either process only part of the data and then merge the tables or export the tables to another file format and re-import the data. For the evaluation the latter option was used to convert field formats (TAB-delimited, no text identifier). The Access import routine allows formatting imported fields to some degree they cannot be dimensioned. Therefore, fields containing codes are imported as alphanumeric data with 255 characters. Even in the smaller imported files the format cannot be modified in the RDBMS due to the size of the intermediate file. As a consequence, the tables were imported into another software package (Borland Paradox) and further processed using this RDBMS.

To transfer the alpha-numeric data to a database a parser is used to import the information into formatted fields. Field formats of the parser defined to import the XML files into the evaluation database had to be based on the initial description of the data model. Field dimensions were based on the size of the data recorded in the database.

3.3 Analysis of Soil Data

Depending on the inconsistencies found in the data during the validation process re-submissions of corrected data were possible well after the deadline for submitting BioSoil/Soil data. For the evaluation task the status of the data as found on 30.09.2009 was fixed. A separate instance of the database was generated from data exported from the database using the system functionality.

This arrangement of extracting data from the database and analysing the results in a separate environment was found preferable to interrogating directly the database, because it avoided analyzing data from different stages of processing in the system and distributing the data to perform the evaluation task also to those collaborators without direct access to the database.

Evaluated were thus not the files submitted by the NFCs, but the data stored in the BioSoil/Soil database as potentially made available to other interested parties. While there should not be a difference in the values between the data submitted by the NFCs and those stored in the database, the storage formats, in particular field dimensions, could vary. For the purpose of verifying any unusual situations the original files submitted were available to the evaluation project.

The PLOT table for the layer analysis at Level 1 plots contains references to 4,035 plots. Some plots do not have data on layer properties. An overview of the plots without data soil properties is given in Table 6.

Table 6: Level 1 Plots of the PLOT Table without Data in LAYER Table

NFC	Plot No.	Observation
France	1511	disturbed humus
France	1576	agricultural field
France	1809	a corn field
Niedersachsen	526	No profile and sampling possible cause of high waterstand, fen!
Spain	1130	""no observation""
Bayern	1540	not forested. not sampled
Bayern	1714	not accessable. not sampled
Denmark	103	Sonder Herred original Level 1 - resampling not possible due to massive soil disturbance - Gravel pit

The LAYER table contain references to 4,027 plots. For 1 plot no coordinates were available (windblown site) and for 2 plots in Italy identical co-ordinates were provided (plot codes 35 and 105). The remaining plots were found to be on non-forest land. For 2 plots in Thüringen (CODE_PLOT 200416001 and 200416002) the value in the field REPETITION is set to 0. This has to be considered when selecting data for the analysis to avoid excluding the plots.

In the analysis the data extracted from the BioSoil database was subjected to several standard checks intended to verify that the data evaluation would provide meaningful results. Rather than repeating the validation process the checks concentrated on excluding conditions causing spurious results. One of the main situations which could lead to computing inaccurate or biased results is the treatment of missing data. For single-parameter analyses including values of zero, which signify missing data, should be excluded when computing summary statistics. The description of a profile should be complete without duplication or absent depth sections. When computing data from several parameters, as is the case when computing SOC densities, a result must not be computed when the information from one of the parameters is missing. Care in processing the data is also needed to ensure that a soil sample is fully covered by valid data to the depth limit, for which a parameter is computed, taking into account that the soil may be shallower than the depth limit. The latter issue is specifically valid for the analysis of Level 1 data sampled by depth layer because the Manual does not foresee sampling parameters below 20cm as a mandatory task. It is therefore not always evident form the layer data alone whether the absence of any data indicates the nonexistence of soil or simply the deficiency of data. For the layer data depth to rock or obstacles to roots are not reported (the parameters are specified for sampling by pedological horizon).

In the analysis of the samples from the level survey data the organic layers were first processed separately for the organic and soil strata. The differentiation was necessary because in the previous survey performed on Level I plots the depth of the organic layer was not stored in the database. As a consequence and rather paradoxically, the survey data is not suited to compute soil characteristics for a given depth, for example for the widely used topsoil and subsoil sections of 0-30cm and 30-100cm.

3.3.1 BioSoil / Soil Level 1 Plot Location

An overview over the location of the Level 1 plots taken from the PLOT table is given in Figure 4.

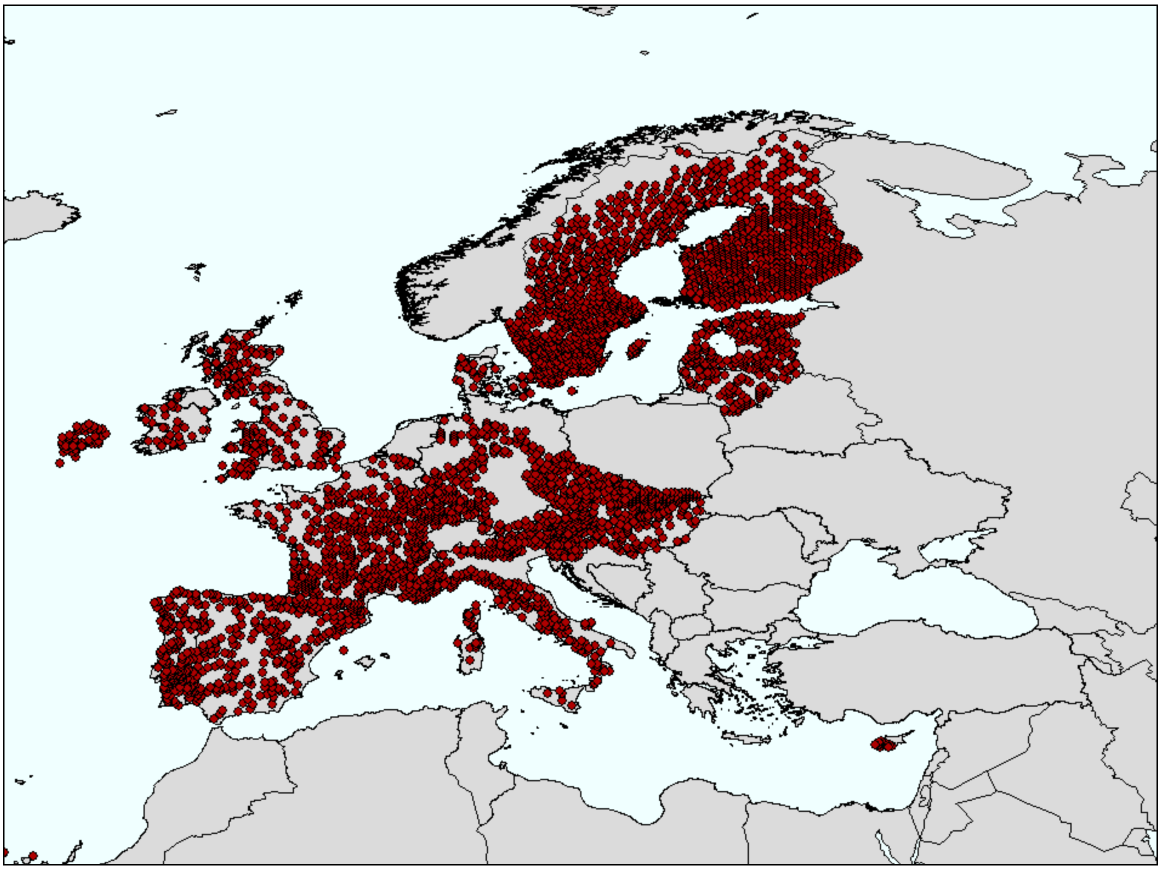


Figure 4: Position of Level 1 Plots of BioSoil/Soil Survey

The location of the plots was overlaid over the spatial layer of administrative regions of the GISCO database (Eurostat, 2009). NUTS level 1 and level 2 regions were rasterized to 1km grids and coded according to the BioSoil/Soil legend for NFCs. For each NFC the position of the plots as given in the PLOT table were overlaid with the administrative layer and plots not inside the area of the NFC they were identified. The result of the analysis is given in Table 7.

Table 7: Number of Level 1 Plots Outside NFC Land Area

NFC	Plots	Inside NFC	Relative
	No.	*No.*	*%*
Austria	135	135	0.0
Flanders	10	10	0.0
Cyprus	15	15	0.0
Czech Republic	146	146	0.0
Denmark	26	25	3.8
Estonia	96	96	0.0
Finland	630	630	0.0
France	548	548	0.0
Baden-Württemberg	50	50	0.0
Bayern	97	0	100.0
Brandenburg-Berlin	52	0	100.0
Hessen	29	29	0.0
Mecklenburg-Vorpommern	17	0	100.0
Niedersachsen	42	42	0.0
Nordrhein-Westfalen	39	0	100.0
Rheinland Pfalz	26	26	0.0
Saarland	9	9	0.0
Sachsen	19	19	0.0
Sachsen Anhalt	19	19	0.0
Thüringen	26	0	100.0
Hungary	78	78	0.0
Ireland	36	36	0.0
Italy	239	238	0.4
Latvia	95	95	0.0
Lithuania	62	62	0.0
Portugal - mainland	103	103	0.0
Slovak Republic	112	112	0.0
Slovenia	45	0	100.0
Spain	272	270	0.7
Sweden	795	795	0.0
United Kingdom	167	163	2.4
TOTAL	**4035**	**3751**	**7.0**

Of the 4,035 plots with coordinates 3,751 (93.0%) were found to be inside the area of the declaring NFC. For 6 NFCs the coordinates placed all plots outside the NFC.

For these plots the submission status was given as ‘OK’ and the validation status for the uniformity check was set to ‘True’. It later transpired that the positions of latitude and longitude coordinates were inversed in the files. The NFC for Poland cancelled a previous submission and could not re-submit new data by the time the data were extracted from the analysis for the evaluation task (30.09.2009).

The check was performed with a buffer zone of 3km around the land area of an NFC. This buffer is needed to accommodate plots situated in coastal zones where the coordinates were degraded to minutes rather than seconds. The lower level of precision in reporting plot coordinates may place a plot outside the land area of an NFC. An example is given in Figure 5.

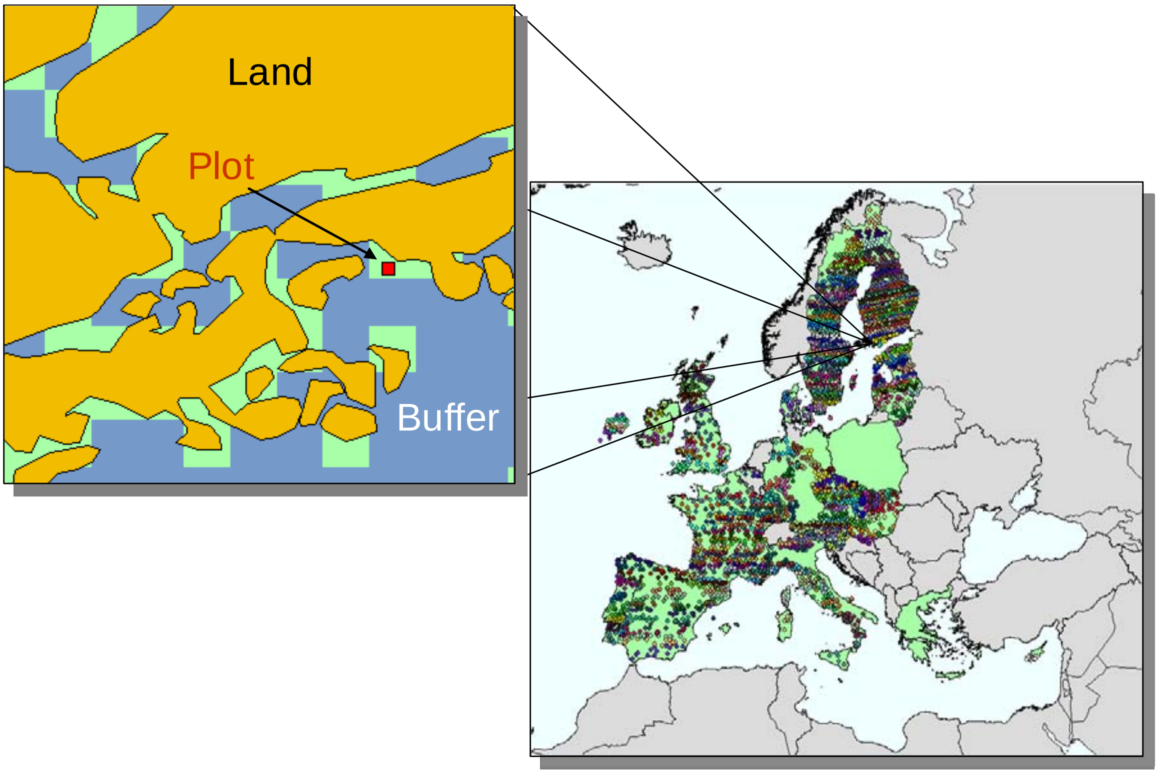


Figure 5: Shift of Plot Outside NFC Area (Level 1)

According to the coordinates restricted to minutes the plot has been positioned in the sea. It does not appear as a displaced plot because it is still within the buffer zone of the NFC land area.

The findings from the check on plot locations are not convincing that plot positions are reliably reported in the data and erroneous coordinates are highlighted by the validation process adequately obvious for the user to exclude those plots from the analysis.

3.3.2 Structure of Sample Layer Arrangement

The sampling procedure distinguishes between organic layers overlaying the soil material and the soil material (Forest Focus, 2007; ICP Forests, 2006). The use of the word "layer" for the organic part and "material" for the soil part can be confusing, because the procedure of sampling soil properties by layers applied to both sections. Also in the evaluation of the ICP Forest sub-Manual for sampling Soil Conditions the coding of the soil material by the letter "*M*" (*Mij* to specify the depth segment in the soil material) has at times been incorrectly interpreted as relating to the mineral part of a soil (Cools, 2005). Organic soil material was not included in the definitions given in the report on the previous Level I soil condition survey (EC, UN/ECE and the Ministry of the Flemish Community, 1997). However, the soil material can be designated as either mineral (*Mij*) or organic (*Hij*), depending on the water saturation status.

The generalized arrangement of layers in the soil sample is given in Figure 6.

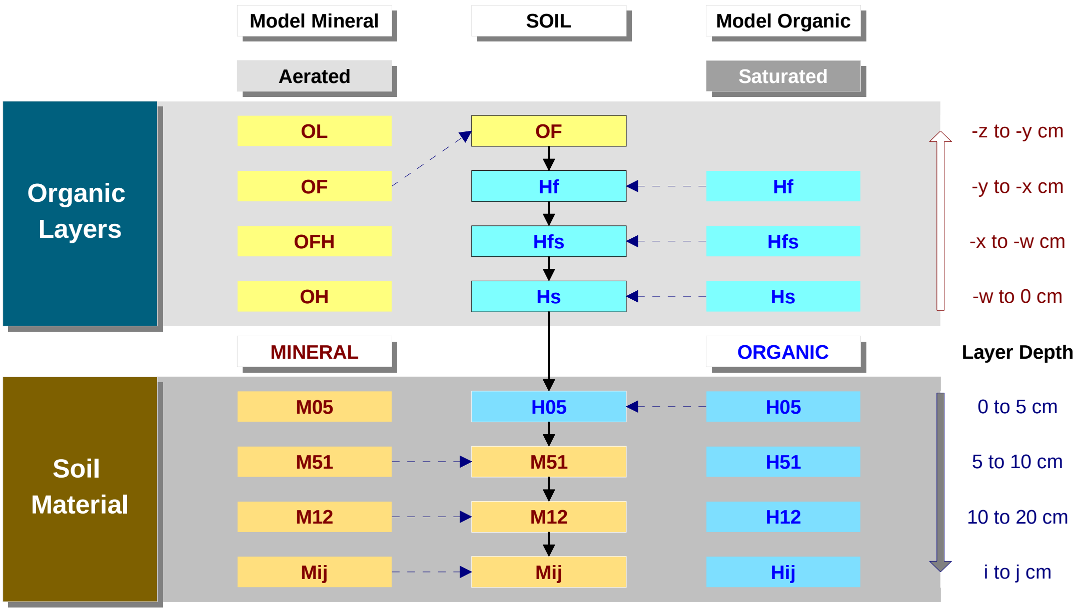


Figure 6: Schematized Arrangement of Soil Sample Layers

Compared to previous versions of the ICP Sub-Manual IIIa, the new Manual is in this respect more elaborate:

- **Organic layer(s)** consist of "… *undecomposed or partially decomposed litter, such as leaves, needles, twigs, mosses and lichens, which has accumulated on the soil surface; they may be on top of either mineral or organic soils.*"
- **Organic soil material** consists of "…*organic debris which accumulates at the surface under either wet or dry conditions and in which the mineral component does not significantly influence the soil properties.*"

The definition for organic soil material corresponds to the specifications for diagnostic organic soil material (FAO, 1998). The reference to an accumulation of organic substances on the surface in both definitions may be confusing. The instructions in the Manual that "…*Care should be taken to correctly separate the organic layer from the mineral soil material.*" are not helpful. Rather, the text relates to the separation of the organic layer from the organic or mineral soil material.

The depth of any organic layers overlaying the soil is recorded according to the status of the material while layers of the soil material use a fixed depth. A further distinction in reporting organic layers and soil material is made between aerated (*O*) and saturated (*H*) organic layers. The Manual specifies the same suffixes be used for both types, although the specifications for the SOM file use "*f*", "*s*" and "*fs*" suffixed for water saturated organic *H* layers. Organic *O* and *H* layers may both be on top of either mineral or organic soil material.

Organic soil material should be designated as *Hij* and is not to be confused with the organic *H* layer, which is on top of the soil material. Following the specifications the code *O* should not be used to denote organic soil material, not even for soil material never saturated with water for more than a few days. Only the *Mij* codes are available to record parameters for those soils, since the *Hij* codes are reserved for soil material saturated with water.

In-field difficulties of separating the organic layer from the soil material were recognized early on in the soil sampling activity of ICP Forests (Baert *et al*., 1998). The situation is better defined where a mineral layer is clearly present in the soil profile than for organic soils. For the latter only organic layer data are reported or organic soil data.

Separating organic from mineral soil material in the field can be problematic.. According to FAO (FAO, 1988) diagnostic organic soil material "*…consists of organic debris which accumulates at the surface under either wet or dry conditions and in which the mineral component does not significantly influence the soil properties*." Other than the organic carbon content clay content is a decisive parameter in defining organic soil material for soils saturated with water for long periods. A definite classification may require the analysis of samples in a laboratory.

The identification of organic soil material (*Hij*) over mineral material (*Mij*) led in some cases to a duplication of the depth identifiers and negative values for the depth limits of the organic material (positioned as an organic layer rather than organic soil). In those cases a perfectly acceptable arrangement of the sections by depth does not correspond to the range limits specified by the Manual. Negative depth limits for *Hij* sections were found for 156 plots from 5 NFCs (Finland: 66; Estonia: 14; Sweden: 74; Ireland: 1; Sachsen: 1).

In other cases the presence of an organic layer shifts the limits of the underlying soil material. An example is given in Table 8:

Table 8: Example of Confounded Assignment of Depth Limits to Soil Layers

Layer Label	Upper Limit	Lower Limit
OFH	-	-
M51	0	5
M12	5	10
M24	10	20
M48	20	40
OL	40	80

- no values recorded

The example shows a logical sequence of depth limits, but an incorrect assignment of layer labels. The presence of a layer of litter at a depth of 40 to 80cm is highly unlikely. The sequence of the data suggests that the layer M05 has somehow been lost and row containing layer labels has shifted upwards. With the inconsistencies in the data such samples should be excluded from the analysis.

The depth baseline for recording the upper and lower limits of the layers is the line of separation between the organic material and the soil material. Layer limits upwards from the baseline are increasingly negative while they are positive with depth in the soil section.

From the generalized model for mineral and organic soils the situation found in the sampled data is frequently a combination of aerated and saturated sections. An example is given in Figure 6. Not any combination of sections is viable. While some situations are dubious others are quite invalid. For example, it is unlikely to have an organic layer below soil material, but using limits of a soil layer that differ from the defined ranges represent an error in the data.

3.4 BioSoil/Soil Level 1 Organic Carbon

The main objective in the evaluation of the data was the estimation of SOC stocks and changes to SOC from the previous survey. SOC stocks are estimated from density for a given depth applied to an area. SOC stock is calculated from SOC content, dry bulk density, volume of stones or coarse fragments and for a given depth as:

$$SOC_S = SOC_C \times BD \times \left(1 - \frac{VS}{100}\right) \times LD \times 10^2$$

where

- SOC_S: total amount of soil organic carbon to given depth ($t\ ha^{-1}$)
- SOC_C: soil organic carbon content for given depth (%)
- BD: dry bulk density ($g\ cm^{-3}$)
- VS: volume of stones (%)
- LD: depth of soil layer (m)

For the organic layer the amount of organic carbon can also be determined by using the OC content of the layer and the organic layer weight. In this case data on layer depth and bulk density are not needed.

3.4.1 Organic Carbon Content

The relative presence of organic carbon in the soil is expressed in units of $g\ kg^{-1}$. For Level 1 layer data the measurements are stored in the LAYER_ANALYSIS_RESULT table with the variable name "*organic_carbon*". According to the specifications ion the Manual the parameter should have been provided for all organic layers with decomposed material (*OF*, *OH*, *OFH*, *Hf*, *Hfs* and *Hs*) and all mineral layers to a depth of 20cm. For Level 1 plots reporting organic carbon for deeper layers is optional. An overview of the conditions found in the data table is given in Table 9.

Table 9: Availability of Level 1 Plots for Computing Organic Carbon Content for Layers

Condition	Occurrence	
	Plots	of Plots (%)
Records	4,027	99.8
Only organic layer data	168	4.2
No organic layer / only soil material	670	16.6
*Missing data for organic layer**	*321*	*8.0*
*Missing data for soil material**	*354*	*8.8*
*No data for 0-10cm soil segment**	*130*	*3.2*
*No data for 10-20cm soil segment**	*52*	*1.3*

* 8 plots excluded from analysis due to incomplete layer description.
Note: more than 1 condition can occur at a plot

Of the 4,027 plots with data for the soil layer survey one or more value(s) for OC were reported for 3,800 plots (94.4%). For 3 plots a value of 0 was given for the OC content in a layer, where an actual value could be expected (Hungary: Plot 8, Layer M48; Mecklenburg-Vorpommern: Plot 8083, Layer *OL*; United Kingdom: Plot 30, Layer *OFH*). The value provided by the NFC was not under the detection limit and the values should be declared “not conform”. They were subsequently excluded from the analysis. In this case the absence of a value in the *OL* layer was not relevant to the analysis because the layer is not used to determine below-ground organic carbon content in the soil material.

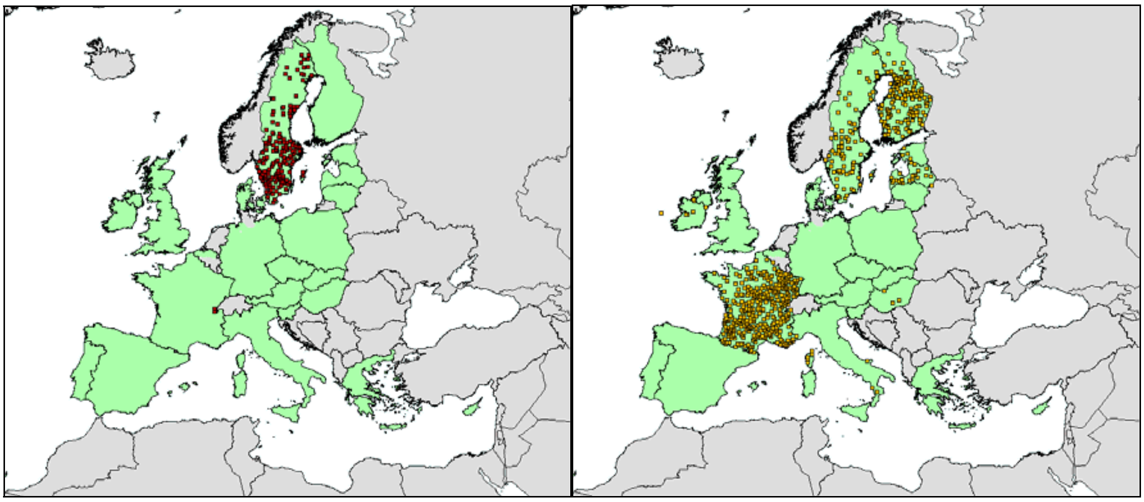
The presence of 1 or more organic layer(s) (*OF*, *OH*, *OFH*, *Hf*, *Hs* or *Hfs*) was reported for 3,140 plots. A layer of organic litter (*OL*) was reported for 1,723 plots. Submitting a value of organic carbon for the litter layer was not requested in the Manual. Nevertheless, a value was submitted for 658 plots by 18 NFCs.

For organic layers where a measurement of organic carbon was requested (*OF*, *OH*, *OFH*, *Hf*, *Hs* or *Hfs*) a value was provided for 2,833 plots. For plots with organic layers data for the organic layer were missing for 321 plots (Spain: 11, Sweden: 238, Austria: 6, Baden-Württemberg: 2, Bayern: 1, United Kingdom: 51, Slovenia: 1).

For soil segments within the topmost 20cm of the soil material, where submitting data is mandatory for Level 1 plots, a value is given for 3,675 plots. No parameter data were provided for the soil material of 354 plots (France: 1; Spain: 170; Sweden: 136; Finland: 31; Baden-Württemberg: 2; Hungary: 6; Estonia: 5; United Kingdom: 3). Data for a soil section was considered missing when the section was indicated in the database but either no data were provided or when a deeper section was also indicated without adequate information on the section above.

For 168 plots only organic layer data were recorded. For 1 plot (Ireland: Plot Code 7) data for just the organic litter were included. Because the OL segment of the organic layer is excluded from the analysis of OC content data from 167 plots could be used.

The spatial distribution of plots with data for only the organic layer and only the soil material is presented in Figure 7.



a) only Organic Layer *b) only Soil Material*

Figure 7: Distribution of Plots with only Organic Layer and with only Soil Material Data (BioSoil)

The large majority of plots with just organic layer data are in Sweden (165), while 2 plots located in France have no soil material. The distribution of plots with only soil material is less concentrated. They are found erratically in Italy, Hungary and Ireland, for the latter also on organic soils with OC contents >30%. The situation is commonly found on plots in France and on plots of most of the Baltic States.

To identify a complete set of values for the organic carbon content to a soil depth of 20cm several steps of processing were applied. The steps were:

1. Exclude the litter layer (*OL*) from the soil sample.
2. Compute mean values for repeated samples.
3. Mark the presence of a layer in the soil sample, regardless of whether a value for organic carbon was recorded or not.
4. Analyze completeness of data for sample.

The last step required formulating rules to consider the coverage of a soil sample with data complete or not. The potential over-sampling of the 0-10cm section and mixing aerated with saturated layers and mineral with organic soil sections made the task exceedingly complex. The rules also had to take into account that mineral and organic sections could be substituted. In general, when data were found to be missing for a layer or section the plot data was declared incomplete, but only when a deeper section was indicated. For example, the soil data for a plot was considered complete when only data for the *X05* section were reported or *X01* in the absence of an *X05*. When the data indicated a depth of at least 10 cm (presence of *X01* or *X12*) the availability of only one of the *X05* or *X51* sections led to the plot data being declared incomplete. Hence, data for an *X01* section would not substitute an incomplete set of data for the *X05-X 51 sections*. The later decision was taken in line with the specifications than when measuring the first 10 cm of soil in 5 cm intervals the results take precedence over those of a single measurement for the section. While parameters are not always recorded for only the *X05/51* or *X01* sections duplicate recordings for data on organic carbon occur in just one case, which is given in Table 10.

Table 10: Example of Duplicated Section Data

Layer / Section	Upper Limit		Lower Limit		Organic Carbon Content
	cm		*cm*		*g kg-1*
OL	0	*-4*	1	*-3*	414.00
OF	1	*-3*	4	*0*	486.10
H01	4	*0*	14	*10*	477.30
H12	14	*10*	24	*20*	542.70
H24	24	*20*	44	*40*	486.00
H48	44	*40*	84	*80*	503.10
M81		*80*		*100*	*9.8*
M05	84		89		19.70
M51	89		94		12.90
M12	94		104		3.30
M24	104		124		-
M48	124		164		-

n: intended description of soil sample by layer

The example given in Table 10 demonstrates a number of objectionable conditions in the data sampled:

- Organic layers positions should have been recorded upward from the top of the soil section with distances expressed in negative values.
- *Hij* and *Mij* are both soil sections, *Hij* denoting peat (water saturated), Mij denoting either an organic soil (not water saturated) or a mineral soil.
- The upper and lower limits of soil sections are pre-set and cannot be re-defined.

- No data are provided for sections *M24* and *M48* (probably because they are located below 100cm)

The example also demonstrates a dilemma in the analysis of the data submitted: while the soil sample is perfectly interpretable as a single occurrence, it does not comply with the specifications of recording soil properties by layer sampling. As a consequence, the data cannot be readily combined with information from other soil samples, neither by the layer codes nor by the depth ranges. The example also demonstrates that inconsistencies in reporting the profile layers are at times the result of ambiguous or contradictory specifications given in the guidelines for sampling. As concerns the case examined the Manual states under *Section 2.3.3.4. Sampling of peatland* that

> "*…the peatlayer is sampled at fixed depths, mandatory 0 – 10 and 10 – 20 cm and optionally at 20 – 40 and 40 – 80 cm. In the reporting forms a separate name for the peatlayers shall be used, namely H01, H12, H24 and H48 in the records for the organic layers.*"
>
> and later
>
> "*…mineral soil below the peat soil (> 40 cm) can be further sampled according to the standard depths (M01, M12, M24, M48).*"

These stipulations do not fit with the concept of using the depth codes as indicators of the position of the sample in the profile, which then becomes a problem of arranging data in the database. As a consequence, the sequence of depths sections of the example given in Table 10 is correct for the soil material, but the depths of the organic layer should have been recorded with negative limits starting from *H01* with depth 0.

A complete set of values for organic carbon to a depth of 20 cm was available from 2,735 plots (67.9%). Layer data from a plot was considered complete when a value for organic carbon was reported for all layers within the zone of interest. When the presence of an organic layer over a mineral soil was indicated by recording a layer of type *OF*, *OH*, *OFH* but no values were recorded for those layers; the plot was excluded from the analysis. When the presence of an organic layer covering mineral soil was not indicated the mineral data were analyzed for the plot. It was found that a similar logic for the mineral layers to exclude incompletely described soil samples was not applicable. This was caused by the possibility of describing a parameter by more than one layer for the depth 0-10cm. the layer could either be described by a single layer (*M01*) or by two layers (*M05* and *M51*). The depth section could also be described by all three layers. The situation is made more complex because for layers used differ at times with the parameter assessed. As a consequence, for the layer *M01* data may be provided for some parameters, but no data may be reported for organic carbon, which is covered by using layers *M05* and *M51*.

The computation of the OC content in the organic layer should be a straight-forward task. The parameter is reported directly in the database. It is readily available for organic layers with a segment. For organic layers with more than 1 segment the mean OC content has to be weighted by the presence of the segment in the layer. For the soil material this is usually achieved by using the segment depth as a weighting factor. This approach can be used for organic layers where a depth value is provided. This is not always the case. An alternative method is to use the organic layer weight to compute the total amount of OC in the organic layer and then find the mean OC content. For the analysis both methods were applied to maximize the amount of plots with data on the OC content for the organic layer.

The distribution of organic carbon content in the organic layer is presented in Figure 8.

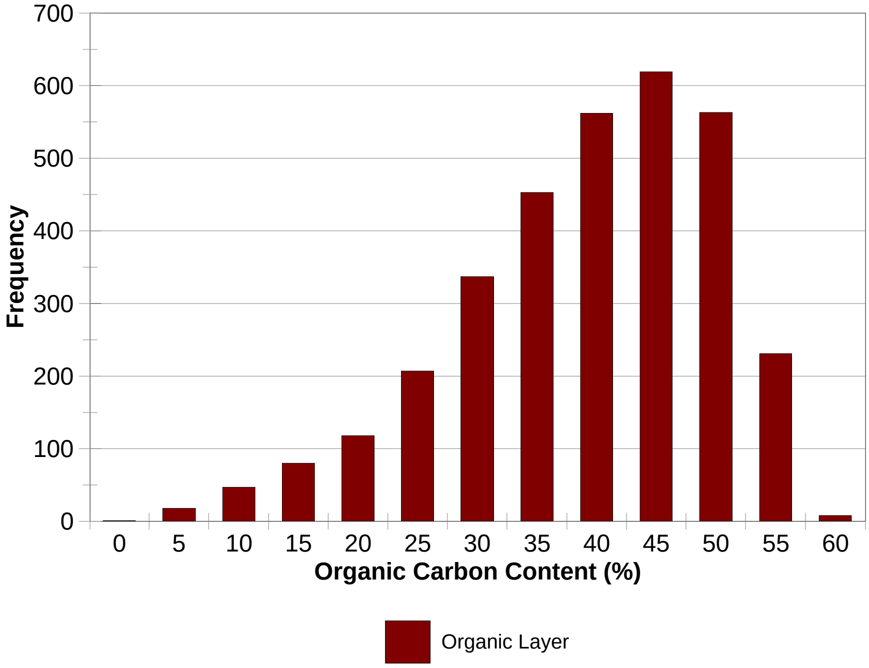


Figure 8: Frequency Distribution of Organic Carbon Content in Organic Layer (Level 1)

There is a gradual increase in OC up to the most frequent values on the class of 40-45% OC, where approx. 20% of the layers with data are positioned. Unexpected are the occurrences of values < 20% OC in organic layers. A closer examination of minimum and maximum values and the number of layers with low values of OC is given in Table 11.

Table 11: Minimum and Maximum Organic Carbon Content in Organic Layer (Level 1)

Layer	Min *g kg⁻¹*	Max *g kg⁻¹*	Layers with *OC <10%*	Layers with *OC <20%*
Hf	162.80	547.90		1
Hfs	195.50	527.60		1
Hs	202.00	542.80		
OF	24.00	562.10	10	31
OFH	25.30	596.50	45	165
OH	20.50	553.10	11	58

g kg^{-1} : reporting unit

It is not immediately obvious why such low values were found for organic layers, such as the *OH*, where the organic fine substance should amount to more than 70% by volume.

The spatial distribution of the OC content in the organic layer is given in Figure 9.

The graph does not reveal a visible difference in the distribution of OC in the organic layer by NFC. It would appear to be less variable plots in the Czech Republic and the Slovak Republic than in plots in other NFCs, but not significantly so. For Finland the OC content in the organic layer appears to be higher on plots in the north than in the south of the country. The division roughly follows the area limit of the 16km and the 32km sampling grid.

The distribution of the OC content by soil segment is given in Figure 10.

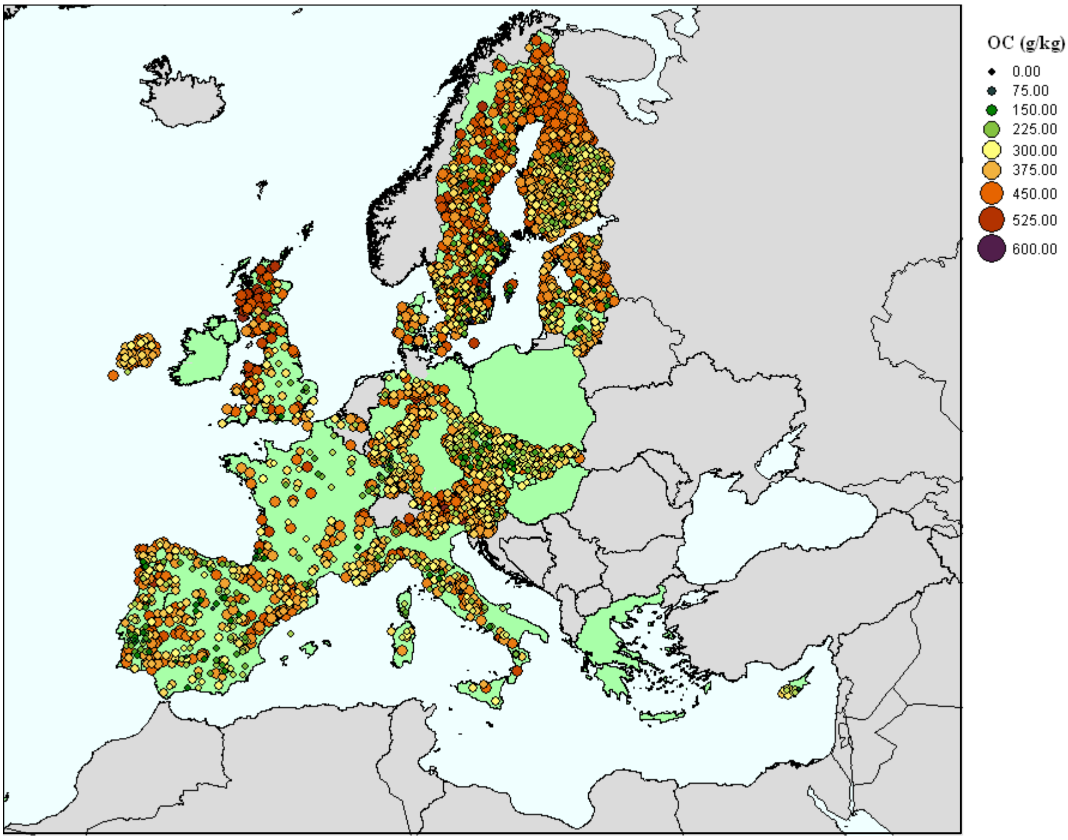


Figure 9: Spatial Distribution of Organic Carbon Content in Organic Layer (Level 1)

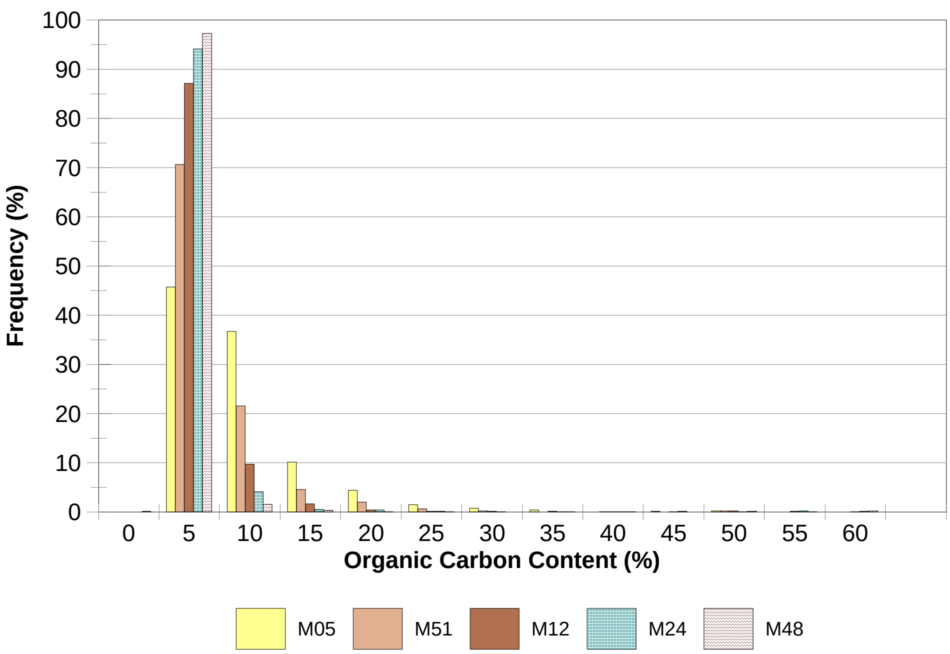


Figure 10: Frequency Distribution of Organic Carbon Content in Soil Material (Level 1)

Most of the soil layers have an OC content of 5-10%. The graph also indicates that the variability on OC content decreases significantly with depth.

The results of the check of minimum and maximum OC values reported for the aerated and saturated segments are given in Table 12.

Table 12: Minimum and Maximum Organic Carbon Content in Soil Material (Level 1)

Layer	Min *g kg*$^{-1}$	Max *g kg*$^{-1}$	Layers with *OC < 12%*	Layers with *OC < 18%*
H05	200.30	540.50		
H51	152.40	551.50		2
H01	185.20	649.50		
H12	111.00	593.00	1	4
H24	133.00	600.50		2
H48	19.70	586.50	1	2
			OC > 12%	*OC > 18%*
M05	1.30	477.70	111	34
M51	1.10	476.50	51	14
M01	1.40	568.00	118	57
M12	0.30	567.00	71	38
M24	0.40	587.00	41	23
M48	-6.49	584.00	19	14

g kg^{-1} : reporting unit

For two plots in Bayern (Plot No. 1606, 1634) negative values for OC content were reported. In some cases values for organic soil segments below 12% and 18% were reported. Conversely, there were a not insignificant number of plots where mineral soil segments with an OC content indicating an organic soil were reported. These cases were found in several NFCs and thus suggest that the problem of separating organic from mineral soils is rather widespread.

The distribution of the OC content in the soil material for the NFCs is given Figure 11.

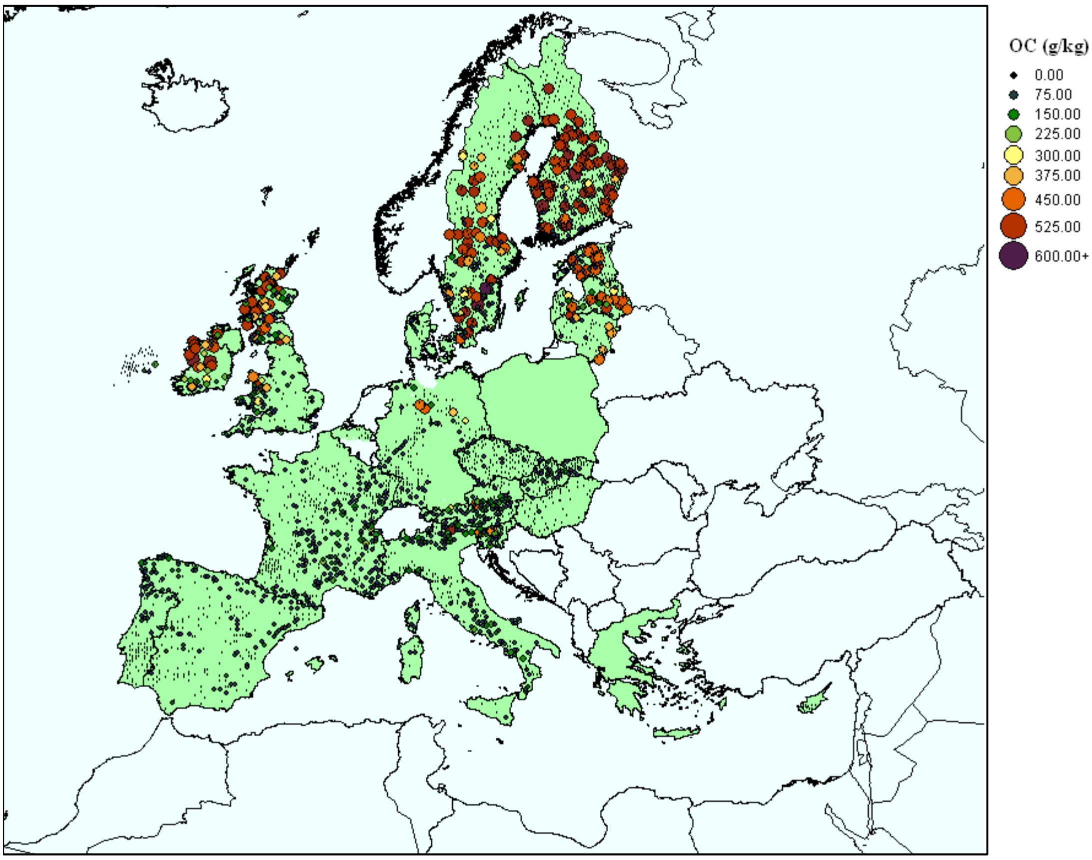


Figure 11: Spatial Distribution of Organic Carbon Content in Soil Material (Level 1)

The spatial distribution of the OC content in the soil material follows the general patter of the distribution of peat in Europe. Mapping the parameter does not reveal any other obvious spatial differences or trend.

3.4.2 Depth

The issue of reporting upper and lower depth values has already been mentioned in the previous section. The values should have been used only to record the limits of the organic layer(s). Depth limits are counted backwards from the organic layer / soil section boundary, which is defined to be of depth 0 cm. The forms allowed providing values of depth also for the soil sections. This has led to the re-definition of the depth limits of the pre-defined soil sections.

A value of the upper (LAYER_LIMIT_SUP) or lower depth limit (LAYER_LIMIT_SUP) is missing from one or more organic layers for 132 plots (*OF*: 13; *OFH*: 104; *OH*: 15; all *Hij* layers with depth values). This count excludes layers of organic litter (*OL*), which are not considered in the computation of the sample organic carbon content. No occurrences were found where only one value for the layer limits was given. Identical entries for the upper and lower depth limits for the organic layers were found for 21 plots (52 cases for *OL* layer). Of those, 20 used a depth of 0.0 cm. This leaves 3,014 plots (96.0% of plots with an organic layer) with data on layer depth for the organic layer.

The relative distribution of the height of the organic layer is presented in Figure 12.

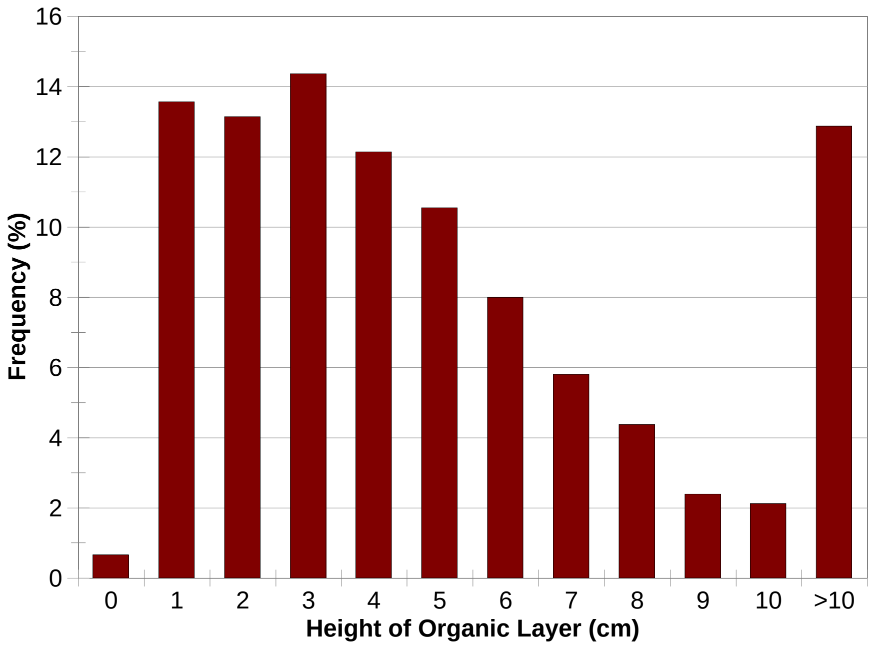


Figure 12: Frequency Distribution of the Height of the Organic Layer (Level 1)

The graph shows that on the Level 1 plots the height of the organic layer is most commonly 1 – 3cm with a steady decrease in frequency of layers with a higher degree of accumulation of organic material. The group of plots with heights of the organic layer of >10cm is only locally significant. Organic layers of this height were reported for 12.8% of the plots.

The height of the organic layer at the sample sites is presented in Figure 13.

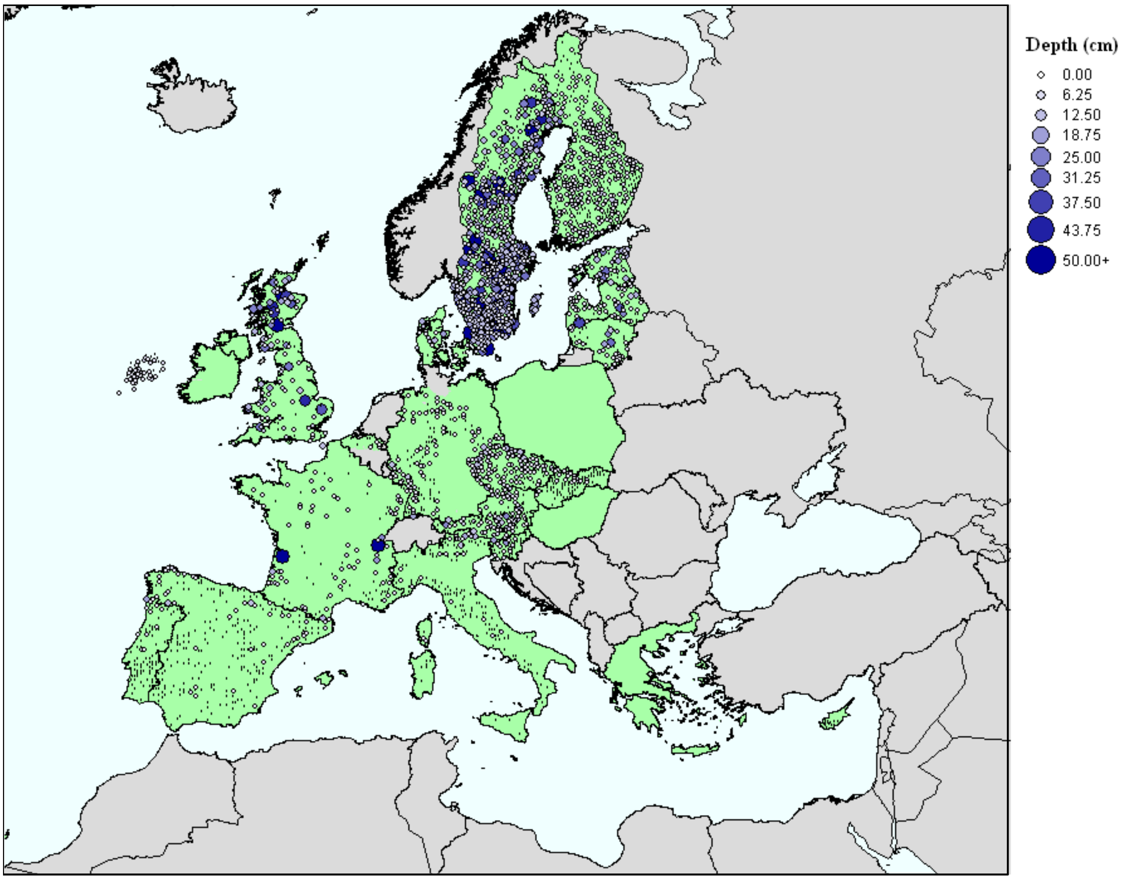


Figure 13: **Spatial Distribution of Height of the Organic Layer (Level 1)**

The height of the organic layer in the Mediterranean forest area is mainly below 2cm. In central and northern areas of Europe the height increases to generally >3cm. Layers with more than 30cm height were reported for 1 plot in Lithuania, 2 plots in France and were reported more widely for plots in the UK and Sweden, but not other NFCs.

For sections of the soil material identical limits were found for 3 plots, 2 for *H12* and 1 for a *H24* section. Duplicate limits of depth were found for 15 plots from 4 different NFCs (Hungary: 1; Portugal: 4; Sweden: 4; Spain: 2). The main cause for duplicate entries was organic layers or sections overlaying mineral sections, such as *H05* and *M05*. For plots in Ireland no values for the limits of the segments of the soil material were recorded in the database. Including such information should indeed not be required because the *Mij* and *Hij* segments have predefined depth limits.

Of the 14,124 segments for soil material the limits of 13,386 (94.8%) were consistent with the defined limits. No data on the limits of the segments of the soil material were given for 146 segments. Therefore, the level of consistency of the reported limits with the defined ranges is 95.8%. The number of plots without data on the limits of the soil segments is 27 (0.7% of all plots with data on soil material). Of those plots with data 43 (1.1%) recorded depth limits of the soil segments different from the defined ranges.

The inconsistency of the reported with the defined limits can be treated in several ways. One option is to use the segments depths as reported, another is to replace the recorded depth with the defined limits. Both options introduce a contradiction in the analysis of separating the organic layer from the soil material for plots where the recording of the organic layer starts at a depth of 0 cm. A third option is to restrict the analysis to only those plots where the reported limits correspond to the defined values. However, the absence of the information on depth limits for the soil material on some plots obstructs the data analysis by requiring an ancillary table to be constructed, which contains the reported values for all plots where a value has been provided and default values for plots without such values.

3.4.3 Bulk Density

For Level 1 sites a value for bulk density has to be provided for all soil sections, but not for the organic layers. It is marked as optional in the database, which is not quite correct. Bulk density can be estimated or measured. When the parameter is measured it should be reported in the field MEAN_BULK_DENSITY. This arrangement can be confusing, because in case several estimates are made they could also be reported in the field[12].

According to the specifications given in the description of the SOM file reference methods for establishing bulk density are given in Table 13:

Table 13: Methods for Measuring or Estimating Bulk Density and Examples of Content of Comments

Method	Code	Comment (shortened)
		Specifications
Measured	sa04a1	Core method (cylinders)
	sa04b1	Excavation method
Estimated	sa04a3	Core method (cylinders)
	sa04b3	Excavation method
	sa04c	Estimation of bulk density according to Adams (1973)
		Database Content
	sa04a3	measured values existent
	sa04a3	not applicable
	sa04a3	not available
	sa04a3	not done
	sa04a3	not measured
	sa04c	Rawls and Brakensiek (1995)
	sa04a3	Tamminen & Starr 1994, Silva Fennica 28(1)
	sa04a3	Callensen et al., 2003

[12] The field name MEASURED_BULK_DENSITY is used in the HORIZON table.

The table indicates that a method code could actually mean more than just one explicitly specified method was applied. It also shows that the layout of the form is not compatible with the data model. The same code should not be used to signify different methods. Each method should be given a unique code for the method used. This requires that the method codes can be extended by the NFC, which is not compatible with a standardized survey. In the analysis of the data the information on the method was not included.

A value of mean bulk density was given for 7,242 (38.9%) depth sections out of 18,621 depth sections (including repetitions, but not data for the OL horizon). A value for estimated bulk density was given for 7,108 (38.6%) depth sections. For 1,383 (7.4%) depth sections both values were provided.

For the analysis of the SOC density the information from the two fields containing bulk density was combined into a single value. When two values were available priority was given to the data recorded in the filed MEAN_BULK_DENSITY, which should contain measured values. By combining the information on bulk density 12,679 (68.1%) depth sections could be covered. A complete coverage of the soil sample to a soil depth of 20cm with data on bulk density for the organic layer(s) was available for 166 (4.1%) plots and for the mineral section for 3,234 (80.4%) plots.

The ranges of values for bulk density for the organic layer as given in the LAYER table are given in Table 14.

Table 14: Minimum and Maximum Bulk Density of Organic Layer (Level 1)

Layer	**Min** *kg m^{-3}*	**Max**	**Layers with** *<0.05 g cm^{-3}*	**Layers with** *>0.5 g cm^{-3}*
Hf				
Hfs				
Hs				
OF	0.65	137.22	66	
OFH	50.67	1442.00		3
OH	749.70	749.70		1

kg m^{-3} : reporting unit

The reporting unit for bulk density of *kg m^{-3}* gives 3 decimals for the widely used unit of *g cm^{-3}* (= *t m^{-3}*). This makes a value below 50 *g cm^{-3}* unlikely and values below 10 *g cm^{-3}* improbable. There are 66 cases with values less than 50 *g cm^{-3}* and 15 cases with values <10 *g cm^{-3}*.

The distribution of bulk density values reported for the organic layer is presented in Figure 14.

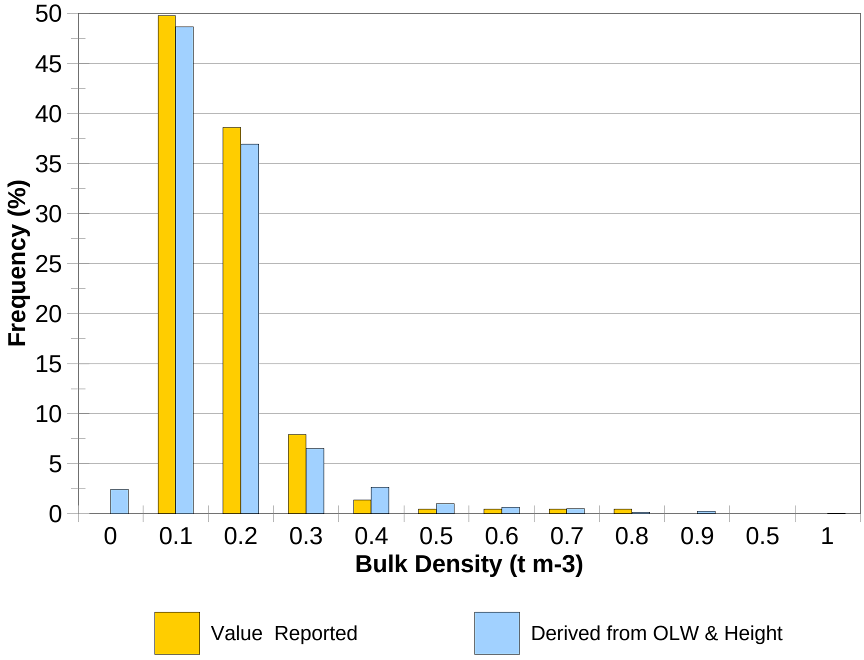


Figure 14: Frequency Distribution of Bulk Density in Organic Layer (Level 1)

The graph is based on 215 organic layers where bulk density was reported. Almost 50% of for the organic layers have values for bulk density <0.10 *g cm*$^{-3}$ and approx. 90% <0.20 *g cm*$^{-3}$.

The location of the plots where a value of bulk density was given for the organic layer is presented in Figure 15.

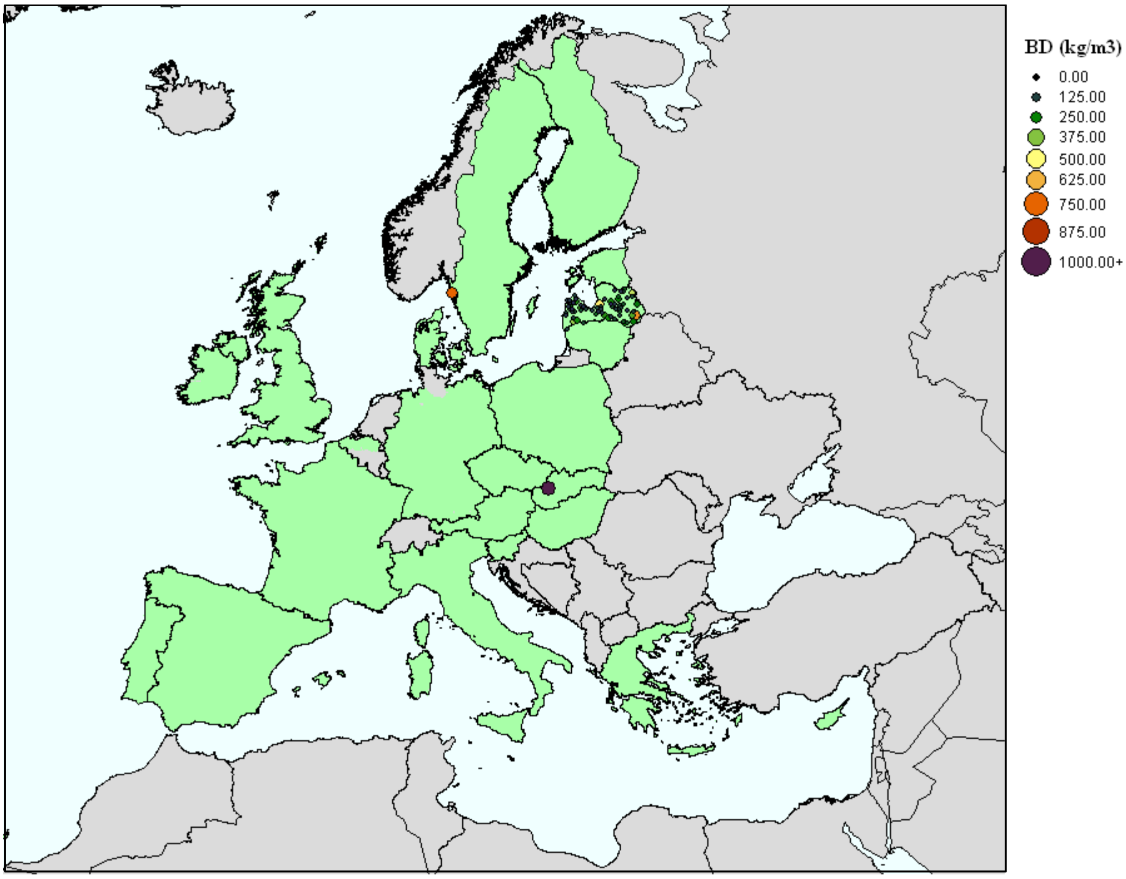


Figure 15: Spatial Distribution of Bulk Density Values of the Organic Layer (Level 1)

With the exception of one plot in Sweden and one in the Slovak Republic all plots for which values of bulk density were reported for the organic layer are located in Latvia. The high value reported for the plot in the Slovak Republic (1.4 $g\ cm^{-3}$) is inconsistent with the normal range of values for organic material, which suggests that the data were reported unintentionally.

For organic layers bulk density could be computed from the parameter "*Organic Layer Weight*" (OLW) and the height of the organic layer. The value is recorded for 3,579 layers of 2,969 plots (not including *OL*). For two plots a value was also given for a mineral soil layer (Hungary, Plot 96,*M05*; Sweden, Plot 1734, *M01*). In 67 cases the OLW was given as 0 although values were recorded for the layer limits with a layer thickness ranging between 1.0 cm and 50.0 cm. The database contained also 2 plots (1 in Hungary; 1 in Sweden) where a value for the OLW was recorded for the soil material. The relative distribution of bulk density derived from the OLW is presented together with the reported values in Figure 14. The distribution of values derived from the OLW over the range of values does not indicate any significant difference with the distribution of the reported values. This correspondence is unexpected because the spatial distribution of the reported values is very limited.

The relation between the bulk density as reported and the value computed fro the organic layer weight and the layer thickness is graphically presented in Figure 16.

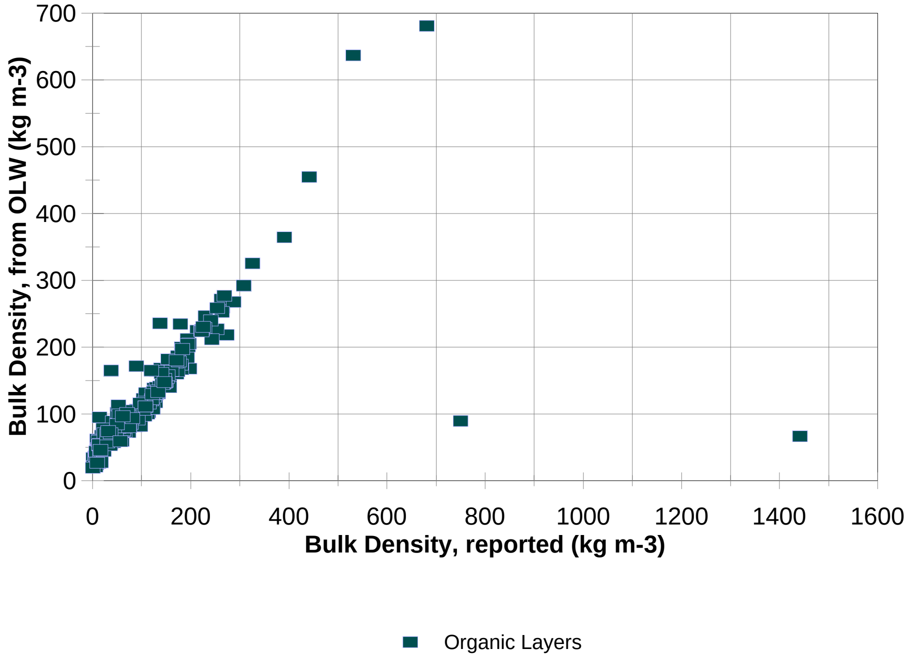


Figure 16: Relationship between Reported Bulk Density and Bulk Density Computed from Organic Layer Weight and Layer Thickness (Level 1)

The graph shows a strong relationship between the bulk density values from the two data sources, but also some outliers. For the two values with a reported bulk density > 700 $kg\ m^{-3}$ no particular reason for the difference could be found in the data or the comments. When computing a regression for the reported and derived values the origin of the line shows an off-set of 27 $kg\ m^{-3}$ (not including two outliers). The data also suggest a somewhat non-linear relationship between the reported and the derived data.

The spatial distribution of bulk density in the organic layer by plot is presented in Figure 17.

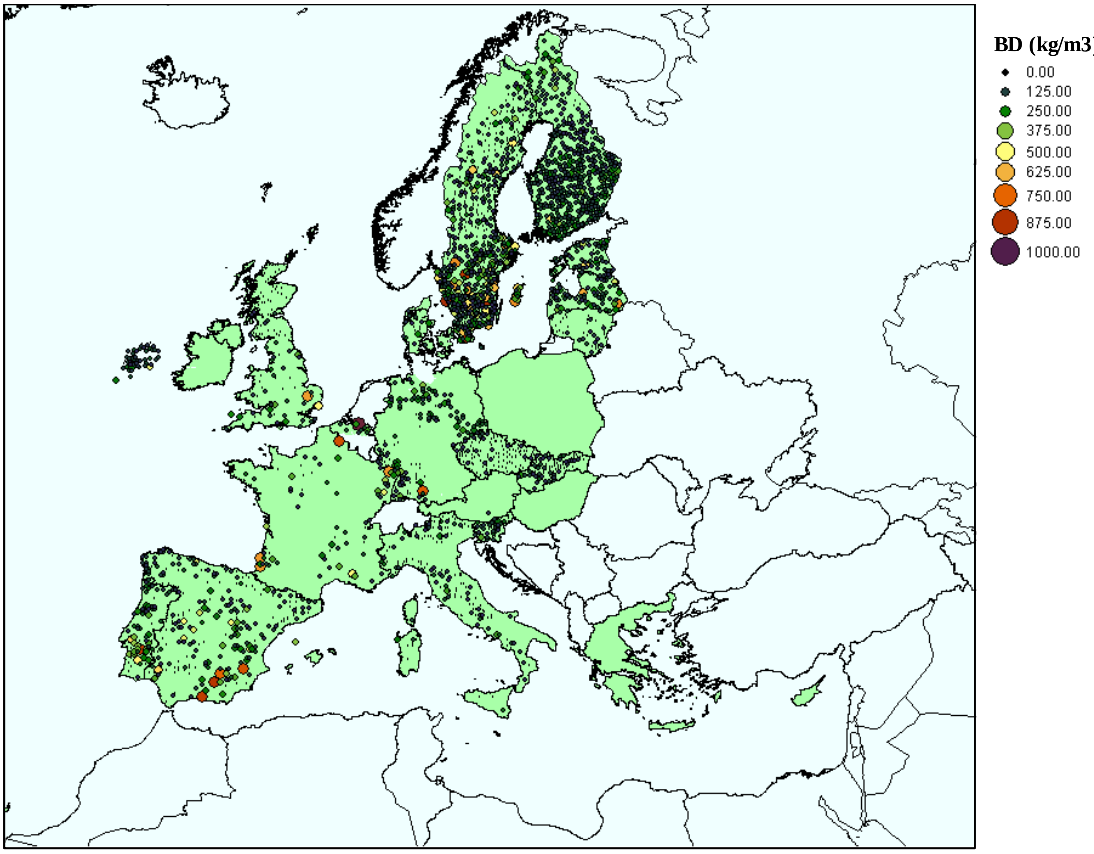


Figure 17: Spatial Distribution of Bulk Density Derived from Organic Layer Weight and Height of the Organic Layer (Level 1)

The graph shows that plots with a bulk density >0.5 *g cm*$^{-3}$ are not geographically clustered. The apparent higher density of such plots in southern Sweden is attributed to the density of plots in the area rather than a methodological deviation. For Ireland no values for bulk density could be established because none were reported for the organic layer. It was further not possible to compute bulk density from the weight from the organic layer since no values for the depth of the layer were reported.

The extreme values of bulk density for the sections of the soil material are summarized in Table 15.

Table 15: Minimum and Maximum Bulk Density in Soil material (Level 1)

Layer	Min	Max	Layers with	Layers with
	kg m^{-3}	*kg m*$^{-3}$	*<0.05 g cm*$^{-3}$	*>0.5 g cm*$^{-3}$
H05	41.00	1030.00	2	4
H51	41.00	1030.00	2	3
H01	119.00	787.4.00		2
H12	58.00	1203.00		5
H24	64.00	1158.00		3
H48	64.00	1250.00		3
			<0.50 g cm^{-3}	*>1.90 g cm*$^{-3}$
M05	1.30	7000.00	65	2
M51	84.00	1850.00	64	
M01	58.00	1868.00	244	
M12	1.93	3359.00	150	1
M24	75.00	2963.00	110	3
M48	43.00	2200.00	62	7

g kg^{-1} : reporting unit

The table indicates at some inconsistencies in separating mineral from organic segments, similar to the results found when analyzing the layer data for *OC*. Soil segments' with a bulk density of 1.20 *g cm*$^{-3}$ point towards a mineral soil, while those below 0.3 *g cm*$^{-3}$ could be considered to indicate an organic substrate. These irregularities not necessarily affect the analysis when the data are pooled. Other findings suggest that also incorrect values found their way into the database. The normal range of bulk densities for mineral soils is 1.0 – 1.6 *g cm*$^{-3}$.Values of over 1.9 *g cm*$^{-3}$ can be considered dubious. The bulk density of quartz is approx. 2.65 *g cm*$^{-3}$. Several values were found in the database which cannot be attributed to soil because they signify solid rock.

For soil segments the frequency distribution of bulk density values is presented in Figure 18.

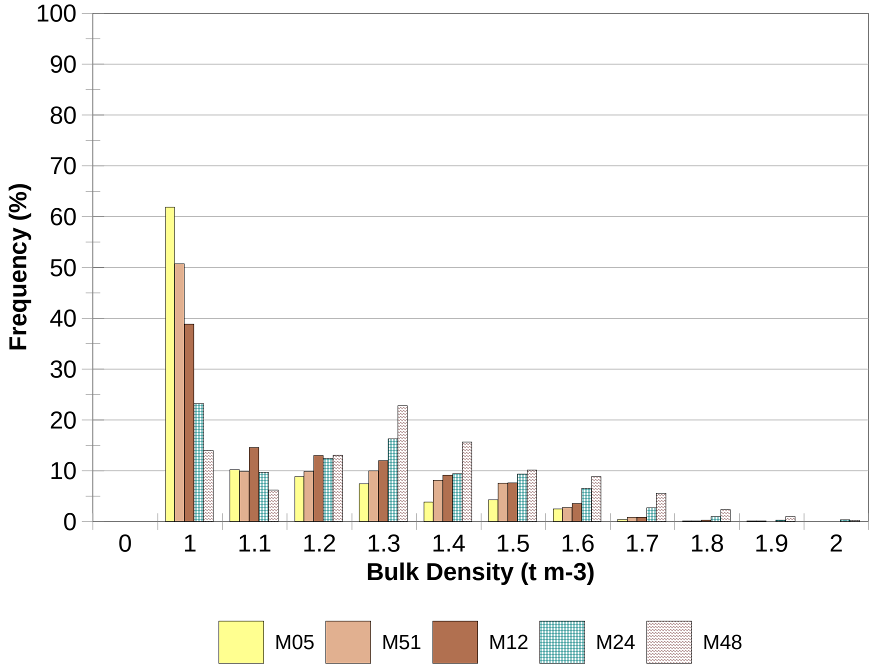


Figure 18: Frequency Distribution of Bulk Density in Soil Material (Level 1)

For soil segments to a depth of 20cm bulk density values below 1.0 *g cm*$^{-3}$ were reported for 40 to 60% of the segments. For the soil segment *M48* values for bulk density vary around a range of 1.2 to 1.40 *g cm*$^{-3}$. This is also the range of the default value used for mineral soils (1.33 *g cm*$^{-3}$; Manual, p. 13).

While the field MEAN_BULK_DENSITY should contain measured values some doubts were raised when analyzing the frequency distribution of values. For values < 1.0 *g cm*$^{-3}$ only numbers fully dividable by 100 were found. Those values are very unlikely the result of measurements unless more precise figures were lost during a process of transforming data between units.

The distribution of the bulk density for the soil material 0-20cm is presented in Figure 19.

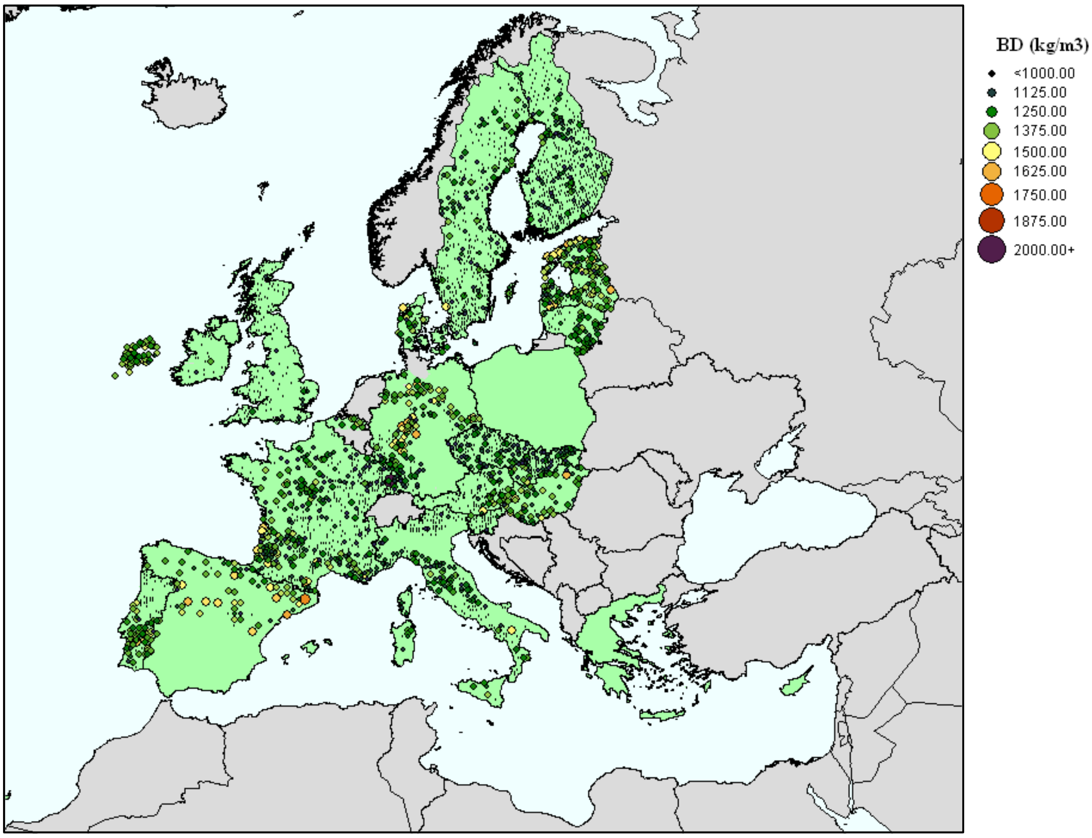


Figure 19: Spatial Distribution of Bulk Density in the Soil Section 0-20cm (Level 1)

The map illustrates the absence of data for bulk density for the soil material for the southern part of Spain. For plots in this area the data were either completely missing or absent for part of the profile. The *M05* soil section seems to have been most affected by missing data in that region, while data for the *M12* data are provided. As a consequence of missing data in the upper sections the mean bulk density for the 0-20cm section could not be computed for those plots. The NFC for Ireland did not provide data for the layer depth of the soil sections. This should not be necessary as the section depths used should only be the ones specified in the Manual. The values were therefore replaced with the default values of the soil sections.

3.4.4 Volume of Coarse Fragments

The volume of coarse fragments (volume %) should include stones and gravel with a diameter > 2mm. For Level 1 samples it is requested for all mineral soil sections. Similarly, the mass of the coarse fragments should also be reported for all mineral sections when sampling Level 1 plots.

A list of methods available to determine mass and volume of coarse fragments (*cf*) is given in Table 16.

Table 16: Methods for Measuring or Estimating Bulk Density and Examples of Content of Comments

Indicated	Code	Comment (shortened)
		Mass
17,346	sa05a	Method by sieving and sedimentation
0	sa05c	Determined by previous survey
		Volume
16,168	sa05a	Method by sieving and sedimentation
0	sa05b	Estimation be Finnish method
0	sa05c	Determined by previous survey by sa05a
0	sa05d	Determined by previous survey by sa05b
991	sa05e	Estimation by chart of *cf* content

From the list of possible methods only method "*sa05a*" has been used to determine the mass of coarse fragments. To determine the volume of coarse methods method "*sa05a*" has been used in 94.2% of cases when the information was provided. The remainder indicated the use of method "*sa05e*".

For 147 organic layers from 98 plots a value for the mass of *cf* was found in the database. For 144 organic layers the value was actually 0. For the soil material no data were provided for 8,097 sections. A value was provided for 6,037 soil sections, in 1,198 cases the value was 0.

The volume of *cf* was recorded for 165 organic layers from 116 plots. In 96 of those cases the volume indicated was 0. There was no inconsistency between the mass and the volume of *cf* for layers with a value of 0 for one of the parameters. For 9,330 segments of the mineral stratum a value for the volume of *cf* was given, while a value was missing for 4,786 sections. Some inconsistencies between the entries for mass and volume of *cf* were found for the mineral sections:

- Mass = 0 AND volume > 0: 121 sections
- Mass > 0 AND volume = 0: 15 sections

The difference in the latter combination can be explained by the small numbers for the mass of *cf*, which can lead for the volume to be below the dimension of the field. This is not the case when the mass is set to 0 and a volume for *cf* is reported. Here the 0 in the field for the mass of *cf* seems to indicate the absence of a measurement rather than absence of a measureable value. For the computation of SOC density only the data on the volume of *cf* was used.

The spatial distribution of the plots where a value of coarse fragments was reported for the organic layer is given in Figure 20.

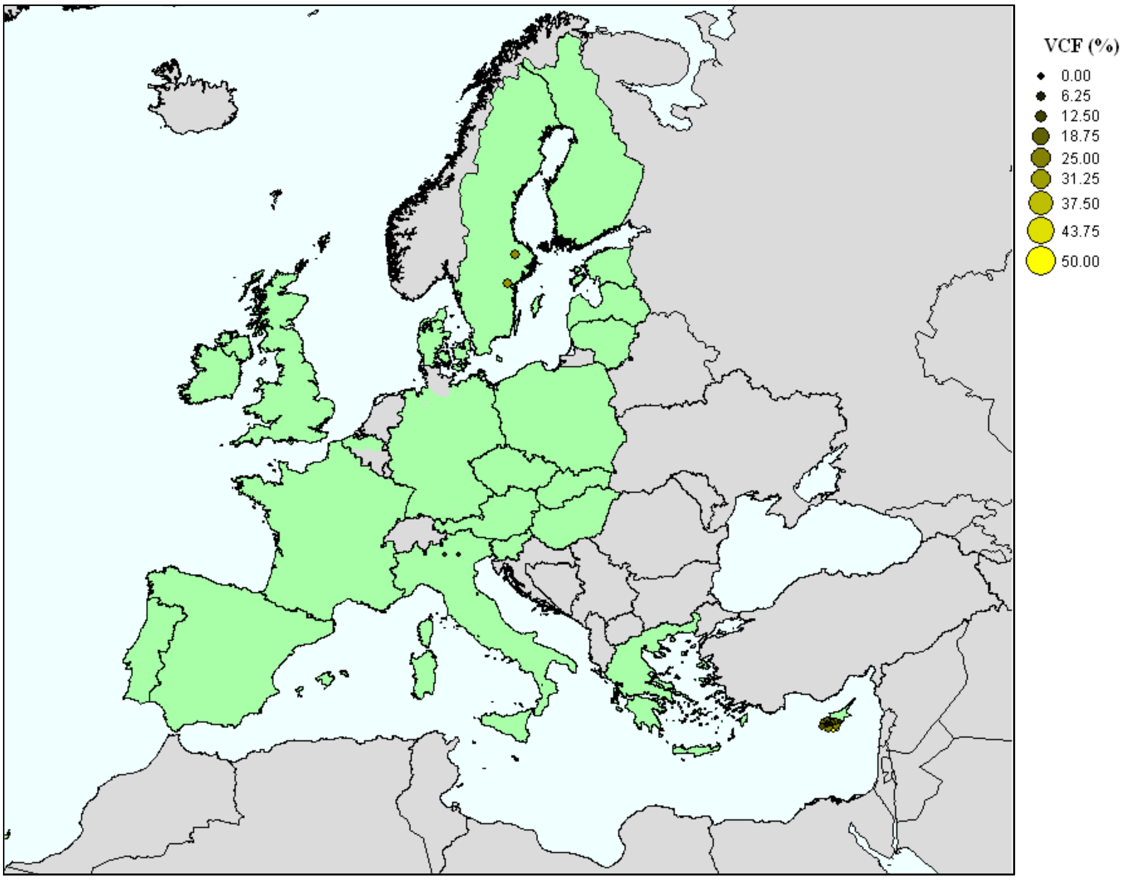


Figure 20: **Spatial Distribution of Volume of Coarse Fragments in the Soil Section 0-20cm (Level 1)**

For plots in Cyprus a value of volume of *cf* was generally reported. Values were also recorded for 2 plots in Sweden and 3 plots in Italy, 1 of the plots in the latter with a value of 0.

The relative frequency of the volume of *cf* by segment in the soil material is presented in Figure 21.

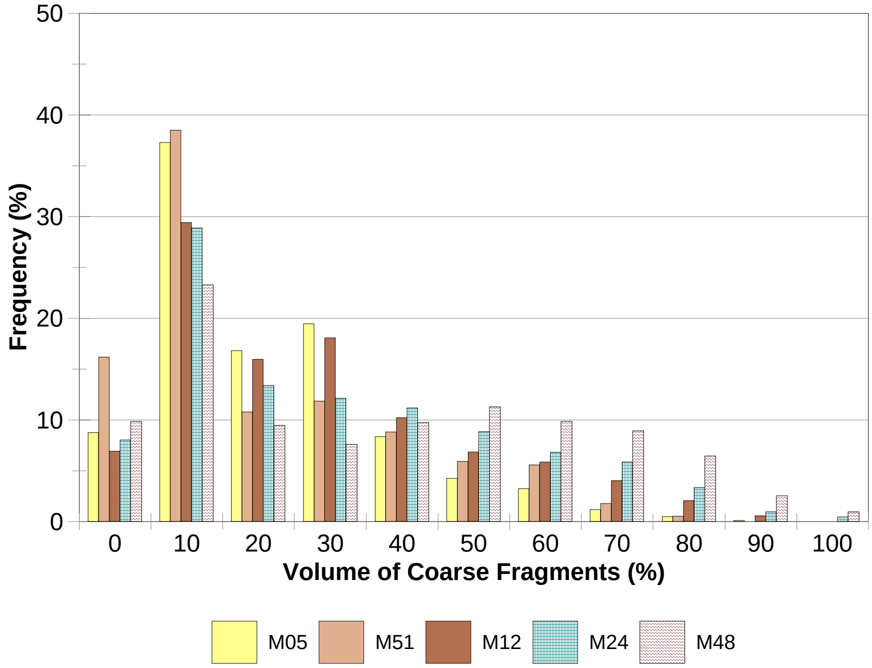


Figure 21: Frequency Distribution of Volume of Coarse Fragments in Soil Material (Level 1)

The distribution of the volume of *cf* in the soil material shows a prevalence of values in the range of 0-10% for all segments. For soil depths to 20cm the volume of *cf* is generally <30%. Higher values occur with a frequency of <10% and mainly at lower depths. The distribution is not necessarily representative for the ensemble of the plots. Of the 14,124 segments 9,338 (66%) contain an entry for the volume of *cf*. From the data it is not evident whether the third of the segments without an entry follow the same distribution or that a higher proportion of segments without coarse fragments exists in the plots without data.

The identification of differences by NFC in reporting the parameter is aided by mapping the plot values. The spatial distribution of the plots with data for the volume of *cf* is given in Figure 22.

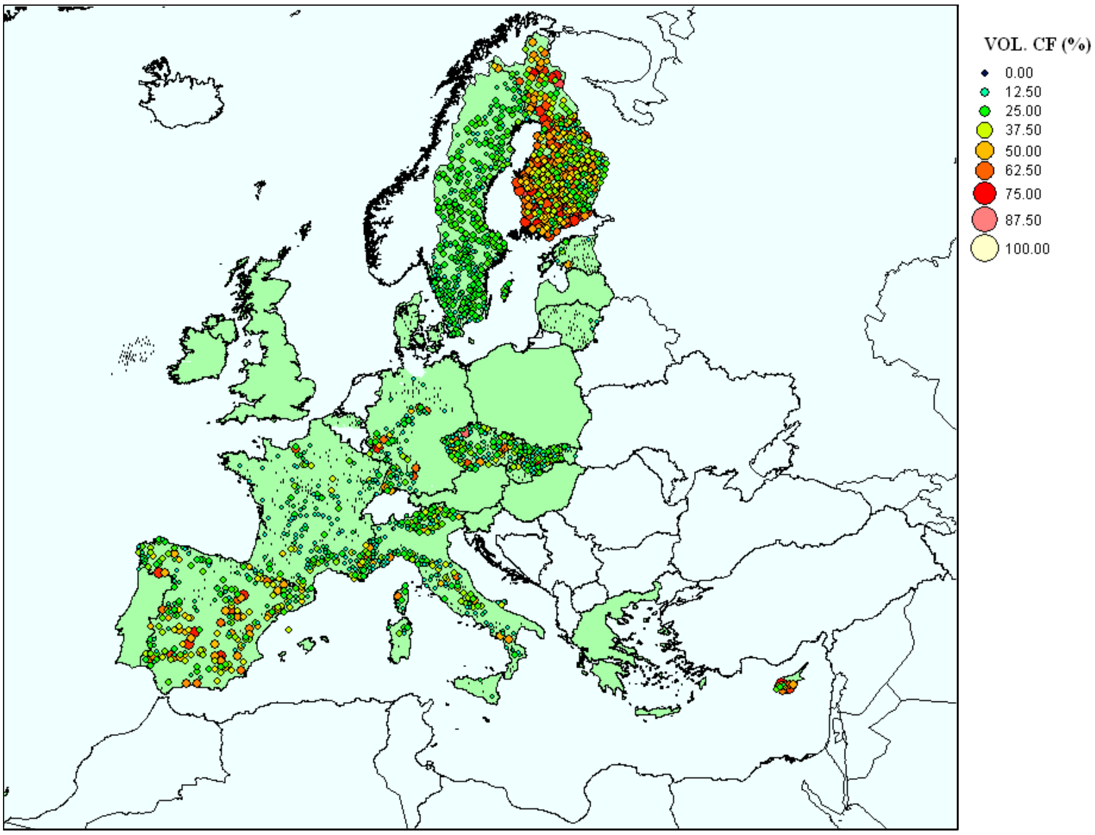


Figure 22: **Spatial Distribution of Volume of Coarse Fragments in the Soil Section 0-20cm (Level 1)**

There are higher than average occurrences of plots with a volume of *cf* >50% in Cyprus, Spain and Finland. The difference in the values between Finland and Sweden or Estonia is remarkable. It is very much linked to national boundaries, although this by itself does not necessarily signify a difference in methods of assessing the parameter. The parameter was not reported by several NFCs. This potentially distorts the computation of SOC densities towards higher values in areas where the parameter was not reported but is still present. The distribution of the volume of *cf* in the organic layer was not mapped. The amount of plots with entries was small and the use of zero entries could not be reliably determined.

3.4.5 Soil Organic Carbon Quantity

SOC quantities are generally computed for a given depth and therefore related to a volume of the soil material. The depth is determined starting from the surface of the soil material and counting downwards. This concept is consistent with the procedure applied to code the depth of organic layers where the 0-horizon is the interface between the organic layer and the soil material. Taken literally the organic layer is not part of the soil. In practice the organic soil material is at times coded as an organic layer and information sampled would thus be excluded from an analysis of the OC of the soil material.

An *a posteriori* separation of the organic layer from the organic soil material, as suggested by the sampling manual, is not always possible (clay content not recorded for organic layers). The evaluation of the data therefore processed the information as declared by the NFCs and separately for the organic layer and soil material.

For the organic layer the amount of SOC was determined for the depth of the layer. The volume of *cf* was considered when such data were available for a layer, but absence of a value was not treated as a constraint that prevents computing a figure for the OC quantity. A value for bulk density of the organic layer was reported for just 166 plots. Therefore, the bulk density derived from the organic layer weight and depth was used for cases where no corresponding value was reported.

The relative frequency of the amount of OC in the organic layer and the soil material 0-20cm is presented in Figure 23.

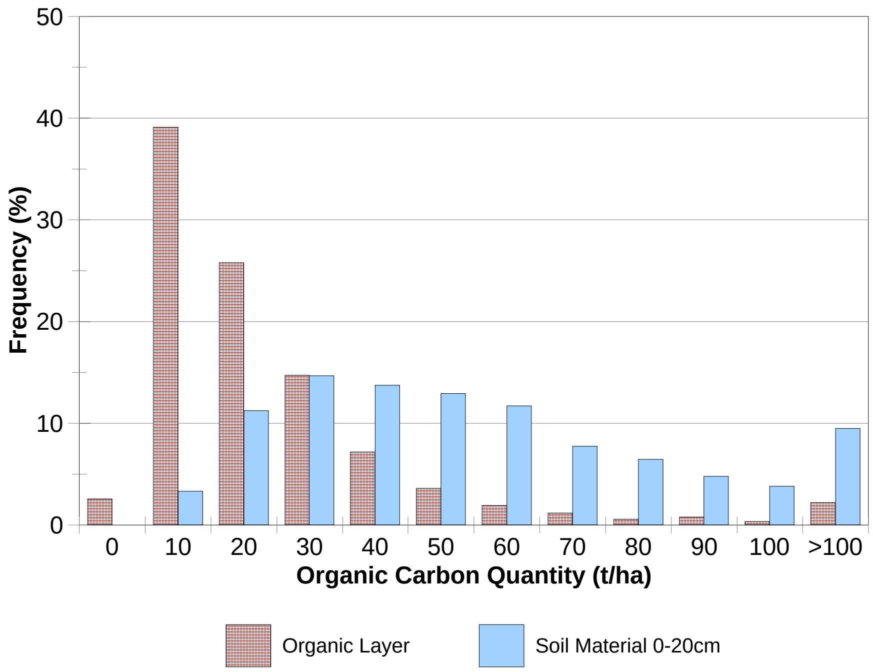
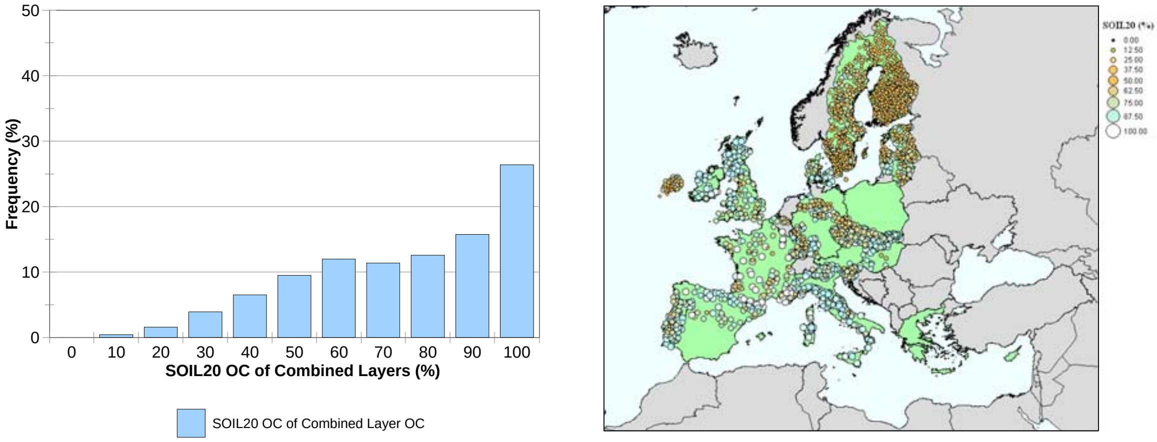


Figure 23: Frequency Distribution of Organic Carbon in Organic Layer and in Soil Material 0-20cm (Level 1)

The graph shows a distinctly different distribution of OC between the organic layer and the soil material. On 2/3 of all plots (67.5 %) with sufficient data the amount of OC in the organic layer is <20 $t\ ha^{-1}$. For the soil material 14.6% of the plots have OC quantities in this range. For most plots there is also considerably more OC in the soil material than the organic layer.

A different representation of the relationship between OC in the organic layer and the soil material is given in Figure 24.



a) Frequency Distribution *b) Spatial distribution*

Figure 24: **Relative Contribution of OC Quantity in Soil Material 0-20cm to OC Quantity in Combined Organic Layer + Soil Material 0-20cm (Level 1)**

On more than 55% of the plots the contribution of the soil material of the first 20cm to the quantity of OC in the combined layer is over 70%. Equal or more OC in the organic layer is found on 22% of the plots. The spatial distribution of the ratio shows that most OC is reported for the soil material for plots in France. At the other end are plots in Sweden, Finland, Estonia and Latvia. For other areas the concentration of OC in one or the other stratum is less distinct.

The amount of OC in the organic layer could be determined for 2,551 plots. The distribution of OC in the organic layer of Level 1 plots is presented in Figure 25.

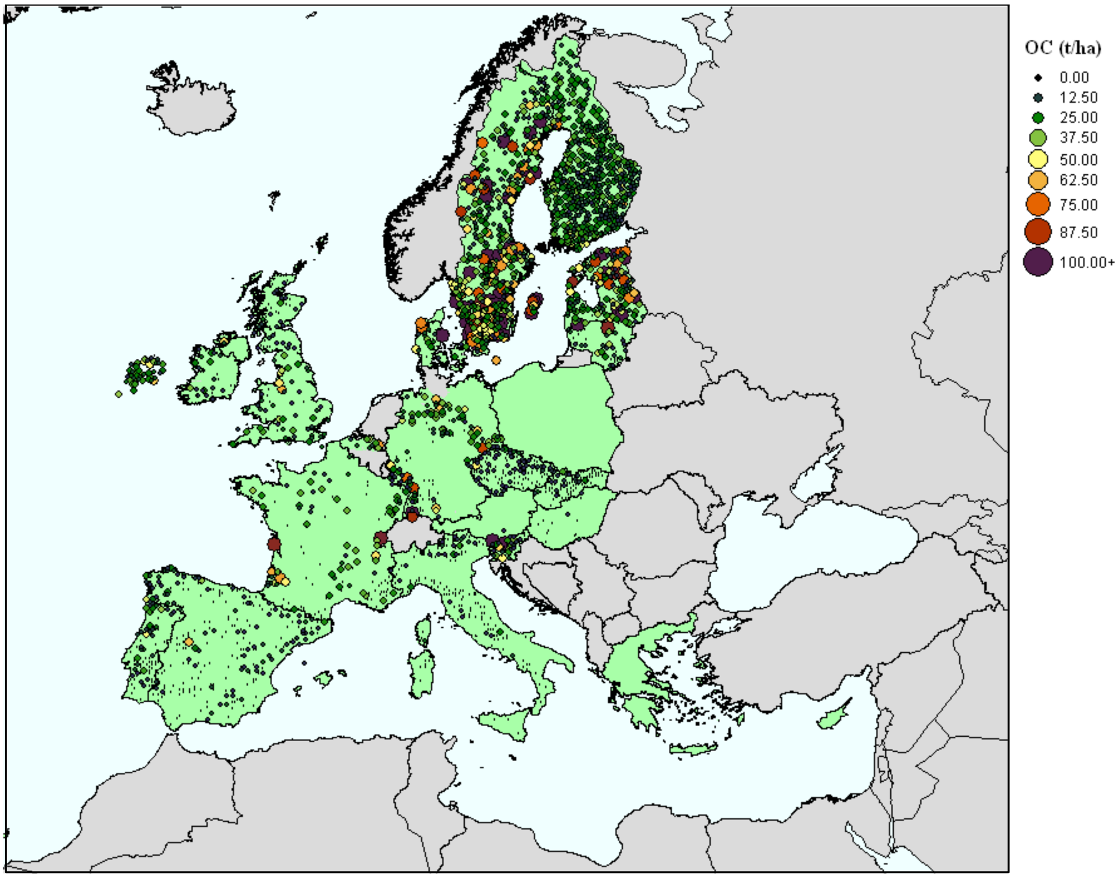


Figure 25: Organic Carbon Quantity in Organic Layer (Level 1)

The count includes plots with apparently erroneous co-ordinates, of which some are visible to the West of Ireland. Those plots were included because the correctness of plot co-ordinates was not a criterion for determining the amount of OC in the organic layer. In applications of the data where geographic positioning is of importance the count of suitable data is correspondingly lower.

The build-up of organic layers is most widespread in the Baltic States. Plots with >30t/ha OC in the organic layer are more sporadically found in France, Germany, Slovenia and the UK. Compared to plots in other Baltic countries the distribution of OC in the organic layer on plots in Finland is comparatively limited.

The amount of OC by plots in the soil section for a depth of 0-20cm is graphically presented in Figure 26.

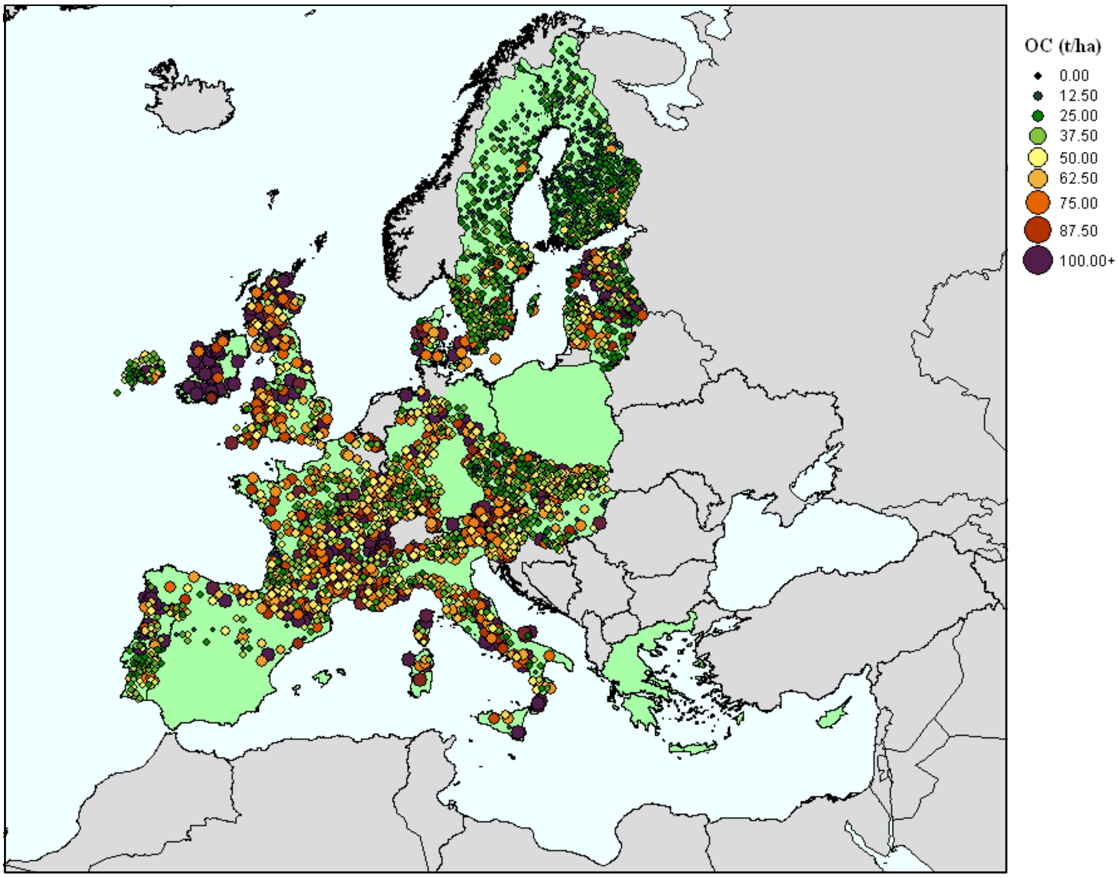


Figure 26: Organic Carbon in Quantity in Soil Material 0-20cm (Level 1)

As with the computation of OC of the organic layer data on coarse fragments was used to compute the OC of the soil material when available. Absence of corresponding values did not prevent computing the soil OC quantity.

The amount of OC in the soil material is generally high for plots in Ireland, Scotland and Wales and frequently for plots in most other countries. The amounts on plots in Sweden and Finland are more uniform and low by comparison. In both countries a spatial trend of lower OC amounts with latitude seems to characterize the amount of OC in the soil material. This trend is not a function of corresponding changes in the volume of coarse fragments, bulk density or a decrease in the depth of the soil material (to 20cm) but rather driven by decreasing OC contents in the soil material.

A combined organic layer & soil material (0-20cm) data set could be produced for 2,250 plots. A map on the location of the plots and the amount of OC is given in Figure 27.

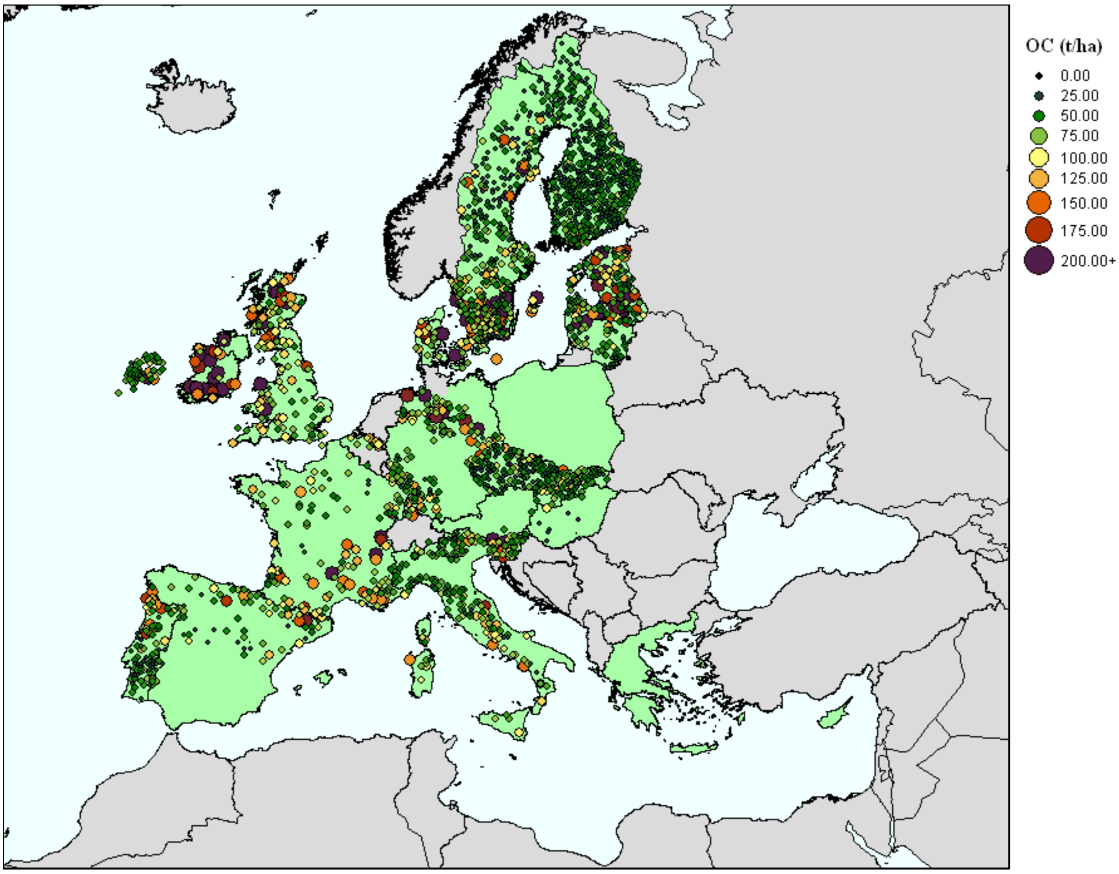


Figure 27: Organic Carbon in Quantity in Combined Organic Layer and Soil Material 0-20cm (Level 1)

The distribution of OC in the combined data from the organic layer and the soil material 0-20cm follows the distribution of OC content on the plots. Plots with amounts of OC >100 $t\ ha^{-1}$ correspond to the areas of peat. However, such plots also occur in other areas, including plots in the Mediterranean.

3.5 Temporal Changes of Organic Carbon on Level 1/I Plots

A survey collecting data on soil conditions on ICP Forests Level I plots was previously performed mainly during 1994/95. An evaluation of the data has been published by EC, UN/ECE and the Ministry of the Flemish Community, 1997. For the purpose of managing the data the *Forest Soil Co-ordinating Centre* (FSCC) has been created in 1993 at the Laboratory of Soil Science of the University of Gent. Since 2001 the

Research Institute for Nature and Forest[13] hosts the FSCC. In 2002 the data have been re-checked, reorganized and transferred to a new data model (see Data Model). Of the two formats provided by the FSCC (Oracle and Microsoft Access) the Access tables were used. The data were processed using the same procedures applied to prepare the BioSoil data unless a deviation from the procedure is specifically mentioned. In this report the previous survey on Soil Conditions on Level I plots is referred to as the ICP Forests Level I survey. The data used are referred to as FSCC – ICP Forests data. When specifically addressing the database the FSCC is referred to.

3.5.1 FSCC – ICP Forests Survey Characteristics

The original specifications setting out the sampling procedures of the ICP Forests Level I survey were not available to the evaluation task. They are assumed to be compatible with the provisions made in *Commission Regulation (EEC) No 1696/87* and *Commission Regulation (EEC) No 926/93*, although some instructions were modified in subsequent regulations, e.g. the sampling depth of the organic material in *Commission Regulation (EC) No 1091/94*. A file containing both ICP Forests sub-Manuals IIIa and IIIb from 30.7.2001 can probably be used to serve as a suitable substitute. Whereas the Commission regulations for the implementation of the soil survey contain provisions for the height segments of the organic layer when sampled by fixed depth such information is not part of the database. There are also some differences in the definition of the organic layer. The 2001 Sub-Manual IIIa states:

> *"O-horizons or layers: layers dominated by organic material, consisting of undecomposed litter,…"*

The definition of organic soil material follows the specifications of FAO, 1988. In the context of organic material the term "layer" and "horizon" were used as synonyms in the sampling procedures (Baert *et al*., 1998). The definition describes the organic litter horizon *OL* of latter versions of the Sub-Manual. As a consequence, the classification of the organic horizon or layer varies depending on the document used and therefore may vary depending on the survey date, but is also subject to interpretation. The situation is further obscured by the publication dates of the instructions, which are notably later than the periods of sampling soil condition data on the plots in some countries.

Although the ICP Forests Soil Condition survey at Level I sites is referred to as a 1996 survey that database contains samples spanning more than 10 years (1985 to 1998). For most countries the survey was performed during as single year. Yet, in some cases data were sampled in stages stretching several years, for example in Spain and Finland. A graphical impression of the survey years as recorded in the FSCC database is given in Figure 28.

[13] http://www.inbo.be/content/page.asp?pid=EN_MON_forest_soils

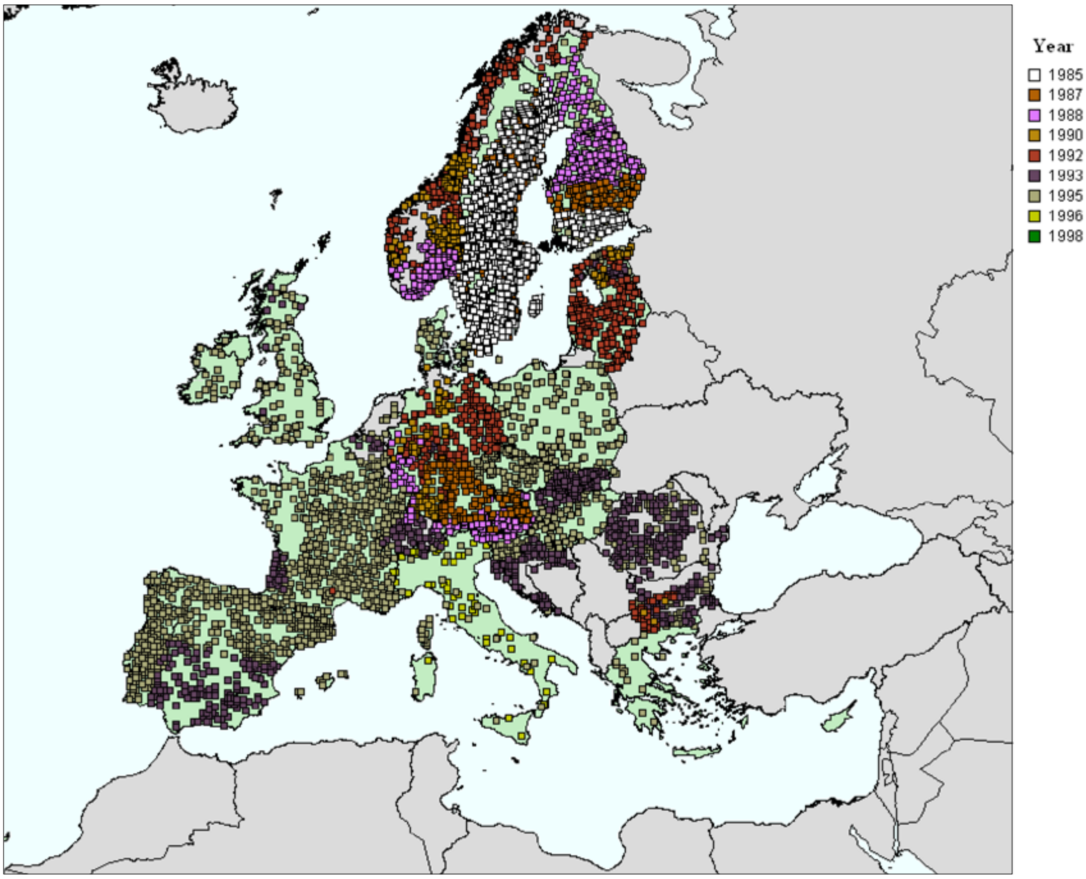


Figure 28: Sampling Year for Forest Focus / ICP Forests Level I Soil Condition Survey

The date of the previous survey can have an effect on parameters which may change over time, such as OC content. Instead of analyzing change over a period of 10 years for plots in Sweden and southern Finland this period is almost doubled to 19 years. The various manifestations of the Sub-Manual are an additional source of variation to the sampling process.

3.5.2 Co-Location of FSCC – ICP Forests and BioSoil Survey Plots

Soil condition data from the previous survey were sampled at the sites of the systematic monitoring network of ICP Forests (Level I). Site locations were identified on a regular grid with a 16km distance between points. The origin of the grid was defined in *Commission Regulation (EEC) No 1696/87* and *Commission Regulation (EEC) No 926/93*. The Regulations did not define the parameters for the projection used to identify the grid and the coordinates were transmitted to the participating states by country. There were deviations from the nominal grid size to one of 32km (e.g. northern Finland) and 8km (e.g. Czech Republic). The files with original coordinates sent to the participating states could not be recovered and were therefore not used to co-locate the sample sites. Because countries were also allowed to position Level I sites at locations of an existing national forest monitoring network using the information of the nominal site locations is only of limited use.

One method of assessing results of the BioSoil survey is to compare data on a plot-by-plot basis with results of the previous survey. It was originally intended to perform the BioSoil survey at the sites of the ICP Forests Level I soil survey. This would not have been possible for all sites because the positions of some Level I sites have changed over time for several reasons. Changes to site positions can be of two types:

1. **Sample site moved to new location**

   Plots have been moved to new locations following changes in land cover as a consequence of deforestations by fire, logging or wind fall. Other reasons for selecting new positions also apply: BioSoil plots in the UK were moved to better coincide with the 16x16km grid positions.

2. **Change in Co-ordinates reported for site**

   The plot location on the ground may not have changed, but using more accurate instruments of determining the geographic position can introduce a change in reported co-ordinates. Another change in the reported position of a plot is the reduction in the precision of reporting co-ordinates to minutes instead of seconds, as in the case of Finland.

Changes in plot location, recoded geographic position and IDs make it almost impossible to reliably relate plots of the BioSoil survey to those of ICP Forests Level I sites by linking plot IDs or LAT/LONG fields between data tables from the two surveys. Therefore, to identify plots shared between the two surveys a spatial neighbourhood analysis was performed. The procedure involves identifying the nearest plot of the ICP Forests survey to the BioSoil survey and vice versa. The two-way analysis of the nearest plot is obligatory because Plot *P* of the previous survey may be nearest to Plot *B* of the BioSoil survey, but the inverse relationship may well not be true. A threshold on the distance is then applied to remove any plots not likely to coincide. The distance threshold has to balance identifying plots within the radius of imprecise geographic coordinates with avoiding assigning a new plot to an old one. The minimum threshold was set to 2,750m. The value was used to account for the reduced precision of 1’ of reporting plot coordinates at 60°N. The evaluation found that plots are related also when separated by larger distances in the geographic coordinates where systematic errors in recording plot locations were present, but that at distances above 4,000m no-related plots would be linked in areas without systematic variations in plot positions.

The number of plots which could be linked by varying the distance threshold value is presented in Figure 29.

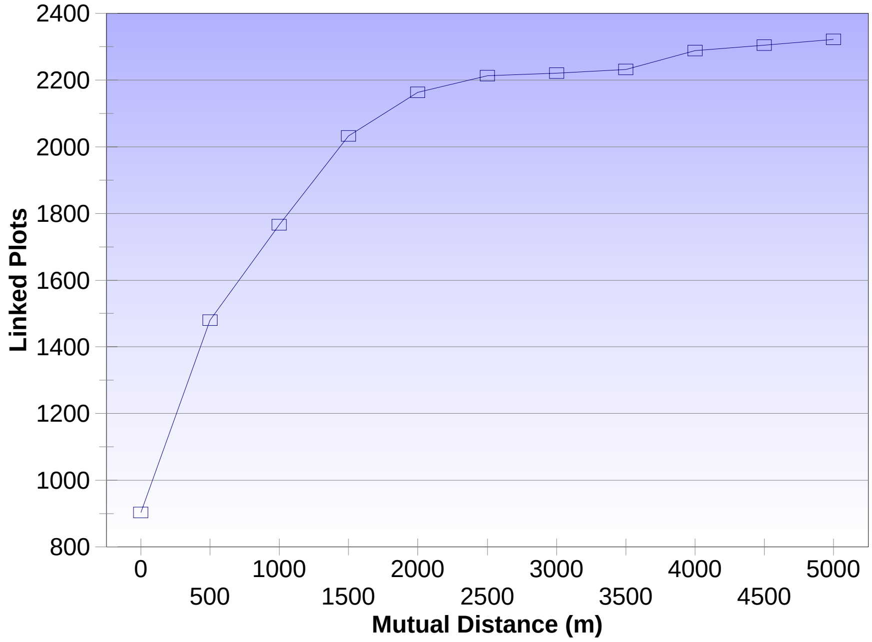


Figure 29: Number of Linked BioSoil and ICP Forests Plots with Increasing Distance in Geographic Position

The BioSoil database contains 903 plots where the longitude and latitude values were identical to those of the previous survey. From the neighbourhood analysis 1,480 plots were found within 500 m of a previous plot and 2,216 plots could be linked when using a distance threshold of 2,750 m.

The distance of FSCC – ICP Forests plots to BioSoil plots is graphically presented in Figure 30.

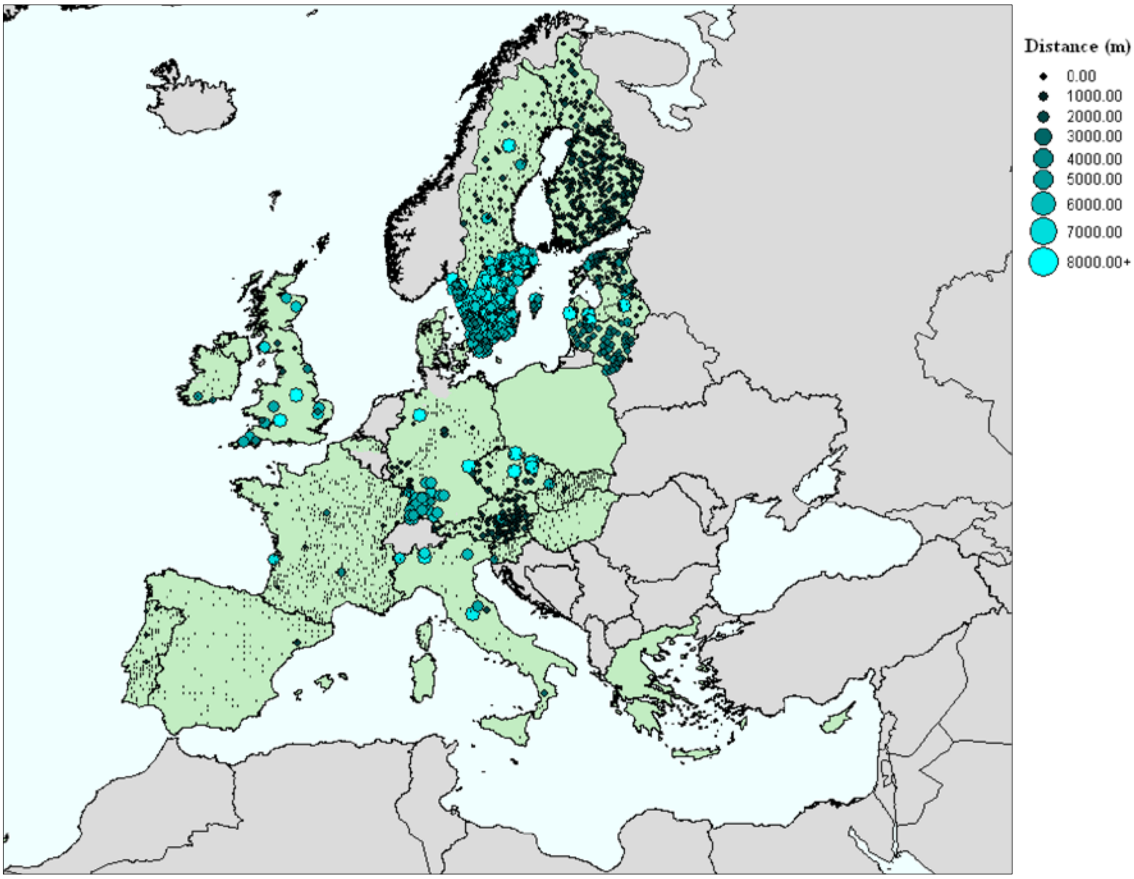


Figure 30: Distance of FSCC – ICP Forests Plots to BioSoil Plots

There is a distinct relationship between the distance between the plots computed from the geographic coordinates stored in the database and NFCs. For some NFCs, such as Spain, Ireland, Slovak Republic and Hungary, the co-ordinates of the BioSoil plots generally are identical to those from the previous survey. For plots in other NFCs, including Austria, Finland and Estonia, the difference in plot coordinates exceed 1,000m. The changes in plot locations from the previous survey to BioSoil in the UK are noticeable by showing only a few plots within the vicinity of the previous plots. Plots or plot coordinates in southern Sweden seem to have been relocated, while those in the northern parts of the country remained. Visible in the graph is the variation in geographic plot positions in Finland introduced by the reduced precision in recording the locations.

Differences in some other NFCs are not random, but appear as a constant shift. Examples of the co-ordinate shift for Baden-Württemberg and Lithuania are illustrated in Figure 31.

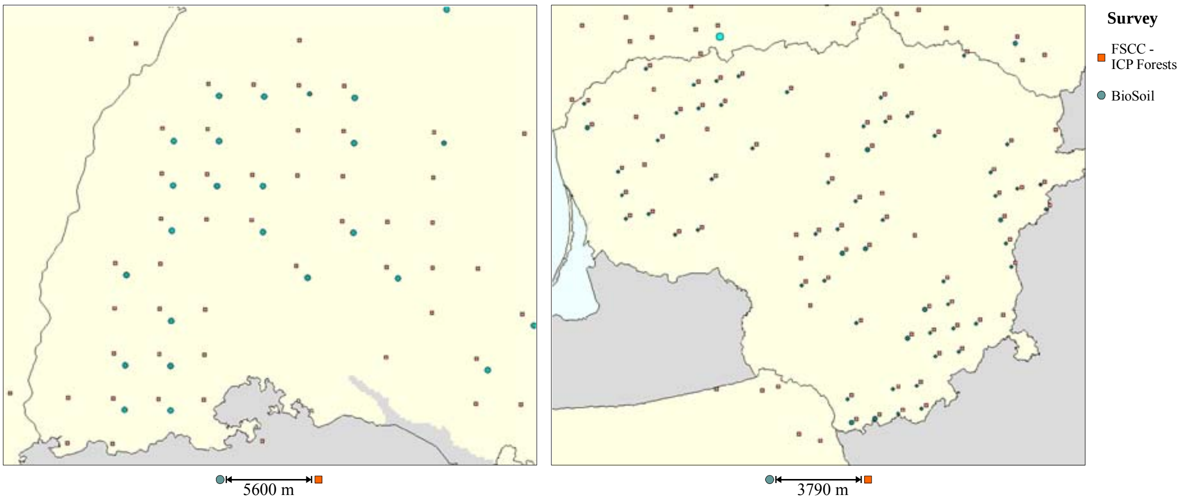


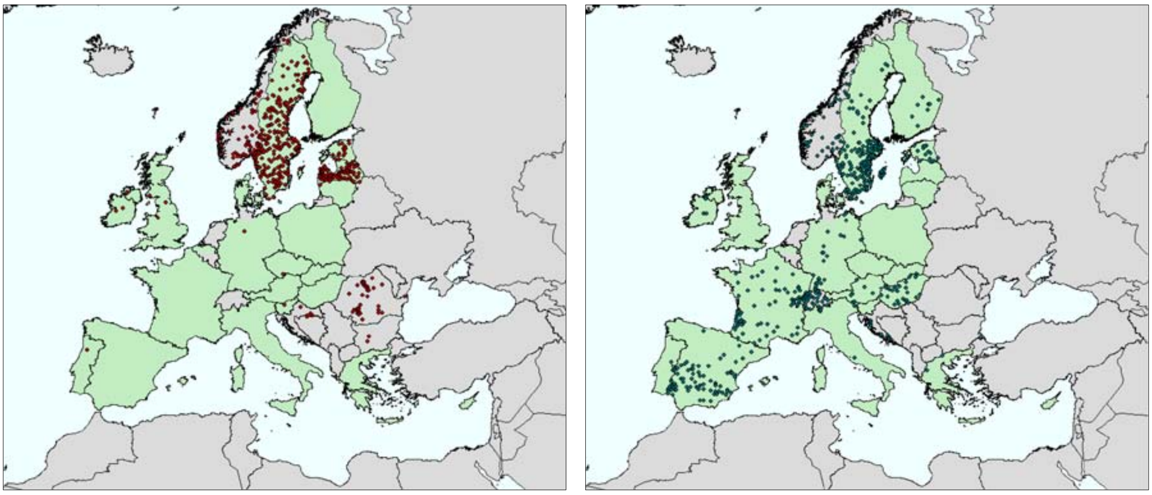
Figure 31: Constant Shift in Plot Location in Baden-Württemberg and Lithuania from FSCC-ICP Forest to BioSoil Survey

For the purpose of co-locating plots the shifts found are quite substantial, approx. 3,800m for Lithuania and 5,600 m for Baden-Württemberg. A number of causes could lead to these geographic shifts. Most likely are conditions leading to systematic changes in reporting plot co-ordinates, which can occur when re-projecting data to a new co-ordinate system. Enlarging the tolerance in geographic locations when linking plots to include the data from these NFCs would cause the creation of false links in other areas, for example southern Sweden. Systematic differences in plot positions between the two surveys can be accounted for but require a detailed analysis by NFC and treatment on a case-by-case basis.

3.5.3 Organic Carbon Content

In the FSCC database the organic layer is coded as either *O* (not saturated) or *H* (saturated). No further distinction of sub-layers is made and the layer of organic litter is not recorded. The OC content in the soil material is recorded according to either a saturated (*H*) or unsaturated status (*M*). The origin of recording the *H* segments in the soil material is indeterminate. Such segments in the soil material appear in the sampling documents after the survey dates. While there are 4 depth classes for the *H* segments there are 31 codes for mineral segments of the soil material.

As with BioSoil data the FSCC – ICP Forests data contain plots with only an organic layer and plots with only soil material. The location of the plots with data only one stratum is given in Figure 32.



only Organic Layer

only Soil Material

Figure 32: Distribution of Plots with only Organic Layer and with only Soil Material Data (FSCC - ICP Forests)

The identification of just an organic layer without an underlying soil material might be expected for plots on organic soils. As with BioSoil data, plots with data only covering the organic layer are rather aligned to country boundaries than soil properties. The opposite condition, i.e. only soil material was reported as *Mij* segments, is not restricted to administrative units.

Compared to BioSoil data the FSCC ICP Forests data contains a similar interpretation of the organic layer between the two surveys for plots in Sweden. Plots in Estonia and Latvia report the soil material under BioSoil. The situation is more variable for reporting only the soil material without an organic layer. The number of such plots is largely higher for the BioSoil data in France, Finland and Latvia. In contrast, plots lacking an organic layer in the FSCC – ICP Forests data have disappeared in Spain, Germany and Austria and are very much lower in Hungary.

The OC content in the organic layer of the FSCC – ISP Forest plots is presented by geographic position in Figure 33.

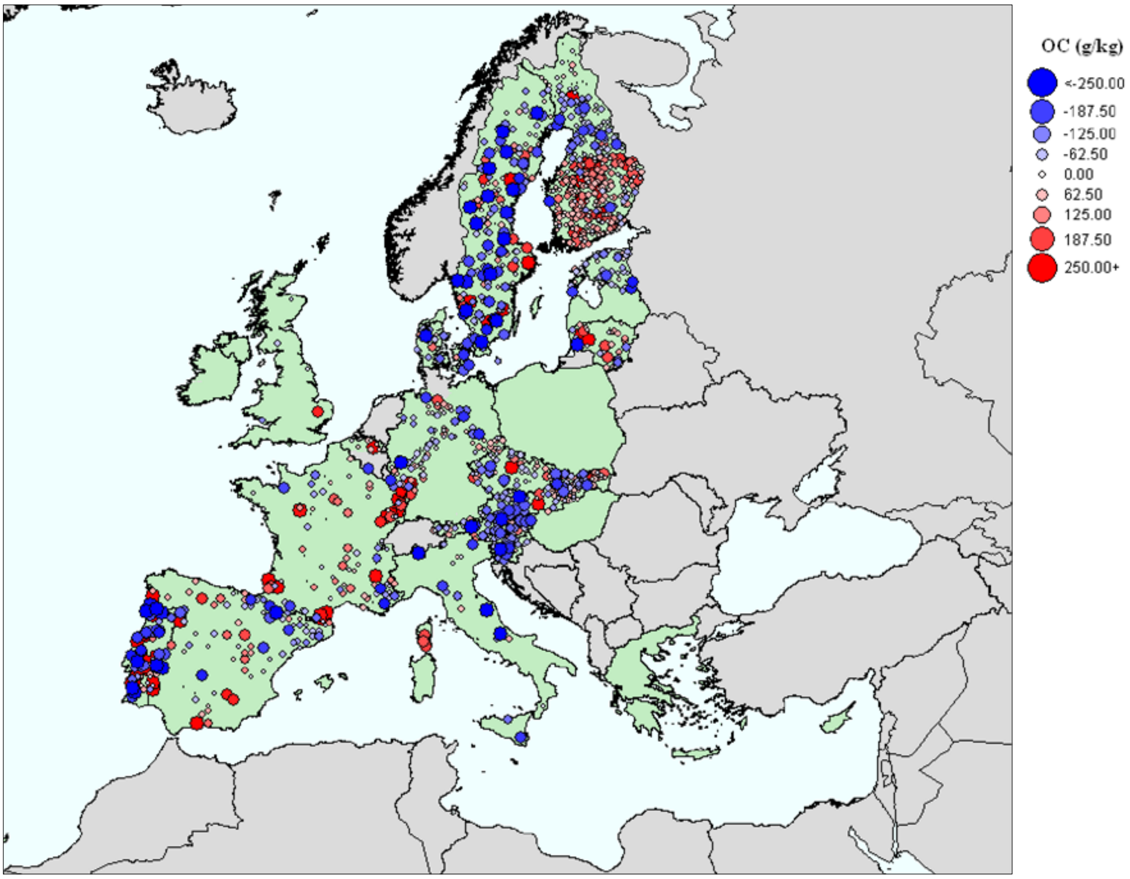


Figure 33: Change in Organic Carbon Content in Organic Layer from FSCC – ICP Forests Level I to BioSoil Survey

The graph indicates a lower OC content in the organic layer in the BioSoil survey on plots in Austria, in Portugal as compared to Spain and in Sweden as compared to Finland and Norway[14]. In Finland a division between the southern and northern part is caused by the BioSoil rather than variations in the FSCC – ICP Forests data.

The geographic spread of OC content in the soil material 0-20cm by plot is presented in Figure 34.

[14] The map also shows values for countries that did not participate in the BioSoil project for reasons of completeness.

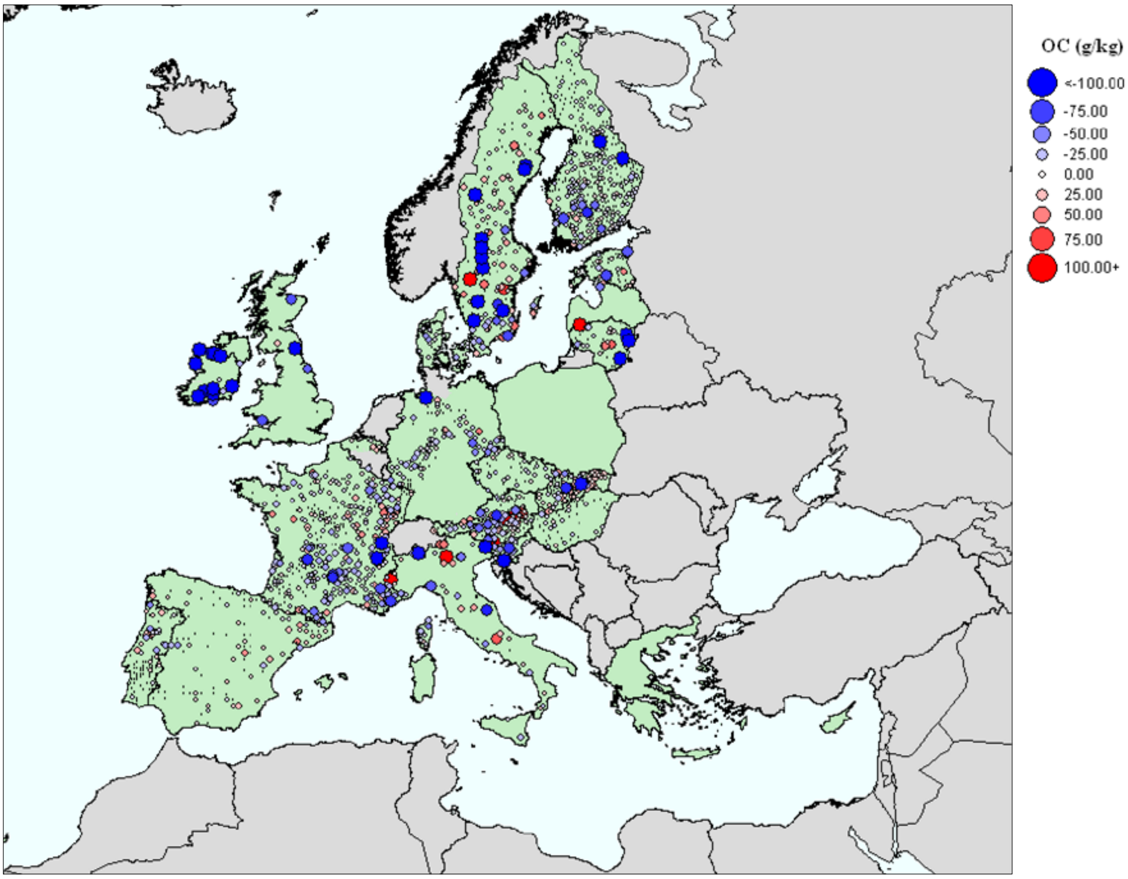


Figure 34: **Change in Organic Carbon Content in Soil Material 0-20cm from FSCC – ICP Forests Level I to BioSoil Survey**

The graph indicates that whenever changes in the OC content in the soil material occur they are substantial. This indicates a change in the classification of the soil material to the organic layer or *vice versa*. It can also be noted that changes in the OC content of the soil material are not necessarily inversely related to changes in the organic layer. Complete reclassifications from the organic layer in the FSCC – ICP Forests survey to the soil material in BioSoil occurred at times, for example on plots in Ireland.

3.5.4 Profile Depth

The FSCC database does not contain the depth of a segment explicitly as an attribute to the plot. Rather, the parameter is stored in the segment code, at least for the soil material, and attached to the segment from a dictionary table. The depths limits of the segments of the organic material (horizon or layer) are not stored in the database, neither directly as a field entry nor indirectly through a segment code.

The FSCC data model differs fundamentally from the BioSoil data model with consequences on the possibility to link information from a depth segment between plots. The problem is not so much caused by the differences in the data models but by those plots where the depth limits of the segments in the soil material do not conform to the specifications. Affected by the condition are 165 plots with idiosyncratic definitions for the segment depth limits. Because the link for database queries uses the segment code and corresponding depth those plots were excluded from the evaluation to avoid spurious results.

Another problem is posed by the presence of duplicate values for sample depths in the FSCC – ICP Forests data. For 9 plots information on a segment overlaid the depth limits of another segment on the same plot. Most cases of data duplication were caused by reporting segments *M05* and *M51*, but also *M01*. The general rule applied when preparing the data was to retain the more detailed information and remove the segment causing the data duplication or overlap from the analysis.

In contrast to the BioSoil data the FSCC – ICP Forests Level I database contains plots where the depth limits of 20cm was within the limits of a sampled segment, for example the segment *M13* (10-30cm). In those cases the value of a parameter was estimated by a linear interpolation from the depth limits of the segment. This method is only an approximation of the actual value because some parameters change with depth, such as OC content and bulk density. With frequently only two data points available to estimate the change in a parameter with depth (*M01* and *M13*) only generalized functions could be applied. The use of a linear function was considered an acceptable alternative.

3.5.5 Bulk Density

The FSCC – ICP Forests database did not contain values for bulk density for organic layers. Due to the absence of the layer height the parameter could not be computed from the layer weight. Changes in the weight of the dry organic layer between the surveys are given in Figure 33.

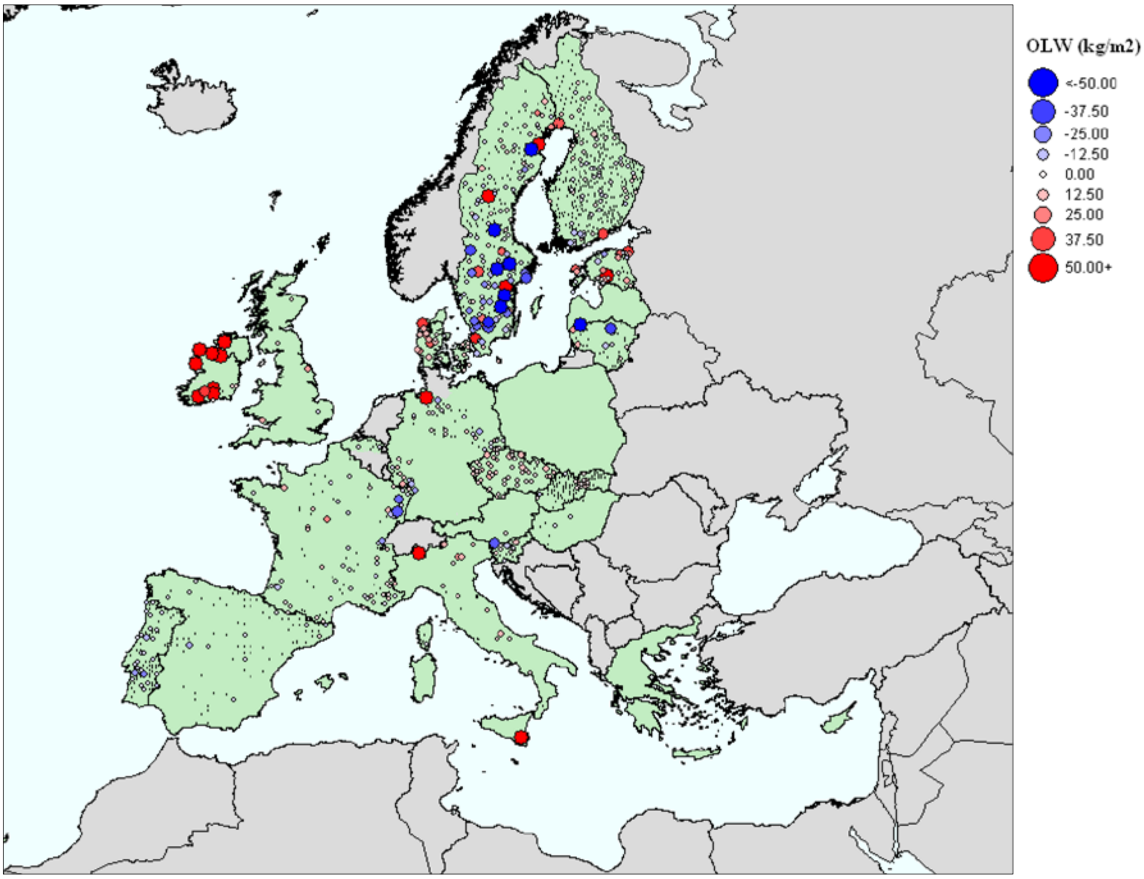


Figure 35: **Change in Dry Weight of Organic Layer from FSCC- ICP Forests to BioSoil**

The changes in organic layer weight are limited on most plots. Notable increases are reported for Ireland and decreases for scattered plots in Sweden and Lithuania. Except for Ireland no spatial correlation in the changes in organic layer weight seems to exist.

For the soil stratum bulk density is reported in the data. The specifications on how to asses the parameter was rather vague. The specifications state:

> "*It is recommended that the dry bulk density is determined from undisturbed soil to enable the calculation of the total nutrient contents. If the dry bulk density is not determined, a reasonable estimate of this parameter should be made.*" (Commission Regulation (EC) No 1091/94).

More detailed provisions on how to assess bulk density were made in guidelines published after the survey had been conducted. The values on bulk density found in the database are therefore to be interpreted with some caution. The spatial distribution of changes to bulk density in the soil material to a depth of 20cm of the FSCC – ICP Forests to BioSoil data is given in Figure 36.

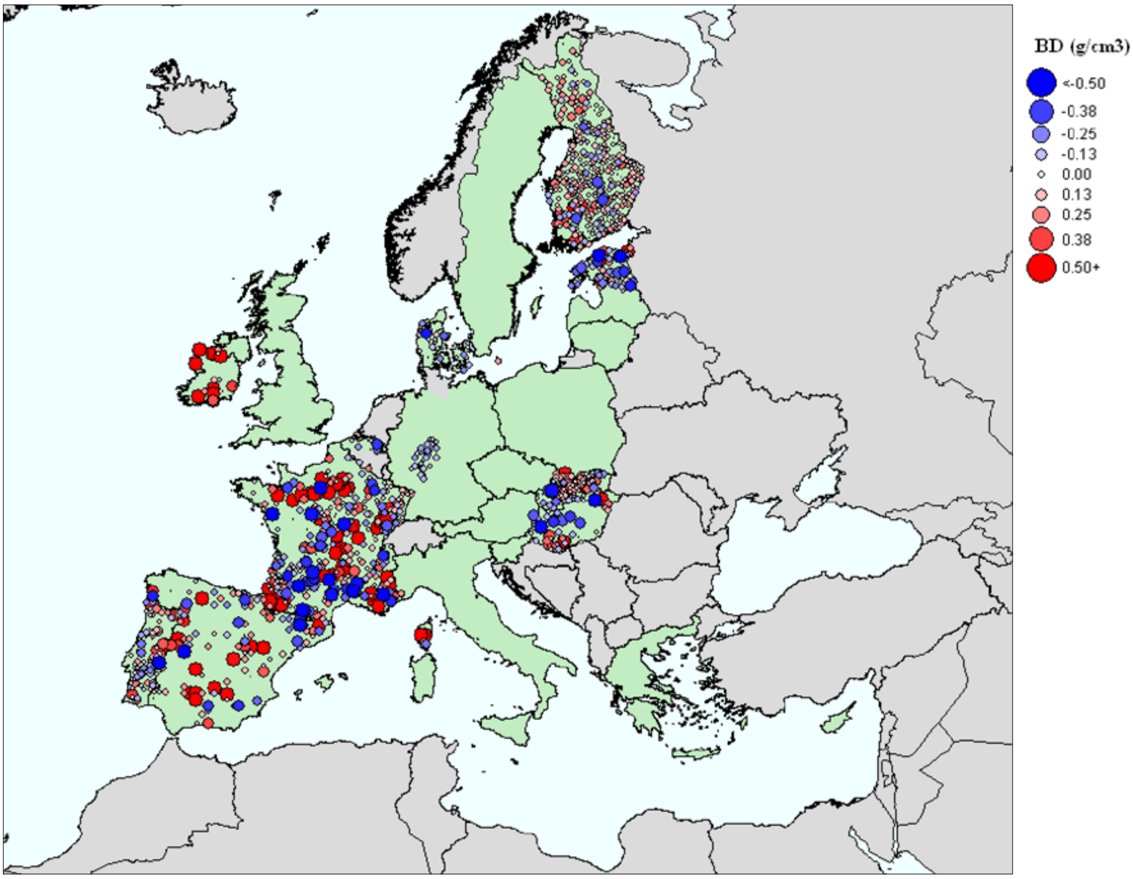


Figure 36: **Change in Bulk Density in Soil Material 0-20cm Layer from FSCC- ICP Forests to BioSoil**

The evaluation of changes in bulk density is hampered by the limited amount of plots with data for the parameter and as a consequence cannot be assessed for about half of the participating countries. With the exception of plots in Ireland, where the soil has been reclassified, there is no particular spatial trend discernable from mapping the data. Rather, the variability of values for bulk density appears to be greater for plots in Spain, France and Hungary and on some plots in Estonia and Denmark. By comparison, the variations are less extensive on plots in Portugal, Hessen, Finland and the Slovak Republic.

3.5.6 Volume of Coarse Fragments

While some variation over the years could be expected for the OC content and bulk density in the soil the volume of coarse fragments should remain stable over time. Variations in the parameter indicate the natural variability of the soil whereas trends indicate changes in methods applied to assess the parameter. The changes in the volume of coarse fragments from the FSCC – ICP Forests to the BioSoil survey are presented in Figure 37.

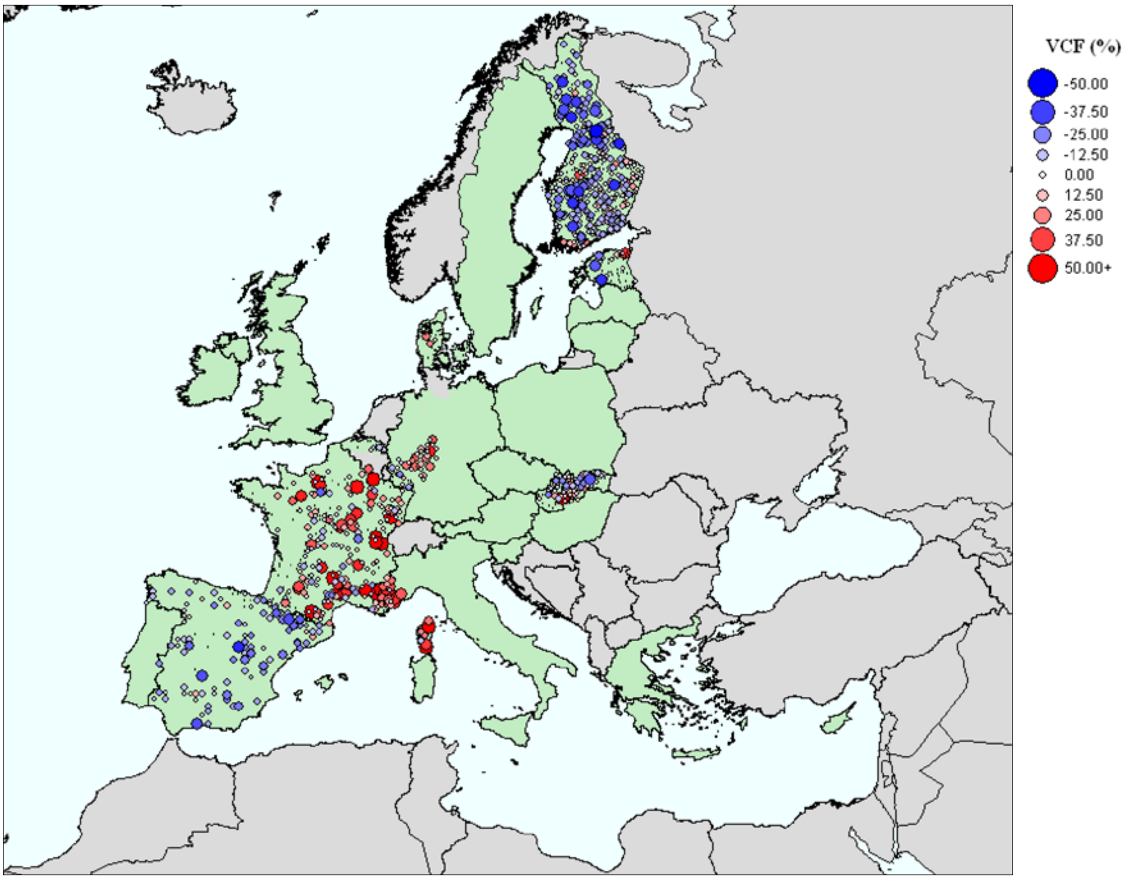


Figure 37: Change in Volume of Coarse Fragments in Soil Material 0-20cm Layer from FSCC-ICP Forests to BioSoil

Compared to the previous survey lower values are reported for plots in Spain, Finland and the Slovak Republic. Increases are reported for France and Hessen. The data points toward a strong regional dependency of the changes on the reporting NFC. The changes are not minor, at times 50% are exceeded, and directly affect the amount of OC stored in the soil.

3.5.7 Organic Carbon Quantity

The quantity of OC in the organic layer and the soil material is determined for a given depth and based on the calculation of the OC density found at a sample plot. The parameter is not measured directly but derived from other measured parameters. When calculating the temporal change in OC density or quantity for a plot one or more of the parameters may vary. The effect of changes in controlling parameters on OC quantity is cumulative: they can be additive or subtractive and are at times related. Under forests an increase in OC content in the soil material is generally associated with a decrease in bulk density. Hence, a widespread change in only OC content or bulk density without an equivalent change in the other parameter points toward a modification of methods rather than distribution of the parameter. These effects may not be visible when computing OC quantities and should be kept in mind in the interpretation of the results.

Data collected under the ICP Forests Level I survey does not contain information on the height of the organic layer. It is therefore not possible to establish OC densities for the organic layer, only the amount of OC in the organic layer can be determined. This restriction also applies to the combined amount of OC in the organic layer and soil material.

The change in the quantity of OC in the organic layer is presented in Figure 38.

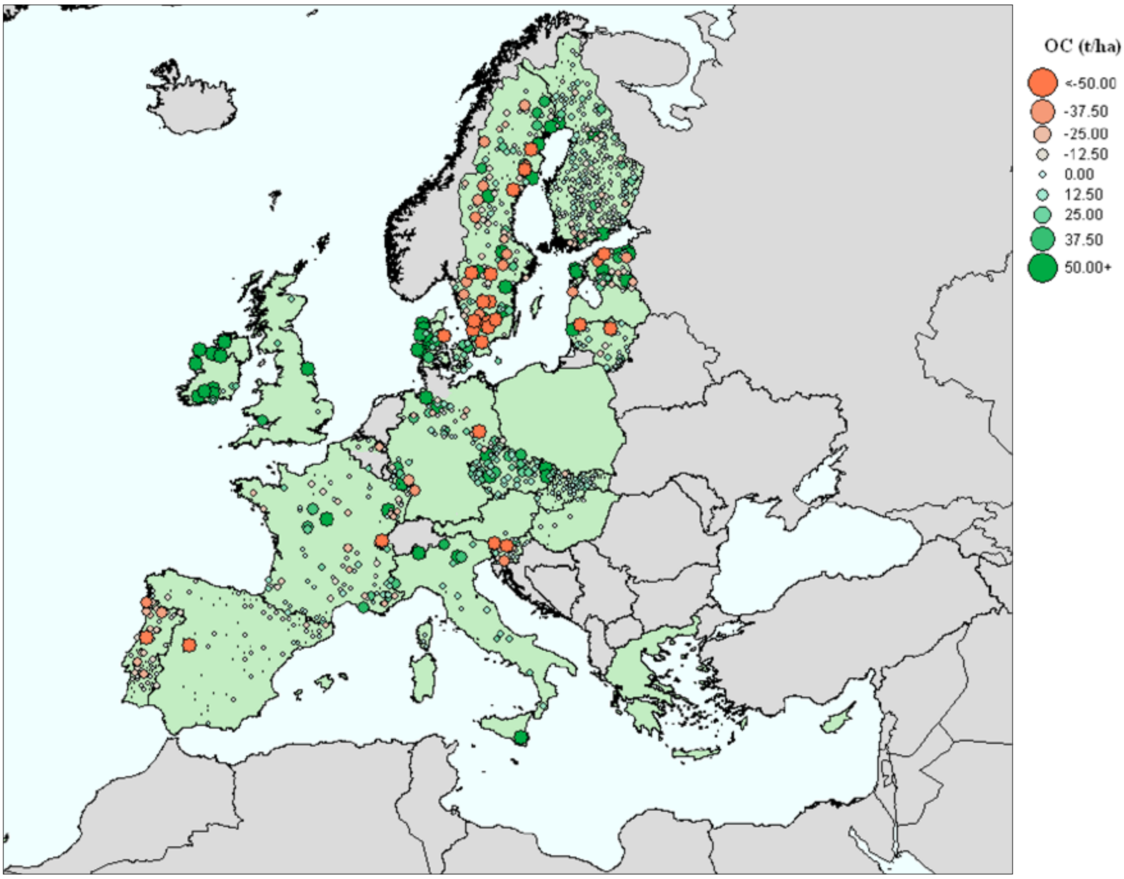


Figure 38: Change in Organic Carbon Density in Organic Layer from FSCC- ICP Forests to BioSoil

Noteworthy regional increases in the organic layer are recorded for plots in Ireland, Denmark and the Czech Republic. A general decrease is reported for plots in Portugal. On plots of other NFCs both increases and decreases are found. Comparatively small changes are reported for plots in Finland and the Slovak Republic.

Changes in OC quantity in the soil material are depicted in Figure 39.

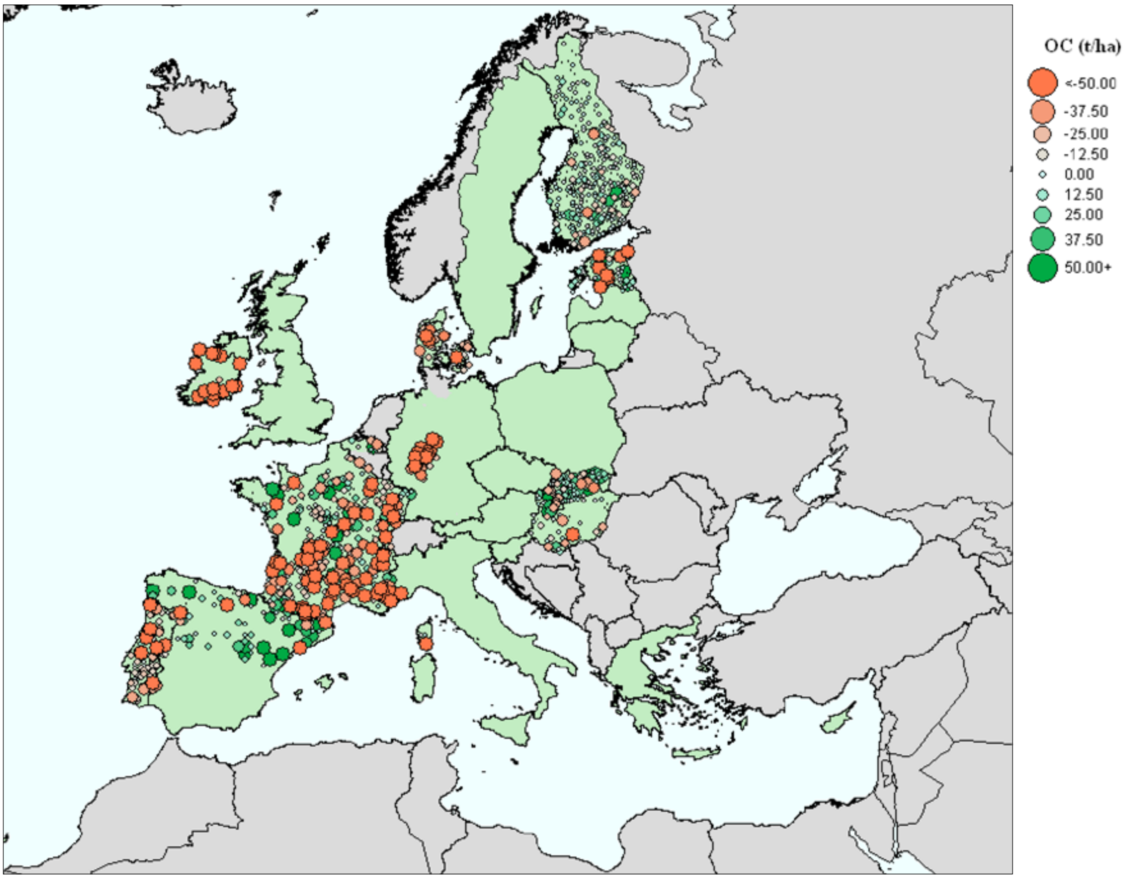


Figure 39: Change in Organic Carbon Density in Soil Material 0-20cm Layer from FSCC- ICP Forests to BioSoil

The graph shows a widespread decrease in OC quantity for plots in Portugal, Ireland, France, Hessen, Denmark and Estonia. Plots with significant increases in OC quantity in the soil material are less numerous and more frequently found in Spain and the Slovak Republic. The changes are in part a consequence of variations in the delineation of the organic layer from the soil material between the two surveys, for example in Ireland. Another factor with considerable effect on OC quantity is the reported change in the volume of coarse fragments, which affects for example the results in France.

The changes in OC quantity in the combined organic layer and soil material to a depth of 20cm is presented in Figure 40.

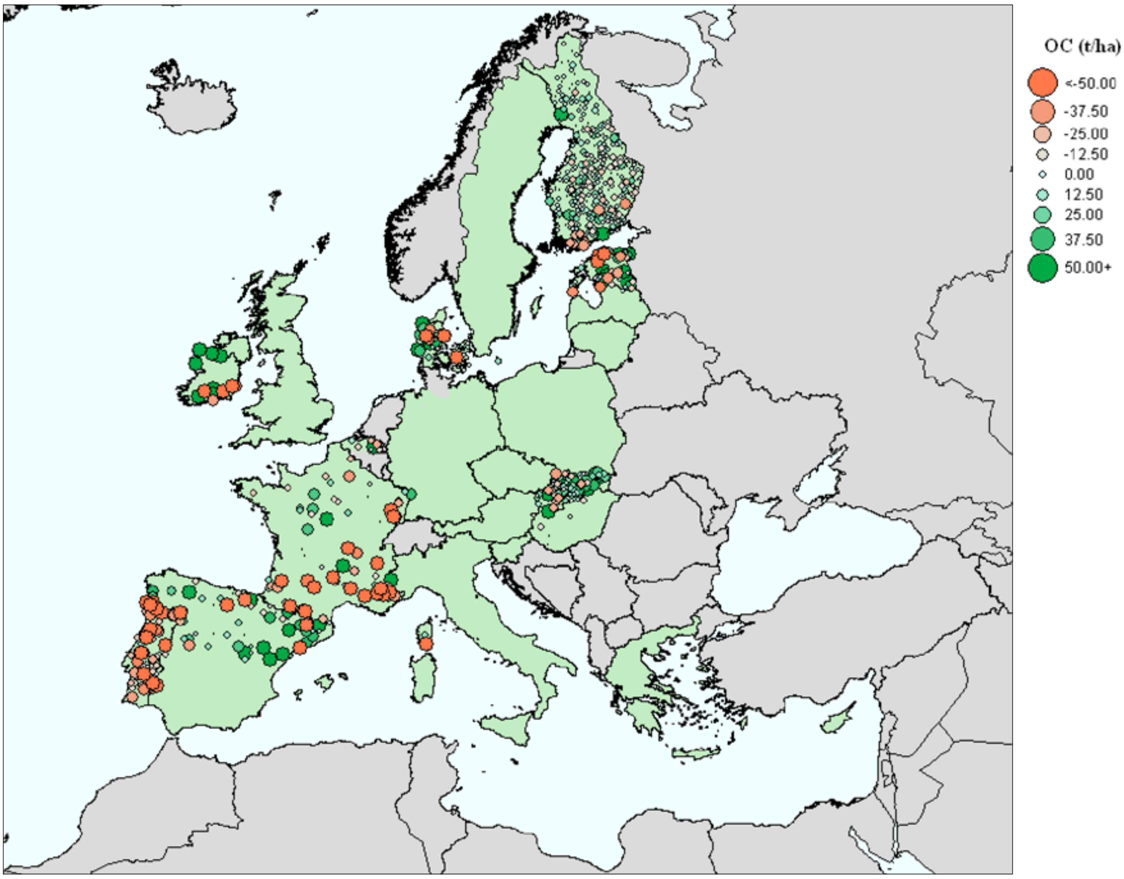


Figure 40: **Change in Organic Carbon Density in combined Organic and Soil Material 0-20cm Layer from FSCC- ICP Forests to BioSoil**

As a consequence of limited data availability the graph allows mapping the plots of a restricted number of NFCs. A clear trend is only found on plots in Portugal. On plots in other NFCs both increases and decreases are reported. Variability between surveys is less on plots in Flanders, Finland and the Slovak Republic.

The results are based on information from plots for which data for all parameters were available for the organic layers or the soil material, except for the volume of coarse fragments. The plots compared in the analysis could have been further restricted to those where reporting organic layers and soil material in the surveys was used as criterion. It is arguable whether such additional restrictions should be applied or not. Under the assumption that the methods used for the surveys should lead to comparable results the restrictions should not be applied. Yet, when variations are attributable to methodological differences the results obtained from the spatial or temporal analysis reflect those differences rather than actual change of a parameter. In the interpretation of the results from the analysis of changes in OC quantity the element of methodological divergences between NFCs and over time would appear to play an important role in the differences obtained from the reported data. Difficulties in describing procedures to separate the organic layer from the soil material were recognized at meetings from expert groups (FSCC, 2004; UN/ECE, 2006). From the findings it appears that the extensive narrative on organic layers and soil material will need further elucidation.

3.6 Analysis of Procedures for Soil Data

The evaluation of procedures implemented within the project concentrates on aspects related to assuring data quality. An evaluation of management procedures is covered in the final project report. The two main areas of procedures concerned with data quality are the specifications provided in the sampling manual (*a priori* provisions for data control) and the validation of the data submitted by NFCs (*a posteriori* procedures for quality assurance).

3.6.1 Manual on Soil Sampling

The specifications for sampling data under the BioSoil project by fixed depth in the soil material are based on Sub-Manual IIIa and Annex of the ICP Forests in version 06/2006. The document went through several draft versions and is based on guidelines on the implementation of the survey since 1993. A summary of documents related to sampling data for the Forest Focus / ICP Forests Soil Condition survey and the BioSoil survey is given in Table 17.

Table 17: Documents Providing Guidelines to Sampling Soil Condition under Forest Focus / ICP Forests and BioSoil

Survey	Forest Focus / ICP Forests		Forest Focus – BioSoil
	Level I & II	Level II	Level 1 and Level 2
Manual	(EEC) No. 926/93 (EEC) No. 1091/94	Sub-Manual IIIa, V. 06/2003	Sub-Manual IIIa, V.06/2006 BioSoil adaptation
Forms	PLS SOM SOO	PLS SOM SOO	PLS SOM SOO PFH PRF
Period	1996 - 2002	2003 – 2006 (incl.)	2006 - …

Up to 2002 sampling data for the ICP – Forests Soil Condition survey was performed mainly according to the regulations of the implementation of the monitoring scheme and unspecified versions of Sub-Manual IIIa. These procedures were applied to the previous survey on Level I plots and surveys performed on Level II plots until 2002. For the duration of Forest Focus (2003 – 2006) no data on soil conditions were collected on Level I plots, but on some cases on Level II plots. The provisions made were published in the ICP Forests Sub-manual IIIa, V. 06/2003. Version 06/2006 of the Sub-Manual was applied to sampling on Level I and Level II plots from 2007 onwards. This version of the sub-Manual was not applied on Forest Focus / ICP Forests Level I or Level II plots for the monitoring period of 2006. However, the BioSoil project used a modified version of the sub-Manual to sample soil condition parameters on Level 1 and Level 2 plots in 2006.

The provisions made in the Sub-Manual have to be considered in the definitions of the format for submitting the information. The data collected were arranged according to the formats given in 3 tables PLS, SOM and SOO for information on the plot, mandatory measurements and optional measurements. The formats of the forms changed over time and also the parameters to be reported. For reporting data under BioSoil amendments were made to accommodate data from the pedological horizon, which are not assessed in the Soil Condition surveys of Forest Focus / ICP Forests. Modifications were also made to the dictionary tables, for example adding country codes for the German Länder. Under BioSoil the German Länder were set up as NFCs, while under Forest Focus / ICP Forests Germany reported under a single NFC.

Apart from the changes in reporting the results of the survey there are inconsistencies between the Sub-Manual and the specifications for the formats of the submission files. The evaluation of the soil data identified:

- File Format specifications: Reference is made to the ”mineral layer” instead of the “soil material”.
- SOM format specifications, Organic Carbon (Table 4.22): For mineral layers >20cm the parameter is optional for Level 1 sites, but mandatory for Level 2 sites (specifications reversed).
- Layer depth in soil material should be either *M05* and *M51* or *M01* for all plots.
- Separation of organic layer from organic soil is not covered by file format specifications.
- Treat saturation status should be treated as an attribute to a section of the soil material, i.e. remove separate coding for layers (*H*,*M*)
- Either bulk density and the height of the organic layer(s) or the dry weight of the organic layer(s) and the height.
- Field MEAN_BULK_DENSITY for Level 1 plots hold measured values. It should separate between the mean from several estimates and from one or several measured values.
- Sampling the mass of coarse fragments is reported, but not specified in the Sub-Manual.
- Values for layer depth should be added to the Sub-Manual provisions for organic layers.

- Layer depth should not be recorded separately for the soil material unless depth is made an attribute of the segment sampled.

The separation between mandatory and optional parameters should be removed, in particular the dependence to previous surveys. With a sampling frequency of 10 years and variations in sample conditions all parameters should be re-assessed. The depth limit in the soil material should be extended to include a limit of 30cm. This depth is widely used to characterize the topsoil conditions. To assess changes in soil conditions it is not sufficient to focus only on the uppermost 20cm. This would allow analyzing the vertical movement of soil parameters from and to the subsoil.

However, the main element introducing uncertainty into the sample data is the separation of the organic layer from the soil material. The guidelines given are ambiguous and the description referring to organic horizons, layers and soil confusing. Soil material is at times referred to as mineral soils or the mineral layer. As the evaluation of the OC content data shows a re-classification of layers leads to considerable changes in the data reported. A simplified and coherent description of the method to be applied to separate the organic layer from the soil material would reduce the spatial and temporal variation caused by different interpretations of the sampling method to be used.

3.6.2 Validation Procedure and Parameters

The purpose of the data validation is to ensure that the information stored in the system can be used for an assessment of the state of a parameter sampled and in the evaluation of temporal and spatial trends between plots. It should also allow the integration of the data with other data sources in more extensive thematic analyses.

- **Validation Principles**

  Data are validated based on the principle that it is not possible to identify the correctness of data, but rather that it may be possible to identify the probability that data represent valid measurements. The BioSoil validation is based on the procedure applied to data from the Forest Focus monitoring scheme. It consists of three main stages, as depicted in Figure 41.

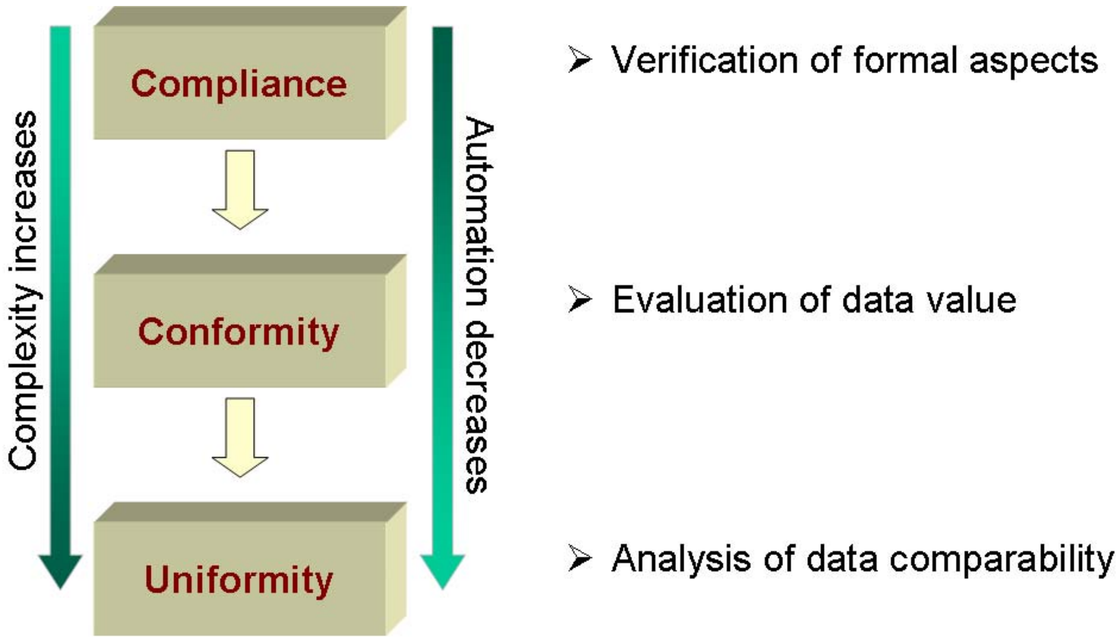


Figure 41: Data Validation Phases

The tests applied during the phases verify different aspects of the data and have to be performed in sequential order.

- **Compliance Check**

  The tests applied as part of the Compliance Check verify if the data in the submitted files of a survey comply with the specifications of the fixed formats ASCII files as stipulated in the file specification documents. Data ranges are not verified, only syntactic checks are applied.

- **Conformity Check**

  The Conformity Check comprises a number of tests that are applied after the submitted data have been subjected to the Compliance Check. The principle of the Conformity Check is to evaluate the probability that a data value is an actual observation. The condition is evaluated with the aid of single parameter range tests, including test of boundaries for geographic coordinates. The tests can also detect impossible values, e.g. pH = 0. All these tests aim at assessing plot-specific conditions. Information from other plots is not taken into account at this stage.

  The results of the tests are at times extensive lists of flagged values, which indicate either an error for values indicating potentially unusual conditions or a warning for values outside a pre-set range. All flagged values are listed and described with an explanatory legend in a report, which is transmitted to NFCs to allow verifying the situation.

- **Uniformity Check**

  The tests applied to check data Uniformity are intended to identify temporal and spatial data inconsistencies which could not be found during any of the previous checks. The Uniformity Check consists of an interpretation of temporal and spatial development of parameters using data from all plots. Contrary to Conformity data Uniformity is verified by comparative tests using more than the information from a single plot. Uniformity tests are more qualitative and require the interpretation of the results by an expert in the field. The interpretation includes a comparison with external data as far as such information is available in a suitable form.

  The check includes generating maps for various key parameters monitored to assess the spatial variation of a parameter. For the analysis of regional temporal changes the maps should also compare new data with data from plots of the previous survey.

To provide consistent results a test belonging to a type of check cannot be applied in another group. Before a value can be evaluated it has be correctly interoperated by the parser and transferred without loss to the database for verification. Conversely, before methods or differences in procedures can be assessed the correctness of the values must be established.

The results of the compliance and conformity checks can be warnings or errors. Warnings need to be commented by the submitting NFCs while in the case of one or several errors corrected data needs to be re-submitted. The output of the uniformity check may be warnings, but not errors. Therefore, the data analyzed for uniformity would not have to be corrected and resubmitted, only commented.

This arrangement has consequences on the data management procedures. Until all tests of the compliance check have been performed the submission can contain errors and corrections will have to be re-submitted.

For the validation of the Forest Focus monitoring data the 3 phases of validation checks were clearly separated. The tests for data compliance were performed on-line at the time of data submission. Tests for conformity were found to be too involved to be performed online and were thus run on the processing database. Conformity reports were then sent separately to NFCs.

Under BioSoil part of the tests for conformity were also performed by the on-line. This procedure should provide an immediate feedback to the NFC and allow corrections to be made with short delays. It also reduces the burden on staff processing the data and generating the reports. The disadvantage of this approach was that the check of data conformity was split into two parts, one on-line and one relegated to be performed by project staff.

This arrangement resulted in detecting errors requiring corrections of data and re-submissions during the check for uniformity. In effect the uniformity check as defined could not be performed because data values were still evidently erroneous and needed to be corrected. On example is the geographic position of plots. The test is by nature part of the conformity check but has not been included in the on-line procedure. Therefore, NFCs are informed about any invalid positions of their plots only when the reports on uniformity have been sent. Because the reports on the BioSoil uniformity check were sent rather late in the project NFCs were not always able to correct their data and submit the forms within the period of the project. The evaluation task was affected by delays as no Level 2 data were fully validated at the time of processing the data.

- **Submission File Format**

In contrast to Forest Focus forms data from the BioSoil project were submitted using a field-delimited format. The advantage of the format over the fixed-format of Forest Focus monitoring data is the flexibility in field dimensions: data do not have to be exactly right-aligned within the positions assigned to a value, inserting fields into or deleting fields from a form is less arduous and changes to field dimensions are straightforward.

There are not only advantages to the format. The format is not universally defined. A separator value used in a string can trigger the start of a new field unless the string can be identified. Regional differences in data formats, in particular the use of a comma as a decimal separator, can lead to loss of data or miss-interpretation of data entries. Date entries, unless the specifications are completely adhered to, can become unrecognizable or mistaken. In the file formats non-specific alpha-numeric entries appear only in the observation field. Some problems in transferring the data from the data submitted to the database were evident in the export files. Several entries contained duplicated double quotes surrounding observation entries.

Any particular hitches in the import of the data submitted by NFCs were not found during the evaluation. The database provides some help in identifying potential problems by providing the entries of measurements also in form of string entries.

4 Analysis of BioSoil/Biodiversity Module

For the collection of biodiversity data a stand structure approach was adopted, which assumes an increased potential for biological diversity with increasing complexity of the forest stand. This approach was complemented with the addition of biological data such as information on the ground vegetation community.

4.1 File Formats

Data were requested to be submitted by e-mail to the JRC in 6 ASCII comma separated files. In practice some countries found it difficult to work in ASCII, so Excel files were also accepted provided that they followed a given template and that the columns and worksheets were clearly labelled.

The six requested files contained information on different aspects of forest biodiversity.

- **GPL**

  This file contains general information about the plot.

- **DBH**

  This contains information about the trees within the plot. Collected data includes tree species, status (live, dead) and DBH. Optionally countries were also able to provide information about the relative positions of all the trees in the plot.

- **THT**

  Contains tree height and canopy height for a subset of the trees in the plot.

- **CAN**

  Gives canopy closure score and number of tree layers in the plot. The total number of trees in the plot and the percentage of trees measured are also reported.

- **DWD**

  This file contains information about all the coarse woody debris found in the plot, including length, diameter and state of decay.

- **GVG**

  This contains a list of all the ground vegetation species found in the plot. The procedure for reporting ground vegetation is very similar to that used in the Forest Focus Level II Ground vegetation survey (ICP Forests, 2007) and the sampling area is the same, although a different shape.

The deadline for data submission was June 2008. Most, but not all, countries sent their data by the deadline. Initial validation took place during the summer and reports were sent on 24/10/2008 to those countries who had submitted data. They were given until 21/11/2008 to respond. For those countries who had submitted data late, reports were compiled and deadlines for response were given on an individual basis.

As a result of the validation checks every country resubmitted data at least once. Resubmissions went through the same validation process, and sometimes resulted in further submissions or email confirmations of minor problems.

When a country resubmitted only a subset of the 6 data files, the most recent previous versions of the omitted files were added to the submission to allow complete validation to be carried out. The general principal was not to modify anything the country sent, and to request all modifications to made by them. A few exceptions were made for very minor issues (e.g. change of date in one or two records) if the country explained the necessary updates clearly by email. In these cases an export was made of the modified data and sent back to the originator of the data, who was requested to check that the modifications had been made correctly. These data then became the definitive version.

4.2 Work Flow

Data submission/resubmission dates are given in Table 18. Only full submissions are shown; email confirmations are not included. Every country had to resubmit at least once; some required up to 6 attempts. On average, 2-3 attempts were made before the submitted data had no compliance/conformity errors and the remaining warnings were clarified.

Table 18: Data Submission Process

Country Name	GPL	DBH	THT	DWD	CAN	GVG
France	12.06.2008 04.11.2008	12.06.2008 04.11.2008	12.06.2008 04.11.2008	12.06.2008 04.11.2008	12.06.2008 04.11.2008	12.06.2008 04.11.2008
Belgium (Flanders)	27.11.2007	27.11.2007	27.11.2007	27.11.2007 19.11.2008 25.08.2009	27.11.2007	27.11.2007
Italy	06.08.2008 10.12.2008 14.08.2009 03.09.2009 19.10.2009	06.08.2008 28.11.2008 03.12.2008 10.12.2008 14.08.2009 03.09.2009	06.08.2008 28.11.2008 03.12.2008 10.12.2008 14.08.2009 03.09.2009	06.08.2008 03.12.2008 10.12.2008 14.08.2009 03.09.2009	06.08.2008 03.12.2008 10.12.2008 14.08.2009 03.09.2009	06.08.2008 10.12.2008 14.08.2009 03.09.2009
United Kingdom	29.04.2008 21.11.2008	29.04.2008 21.11.2008 27.05.2009	29.04.2008 21.11.2008 27.05.2009	29.04.2008 21.11.2008 27.05.2009 19.08.2009 20.08.2009	29.04.2008 21.11.2008	29.04.2008 21.11.2008
Ireland	12.06.2008 03.12.2008	12.06.2008 03.12.2008	12.06.2008 03.12.2008	12.06.2008 03.12.2008 18.05.2009	12.06.2008 03.12.2008	12.06.2008 03.12.2008
Denmark	05.05.2008 21.11.2008 26.06.2009	05.05.2008 21.11.2008 26.06.2009	05.05.2008 21.11.2008 26.06.2009	05.05.2008 21.11.2008 26.06.2009	05.05.2008 21.11.2008 26.06.2009	05.05.2008 21.11.2008 26.06.2009
Spain	24.06.2008 01.07.2008 21.11.2008 25.05.2009 05.10.2009	24.06.2008 01.07.2008 21.11.2008 25.05.2009	24.06.2008 01.07.2008 21.11.2008 25.05.2009	24.06.2008 01.07.2008 21.11.2008 25.05.2009	24.06.2008 01.07.2008 21.11.2008 25.05.2009	24.06.2008 01.07.2008 25.05.2009 17.06.2009
Sweden	28.12.2007 21.11.2008 28.11.2008	28.12.2007 21.11.2008	No THT submitted	28.12.2007 21.11.2008	28.12.2007	No GVG submitted
Austria	24.06.2008 20.11.2008	24.06.2008 20.11.2008	24.06.2008 20.11.2008	24.06.2008 20.11.2008	24.06.2008 20.11.2008	24.06.2008 20.11.2008
Finland	13.06.2008 31.10.2008 04.12.2008	13.06.2008 31.10.2008	13.06.2008 31.10.2008	13.06.2008 31.10.2008	13.06.2008 31.10.2008	13.06.2008 31.10.2008
Hungary	16.09.2008 12.11.2008 22.07.2009 27.07.2009	16.09.2008 12.11.2008 22.07.2009 23.07.2009 27.07.2009	16.09.2008 12.11.2008 22.07.2009 27.07.2009	16.09.2008 12.11.2008 22.07.2009 27.07.2009	16.09.2008 12.11.2008 22.07.2009 27.07.2009	16.09.2008 12.11.2008 22.07.2009 27.07.2009
Poland	13.06.2008 20.11.2008	13.06.2008 20.11.2008 20.05.2009	13.06.2008 20.11.2008	13.06.2008 20.11.2008	13.06.2008 20.11.2008 20.05.2009	13.06.2008 20.11.2008
Slovak Republic	25.06.2008 11.11.2008 05.12.2008 27.07.2009	25.06.2008 11.11.2008 05.12.2008 27.07.2009	25.06.2008 11.11.2008 05.12.2008 27.07.2009	25.06.2008 11.11.2008 05.12.2008 27.07.2009	25.06.2008 11.11.2008 05.12.2008	25.06.2008 11.11.2008 27.07.2009
Lithuania	11.06.2008 19.08.2008 22.11.2008	11.06.2008 19.08.2008 22.11.2008	11.06.2008 19.08.2008 22.11.2008	11.06.2008 19.08.2008 22.11.2008	19.08.2008 22.11.2008	11.06.2008 19.08.2008 22.11.2008
Czech Republic	19.12.2008 26.05.2009 07.10.2009	19.12.2008 26.05.2009 07.10.2009	19.12.2008 26.05.2009 07.10.2009	19.12.2008 26.05.2009 07.10.2009 27.10.2009	19.12.2008 26.05.2009 07.10.2009	19.12.2008 26.05.2009 07.10.2009 27.10.2009
Slovenia	25.11.2008 09.12.2008 28.05.2009	25.11.2008 09.12.2008 28.05.2009	25.11.2008 09.12.2008 28.05.2009	25.11.2008 09.12.2008 28.05.2009	25.11.2008 09.12.2008 28.05.2009	25.11.2008 09.12.2008 28.05.2009
Latvia	16.06.2008 21.11.2008 24.11.2008 01.12.2008	16.06.2008	16.06.2008 21.11.2008	16.06.2008	16.06.2008 21.11.2008	16.06.2008
Cyprus	13.05.2008 30.10.2008	13.05.2008 30.10.2008	13.05.2008 30.10.2008	13.05.2008 30.10.2008 05.11.2008	13.05.2008 30.10.2008	13.05.2008 30.10.2008

Country Name	GPL	DBH	THT	DWD	CAN	GVG
Canaries (Spain)	24.06.2008 01.07.2008 21.11.2008 05.10.2009	24.06.2008 01.07.2008 21.11.2008	24.06.2008 01.07.2008 21.11.2008	24.06.2008 01.07.2008 21.11.2008	24.06.2008 01.07.2008 21.11.2008	24.06.2008 01.07.2008 25.05.2009
Germany (Baden-Württemberg)	07.08.2008 13.08.2008 11.11.2008	07.08.2008 13.08.2008 11.11.2008	07.08.2008 13.08.2008 11.11.2008	07.08.2008 13.08.2008 11.11.2008	07.08.2008 13.08.2008 11.11.2008	07.08.2008 13.08.2008 11.11.2008
Germany (Bavaria)	13.06.2008 02.11.2008	No DBH submitted	No THT submitted	No DWD submitted	No CAN submitted	13.06.2008 02.11.2008
Germany (Brandenburg-Berlin)	29.04.2008 15.11.2008	29.04.2008 15.11.2008	29.04.2008 15.11.2008	29.04.2008 15.11.2008	29.04.2008 15.11.2008	29.04.2008 15.11.2008
Germany (Hessen)	24.06.2009 06.07.2009	24.06.2009 06.07.2009	24.06.2009 06.07.2009	24.06.2009 06.07.2009	24.06.2009 06.07.2009	24.06.2009 06.07.2009
Germany (Mecklenburg-Vorpommern)	23.04.2008 10.11.2008	23.04.2008 10.11.2008	23.04.2008 10.11.2008	23.04.2008 10.11.2008	23.04.2008 10.11.2008	23.04.2008 10.11.2008
Germany (Niedersachsen)	24.06.2009 06.07.2009	24.06.2009 06.07.2009	24.06.2009 06.07.2009	06.07.2009	06.07.2009 15.07.2009	24.06.2009 06.07.2009
Germany (NRW)	13.06.2008 19.11.2008	13.06.2008 19.11.2008	13.06.2008 19.11.2008	13.06.2008 19.11.2008	13.06.2008 19.11.2008	13.06.2008 19.11.2008 09.01.2009
Germany (Rheinland Pfalz)	03.06.2008 07.11.2008 18.11.2008	03.06.2008 07.11.2008	03.06.2008 07.11.2008	03.06.2008 07.11.2008	03.06.2008 07.11.2008	03.06.2008 07.11.2008
Germany (Saarland)	11.06.2008 19.08.2008 25.11.2008	11.06.2008 19.08.2008 25.11.2008	11.06.2008 19.08.2008 25.11.2008	11.06.2008 19.08.2008 25.11.2008	11.06.2008 19.08.2008 25.11.2008	No GVG submitted

4.3 Data Validation

A test database was built in MS-Access, incorporating approximately 85 separate validation checks. The submitted files went through a process of validation following a similar procedure to that set up for the Forest Focus Level II data.

The initial (Compliance) stage checked whether the correct files had been submitted in the requested formats and data types. Because of the difficulty some NFCs had in manipulating ASCII files, some of these checks were relaxed slightly, and if the data were clearly identified and could be easily interpreted, other formats were allowed and the conversion to correct format was made at the JRC. The data were then transferred to the test database for further checks.

The other validation checks raised either error or warning messages, depending on the type and severity of the problem. Error messages were given when there was a clear mistake (invalid code, impossible date) and warnings if the data might be correct but extreme (unusual dbh, height values) or if it was not possible to state the source of the error (inconsistent information between 2 files). A graphical representation of the work flow and process control is given in Figure 42 below.

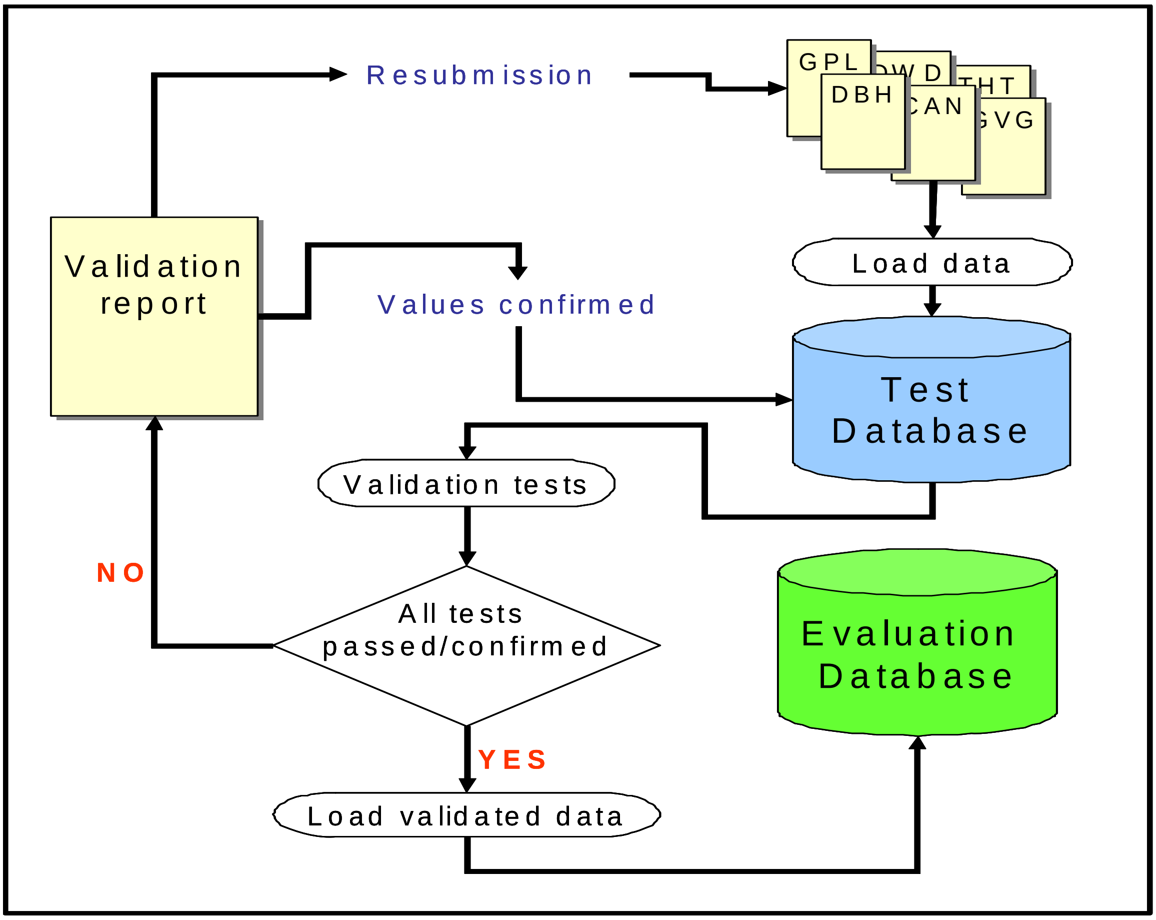


Figure 42: Process Control

The data validation included the following tests:

- Checking for referential integrity (all plots reported in the data files must have a corresponding entry in the Plot information)
- Duplicate values
- No null values allowed in key fields (e.g. plot id, location)
- Checking that all codes were valid.
- Checking for correct date format
- Plausible location of plot (not in sea or outside country boundary)

- Plausibility of date values
- Plausibility of dimensions (size of trees, deadwood)
- Crosschecks between number of trees measured and number reported in plot.
- Check that all occurrences of zero mean 0 rather than null (e.g. zero trees in plot, not "no information available")

After the validation checks were completed each country was given a report detailing every problem and the line on which it occurred. Data that raised error messages had to be corrected; warnings could either be corrected or confirmed as correct but extreme values. Corrected data were resubmitted and went though the full process again until all error messages were eliminated and all remaining warnings confirmed.

The validated data were then transferred to a separate database for evaluation and statistical analysis. All previous versions of the data remain on the test database for audit trail purposes.

Figure 43 shows a summary of the complete data collection and validation phases.

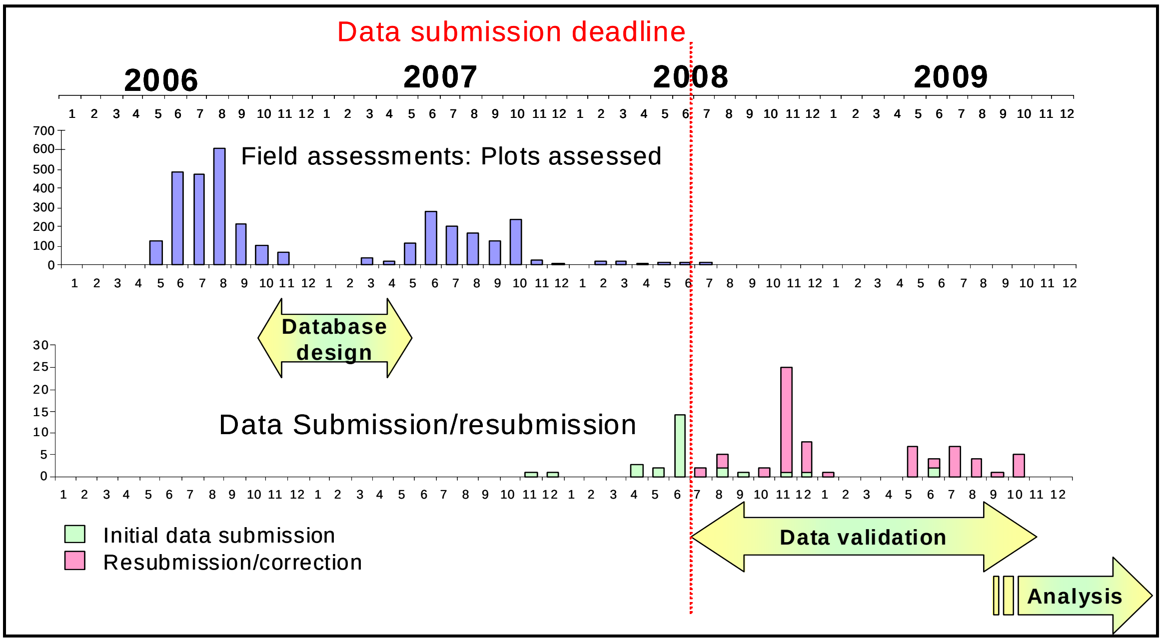


Figure 43: Summary of Work Flow

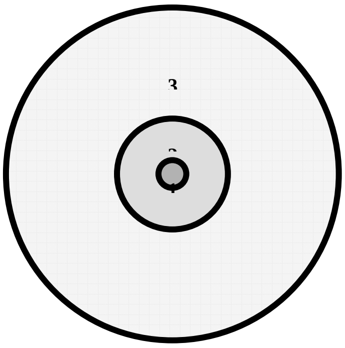
Table 19 shows the records stored in the evaluation database and available for analysis after the validation process was completed.

Table 19: Data Stored in the Database

COUNTRY	GPL	DBH	THT	DWD	CAN	GVG
France	548	18111	2562	6648	1206	14761
Belgium (Flanders)	10	514	46	173	20	154
Italy	224	7780	825	3572	1319	17542
United Kingdom	167	5092	756	1455	484	2285
Ireland	35	1836	173	633	105	292
Denmark	22	701	80	9	66	285
Spain	151	2940	739	828	300	3870
Sweden	100	2836	-	840	100	-
Austria	136	3775	555	2176	272	3295
Finland	630	20098	1858	6870	1260	19429
Hungary	78	2495	284	1312	159	432
Poland	438	12964	1432	4668	955	13608
Slovak Republic	108	2899	441	1537	216	2965
Lithuania	62	2370	291	646	186	2019
Czech Republic	146	4881	436	3772	417	5714
Slovenia	44	1378	243	460	132	2391
Latvia	95	3483	450	1189	190	2749
Cyprus	19	238	115	165	57	592
Canaries (Spain)	4	105	20	15	8	58
Germany (Baden-Württemberg)	50	1425	149	1253	92	1740
Germany (Bavaria)	97	-	-	-	-	3053
Germany (Brandenburg-Berlin)	53	1927	160	446	82	429
Germany (Hessen)	29	667	246	794	58	790
Germany (Mecklenburg-Vorpommern)	17	532	103	289	34	824
Germany (Niedersachsen)	42	1050	358	1048	84	1261
Germany (NRW)	39	970	144	789	78	737
Germany (Rheinland Pfalz)	26	780	189	666	52	637
Germany (Saarland)	9	292	292	186	27	-
Total	**3379**	**102139**	**12947**	**42439**	**7959**	**101912**

4.4 Plot Layout for Data Sampling

Plots are circular and of fixed area, with the plot location related to the location of the crown condition survey (Level I) and to the soil pit of the soil survey of BioSoil. The plot is divided into three subplots: an outer subplot (subplot 3) with a radius of 25.24 m (2000 m^2) and including 2 circular subplots with fixed radii of 3.09 m (30 m^2, subplot 1) and 11.28 m (400 m^2, subplot 2). The scheme is shown below:



Coarse woody debris, snags, stumps, ground vegetation and canopy characteristics are measured in subplots 1 and 2 (a total sampling area of 400 m^2).

Tree species and DBH (diameter at breast height 130 cm) are recorded across the entire plot.

4.5 Plot Location

Plot locations were reported in a wide variety of projections and units. These were converted to a single projection to allow easy display of the data. The INSPIRE compliant European Terrestrial Reference System 1989 and Lambert Azimuthal Equal Area (ETRS89/ETRS-LAEA) projection was chosen for this purpose (Annoni *et al*., 2003).

For the purposes of analysis, the separate submissions from the German Länder were grouped and results presented for Germany as a whole. (NB. Some Länder did not participate in the BioSoil Biodiversity study and therefore the data do not represent coverage of the entire area). Island territories (e.g. Corsica, Sardinia, Canaries etc) were also included with the parent country, unless otherwise stated.

In addition, only Belgium (Flanders) participated in the project so there is no coverage of Wallonia. Figure 44 shows the location of the plots.

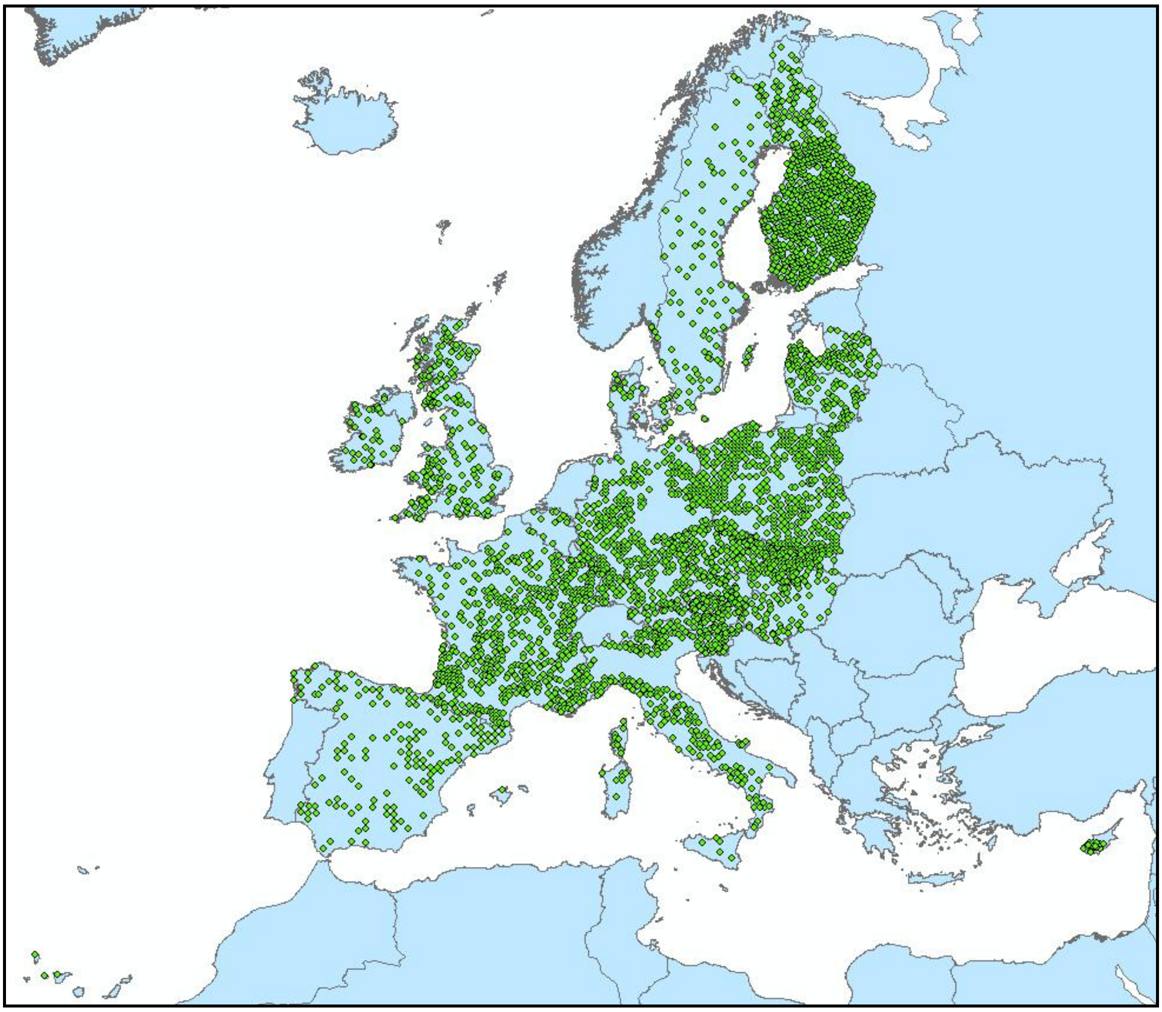


Figure 44: BioSoil Biodiversity Plot Locations

4.6 Missing Values

Unclear definition of what constitutes a missing value or why is it missing can lead to incorrect analysis and interpretation of the data. Some countries submitted zero values when they meant "missing". These were converted to null values in the database after clarification of the situation. Zero values were only allowed where they make biological or statistical sense in the data (e.g. zero % cover. There were also some zero values for DBH when the true value was very small and rounded down).

At other times there was a distinction between missing because no data exist (e.g. no trees in the plot) or missing because the value existed but was not known or not recorded for some reason (e.g. unknown tree species).

4.7 Species Identification

Two separate species codes were used: a short list to identify the tree species in the plot (Forest Focus LII codes) and a more comprehensive one to identify the ground vegetation (Flora Europea codes).

This caused a few problems for data management.

In principle the shorter list is a subset of the second. In practice this was not quite the case since there are some general cases (e.g. “other broadleaves”) and some subspecies (e.g. *Quercus rotundifolia*) that exist only in the shorter list.

One country found several species in their plots that were not covered by the short list and used Flora Europea codes to identify their tree species.

Some countries also reported ground vegetation species in their plots that were not listed in the more comprehensive Flora Europea list. There could be several reasons for this: for example, the species name used by the country may be a synonym of a listed species, or it may be a hybrid or not a native European species. Finally, the species code given may not be complete (e.g. identified only to genus or family level). For the purposes of analysis, all species that were named but not found in the code list were checked. If they were found to be synonyms of listed species the appropriate code was used. For “new” species a new code was created (flagged in the database to distinguish it from the original codes). For partially identified species, existing codes were used but replacing the given numbers with “999” to represent the unknown information (e.g. 026.007.999 for an unspecified *Pinus*). Completely unknown species or those that could not be coded even at family level became 999.999.999.

NB. It should be borne in mind that incomplete identification of some species will tend to lead to an under-estimate of the total number of species reported, since 2 different species of the same genus will have the same code and will be classed as a single “species”. All unknown species have the same code and are all classed together.

4.8 Data Completeness

All countries were required to supply at least proper plot identification (plot id, location, date of assessment). Other variables raised a warning if missing. General completeness of the data was high, but where information was missing it tended to be for all plots within a country, excluding that country from any analysis involving that variable.

4.9 General Plot Information

In addition to location and date of assessment, plots were assessed for a variety of characteristics (Table 20).

Table 20: Assessed Plot Characteristics

NAME	Description	Values
GPSELEV	Elevation reading from the GPS of the plot centre in metres	Values range from 0 to 2223m
ORIENT	Prevalent orientation of the BioSoil plot	N, NE ,E, SE, S, SW, W, NW, Flat
AVSLOPE	Prevalent slope of the BIOSOIL plot in percent	
PREVUSE	Previous land-use	1: Forested more than 300 years 2: Forested more than 100 years 3: Forested for 25-100 years ago 4: Forested in the past 25 years 5: No information
ORIGIN	Origin of the actual stand	1: Planted 2: Seeded 3: Natural regeneration 4: Mixed 5: Unknown
MANAGE	Forest management such as thinning and selective felling	1: Unmanaged (no evidence) 2: Management (evidence but >10 years ago) 3: Managed (within the last 10 years) 4: Unknown
FORTYPE	Forest Type	1: High forest (even-aged) – Femelschlag 2: High forest (even aged) – Small groups 3: High forest (uneven aged)– Plenterwald 4: High forest (other) 5: Young/Medium forest (under development to high forest) 6: Coppice without standards 7: Coppice with standards 8: Other
DWREMOV	Removal of coarse woody debris	1: Yes, all stems and main branches have been removed 2: Yes, stems and main branches have been removed 3: No, stems and main branches are lying in the forest 4: partly, some stems and main branches have been removed, others still present 5: Unknown

NAME	Description	Values
		6: Introduced 7: Presence of accumulation (branches have been stacked in piles or rows)
TREEMIX	Pattern of tree mixture See also glossary for explanations	1: Intimate (different tree species are mixed throughout the stand) 2: Non-intimate (different trees occur in clusters) 3: No mixture
AGE	Mean age of the dominant storey (in 20 year classes from 1-8 and unknown (=9))	1: 0-20 years 2: 21-40 years 3: 41-60 years 4: 61-80 years 5: 81-100 years 6: 101- 120 years 7: >120 years 8: Irregular stands 9: Unknown
FENCE	Fencing	1: Fenced 2: Not Fenced 3: Fenced in parts
EFTC	European Forest Type Classification	1: Boreal forest 2: Hemiboreal and nemoral Scots pine forest 3: Alpine coniferous forest 4: Atlantic and nemoral oakwoods, Atlantic ashwoods and dune forest 5: Oak-hornbeam forest 6: Beech forest 7: Montaneous beech forest 8: Thermophilous deciduous forest 9: Broadleaved evergreen forest 10: Coniferous forests of the Mediterranean, Anatolian & Macaronesian regions 11: Swamp forest 12: Floodplain forest 13: Native plantations 14: Exotic plantations and woodlands

The following give an overview of the distribution of plots with respect to each of these characteristics.

4.9.1 Elevation

Plot elevation ranged from sea level (Finland) to over 2000m above sea level (France, Italy, and Austria). Max and min values are given by country in Table 21.

Table 21: Minimum and Maximum Plot Elevation in m above Sea Level

COUNTRY	Minimum elevation	Maximum elevation
Austria	272	2040
Belgium	3.6	85.5
Cyprus	209	1390
Czech Republic	No information supplied	
Denmark	5.3	148
Finland	0	470
France	7	2223
Germany	2	1280
Hungary	80	490
Ireland	48	382
Italy	14	2212
Latvia	No information supplied	
Lithuania	41	207
Poland	12	1173
Slovak Republic	101	1301
Slovenia	98	1460
Spain	18	1750
Sweden	No information supplied	
United Kingdom	7	553

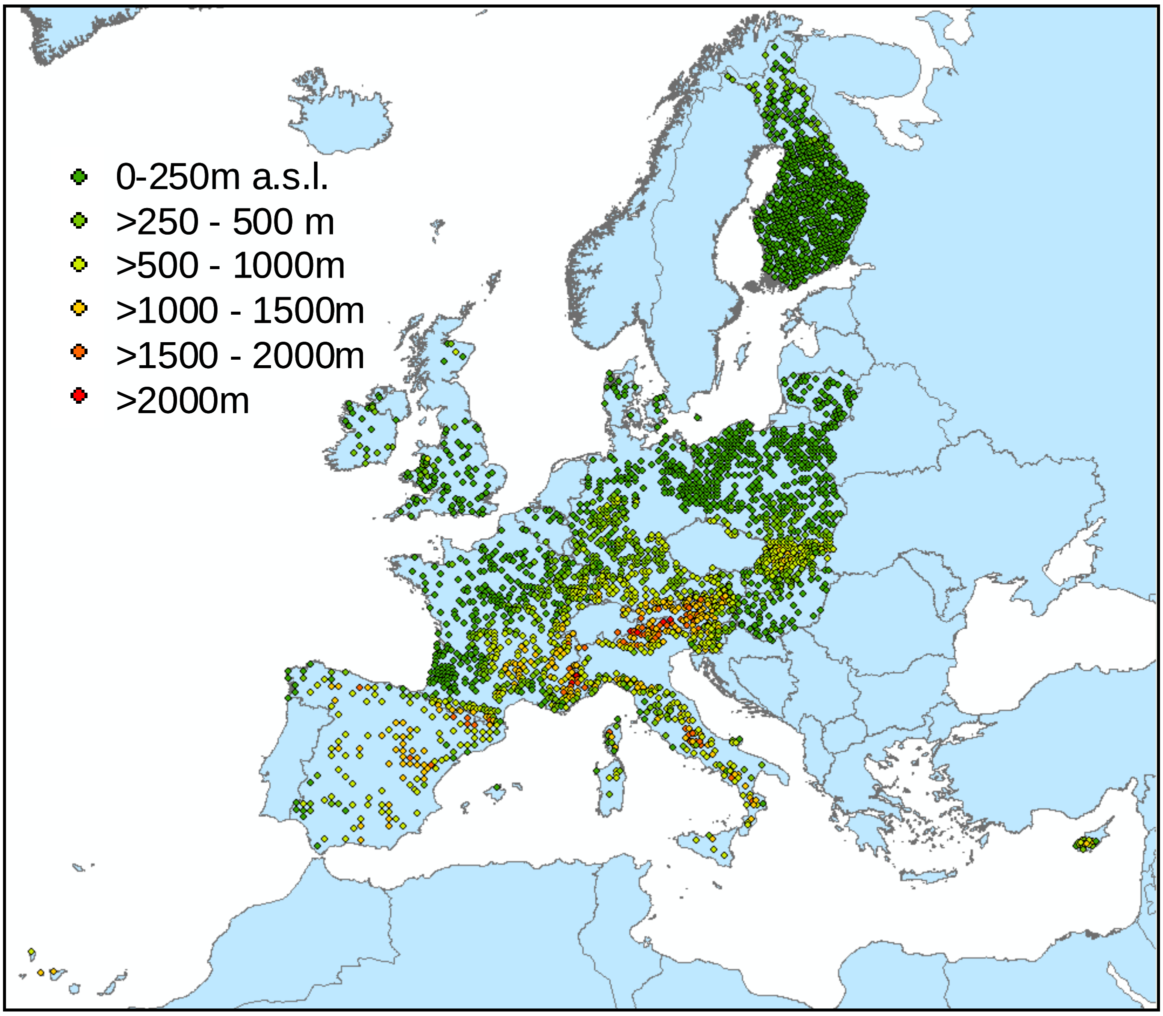


Figure 45: **Plot Elevation**

4.9.2 Previous Use of Land

The majority of plots (65%) have been forested for more than 100 years, with over a third forested for more than 300 years (see Figure 46). A relatively small number of plots were reported as new forests (forested in the last 25 years).

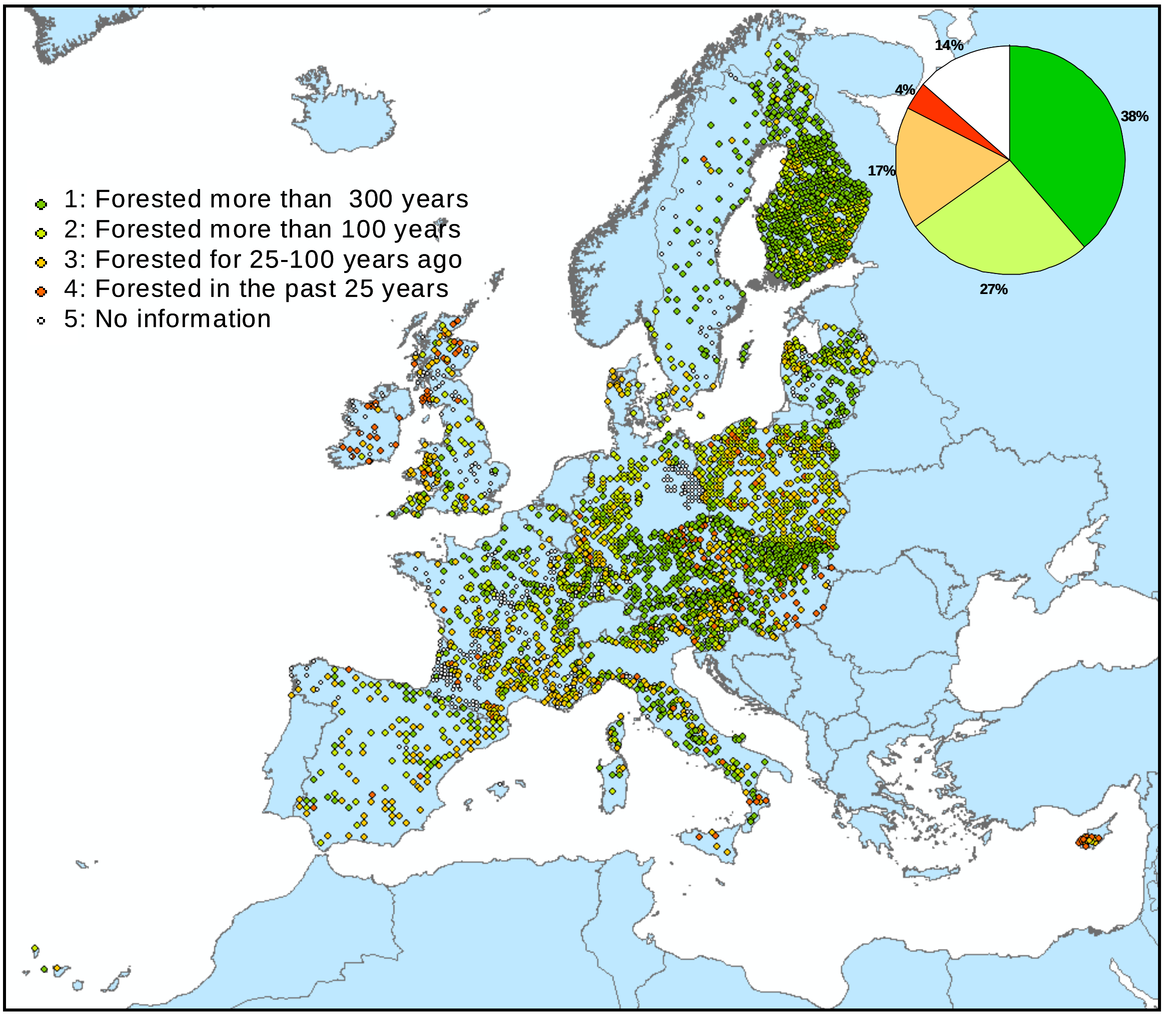


Figure 46: Previous Use of Land

4.9.3 Origin of Stand

Half of all stands are reported to originate from natural regeneration although there are clear country differences (e.g. the majority of plots in UK, Czech Republic and Poland are planted; Table 22).

Table 22: Origin of Stand

ORIGIN	AT	BG	CY	CZ	DK	FI	FR	DE	HU	IE	IT	LV	LT	PL	SK	SI	ES	SE	UK
Mixed	18	1	1	22	1	13	14	124	16		20	8	5	92	43	5	11	3	12
Natural regeneration	87		16	9	7	497	470	44	32		180	49	46	58	43	23	85	49	11
Planted	24	4		101	14	87	58	145	23	35	13	17	11	277	21	8	52	19	97
Seeded	2		2			30	4	3	4		2	5		6		4	4	2	2
Unknown/not reported	5	5		14		3	2	46	3		9	16		5	1	4	3	27	45

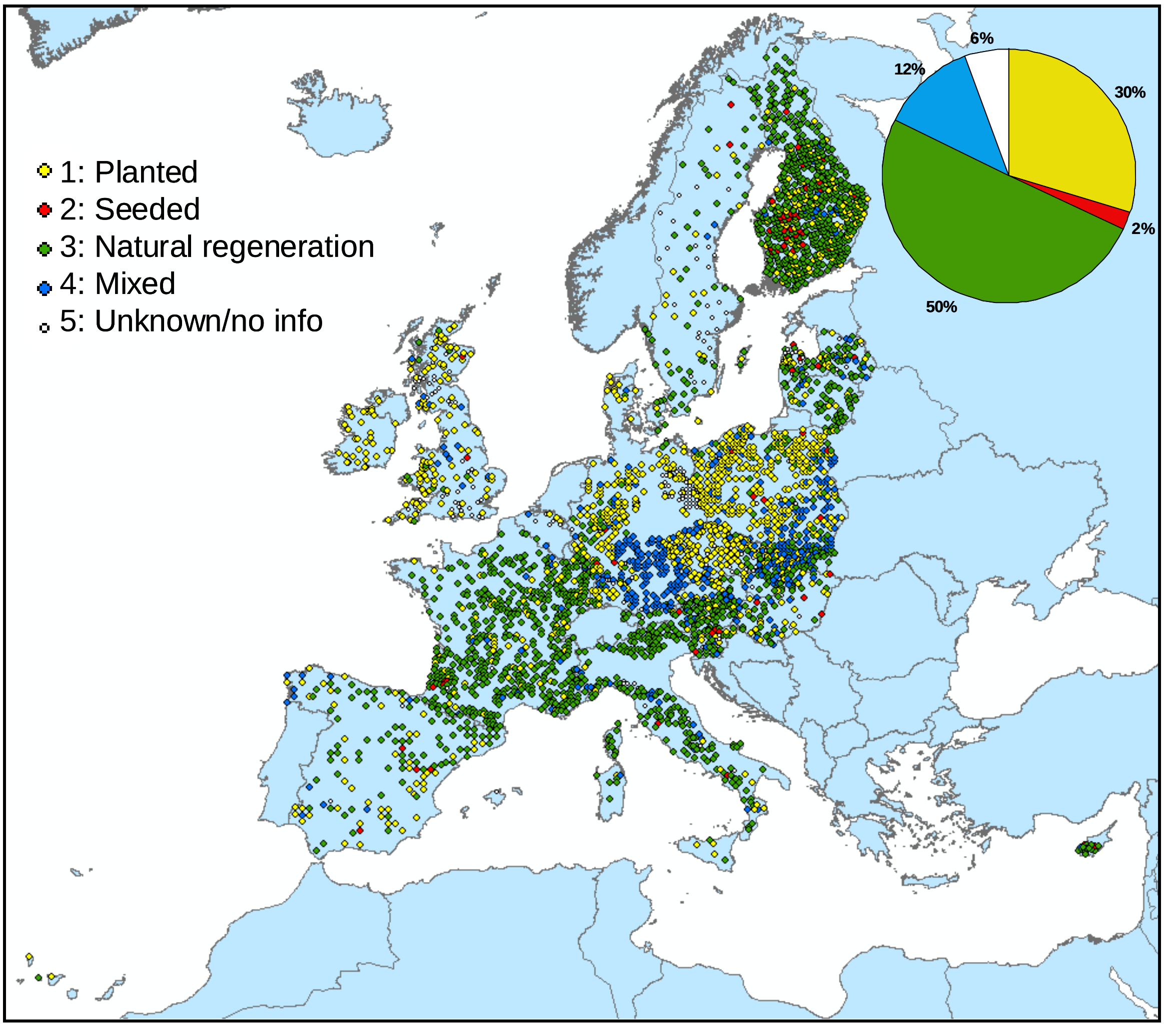


Figure 47: **Origin of Stand**

4.9.4 Forest Management

Two thirds of plots have been managed within the last ten years (Figure 48). The ten percent of plots that show no evidence of management are mostly concentrated in mountainous regions (Alps, Pyrenees, and Apennines).

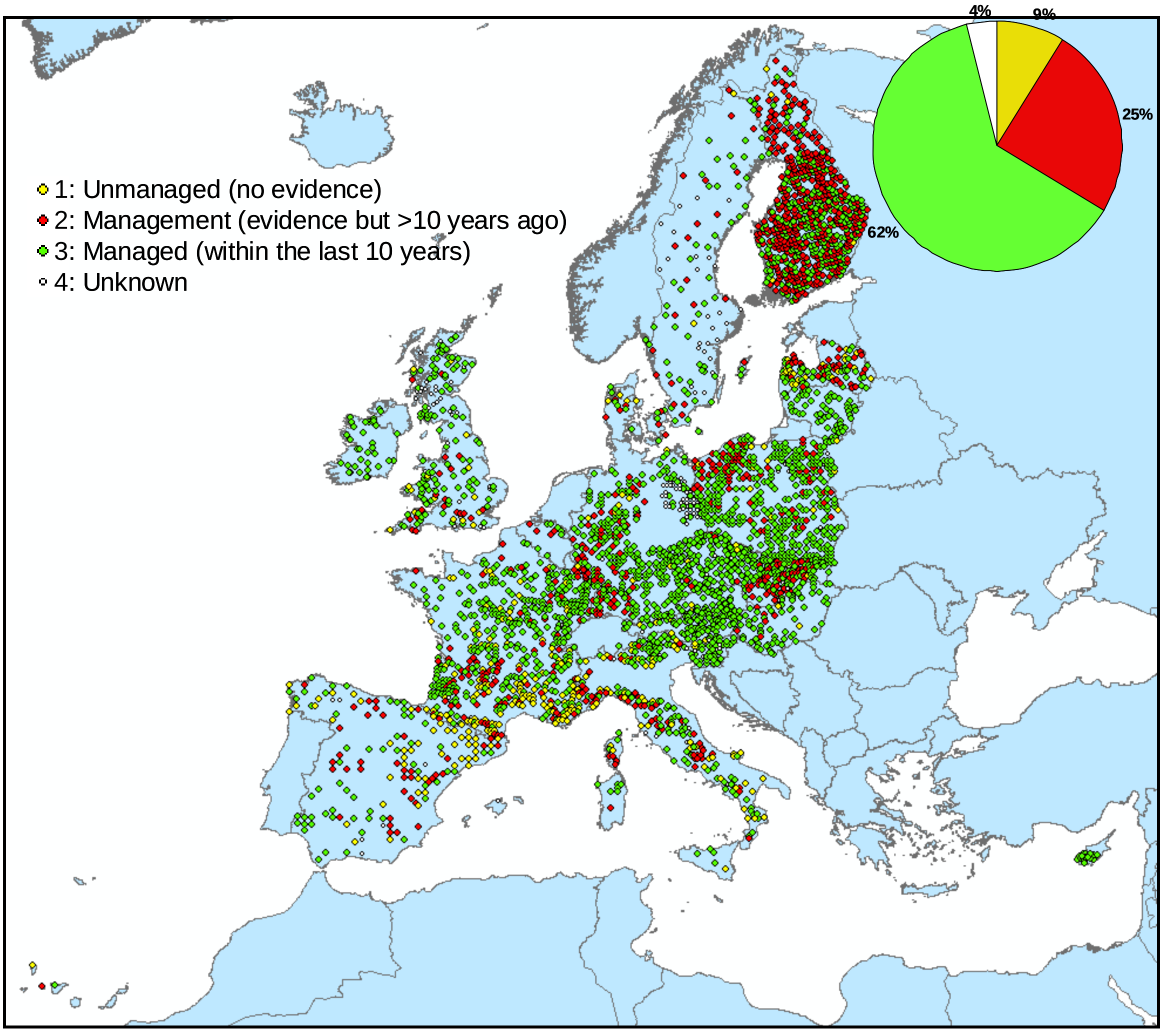


Figure 48: Forest Management

4.9.5 Removal of Coarse Woody Debris

The original 7 point code for deadwood removal was simplified after inspection of the data. The first two codes were amalgamated to one (“stems and main branches removed from the plot”), and the last two were amalgamated to (“presence of accumulation: branches stacked”) resulting in 4 categories plus “unknown” (Table 23).

Table 23: Removal of coarse woody debris

DWREMOVE	AT	BE	CY	CZ	DE	DK	ES	FI	FR	HU	IE	IT	LT	LV	PL	SE	SI	SK	UK
Yes, stems and main branches removed	107	1	8	68	139	13	66	402	67	59	35	31	46	15	301	22	5	71	9
Partly, some stems and main branches removed	2	1	1		186		19	30		1		23	15	23	68		19	29	12
No, stems and main branches are lying in the forest	25	7	10	71	17	2	25	123	240	18		158	1	56	53	1	13	3	116
Accumulation (branches stacked in piles or rows)	1			2	9		8	53	4			11			9		1		4
Unknown/No information	1	1		5	11	7	37	98	237			1		1	7	77	6	5	26

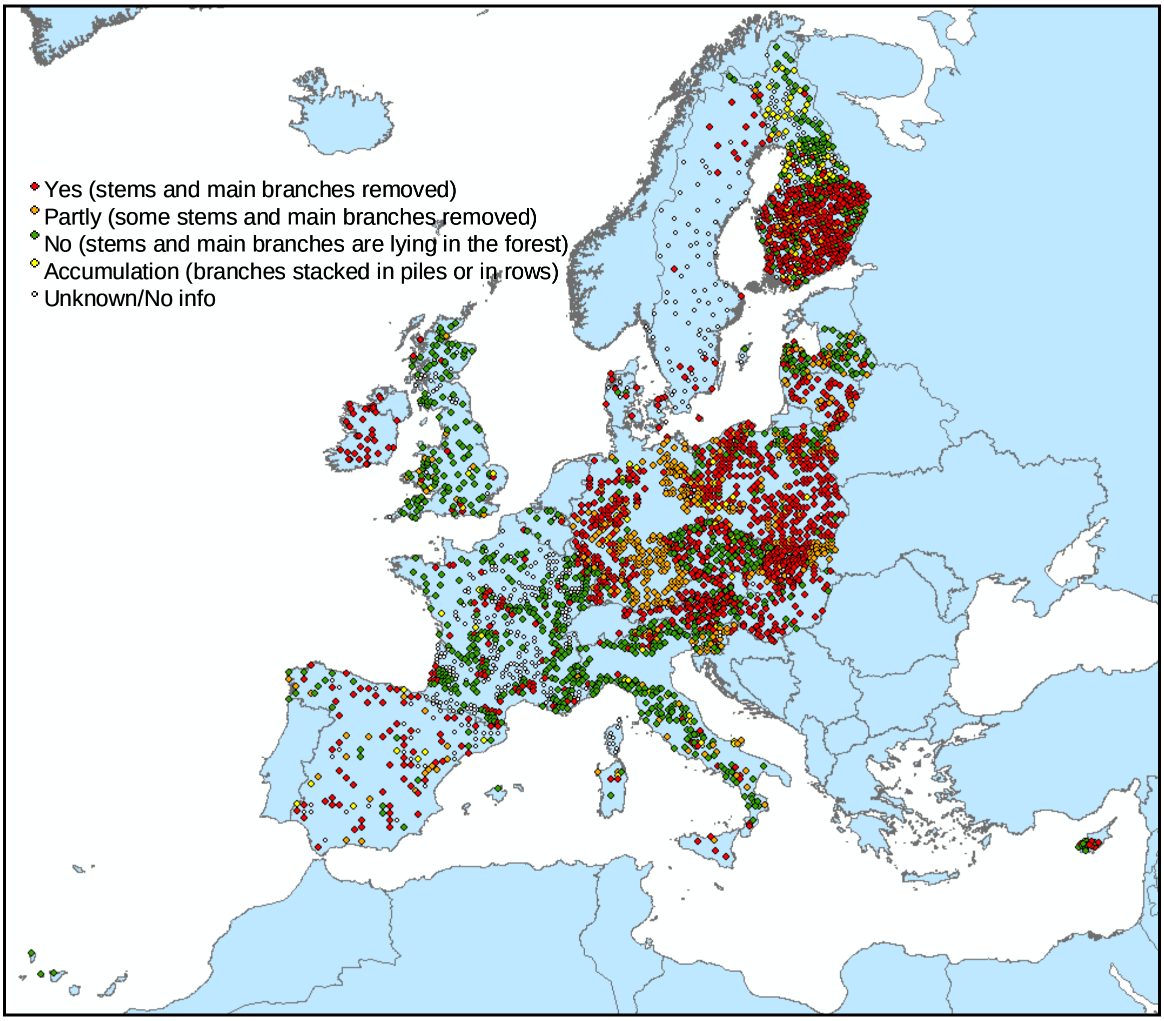


Figure 49: Removal of Coarse Woody Debris

4.9.6 Pattern of Tree Mixture

Nearly half of all plots were reported as being in an intimate tree mixture. 37% were reported as not mixed. However, on analysis of the data submitted in the DBH survey, only 22% of plots were actually found only to contain a single species. The other 15% of "not mixed" plots contained occasional other species.

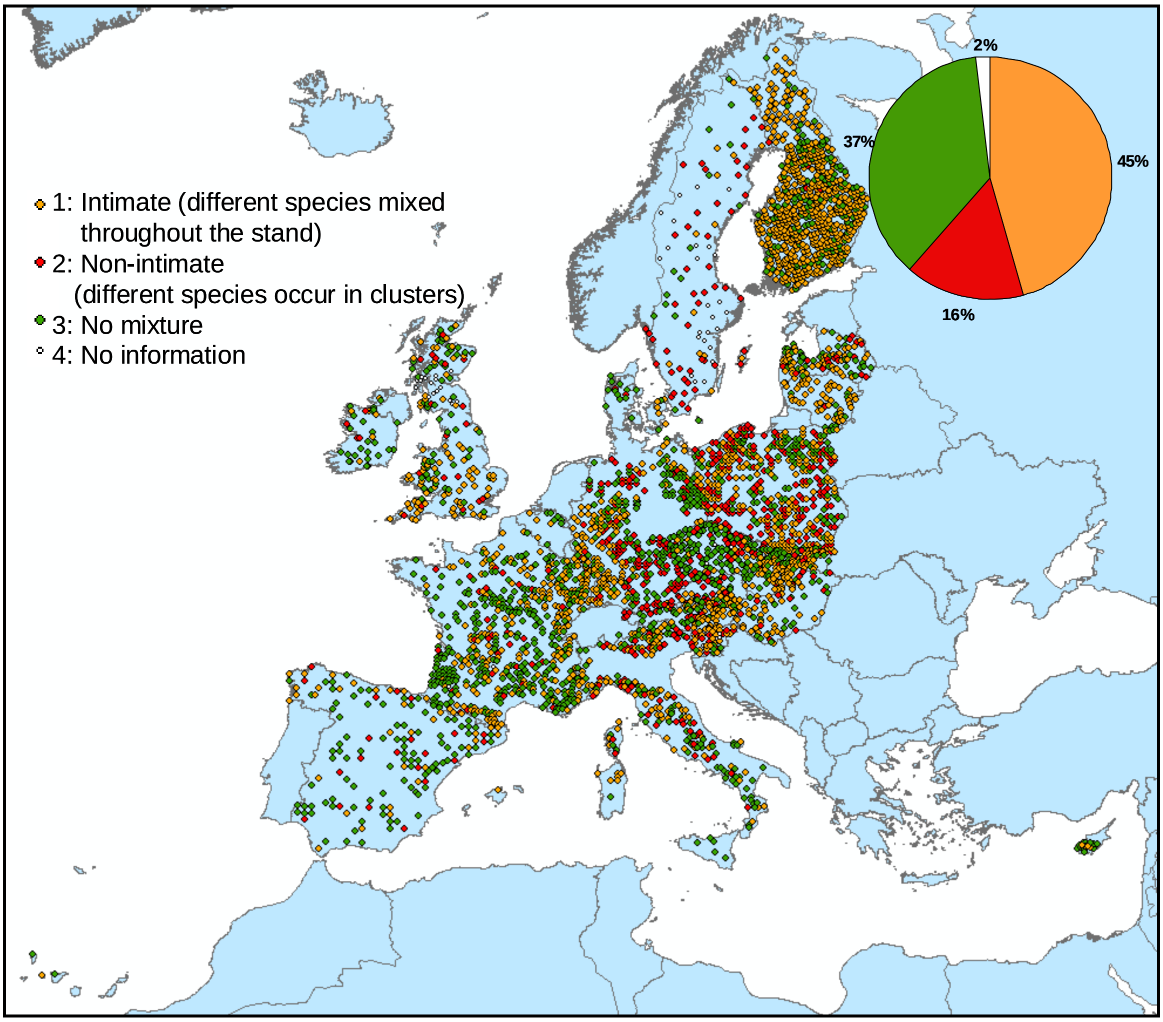


Table 24: Pattern of Tree Mixture

4.9.7 Mean Age of Dominant Storey

The age classes of the plots form a more or less regular distribution with the modal age category reported as 3 (between 41-60 years). France has the highest number of plots in the oldest age category (>120 years). Ireland has the youngest forests, with no plot having a reported age class over 4 (61-80 years).

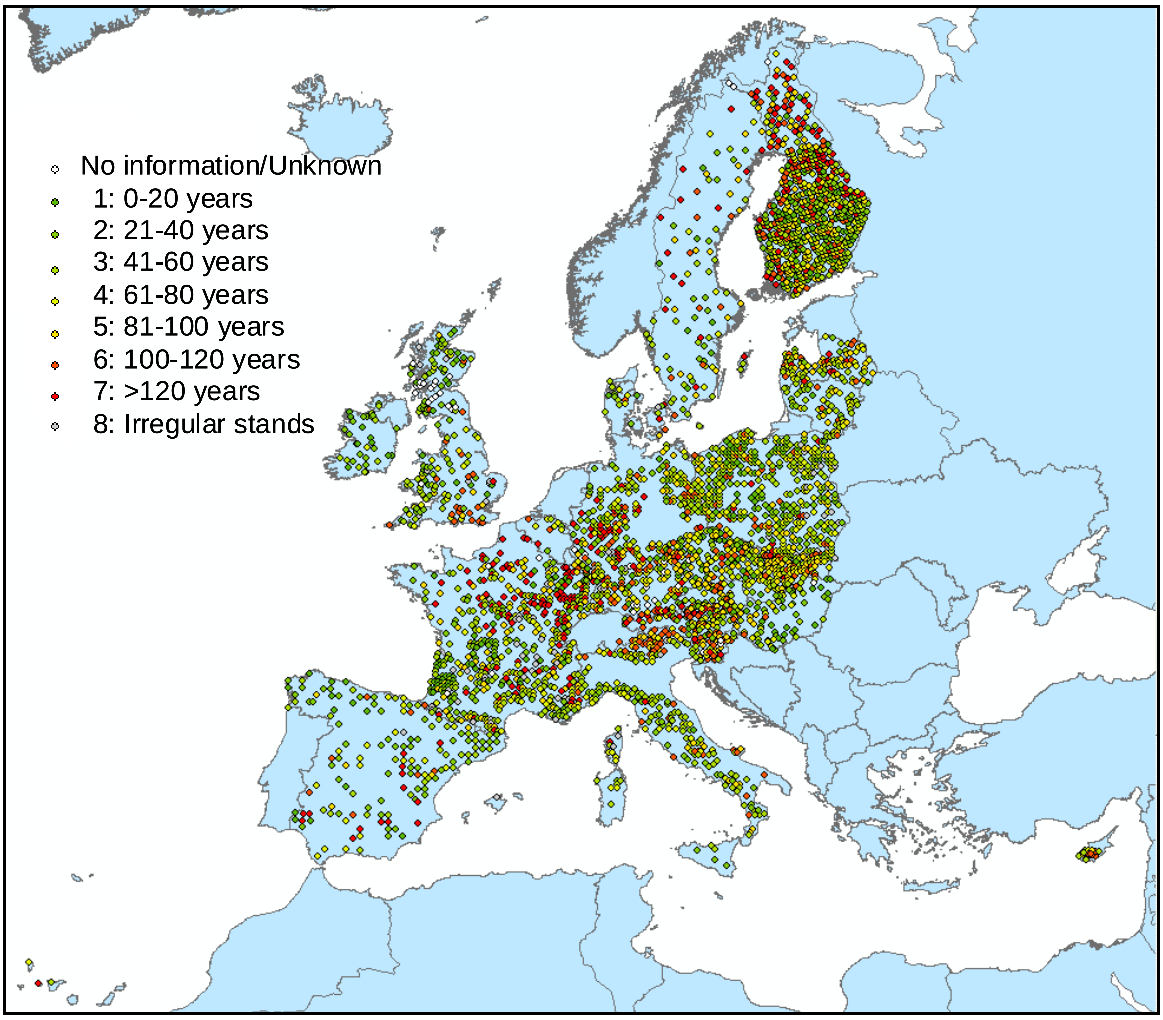


Figure 50: Mean Age of Dominant Storey

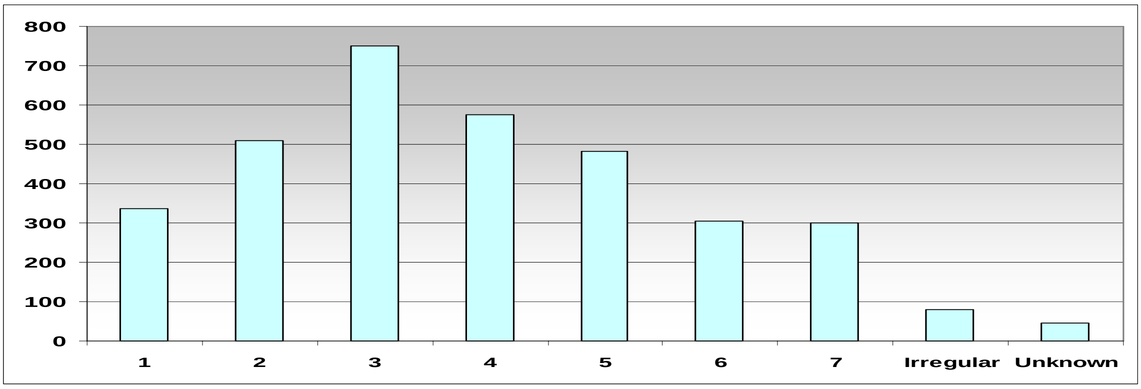


Figure 51: Distribution of Age Classes

4.9.8 Fencing

The vast majority of plots (over 90%) were reported not to be fenced (Figure 52). The UK had the largest proportion of fenced plots with approximately one third fenced. Spain, Italy and France reported more than 10 fenced plots. Several countries (Denmark, Latvia, Lithuania, Slovakia, Slovenia and Sweden) reported no fenced plots in their survey.

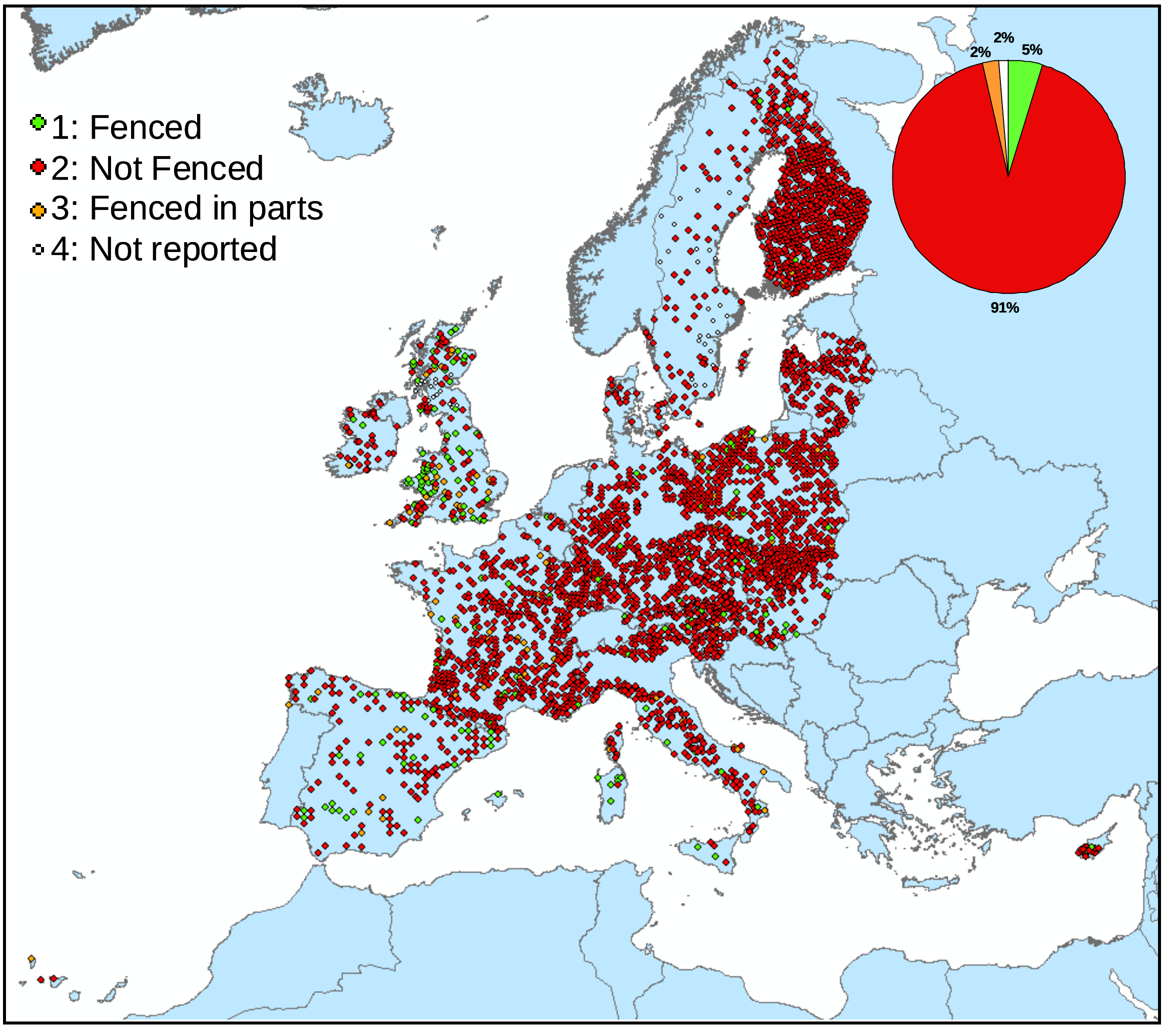


Figure 52: **Fencing**

4.9.9 Type of Forest

More than half of the plots were described as “high forest” of different types. The 20% of plots in the “Other” category were mostly in Finland, which described a large proportion of its plots in this way. The “High Forest: Other” category was used by Germany for nearly 80% of their plots. This implies that, for these two countries, a category that well fits their forests is missing from this code.

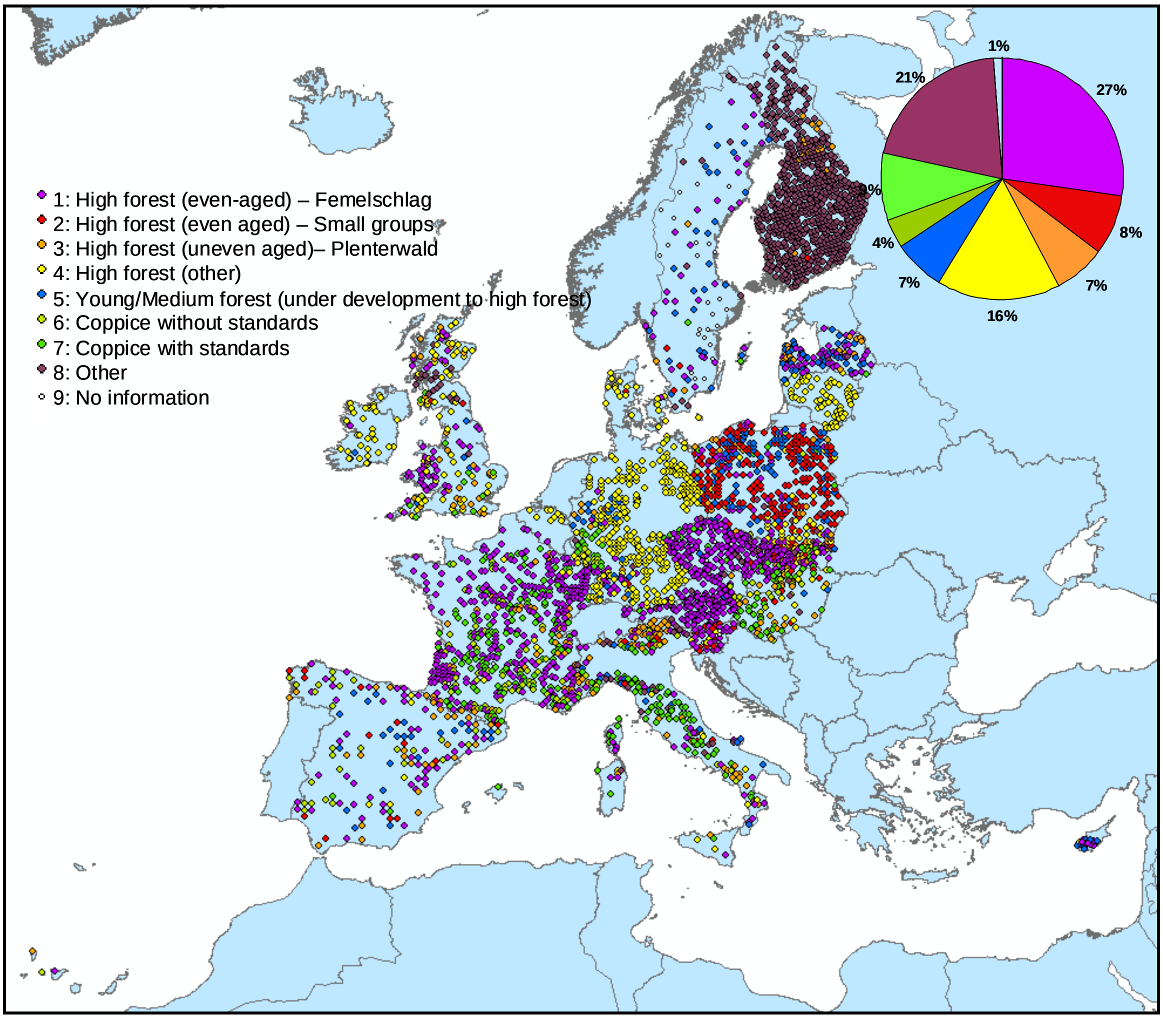


Figure 53: Type of Forest

4.9.10 _European Forest Classification Type

The most prevalent forest type according to the EFTC scores given is class 1: Boreal Forest (18% of plots), followed by Hemiboreal and nemoral Scots Pine forest (12% of plots). Around 12% of plots were not given an EFTC score: 2 countries (UK and Czech Republic) did not report any information and France did not identify around 10% of its plots.

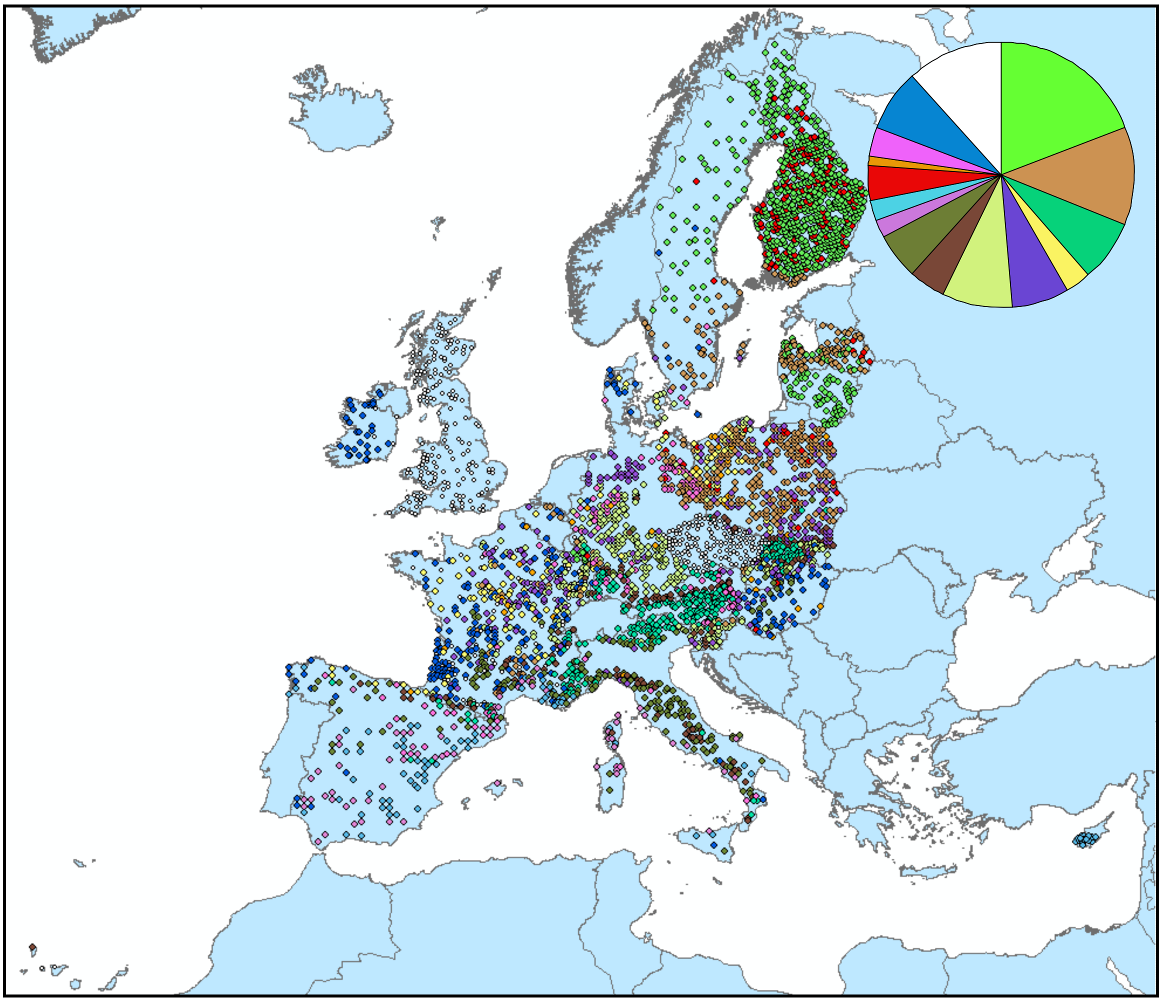


Figure 54: European Forest Classification Type

- Boreal forest
- Hemiboreal & nemoral Scots pine forest
- Alpine coniferous forest
- Atlantic/nemoral oak/ashwoods, dune forest
- Oak-hornbeam forest
- Beech forest
- Montaneous beech forest
- Thermophilous deciduous forest
- Broadleaved evergreen forest
- Conif. forests of Med, Anatolian & Macronesia
- Swamp forest
- Floodplain forest
- Native plantations
- Exotic plantations and woodlands
- No information

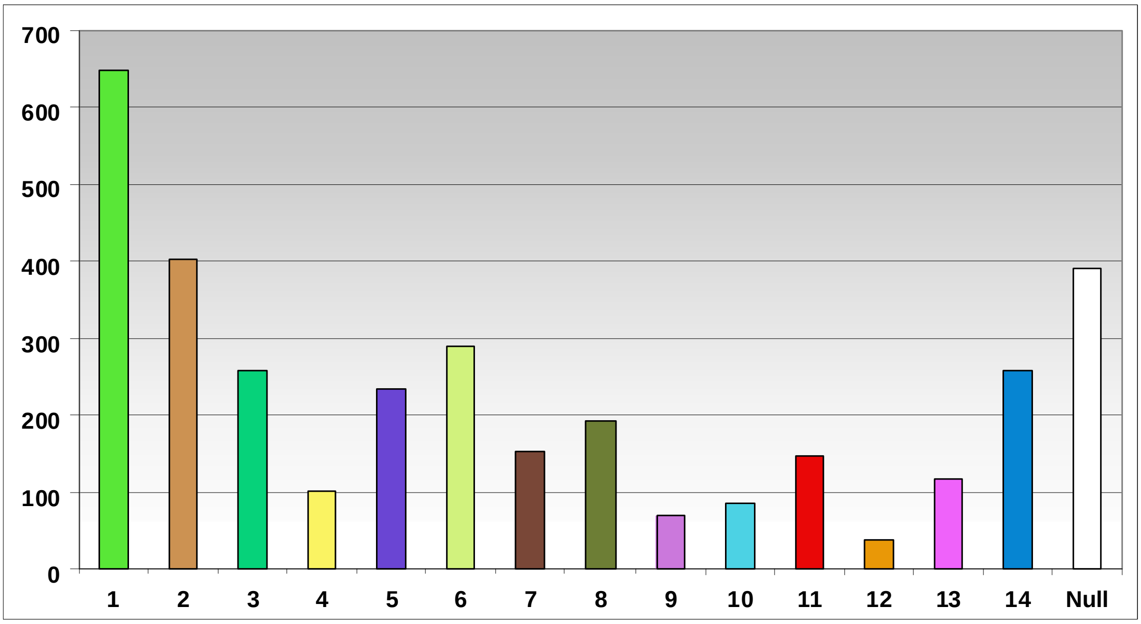


Figure 55: Distribution of EFTC Scores

4.10 Structural Biodiversity

Three of the data files requested from the participants of the project are concerned with the structure of the stand: DBH, THT and CAN.

The tree diameter distribution was used to describe the structure of the forest stand. The diameter at breast height (DBH at 130 cm) and the species of all woody plants were recorded on standing and lying, living and dead, trees taller than 130 cm. DBH measurements were recorded across the entire BioSoil sampling subplots 1, 2, and 3 using different diameter thresholds in each of the three sub-plots (see below).

- Subplot 1: DBH > 0 cm and taller than 130 cm
- Subplot 2: DBH ≥ 10 cm
- Subplot 3: DBH ≥ 50 cm

The status of the tree (living, dead, standing, lying) and its species were also recorded.

Tree top height and height of base of the canopy layer were measured on a minimum of 3 trees with the largest DBH across the entire sampling subplots 1, 2, and 3, regardless of the tree species.

The average number of trees measured per plot and the average number of species found are shown in Figure 56.

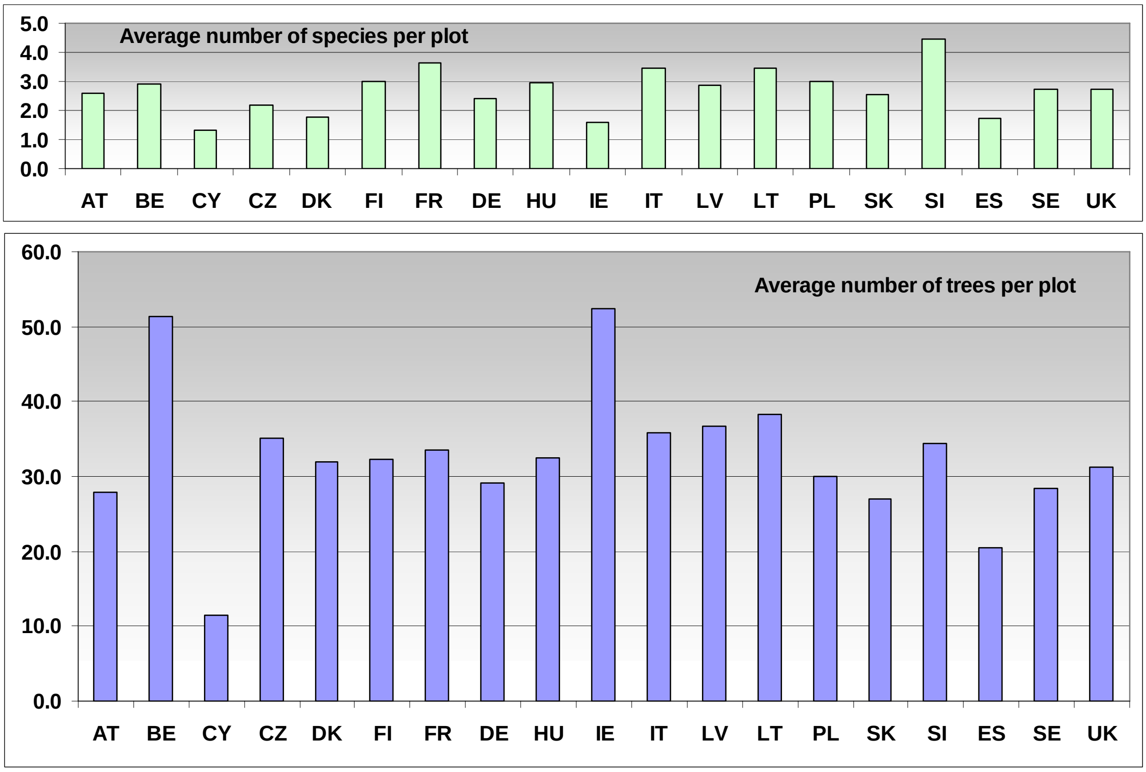


Figure 56: Average Number of Trees and Number of Species per Plot

4.11 Species Richness

One measure of biodiversity is the number of tree species found in a given plot (Figure 57). Approximately half of all plots contained only one or two species (Figure 58). The maximum number of species recorded in a single plot was 13 in one Italian plot.

Species richness was examined with regard to the European Forest Type Classification score (EFTC). Analysis was performed on those plots that had both EFTC and tree species information. There was a significant relationship between richness and EFTC class, with class 5 (Oak/Hornbeam forest) averaging the highest number of species per plot (Table 25, Figure 59).

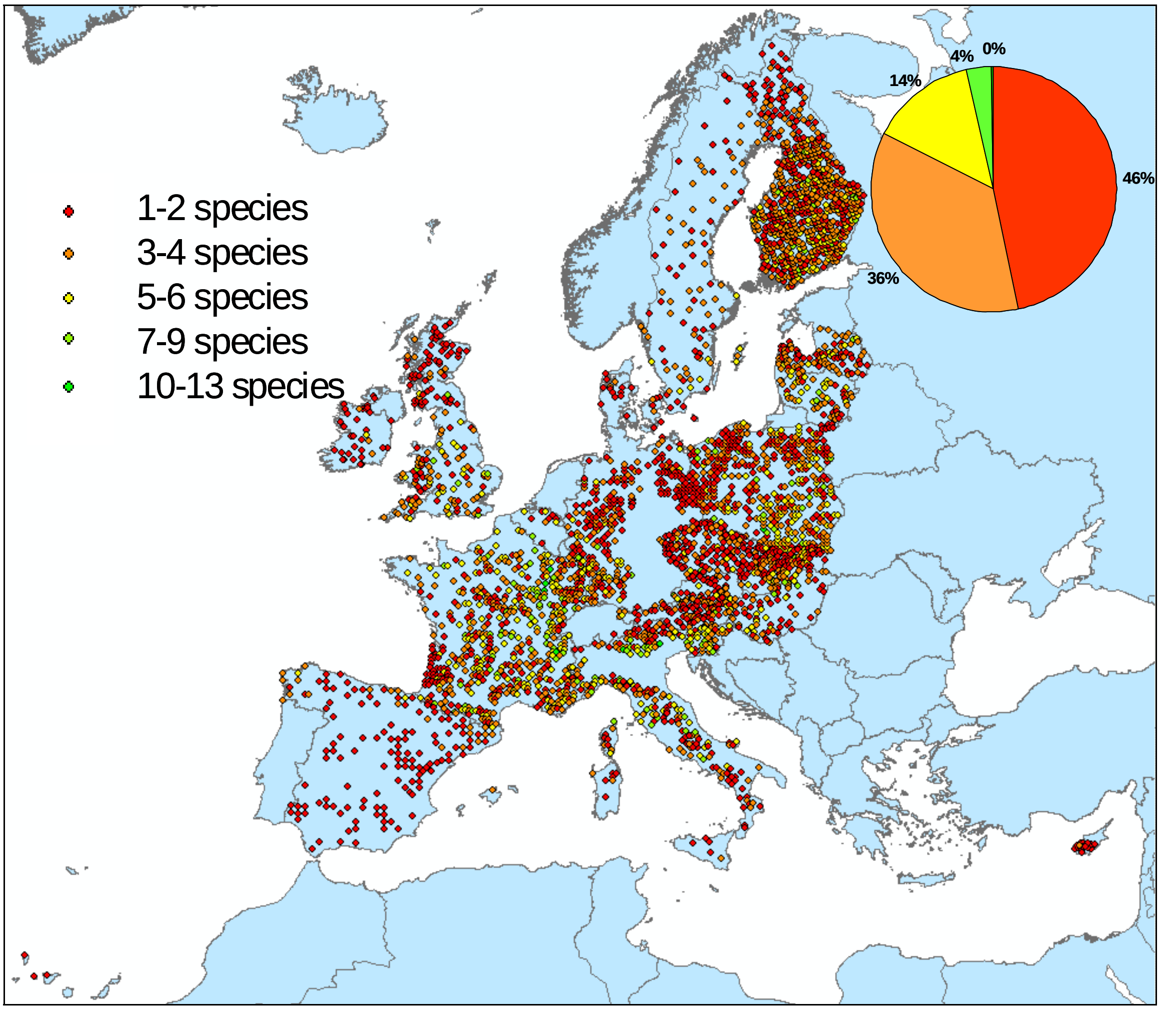


Figure 57: Species Richness

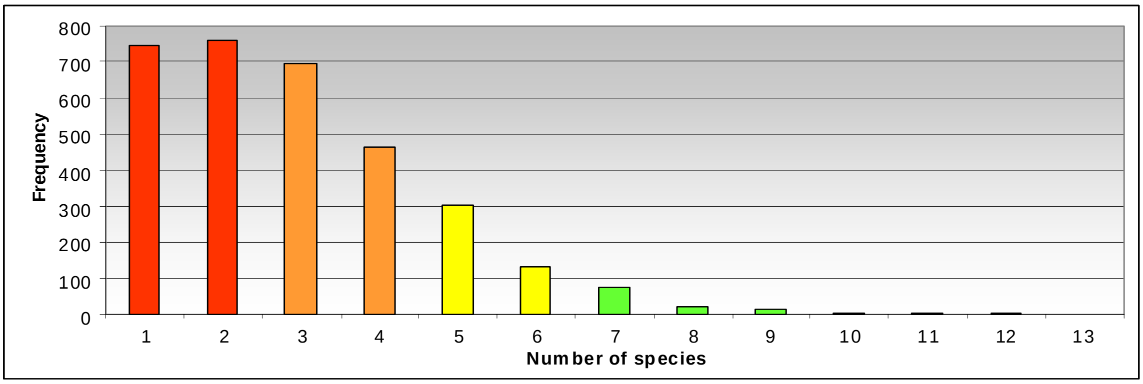


Figure 58: Frequency Distribution of Species Richness

Table 25: Average Number of Species per Plot

EFTC class	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	578	3.08	1.50	0.06	2.96	3.21	1	9
2	364	2.72	1.56	0.08	2.56	2.88	1	10
3	243	2.55	1.43	0.09	2.37	2.73	1	8
4	101	2.94	1.45	0.14	2.65	3.23	1	7
5	212	4.18	2.03	0.14	3.91	4.46	1	11
6	212	3.00	1.76	0.12	2.76	3.23	1	9
7	137	2.81	1.61	0.14	2.54	3.08	1	7
8	162	3.86	2.20	0.17	3.52	4.20	1	13
9	67	2.40	1.73	0.21	1.98	2.83	1	9
10	84	1.81	1.12	0.12	1.57	2.05	1	6
11	143	2.62	1.09	0.09	2.44	2.80	1	6
12	32	3.56	1.79	0.32	2.92	4.21	1	7
13	111	2.60	1.91	0.18	2.24	2.96	1	12
14	218	2.73	1.76	0.12	2.50	2.97	1	9
Total	**2664**	**2.97**	**1.72**	**0.03**	**2.90**	**3.03**	**1**	**13**

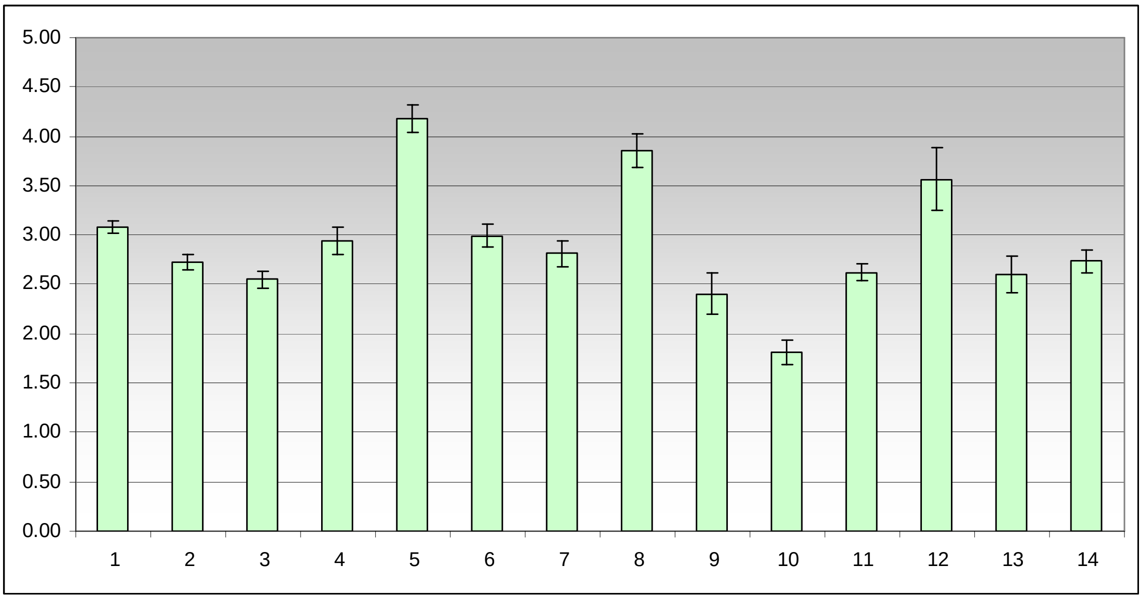


Figure 59: Average Number of Species per Plot according to EFTC Category. Means ±1SE are given.

There are a variety of biodiversity indices in use for further examining the structure of the stand. All have similar, but slightly different functions. One is presented here as an example. The Simpson Index takes into account not only the number of the occurring species but also the abundance of each one. The Index ranges from 0 to 1 and measures the probability that two randomly chosen individuals chosen from a given plot belong to the same species. A plot containing 10 species but in which 90% all belong to a single species thus has a lower score than one with the same total number of species but with equal proportions of each. The score is zero when all species are the same. The formula is given by $D = 1-\sum(n_i(n_i-1)/N(N-1))$ where n_i is the number of individuals of species *i* and N is the total number of species in the plot. Results are shown in Figure 60. Further analysis is ongoing to investigate the links between the index, species richness and other stand variables.

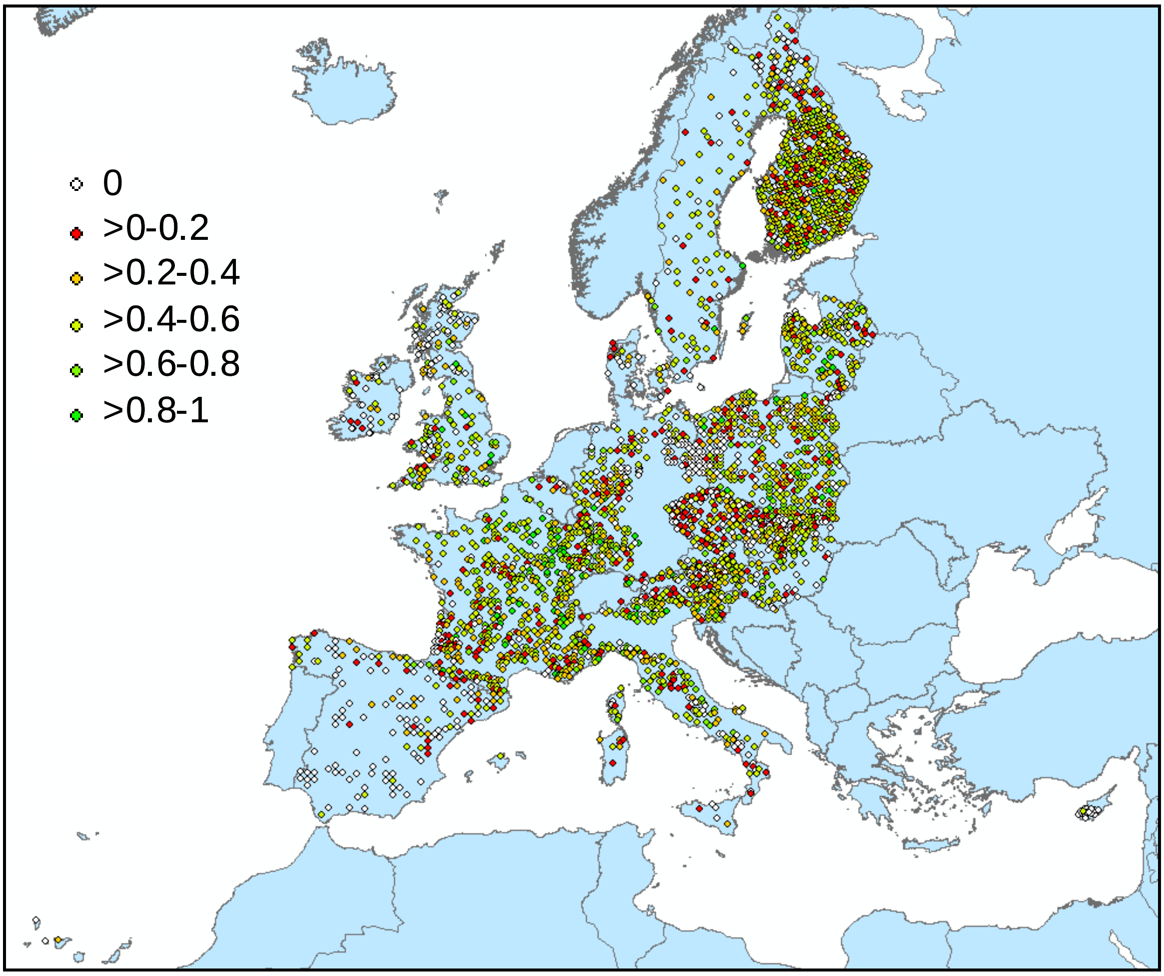


Figure 60: Simpson's Index of Diversity

4.11.1Deadwood

There were significant differences between countries in the amount of deadwood found in the plots.

Table 26: Number of Pieces of Deadwood Recorded per Plot

COUNTRY	No of Plots	Un-known type	Coarse Debris	Fine Debris	Snag	Stump	Other	Total	Average per Plot
Austria	128	0	553	0	1623	0	0	2176	17.0
Belgium	10	0	18	91	4	60	0	173	17.3
Cyprus	17	0	6	107	0	17	35	165	9.7
Czech Republic	142	0	835	91	0	2818	28	3772	26.6
Denmark	6	0	9	0	0	0	0	9	1.5
Finland	630	53	989	0	93	5735	0	6870	10.9
France	504	0	4330	0	175	2143	0	6648	13.2
Germany	251	1	2130	0	221	3119	0	5471	21.8
Hungary	74	0	318	0	31	963	0	1312	17.7
Ireland	35	15	106	0	2	510	0	633	18.1
Italy	179	0	655	2006	112	786	13	3572	20.0
Latvia	95	7	536	0	116	530	0	1189	12.5
Lithuania	58	0	166	0	41	439	0	646	11.1
Poland	436	28	675	0	53	3912	0	4668	10.7
Slovak Republic	104	2	558	11	2	959	5	1537	14.8
Slovenia	40	0	178	44	15	223	0	460	11.5
Spain	152	61	130	208	39	405	0	843	5.5
Sweden	86	0	260	35	67	478	0	840	9.8
United Kingdom	121	0	685	23	177	565	5	1455	12.0
Total	**3068**	**167**	**13137**	**2616**	**2771**	**23662**	**86**	**42439**	**13.8**

Further analysis is required to investigate if there is any link between total amount (volume) of deadwood and/or its class and decay status has any relationship with the other biodiversity indices (e.g. species richness).

4.12 Ground Vegetation

The ground vegetation data were examined in the same way as the tree data. A species richness index was first calculated. Maximum number of species found in a single plot was 111, in Italy. The pattern of species richness accords with that found by the ForestBIOTA study (*Project proposal under Regulation (EC) No 2152/2003 (Forest Focus) for the development of forest biodiversity monitoring (Art 6(2) monitoring test phase*)) (Granke, 2006), with greatest species richness being found in Alpine areas (Figure 61).

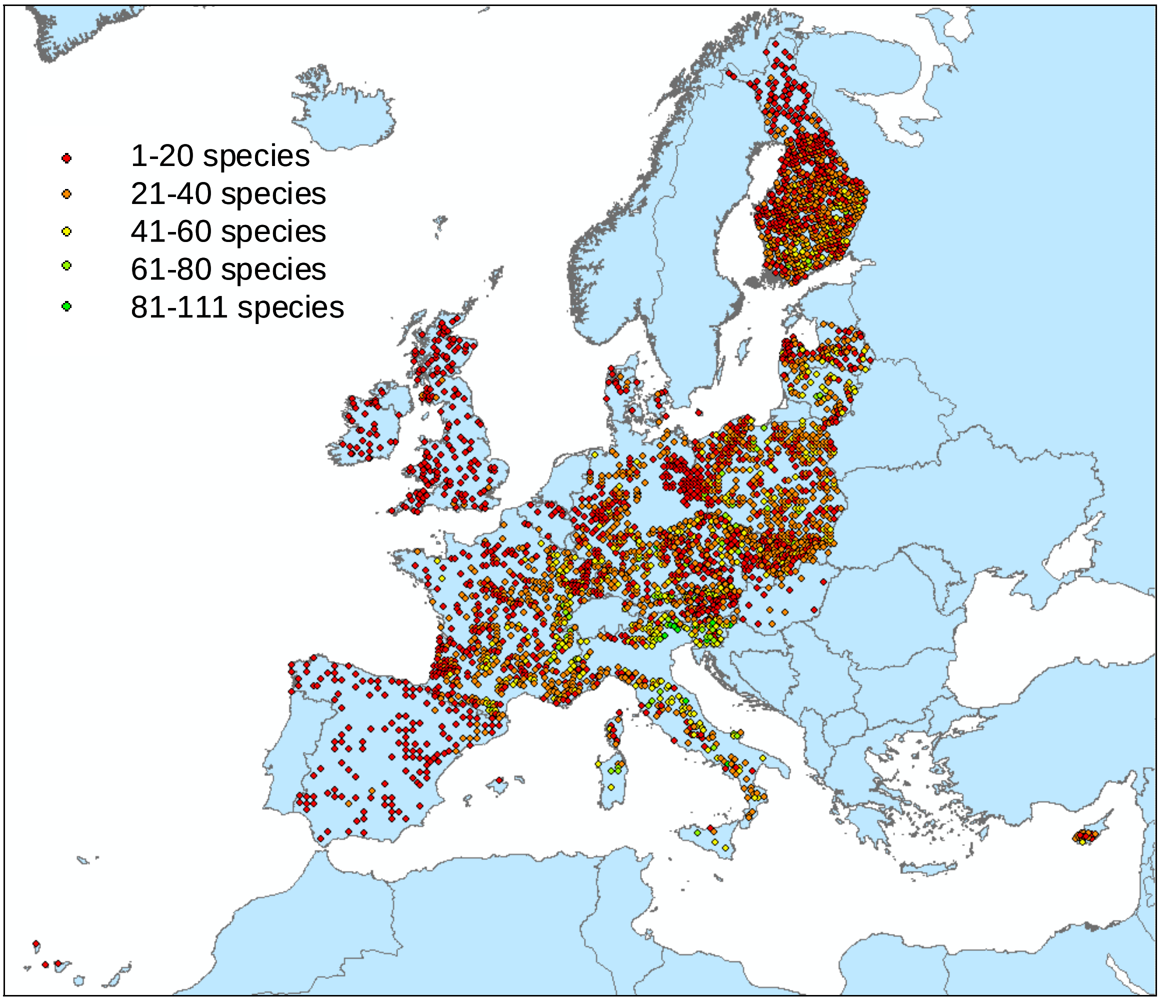


Figure 61: Ground Vegetation Species Richness

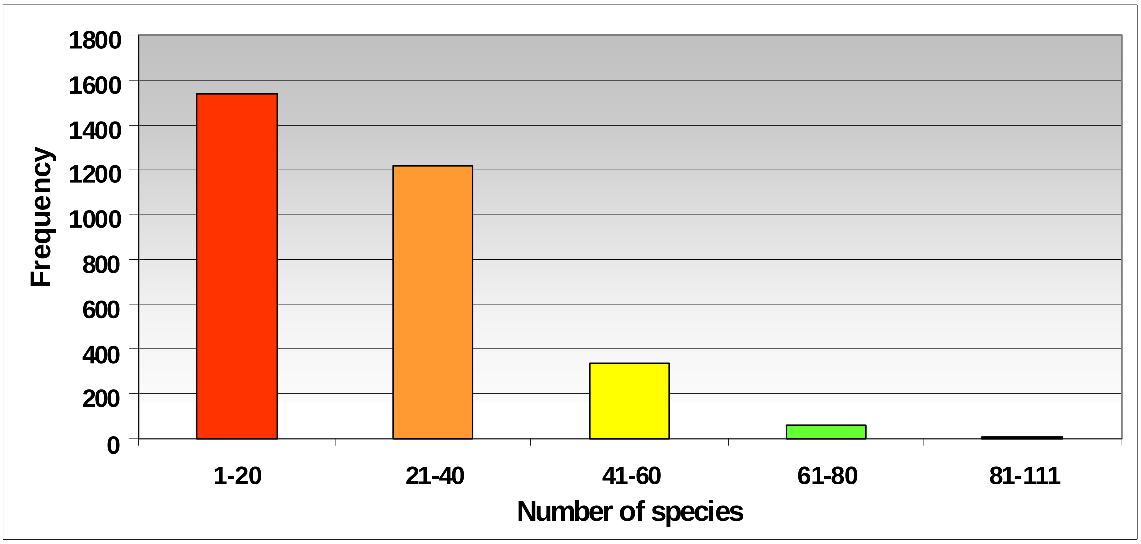


Figure 62: Frequency Distribution of Ground Vegetation Species Richness

The data were also investigated with respect to the EFTC scores. As with the tree species richness data, there was a significant relationship found between the ground vegetation species richness and forest type. Forest type 8 (Thermophilous deciduous forest) had the highest number of species per plot.

Table 27: Average Number of Ground Vegetation Species per Plot

EFTC class	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	578	23.52	12.55	0.52	22.50	24.55	1	77
2	364	23.30	11.85	0.62	22.08	24.52	3	75
3	243	30.48	17.61	1.13	28.26	32.71	3	111
4	101	20.73	9.19	0.91	18.92	22.55	5	47
5	212	29.53	11.93	0.82	27.92	31.15	5	72
6	212	25.22	15.32	1.05	23.15	27.30	2	91
7	137	28.15	17.21	1.47	25.24	31.05	4	99
8	162	33.06	17.51	1.38	30.34	35.77	5	95
9	67	18.99	14.92	1.82	15.35	22.62	3	66
10	84	18.92	11.99	1.31	16.32	21.52	3	63
11	143	23.17	9.96	0.83	21.52	24.81	9	60
12	32	27.72	11.98	2.12	23.40	32.04	11	64
13	111	19.52	12.87	1.22	17.10	21.94	5	54
14	218	18.23	13.04	0.88	16.49	19.97	1	72
Total	**2664**	**24.62**	**14.26**	**0.28**	**24.08**	**25.17**	**1**	**111**

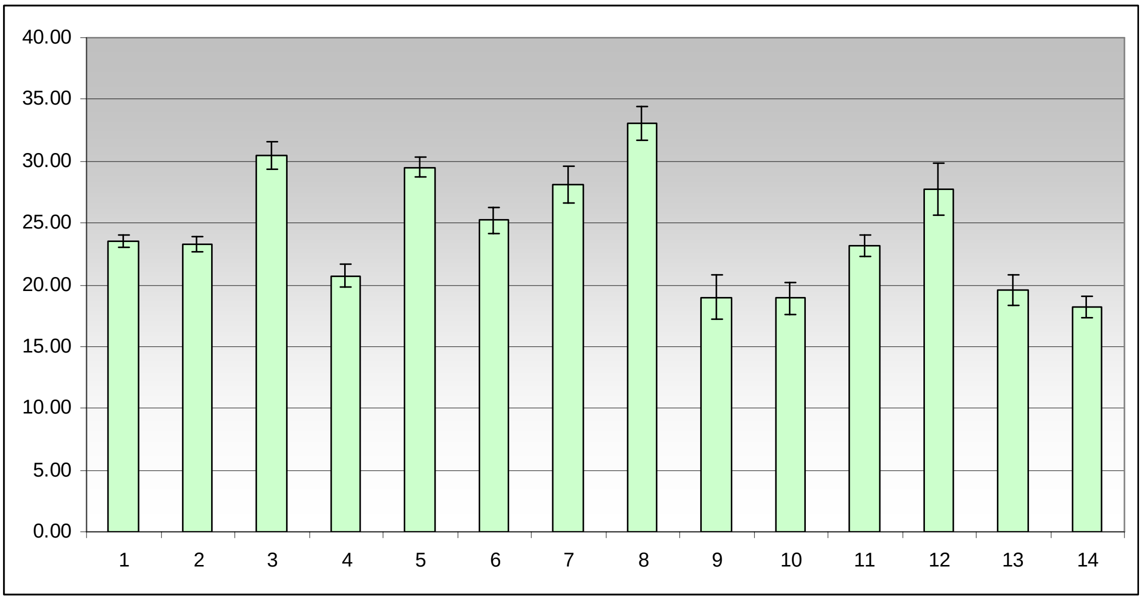


Figure 63: Average Number of Ground Vegetation Species per Plot according to EFTC Category. Means ±1SE are given.

To calculate a diversity index, either individual counts (as for the DBH data) or a percentage cover for each species is required. Percentage cover scores were requested in the Biodiversity data (the COVER variable) but on analysis it was discovered that these were not consistently used between countries (see Table 28). Some countries had omitted them altogether; others had used a conversion from a score (e.g. Braun-Blanquet).

Table 28: Percentage Cover Scores Reported by Country

Country Name	Score Type	Cover scores used in GVG data
France	Class	0,25,50,75,100
Belgium (Flanders)	Class	0,1,2,4,5,8,13,20,30,50,60,90,98
Italy	Percentage	0.01-100 (but some plots conversion from BB score)
United Kingdom	Class	5,10,15,20,50,75
Ireland	-	-none-
Denmark	-	-none-
Spain	Class	5% classes
Sweden	-	-no GVG data-
Austria	-	-none-
Finland	-	-none-
Hungary	-	-none-
Poland	Score conversion	0.1, 1, 2.5, 15, 37.5, 62.5, 87.5
Slovak Republic	Percentage	0.01-100
Lithuania	-	-none-
Czech Republic	Score conversion	0.01, 0.5, 2.5, 10, 20, 37.5, 62.5, 87.5
Slovenia	Score conversion	0.01, 0.5, 2, 4, 8.8, 18.8, 37.5, 62.5, 87.5
Latvia	-	-none-
Cyprus	-	-none-
Canaries (Spain)	Class	2,3,5,then 5% classes
Germany (Baden-Württemberg)	Score conversion?	3,10,20,38,63,88
Germany (Bavaria)	Score conversion?	0.1, 0.5, 2,3,4,10,20,31.75, 43.75, 62.5, 82.5
Germany (Brandenburg-Berlin)	Percentage	0-100
Germany (Hessen)	Class	0.5, 1,2,3,4,5,6,8,10, then 5% classes
Germany (Mecklenburg-Vorpommern)	Percentage	1-100
Germany (Niedersachsen)	Class	1,2,3,4,5,8,10,12,15, then 5% classes
Germany (NRW)	Class	0.0.5, 1,2,3,4,5,6,7,10, then 5% classes (except 1x83, 1x87)
Germany (Rheinland Pfalz)	Class	1,2,3,4,5,8,10,12,15, then 5% classes (except 1x77)
Germany (Saarland)	-	-no GVG data-

Further investigation is required to evaluate whether converting the COVER scores to relative frequencies for each plot can yield meaningful results.

5 Summary and Conclusions

The BioSoil demonstration project was planned in 2004 and implemented from 2006 to 2009. Data were collected in 21 participating countries and managed through 32 National Focal Centres following standard procedures. Over the project period data on soil condition and biodiversity were collected at over 4,500 sites. The data were submitted by NFCs to the JRC at the end of 2008 and validated with corrected data being re-submitted during 2009. The project could thus successfully demonstrate that large-scale monitoring of soil conditions and biodiversity in forests is feasible.

The collection of data and storage in a common structure is one aspect of the objectives of the project. Another is the availability of standardized data that can be readily used for comparative spatial and temporal analysis. In this respect the first general evaluation of the project by the preliminary data analysis gave a more varied picture.

This evaluation used a unified approach processing all data as being part of a single entity and without taking regional variations in sampling into account. The spatial representation of the data showed regional differences in the implementation of the specifications given by the sampling manuals, which depending on the parameter can significantly affect the results of a spatial or temporal analysis of the data. The volume of data to analyse could be increased by processing data by NFC and introducing an additional step for dealing with local data inconsistencies, such as linking BioSoil sites individually to those from the previous soil survey or adjusting soil depths to a common model. These additional steps in processing data result in changes to the values submitted by NFCs and require manual intervention. Such an approach could be considered in the use of the data, but runs contrary to the spirit of evaluating the project data.

The evaluation further confirmed that the success of the 3-phase validation used in BioSoil is closely linked to the procedures of implementing the phases. Therefore, a rigorous procedure for validating the data should be applied.

A summary of the findings and conclusions reached are given separately for each of the two BioSoil modules.

Soil Module

The evaluation of the soil data concentrated on the quality and completeness of the parameters sampled to derive estimates of organic carbon quantities in the organic and soil layers. The data include parameters deemed to be constant over time (volume of coarse fragments) and variable parameters (organic carbon content, organic layer height and bulk density). All parameters were mapped to support identifying differences between plots, but also between NFCs. The parameters evaluated contain both, soil characteristics that vary over time and those that are considered stable. Temporal changes were assessed by comparing the BioSoil / Soil data to data sampled on Forest Focus / ICP Forests Level I plots for sampling in fixed depth. The comparison of the stable soil characteristics allowed an appreciation of changes in methods over time and between NFCs.

The evaluation of the BioSoil data could only be performed on data not yet fully validated. The submission of corrections by NFC may still improve the data quality, but some results obtained from the evaluation are already more than preliminary.

- Positioning and recording the geographic location of the sampling plots after 10 years has been proven to be more problematic than originally anticipated. Linking a sample plot of BioSoil to the corresponding sample plot in the previous survey by a plot identifier is not generally recommended. More promising is the use of a spatial neighbourhood analysis on plot coordinates, but also here systematic variations may not be taken fully into account.
- The verification of the consistency of the constant parameter “volume of coarse fragments” found that changes in the soil material on plots are at least in part dependent on the NFC. While some variation in the values assessed on the plot could be expected as a result of natural variability for some NFCs the changes within plots are comparable but markedly different from those of other NFCs.
- The evaluation of temporal changes in variable parameters was impeded by local methods of separating the organic layer from the soil material. It was found that practices applied varied between NFCs but also between surveys for the same NFC. The data sampled under BioSoil are more detailed than the data available from the previous survey. Very much amiss in the former is information on the height of the organic layer in the previous survey to position the soil material in the profile.
- The spatial variability of the parameters used to calculate OC quantities at NFC level identified significant differences. Some NFCs show low variability for a parameter (OC content) collected under BioSoil and low temporal variability of the parameter. In other NFCs spatial variability between plots is noteworthy, but temporal changes are low (volume of coarse fragments). It is not just high spatial and temporal variability which attracts further investigations. NFC-specific low spatial variability of OC content and bulk density in areas with mineral and organic soils is rather conspicuous.
- The checks implemented to validate the data are wide-ranging, but not complete. Some simple range tests on bulk density and OC content seem to have not been applied as part of the conformity check. Some cross-checks of parameter values, such as the OC content of organic layers or relating bulk density to OC content, are part of the same check and should be implemented for the on-line procedure as are tests on the geographic position of plots within the area of the reporting NFC.

The main recommendation for future soil sampling and monitoring projects resulting from the data evaluation is to focus the range of parameters, to simplify the procedure and to provide coherent specifications. Thus, the number of physical and chemical soil parameters should be revised and possibly reduced. The description of separating the organic layer from the soil material should be improved and the distinction between optional and mandatory parameters removed. These measures alone should improve the quality of the data collected and the reliability of the results obtained from the survey.

Biodiversity Module

The evaluation of the Biodiversity module concentrated initially on exploring and summarising the data in preparation for the more detailed analyses that will follow at a later stage. As a test of practical indicators of forest biodiversity the project was largely successful, although some differences in methodology between countries became apparent during the evaluation, and should be addressed for future similar surveys.

Several of these issues could be addressed by clarifications to the BioSoil Biodiversity Manual, which was produced especially for the BioSoil study as one of the stated objectives of the project. For future similar campaigns the following recommendations should be considered:

- One of the basic requirements is a proper geo-referencing of all sample plots. It should be discussed if, during plot installation, grid plots can be moved slightly away from the grid position, if this would put a grid plot into a more or less representative area with respect to soil or land use.
- The size, shape and use of subplots should be clarified. Not every country used the inner small subplot. One country designated trees into subplots according to their size rather than their spatial position in the plot. Others used different shaped subplots that added up to the same area as the BioSoil subplot. The impact of different sampling designs at sample plots (e.g. use of subplots: size, shape and location) should be investigated to ascertain whether they constrain proper comparisons of results.
- There is currently no agreed written protocol in place for dealing with plots that fall on non-homogeneous land. Some countries recorded in their data when the situation occurred, but with no consistency between countries it is not possible from these data to evaluate the best way of dealing with the situation.
- The C_DWTYPE score caused some confusion. Strictly the only necessary piece of information is whether the deadwood is standing or lying as all the other information (coarse/fine, stump/snag) can be deduced from the measured dimensions. However it was useful as a crosschecking device during data validation. The deadwood type code could therefore be simplified from the present 5 categories (coarse, fine, stump, snag, other) to 2 (lying, standing) if deadwood dimensions are recorded. The more detailed deadwood type score is only necessary in cases where the actual size of the deadwood is not reported.
- The percentage cover assessment for ground vegetation differs in application between countries, making statistical comparisons at EU level difficult. A true percentage score is difficult to achieve, but a common approach (e.g., Braun-Blanquet conversion, 10% classes…) should be agreed for future campaigns.

- Incomplete identification of ground vegetation species (to only genus or family level), and in particular, lack of identification (unknown species) will tend to lead to an underestimate of the total number of species reported.
- Several species were found that are not listed in the current code list. A common approach to coding these species should be adopted, to avoid the same species being given different codes in different countries.
- The specification of integer centimetre values for the diameters of trees proved too crude and DBH measurements for a number of small trees rounded down to zero. The agreed precision to which variables are reported should be checked to ensure that it is sufficient. Rounding down to zero should be avoided wherever possible. The use of zero should be reserved only for cases where the variable is a measured 0 (e.g. number of trees, sample percent).
- Measurements that were not made or where the answer is not known should be indicated with a blank (null value).

The main recommendation for future biodiversity monitoring projects resulting from the evaluation is similar to that found for the Soil survey, which is to clarify and simplify procedures wherever possible. Even apparently simple parameters, such as the number of trees in the plot, and percentage cover of vegetation, were sometimes given a local interpretation (which trees to count, what classes to use for cover), that may affect the comparability of the data at European level.

The BioSoil project has resulted in a considerable amount of data on forest soil conditions and vegetation composition which will take some time to fully analyze and understand. Subsequent to this preliminary data analysis a more wide-ranging evaluation of the final project data including an assessment of the results from the central laboratory is recommended.

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Abstract

The BioSoil demonstration Project was initiated under the Forest Focus-Scheme (Regulation (EC) Nr. 2152/2003) concerning the monitoring of forests and environmental interactions in the Community, and aimed to broaden the scope of previous forest monitoring activities (on atmospheric pollution and forest fires) to the fields of soil characteristics and biodiversity indicators.

The preliminary data analysis concentrated on the evaluation of a selected number of parameters of the data submitted by NFCs and sampling procedures. For soil the parameters needed to establish soil organic carbon densities were analysed. The spatial consistency of data reported between NFCs was found to vary significantly between sources also for assumed constant parameters (volume of coarse fragments). The temporal stability and changes in variable parameters were assessed using data from the previous soil condition survey on Level I sites. A particular problem in sampling and reporting data was the separation of the organic layer from the soil material, which was approached differently by the NFCs. No clear trend in the development of soil organic carbon over the previous survey was found.

The analysis of data on biodiversity concentrated on the consistency and completeness of the parameters reported. Plot characteristics were mapped and species diversity was established based on commonly used indices expressing the richness and distribution of species present on a site. Relationships between forest type and species diversity were explored. Regional differences in identifying and reporting species between sites became evident during the analysis.

The evaluation of both modules concluded that the manuals detailing sampling and analysis of the data collected need to be up-dated with a clear and unambiguous description of procedures to follow and inconsistencies removed.

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