Life PROGNOSES - ACTION A.1.21 Field Mapping and Testing of Indicators

Mapping guideline and field survey protocol for the Assessment of Old-Growth status and Ecosystem Services (Biodiversity & Carbon) in Beech Forests

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Final Version – June 2023

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Introduction

Scientific literature is consistent on the fact that primary and old-growth forests in Europe, although occupying a very limited area, are irreplaceable in harbouring biological diversity, stabilising terrestrial carbon storage, regulating hydrological regimes, enabling ecosystem adaptation to disturbances, and public health benefits. The importance of forest habitats for European biodiversity and their function to remove carbon from the atmosphere, convert CO_2 into biomass and create significant carbon sinks is underlined by the European Biodiversity Strategy 2030. The strategy clearly states the crucial demand to define, map, monitor and strictly protect all the EU's remaining primary and old-growth forests (EU, 2020). This goal was also adopted in the European Forest Strategy (EU, 2021)

Still, there is no European-wide standard to assess the level of naturalness or 'old-growthness' of a forest. Several national and international studies have been published with proposed indicators and protocols (Barredo et al., 2021; Bernier et al., 2017; Buchwald, 2005; Grabherr et al., 1998; Luick et al., 2021; Meyer et al., 2021; Sabatini et al., 2020, 2018; Stein and Walz, 2012; Veen et al., 2010) but no European-wide standard set of broadly acknowledged indicators and thresholds is existent. As the indicators and thresholds have not been fixed, there is no homogenous mapping guideline or map sets of primary or old-growth forests available across Europe.

Within the Life PROGNOSES project, the objective is to develop, test and evaluate a set of indicators of old-growth status, specifically for beech forests. This report describes a standardized field mapping and assessment protocol based on a set of scientifically robust criteria and indicators for characterisation, evaluating, and mapping the old-growth indicators in lowland and mountain beech forests in Europe. The list of criteria and indicators was selected based on an extensive literature study that was also produced within the Life PROGNOSES project (Vandekerkhove et al. 2022).

The mapping and field assessment protocol will be extensively tested during the project Life PROGNOSES in-situ on representative test sites within the World Heritage Beech Forest Network. The components of the World Heritage property cover the full range of beech forest types in Europe and include both primary old-growth and developing (secondary) old-growth forests.

Moreover, the buffer zones of the UNESCO-property contain a wide range of managed beech forests. By applying the same criteria and indicators to selected stands in the managed forests, the full range of old-growth status in beech-dominated forests will be covered. The results of this study will allow us to determine specific standards for old-growth status in beech forests.

These test sites comprise a specifically selected set of component parts and adjacent buffer zones of the World Heritage site 'Ancient and Primeval Beech Forest of the Carpathians and Other Regions of Europe', covering the wide range of managed and unmanaged beech forest types and biogeographical zones.

The following test sites will be assessed:

- Atlantic biogeographic region: **Sonian Forest** (BE),
- Alpine biogeographic region: **NP Kalkalpen** (AT**), Krokar & Snežnik-Zdrocle** (SI), **Central Balkan NP** (BG), **Chornohora in Carpathian Biosphere Reserve** (UA).
- Continental biogeographic region: **NP Hainich and Kellerwald NP** (DE)
- Mediterranean biogeographic region: **Abruzzo NP** (IT)

The field measurements and mapping for WH component parts and its buffer zone will classify forests of different levels of old-growth status.

<u>Delineation of mapping units</u>

The delineation of mapping units will be done in the field using high-resolution areal images and existing map sources (e.g. management plans). Small component parts (including buffer zones) up to 1000 ha will be covered completely, for larger component parts, sections of representative sites covering a gradient from intensively managed forest to old-growth forest will be mapped.

The mapping will focus on beech-dominated forests and will separate different levels of old-growth quality according to the indicators and thresholds developed in action 1.11.

The maps will provide important information on the current state of development of old-growth in the forests in the selected components and buffer zones of the World Heritage site and will provide baseline knowledge for primary forests and for those components that still are in the development process from formerly managed to old-growth forest. The full dataset will cover the full range of levels of old-growthness in beech forests, from young, even-aged, intensively managed stands up to primary forests and this for all relevant biogeographic regions in Europe, and will thus provide a reference of benchmark figures for the different indicators.

The mapping will also serve as an important source of calibration and accuracy evaluation (ground truth) for the remote sensing application in actions 1.23 and 1.24.

<u>Field measurement protocol</u>

Within selected map units, covering a full range of old-growth quality in beech stands, field sampling using a described field protocol (see below) will be performed in order to provide qualitative and quantitative data on selected indicators.

<u>Ecosystem services assessment</u>

In a <u>subset of sites and plots</u>, additional measurements will be performed. This covers measurements related to specific biodiversity features (density and diversity of microhabitats), carbon stock (above- and belowground biomass), microclimatic conditions and recreational values.

For the assessment of microclimate and recreational values, specific protocols and measurements will be developed and performed. These are not included in this document.

In this report, a mapping guideline (to delineate strata and units of evaluation) and field survey protocol are described for standardised field mapping and assessment of the level of old-growth of forest areas, as well as protocols for the assessment of microhabitats and soil carbon.

These criteria and protocols will be available for further application all over Europe in other beech forests after the end of the project and may serve as an inspiration for comparable methods and criteria to be applied to other forest types all over Europe.

Table 1: Overview of the test sites where and the executive organisations by whom the different field assessments will be performed.

Test site		**Structural assessment**	**Executive organization / Ecosystem services**			
Country, Name of the test site	*Biogeographic region*		*Micro-climate*	*Carbon storage**	*Micro-habitats*	*Recreation & Tourism*
BE, Sonian Forest	Atlantic	INBO		INBO	INBO	SOFO
AT, National Park Kalkalpen (NPKA)	Alpine	NPKA		NPKA	NPKA	NPKA
SI, Krokar	Alpine	UL [2)]		UL	UL	
SI, Snežnik-Zdrocle	Alpine	UL		UL	UL	
BG, National Park Central Balkan (NPCB)	Alpine	NPCB			NPCB	
UA, Chornohora in Carpathian Biosphere Reserve (CBR)	Alpine	CBR			CBR	CBR
DE, NP Hainich	Continental	NW-FVA [4]	UNIE [3)]	NW-FVA	NW_FVA	
DE, NP Kellerwald	Continental	NW-FVA	UNIE	NW-FVA	NW_FVA	
DE, Grumsin	Continental		UNIE			
DE, Jasmund NP	Continental		UNIE			
DE, Müritz NP (Serrahn)	Continental		UNIE			
IT, Abruzzo, Lazio and Molise National Park (NPAB)	Mediterranean	UNITUS [5]		UNITUS[)]	UNITUS	NPAB

[1)] BE, INBO Research Institute for Nature and Forest (INBO); [2)]SI, University of Ljubljana, Biotechnical Faculty (UL); [3)] DE, Eberswalde University for Sustainable Development (UNIE); [4)] DE, Northwest German Forest Research Institute (NW-FVA); [5)] IT, University of Tuscia (UNITUS);

* in all mentioned sites, aboveground carbon will be assessed; belowground carbon will be sampled in BE, DE, AT and IT

Expected results

Digital maps with high-resolution assessments of different forest types and different states of old-growth are available for 9 test sites in 4 biogeographic regions. Quantitative and qualitative data on specific stand structures and features will be available, based on field sampling data, for a selection of stands and sites covering the full range of beech forest types and levels of old-growth quality.

1. Old-growth: definition and assessment

The European Commission is looking forward to having a European dataset showing the remaining old-growth forests. This requires a common understanding of a definition of 'primary' and 'old-growth', and transparent mapping based on indicators and local thresholds. Remote sensing approaches may help to pinpoint or pre-select potential sites. The PROGNOSES partners assisted in the formulation of a definition and will provide input to the further process.

The current definition of old-growth forest according to the DG-Environment Working Group on Forest and Nature, and adopted by the Commission is given below (SWD(2023)62 final – published 20.3.2023):

'Old-growth forest: "A forest stand or area consisting of native tree species that have developed, predominantly through natural processes, structures and dynamics normally associated with late-seral developmental phases in primary or undisturbed forests of the same type. Signs of former human activities may be visible, but they are gradually disappearing or too limited to significantly disturb natural processes'.

Explanatory notes:

1. *This definition includes forest stands that originate not only from natural regeneration, but also from planted or sown native tree species (provided that the meet the rest of the definition).*
2. *This definition includes forest stands where indigenous peoples engage in traditional forest stewardship activities that otherwise meet the definition.*
3. *This definition includes forest stands with visible signs of abiotic damages (e.g. storms, snow, droughts and fires) and biotic damages (e.g. from insects and diseases) that meet the definition.*
4. *Forests with visible signs of past human activity are not excluded from the definition of old-growth forests, unless the magnitude of the impact of the activity is such as to prevent the forest stand from counting as old-growth.*
5. *Old-growth forest stands do not include forest for which there is evidence that they are under active productive management . This includes low-intensity sylvicultural regimens and coppicing*
6. *Some key characteristics of old-growth forest stands are:*
    - *They contain structural features and dynamics such as natural regeneration, gap dynamics, large and diverse dead wood, structural complexity, and the presence of old trees, and trees reaching senescent stage and tree-related microhabitats*
    - *They have acquired these structural features and dynamics through several decades of natural development without human intervention.*

An extensive literature study on the definition and criteria of old-growth (in Action A1.11 of PROGNOSES) concludes that old-growth status of a forest is not a binary approach: it involves different (structural) features, that may have a progressive scale of presence and density. Moreover, they don't simply add up to decide whether a stand or site is old-growth or not (Vandekerkhove et al. 2022). Forests will therefore represent different 'levels of old-growthness'.

So, in order to evaluate the level of old-growthness of a forest area or stand, a wide set of indicators must be assessed and scored. For this assessment, a full range of reference values is needed as benchmarks for the scoring, covering the widest available range of levels of old-growthness. The EU definition is of generic format and can be generally applied across Europe. The selection of the appropriate reference values and benchmarks to measure the degree of old-growthness for different forest types and growth conditions will be a challenge. We expect that different forest types will have different value ranges, benchmarks, criteria and characteristics, so a unified approach might not work for all forests in Europe.

The PROGNOSES project aims to provide a first set of benchmark values, specifically for beech forests, based on the results of nine well-selected test sites that cover this wide range of levels of old-growthness in four different biogeographic zones of Europe.

1.1. Assessing the level of old-growthness in beech forests

Within the Life PROGNOSES Project, we will focus on pure and mixed beech forests and we want to deliver specific criteria sets and benchmarks to assess and fingerprint different levels of old-growthness in beech forest ecosystems. These field data will also be confronted with remote sensing data and used as ground truth data to assess the possibilities for old-growth mapping through remote sensing.

To calibrate remote sensing approaches, empirically proofed reference data from the field with very detailed descriptive information is needed to understand the forest structure and features of the inside of the forest, the human impact and tree species composition, while remote sensing only can classify the structure and spectral composition of the crown.

The output of this action consists of at least nine digital maps of managed and old-growth forests of the component parts (core areas) and managed buffer zones (or neighbouring managed forest), delineating different forest types and stands with diverging levels of old-growth qualities.

Within (a selection of) these polygons often of several hectares, we need to collect quantitative data using statistically sound sampling designs (stratified random or systematic sampling)

This document will give a general guideline of the process and is divided into the different phases of the action (see Figure 1):

- Selection of the mapping area
- Delineation of homogenous forest patches/stands (pre-classification)
- Set up of the sampling design
- Collection of field data on sampling plots (including structural parameters and in a selection of sites also tree-cores, microhabitat inventory and soil samples)
- Final assessment of old-growth indicators of each polygon

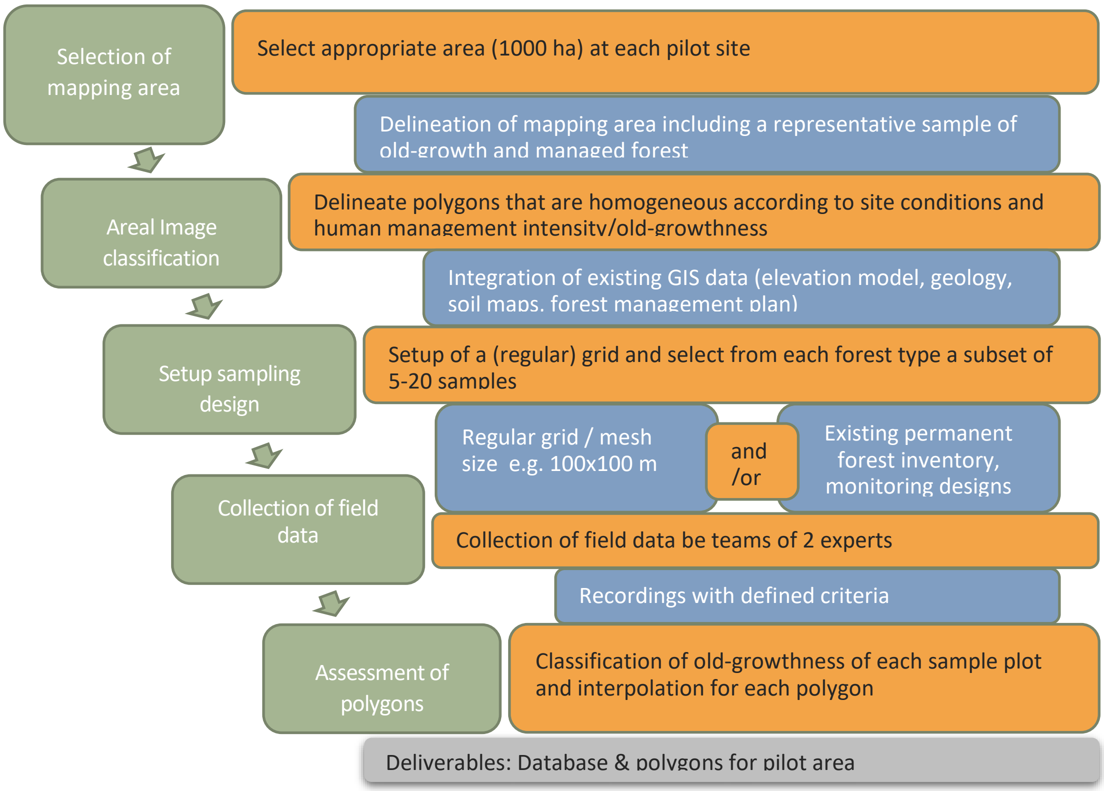


Figure 1: Workflow for the mapping and field sampling approach.

2. Selection of the mapping area

Within the set of pilot sites, we are facing component parts, buffer zones and clusters of different sizes and site configurations.

In

Table 2 a list of the relevant component parts and their buffer zone are shown. **Our target is to map around 1000 ha at each of the nine sites**. In Krokar, which is significantly smaller, a mapping area of 250-500 ha might be sufficient.

In this first phase, the outer boundary of the mapping area should be delineated on a map. It is important that the mapping area includes old-growth forests as well as managed forests (at least forests, that have been managed up to recent years. If the full range from intensively managed to unmanaged old-growth cannot be found in the same area, the mapping area might be split into 2 (max 3) separated polygons.

Besides the important criteria to include a wide range of old-growthness levels in beech forests in the mapping area, other criteria like accessibility, availability of existing data or other ongoing projects could be used to delineate the area. The selection of the mapping area should be finished by October 2021 to be able to prepare the next steps in time before the field mapping starts in May 2022.

It is recommended to prepare a working map of the wider area and organise a workshop with the site managers to delineate the proposed area on the draft map. The mapping area should be stored in a geographic information system (shape file,) and delivered in WGS84 to the lead of the work package (INBO) and the coordinator of this action (E.C.O.).

Table 2: Size of component parts and buffer zones of WH-sites for field mapping in Action 1.21

CLUSTER ID	Name of component part	Property	Buffer Zone
	Kalkalpen - Hintergebirge	*2 946 ha*	*12 238 ha*
	Kalkalpen - Bodinggraben	*891 ha*	
	Kalkalpen - Urlach	*265 ha*	
	Kalkalpen - Wilder Graben	*1 150 ha*	
AT01	**Total NP Kalkalpen**	**5 252 ha**	**12 238 ha**
	Sonian Forest - Forest Reserve 'Joseph Zwaenepoel'	*187 ha*	*4 651 ha*
	Sonian Forest - Grippensdelle A	*24 ha*	
	Sonian Forest - Grippensdelle B	*37 ha*	
	Sonian Forest -Réserve forestière du Ticton A	*14 ha*	
	Sonian Forest -Réserve forestière du Ticton B	*7 ha*	
BE01	**Total Sonian Forest**	**269 ha**	**4 651 ha**
	Central Balkan - Boatin Reserve	*1 227 ha*	*851 ha*
	Central Balkan - Tsarichina Reserve	*1 486 ha*	*1 946 ha*
	Central Balkan - Kozya stena Reserve	*644 ha*	*290 ha*
	Central Balkan - Steneto Reserve	*2 466 ha*	*1 762 ha*
	Central Balkan - Stara reka Reserve	*591 ha*	*1 480 ha*
	Central Balkan - Dzhendema Reserve	*1 774 ha*	*2 577 ha*
	Central Balkan - Severen Dzhendem Reserve	*926 ha*	*1 067 ha*
	Central Balkan - Peeshti skali Reserve	*1 049 ha*	*968 ha*
	Central Balkan - Sokolna Reserve	*825 ha*	*781 ha*
BG02	**Total Central Balkan National Park**	**10989 ha**	**11 721 ha**
DE04	**Hainich National Park**	**1 573 ha**	**4 088 ha**
DE05	**Kellerwald National Park**	**1 467 ha**	**4 273 ha**
	Abruzzo, Lazio & Molise - Valle Cervara	*120 ha*	*752 ha*
	Abruzzo, Lazio & Molise - Selva Moricento	*193 ha*	
	Abruzzo, Lazio & Molise - Coppo del Morto	*105 ha*	*416 ha*
	Abruzzo, Lazio & Molise - Coppo del Principe	*194 ha*	*447 ha*
	Abruzzo, Lazio & Molise - Val Fondillo	*325 ha*	*701 ha*
IT16	**Total Abruzzo, Lazio & Molise National Park**	**1 849 ha**	**11 632 ha**
SI03	**Snežnik-Ždrocle Forest Reserve**	**720 ha**	**129 ha**
SI05	**Krokar Forest Reserve**	**75 ha**	**48 ha**
UA14	**Carpathian Biosphere Reserve Chornohora**	**2 477 ha**	**12 925 ha**

3. Delineation of homogeneous forest stands ('field units')

In order to be able to assess the different stages of old-growthness in lowland or mountain beech forests in all 9 test sites, a uniform method for the delineation of units and field sampling for the assessment of relevant indicators will be implemented.

For a representative selection of sampling plots within the sampling units, a stratified selection procedure will be applied. The stratification divides the whole forest area into sub-areas (strata), which represent homogeneous areas with respect to the stratification factors. The factors relevant for the classification are the tree species composition, the silvicultural management type, the age class, the estimated potential natural beech forest type (pure beech, mixed oak/hornbeam-beech, or spruce-fire-beech forest) based on the main climatic situation as well as elevation, inclination, and geology/soil.

When forest management plans or habitat maps are available, this is a good base layer to start with.

In the first step, forest stands are assigned to specific strata, delineated based on the areal image, each of which is homogenous according to the following five characteristics:

- Dominance of beech
- main admixed tree species
- management type
- age class (if managed forest)
- Upper canopy cover

Different development stages within these natural forest areas do not need to be separated into different polygons: they are in one polygon but will be covered by the sampling plot design (see Chapter 5).

The assignment for every criterium should be stored in a separate column of the shape file. To have a comparable dataset, we propose the following classes for each characteristic :

Dominance of beech

- pure (>95% of the canopy share)
- >2/3
- 1/3-2/3
- <1/3

The areas with <1/3 of beech in the canopy are to be excluded from the sampling plot design: they are out of scope for our study

Main admixed/tree species

- spruce/fir
- pine
- oak/hornbeam
- acer/ash

Dominant management type

- unmanaged
- single tree selection, selective cutting, group-felling
- Even-aged or two-aged (the result of shelterwood or clear cuts)
- Coppice wood (with or without standards)

Age class

- Even-aged – young: clear cut/regeneration stage (< 10 y.)
- Even-aged - young growth / dense stands up to pole wood (appr. 10 – 30 y.)
- Even-aged young timber (30 up to 60 y.)
- Even-aged mature stand (60-150 y)
- Even-aged old-mature stand (>150 y)
- Uneven-aged mixed-age classes/natural age structure
- Two-aged (from shelterwood or coppice-with-standards)
- (add if missing)

Upper canopy cover

- dense/closed Crowns fill the crown space: >90% cover
- spacious Crowns don't touch but are evenly distributed (2/3-90% cover)
- irregular Gaps in the canopy with a size of less than one upper-layer crown (2/3 - 90%)
- sparse 1/3 to 2/3 cover
- patchy total cover <1/3

The delineation should be done at a scale of 1:5,000 and the **minimum mapping area is 0.5 ha.**

In the selection of managed forest set a priority on the most dominant management regime, but select samples from different stages (young, mid-aged, old) within this management regime. Select the managed forest on the same site conditions: same altitude, same soil conditions, same climate conditions, same water regime (or same PNFT if applied) as your OGF is located. If the grid or systematic sampling approach is too coarse to match all relevant management classes, non-systematic and non-random but representative sample selection in small management units is possible.

Rare beech forest types and rare management regimes can be skipped to have more plots and representativeness for the most frequent forest types and management regimes at the site.

It is important that this delineation process is done thoroughly and in coordination with local managers who know the context of the field. Provide at least 2-3 days for this process.

The layer should be delivered in WGS84 in shape file format to the coordinators of the action (E.C.O. and INBO), the latest beginning of April 2022.

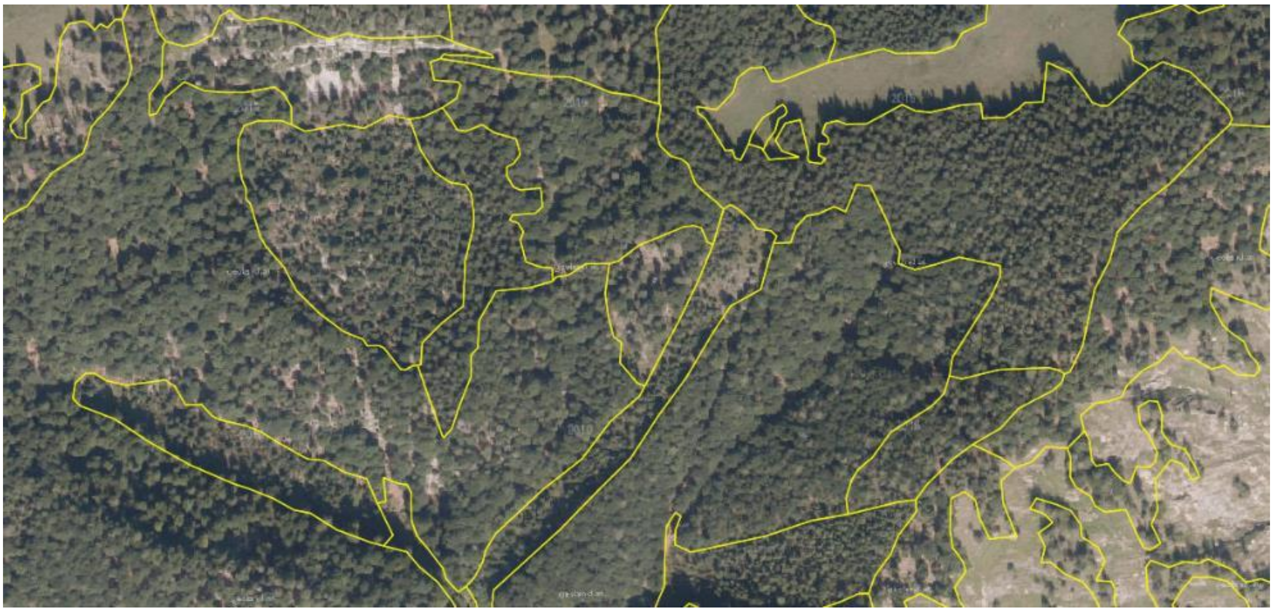


Figure 2: example of a delineation of homogenous forest stands.

OPTIONAL: in some countries, the concept of Potential Natural Forest Type (PNFT) is widely applied and detailed maps of PNFT are available. Wherever relevant and available, this PNFT can be applied as an additional characteristic of the mapped units or an extra element in the stratification of the test site.

A rough classification of the potential natural forest type (PNFT) will be applied in order not to over-stratify. The PNFT can be classified using the following categories:

Pure beech forest

Mixed beech forest with Quercus and/or Carpinus

Mixed beech forest with Ostry and or Pinus

Mixed beech forest with Picea and or Abies

Mixed beech forest with Acer and or Ash Other (all sites not to be classified as a beech forest)

The result of the stratification is a map with homogeneous polygons/areas concerning the factors listed above Figure 2.

Each unique combination of the characteristics described above will result in one specific **stratum**. A stratum can be composed of several polygons having the same amount of beech cover, the same management type, the same age class, the same canopy density and if included in the stratification, the same PNFT.

If one sampling area covers several discretely different abiotic conditions (soil type, elevation) relevant enough to discriminate them, then this can be an additional characteristic to further subdivide the assessment units.

In this case, the PNFT has been included in the stratification process: select the 1-2 most representative PNFT types in your area. Samples should be randomly selected within the unmanaged polygons to represent different development stages/phases.

4. Set up of the sampling design

If there is already an existing sampling design in the test-area providing enough sampling plots for each forest type and management regime to select from and meet the requirements for replication (at least 5-10 plots per stratum, see below), we recommend using this existing sampling design. The sampling design needs to ensure a statistically sound data acquisition (random sample or regular sample with low bias that could influence the indicators assessed in this study). This will create synergies with other research questions addressed on the site. When data was assessed within the last 5 years, it can still be used within the project as long as no major changes (logging, windthrow, die back) took place. Such changes need to be indicated as the 'old' reference data should not be used for calibration of remote sensing data in such cases.

In cases without existing sampling plots, we recommend creating a virtual sampling grid (100-300m width depending on the size of the mapping area)

Intersect all potential sampling points (from existing sample design or new grid-nodes) with the map of field units (see Figure 3 and Chapter 4). Each unique combination of characteristics (see above) forms one 'stratum'.

In the first phase, we will exclude 'border points'. When selecting plots, both when using existing networks or new sampling designs, it is important that sample points are **not located near stratum boundaries** (minimum distance 25m), because the sample plots should represent homogeneous conditions and stand properties. Also, when the data are to be used as ground-truth-data for the remote sensing section of the project, the data should be robust for limited spatial imprecisions.

Therefore, sample points within a buffer of 25m to polygon lines are not considered for potential sample point selection. This can be done by applying a GIS-buffer of 25m to the intersection lines and overlaying this with the potential plot points, and excluding all points within this buffer area.

Based on this pre-exclusion and the required number of replicates per stratum, the final selection of sample plots can be made. A stratum can consist of more than one polygon (having the same attributes). **From each stratum, select at least 5-10 field sample points** using a statistically sound approach (randomly, systematically stratified sampling approach). Very small and rare combinations can be excluded from the field sampling design. Also, all non-forest areas as well as stands with less than 1/3 of beech in the current tree species compositions (based on the crown cover or basal area) are excluded…

A total of 150 – 300 sample points per study site have to be surveyed.

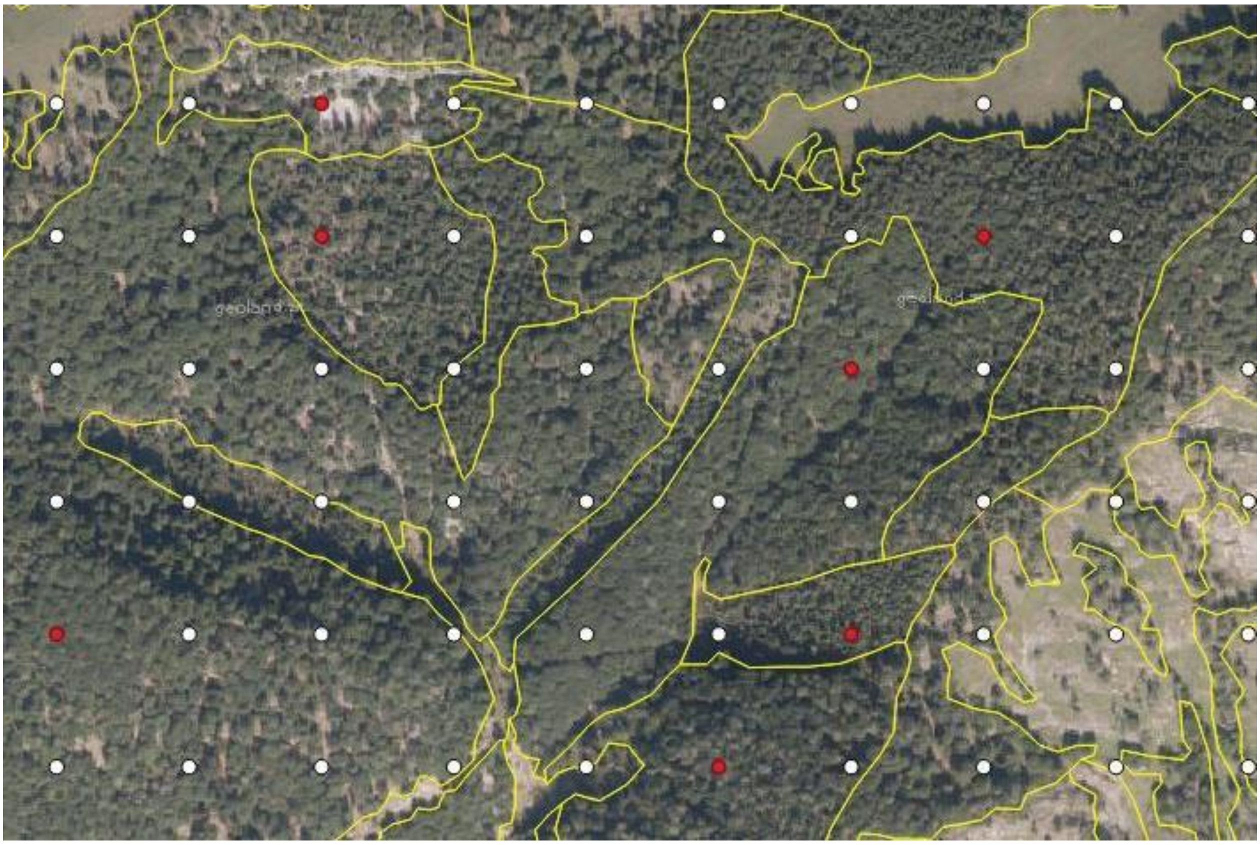


Figure 3: North-south oriented recording grid with a mesh size of 100m. Red dots are selected for field sampling.

In case the randomly selected plot is not accessible in the field, take the next raster point within the same polygon to the north. If this next raster point is neither accessible, take the next to the east and so on.

Make sure that you do this selection thoroughly and in coordination with the other project partners and coordinators. This process may require several working days (both for GIS-expert and fieldwork coordinator).

Finally, if a sample plot appears in the field to be inhomogeneous (although located within a presumed homogeneous polygon) the plot is skipped and the next plot located to the North (first choice), East, South or West is assessed.

5. Collection of field data on sampling plots: required parameters and survey protocol

For the 150-300 plots per test site, a comprehensive set of indicators will be assessed. This set of indicators is linked with the assessment of old-growthness as well as with the assessment of biodiversity and carbon. Some of the data might be also useful for the interpretation of the microclimate data collected by HNEE in Kellerwald and Hainich.

5.1. Assessed key indicators for old-growthness, biodiversity and carbon storage

The criteria set is in accordance with the old-growth criteria and indicators for beech forest (*Fageta)* presented by Vandekerkhove et al. (2022) and for the assessment of forest carbon and structural diversity by Di Filippo et al. (2022; Report of Action 2.02 and 2.03).

It suggests a multi-criteria approach where the assessments of several criteria are combined in parallel.

As many researchers already have existing protocols, we do not impose one specific sampling plot design, but we will list all items that should be assessed, together with minimum requirements of detail and precision. Each field team can select the appropriate methodology to assess the field data and provide for each field plot the key indicator values listed in Table 3. For those who have no local existing protocol, a proposed design is presented.

Table 3: Overview of potential quantitative indicators of old-growth, and the link to the assessed data, at plot or 'stratum'-level

Indicator	Parameter	Sampling required
Total aboveground biomass	V/ha (L+Dead)	Plot estimator OK; SD, range requires multiple plots (N>10)
Share of late-succ. species	V/ha per species	Plot estimator OK; SD, range requires multiple plots (N>10)
Density of large trees and VLT	N/ha: absolute or in classes	Multiple sample plots (N>10)
Biomass share of LT & VLT	BA-share / V-share	Multiple sample plots (N>5)
Size range of living and dead trees	Diameter range (Min-Max, IQR, confidence interval)	One figure per plot and/or multiple plots
Size distribution of living trees	DBH-distribution shape	One figure for multiple plots (N>10)
Dead wood volume	V/ha (Lying vs. standing)	Based on plot survey: local est. OK; based on a line intersect: multiple plots are required for a good estimate of the average

Dead wood decay range and distribution	N/ha per decay class V/ha per decay class	Based on plot survey: local est. OK; based on line intersect: multiple plots are required (N>5) for a good estimate of the average
Horiz. Diversity - species mixture	Nspecies/plot Spatial pattern (ind. mixed, clumps, monospecific...)	Plot level estimator OK, but multiple plots are required for a stable figure

Multiple uses of field data

The data collected in the field should serve several purposes within the PROGNOSES-project. We will use them for the assessment of old-growthness as well as to assess carbon storage and biodiversity. In the following description, in the headline of each indicator the relevant purpose is indicated:

Code	*Description*
[B]	*biodiversity*
[C]	*carbon storage*
[M]	*microclimate*
[O]	*Old growth indicator*

5.2. Basic Plot design

As described above, field teams can have their own sampling approach. The proposed sampling design below only gives an example of how it can be implemented.

The sample point selection is based on a statistically sound selection described above.

The **sample unit should have a minimal size**. It is preferentially a circular plot or nested circular design.

All living and dead trees that meet a lower threshold of at least 10 cm are assessed on an area of at least 300 m², **preferably a circular plot with a radius of at least 10 m.**

Lying dead wood can be sampled using Full Area Sampling **(FAS) of the 10m radius plot,** or using Line Intersect sampling **(LIS) applying at least 2x40 m in two perpendicular lines.**

Structural descriptive indicators (Layers, crown density), and rare elements such as large deadwood, very large trees (VLT) and pit-and-mount-structures are assessed in a wider area of at least 1000 m², preferably on a circular plot of at least 20m radius.

In case recently acquired data are used that applied lower size limits, this can be compensated by having more sample plots in every stratum, in the end covering at least the same surface (e.g. 20 plots of 500 m² instead of 10 plots of 1000 m²).

Marking of sample plots (optional)

If desired, the centre of each sample plot can be marked with an iron nail or other marking device driven into the soil. This allows the exact relocation using a metal detector.

Inhomogeneous areas

If a sample plot is inhomogeneous (different forest types, different age classes or management types) the plot is skipped and the next plot located to the North (first choice), East, South or West is assessed.

5.3. Descriptive parameters - assessment in the field + use of current and historic management plans and maps

These are a set of parameters and characteristics that are assessed in every sample plot. This is done through **visual assessment from the plot centre. The observation distance is ca. 20m from the plot centre.**

In some cases, information can also be **derived from existing maps or** management plans.

Use a '**stand description sheet**' (paper or electronic) using tick boxes and fill-in boxes to assess the following parameters :

5.3.1. Site/soil characteristics

To document site characteristics, some essential indicators will be assessed.

Exposure
The exposure (azimuth) is the general direction of the slope. If located in a concave relief, the flow direction of the baseline gives the main exposure. The exposure is categorised in the 8 cardinal and intercardinal directions or 'flat' (if the inclination is less than 5%).

Slope
The slope or inclination is measured in percentage (%, NOT in degree!).

The inclination value will be used for the correction of length-measures in sloped sites. Make two measures, one down-hill and a second one uphill and calculate the mean value. Note this mean value in the form.

For recalculating the thresholds from degree to percent use

Table 4.

For the **slope correction of field measurements** two options are available :

- Use of predesigned distances along the slope (results in an oval horizontal projection of the circular plot)
- Measurement or correction to horizontal distances

Both methods are allowed but should be consequently applied over all measurements and plots at one site and well documented.

Table 4: Guidelines to recalculate thresholds from degree to percent

°	%	Expansion horizontal>slope		Reduction slope>horizontal	
0,0	**0**	**10,00 m**	**20,00 m**	**10,00 m**	**20,00 m**
2,9	5	10,01 m	20,02 m	9,99 m	19,98 m
5,7	10	10,05 m	20,10 m	9,95 m	19,90 m
8,5	15	10,11 m	20,22 m	9,89 m	19,78 m
11,3	20	10,20 m	20,40 m	9,81 m	19,61 m
14,0	25	10,31 m	20,62 m	9,70 m	19,40 m
16,7	30	10,44 m	20,88 m	9,58 m	19,16 m
19,3	35	10,59 m	21,19 m	9,44 m	18,88 m
21,8	40	10,77 m	21,54 m	9,28 m	18,57 m
24,2	45	10,97 m	21,93 m	9,12 m	18,24 m
26,6	50	11,18 m	22,36 m	8,94 m	17,89 m
28,8	55	11,41 m	22,83 m	8,76 m	17,52 m
31,0	60	11,66 m	23,32 m	8,57 m	17,15 m
33,0	65	11,93 m	23,85 m	8,38 m	16,77 m
35,0	70	12,21 m	24,41 m	8,19 m	16,38 m
36,9	75	12,50 m	25,00 m	8,00 m	16,00 m
38,7	80	12,81 m	25,61 m	7,81 m	15,62 m
40,4	85	13,12 m	26,25 m	7,62 m	15,24 m
42,0	90	13,45 m	26,91 m	7,43 m	14,87 m
43,5	95	13,79 m	27,59 m	7,25 m	14,50 m
45,0	100	14,14 m	28,28 m	7,07 m	14,14 m

Elevation

The elevation above sea level is given in meters with a precision of 5 m – 10 m. The elevation can be measured in the field using GPS or derived from detailed elevation maps or Digital Terrain Models.

Geomorphology

The geomorphology is described by the macro-relief and the micro-relief.

The macro relief describes the dominating landforms at a larger scale that would be visible already in the 20/25m isohypse in a map in the scale 1:50.000.

hilltop (summit)

uphill slope (shoulder)

middle slope (back slope

lower slope (foot slope)

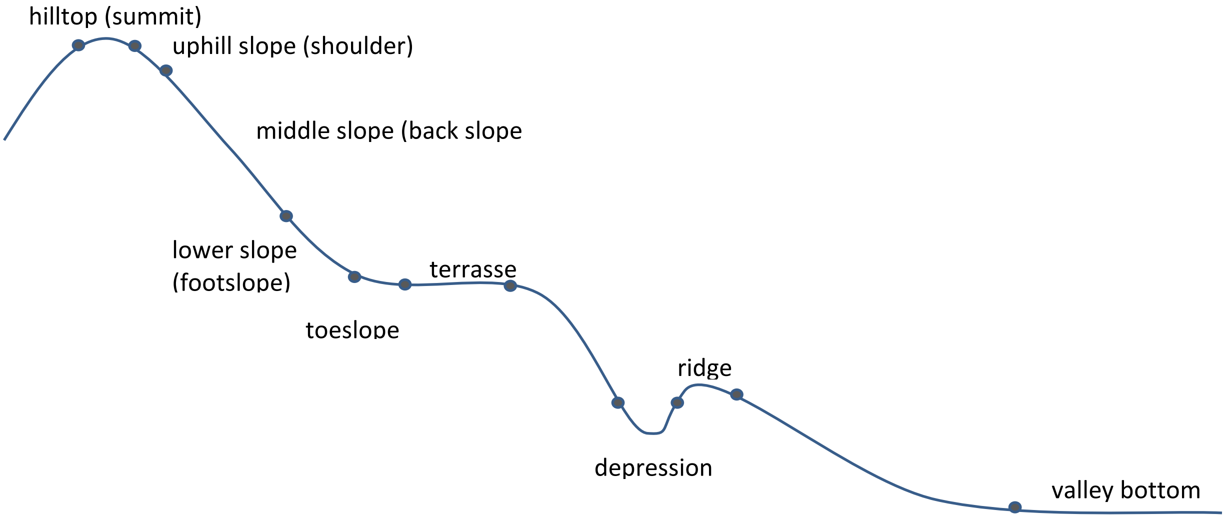
toe slope

terrasse

depression

valley bottom

ridge



In lowland, relatively flat landscapes, the category 'valley bottom' is selected.

Microrelief

The microrelief is on a finer scale describing surface deviations in the range of 1-5m within a distance of 10-30m. The micro-relief can be even, concave, convex or heterogenous (a combination of convex and concave within the 20m radius). Relevant is the deviation from the mean slope surface of the macro-relief.

Soil type

For the assessment of the soil type the local classification system can be used and then transferred into an internationally comparable WRB category. The World Reference Base (WRB) is the international standard for soil classification endorsed by the International Union of Soil Sciences (FAO, 2015: https://www.fao.org/3/i3794en/I3794en.pdf). Some commonly found WRB categories are already on the form. A reference list from common European soil types into WRB will be provided.

WBR soil type on the form:

- Leptosol
- Regosol
- Cambisol
- Podzol

Rockiness

Rocks and stones > 10cm diameter at the surface are estimated in classes of % coverage on the 10m radius plot:
none, up to 5%, --10%, -25%, -50%, >50%

OPTIONAL: Litter layer & depth of humus horizon; soil depth

The litter layer and the depth of the humus horizon (H-horizon) are measured in cm. For this, a small pit can be made with a spate/ shovel, or using a soil auger. The auger, or a metal rod can also be used to assess soil depth. The auger or rod is hammered into the soil until it is blocked by rocks. 3-5 samples should be made to get an average soil depth.

Plots that are selected for soil sampling (see chapter 6) will have a more thorough assessment of soil characteristics and rockiness.

5.3.2. Management history

Derive from background information or assess in the field (based on the presence of skidding tracks, age of cut stumps,...) – select one of the following:

- Currently managed forest
- Not managed for more than 10 years
- Not managed for more than 25 years
- Not managed for more than 50 years
- Not managed for more than 75 years
- No signs of management or >75 years

5.3.3. Current or former management regime

Assess the main management system that is applied at the plot. Also for sites that were (more recently) set-aside: give the former management system.

- no signs of silvicultural treatment (or no longer recognizable)
- irregular selective harvest (single trees have been cut, but no clear silvicultural system)
- single tree selection; continuous cover forestry (systematic management approach)
- group fellings (Femelschlag) : 0.05-0.5 ha gaps
- shelterwood
- coppice
- abandoned coppice (i.e. coppice converted to high-forest, naturally or by silviculture)
- clearcut (>0.5 ha)
- other or comments (free text field)

The combination if this and previous characteristics will allow us to describe the current management context: e.g. area formerly managed as shelterwood, but no longer managed for more than 25 years.

5.3.4. Elements of human disturbance

The criterion of the absence of human disturbance is the basic criterium to identify primary forests. This criterion is, however, not essential for old-growth forests: as described in the definition of old-growth forest, this concept is focusing on forest areas and forest stands containing elements of late-seral stages. They can perfectly be present in formerly managed forests that still exhibit elements of human interference and management. They may even contain signs of relatively recent human interventions like selective felling, removal of invasive species, or recreational paths.

The criterium of the absence of human disturbance, however, is primordial in the delineation of primary forest: the main criteria for inclusion in the category of primary forests was the absence of detectable historical human activities, as assessed based on the combination of forest stand maps, historical maps, and field observations.

If this criterium is assessed (for potential primary forests), the following indicators can be assessed in the field in the 20m radius :

- fresh cut stumps (< 10 y)
- old cut stumps (> 10 y)
- wood harvest tracks, skidding tracks
- planted trees (if still traceable for native species)
- other remains of human activity: constructions, charcoal kiln remains, ditches, ...

Additionally, assess the distance from the plot centre to the nearest roads and paths

5.3.5. Stand age structure / developmental phase

Assess the age structure of the dominant tree layers in the 20m radius from the plot centre.

For managed units:

- Uneven-aged: containing all ages, young up to mature (e.g. Plenterwald)
- Two aged (e.g. in shelterwood and coppice-with-standards)
- Even-aged clear-cut/regeneration stage (0-10y)
- Even-aged - young growth: dense stands up to pole wood (10-30y)
- Even-aged – young timber – stem exclusion phase (30-60y)
- Even-aged - Mature stand (dominant trees 60-150 years old)
- Even-aged - Overmature stand (dominant trees > 150 years old)

For unmanaged/semi-natural dynamics:

- Rejuvenation phase/Initial phase/young growth
- Aggradation phase
- Dynamic steady-state
- Late-seral phase/ overmature stage (dominant trees >150 years old)
- Senescence/decaying phase (collapse of the dominant trees)

5.3.6. Stand canopy layering

select:

- single-layered
- two-layered
- multi-layered/continuous vertical structure (no distinct layers)

A layer needs to have a canopy cover of at least 10% of the plot to be regarded as a separate layer.

5.3.7. Stand canopy cover (consider only trees of the upper tree layer

Assessment on the 20m radius plot. Select:

- dense Crowns interlock with each other (100% cover)
- closed Crowns fill the crown space; they just touch each other (90-99% cover)
- spacious Crowns don't touch but are evenly distributed (2/3-90% cover)
- irregular Gaps in the canopy with a size of less than one upper-layer crown (2/3 - 90%)
- sparse Distance between the crowns of about one crown of the upper layer (1/3-2/3 cover)
- patchy Distance between the crowns of several upper layer crowns [total cover <1/3).

5.3.8. Local site productivity

<u>At the plot, we will also assess the local site productivity, based on the upper canopy height of mature beech trees.</u> Upper canopy height (= hight of the upper canopy of fully-grown mature beech trees of at least 80-100 years old): estimate/measure in meters or at least assess the following three classes: <20m, 20-30m, >30m.

These classes are important to assess the local site productivity as 'low', 'medium' or 'high' as these will determine the threshold diameter of Very Large Trees and Large Deadwood to be registered (see below)

If the plot is in a young stand: note both the actual canopy height and the potential canopy height from neighbouring stands with mature beech trees ('benchmark trees').

5.3.9. *OPTIONAL: Natural forest type.*

For countries where the concept of PNFT is commonly applied and field teams are trained to assess this in the field, the Potential forest type can be assigned.

Existing European typologies (e.g. Bohn et al. 2002) can be used, but also a more

Trough classification of the natural forest type/native tree species composition can be assigned:

- pure beech forests
- Beech mixed with Quercus, Carpinus
- Beech mixed with Ostrya, Pinus
- Beech mixed with Spruces, Abies
- Beech mixed with Acer .

5.3.10. Established regeneration

REQUIRED: record the following aspects

- is established regeneration (young trees higher than 30 cm and less than 130cm) present in the plot (> 1 per 25 m² OR cover > 5%): Yes/no;

First, assess in the **10m** radius plot: when more than **13** young trees (> 30cm and < 130cm) are found, regeneration is checked as present. If less than 13 are in the 10 m radius, check if more than 50 are present in the 20m radius. If there are less than **50 in the 20m** radius (including those, which are in the 10m r), the regeneration type will not be assessed.

If yes (regeneration is present) the regeneration is subdivided into 4 categories:

- Natural regeneration with native tree species
- Natural regeneration with non-native tree species
- Artificial (planted) regeneration with native tree species
- Artificial (planted) regeneration with non-native tree species

For each category, the percentage is estimated in 10% steps.

Non-native tree species are those, that would not naturally grow under the given site conditions at the sample plot but are introduced species by human activities (exotic or out of their natural range).

ADDITIONAL: other features related to regeneration: number per ha per species, cover (in classes), browsing pressure indicators, ...

5.4. Dendrometric survey [B, C, O]

Below, a set of parameters is listed that should be measured in every plot, using minimum standards of precision and threshold size. They are listed under 'REQUIRED'. Other parameters that can be useful and informative, but not essential for the project, are listed under 'ADDITIONAL'.

Many of these parameters are already registered in existing monitoring protocols. Field teams should check the requirements with their protocols and do additional measurements where needed to meet the requirements of the protocol.

<u>Sampling strategy:</u> use sample plots (preferably circular plots), located and selected according to the criteria described in Chapter 5.2.

5.4.1. Plot size

<u>**REQUIRED:**</u> at least R=10m (314 m²) (also 9m is accepted for existing plots) when already established as a standard)

Preferably: larger (500-1000 m²); single or nested plot.

Plotless sampling (Bitterlich method) only allows for BA-assessment and does not allow for volume calculations or DBH-assessments, or dead wood. They do not meet the requirements.

In the case of nested plots, the radius of the plot to cover the minimum DBH trees (see below) should be 9m.

5.4.2. Living and dead standing trees - DBH threshold: 10 cm (preferably 7 cm), Height>130 cm

<u>REQUIRED</u> <u>in all plots:</u> all living and dead trees meeting the size threshold within the plot radius should be surveyed. For the assessment of whether a tree lies within the sampling circle or not, the distance from the plot centre to the tree axis is measured at DBH height. If the distance is less than the selected radius, the tree is recorded.

In the case of multi-stemmed trees with branching less than 1.3m in height, each individual stem is surveyed separately as a single tree.

Diameter at Breast Height (DBH) always measured 130cm above ground surface; vertically for leaning trees. In steep terrain, the measurement is always taken from the highest point around the tree (upslope). Measurement is performed with a diameter measuring tape or a calliper. When using a calliper, to obtain more accurate results, 2 measurements are preferably taken at perpendicular angles.

Dead hanging trees, with a deviation from the vertical axis of more than 45° are classified as ‘ lying deadwood’ and recorded as such.

When using traditional analogue measuring devices and field forms, we recommend enumerating the trees in the sample at the beginning of the survey, in order to ensure that all tree-related data are recorded are linked with the correct tree. Starting from North clockwise is one option.

The following parameters are **<u>REQUIRED</u>** <u>for each tree:</u>

- Tree species (if not assessable for deadwood at least conifer/broadleaf)
- DBH (cm)
- Status (living/dead)

ALSO **<u>REQUIRED</u>** <u>for dead trees</u> :

- Species (if still possible, at least conifer/broadleaved),
- DBH,
- Indication if the tree is dead standing or broken (snag)
- Height for all snags
- decay stage in at least 3 classes (use characters for coding h,p,s; see Table 5).

ADDITIONAL: Decay stage in 5 classes (use numbers for coding 1,2,3,4,5)

ADDITIONAL: cut stumps and snags< 1.3m :

A separate sheet is used for stumps and snags < 1.3 m with the following attributes: Tree species, decay stage, diameter, height

We use the term ‘stump’ for the remnant part of the tree after cutting. The term ‘snag’ is used for naturally broken remnants of dead trees without signs of human interaction. The existence of cut stumps is an indication of human activity.

On plots selected for tree-coring (approximately 5-7 managed and 5-7 unmanaged/OGF forest plots, see details for tree-coring in Chapter 6.8)

- Tree height (for 3 trees of the upper canopy for at least 10% of sample plots)
- Tree age (1 core for each 20 cm diameter class for beech and other dominating tree species for at least 3 old-growth and 3 managed forest plots; 30 cores in total)

ADDITIONAL data :

Tree number (starting from North, clockwise)
Tree position: X/Y or Direction ° (azimuth, 360°)+ Distance (cm)
Relative height of the crown onset (l: lower third, m: middle third, u: upper third

By recording the tree number, tree species, angle and distance to the centre point, the tree can be clearly identified (for a possible repetition of the recordings).

Table 5: Decay stages of dead wood

Minimum (required)	Optional
h: hard	1 (freshly dead)
	2 (hard, bark still on the log)
p: partly decayed	3 (decayed, knife can penetrate deeply in the direction of fibres but not transverse),
	4 (high decay, knife-blade can penetrate also in the transverse direction to the fibres into the log, parts of the original volume already lost)
s: Soft	5 (wood completely soft, mouldered log fall apart into fragments, can be separated easily by hand or foot)

5.4.3. Microhabitats for standing trees [B, O]

An elaborate methodological report, summarizing the literature on tree microhabitats and describing the field method has been developed within the LIFE PROGNOSES project WP2.03 (Di Filippo et al. 2022b). We summarize below the proposed sampling protocol.

Within each plot, each tree (dead, alive) above the minimum DBH threshold of 20 cm will be visually inspected for the presence of each of the tree micro habitats (TreMs). The trunk up to the crown onset (for beech: first large branch reaching into the upper crown half –Figure 4 for conifers: upto the first 3 living branches) will be assessed. Only crown damages will be assessed in the crown.
Micro habitats must exceed their minimum size thresholds (Table 6).

Figure 4: first primary branch (red arrow = lowest large living branch reaching into the upper half of the canopy – sampled area for microhabitats is below this branch (blue arrow)

The proposed TreM thresholds (see Table 6) represent a synthesis including the minimum number of the most common types proposed in the scientific literature.

Table 6: Proposed TreMs and the corresponding thresholds. TreM Category

	TreM Type	Proposed Threshold				Notes
		Diameter / Width (cm)	Length (cm)	Depth (cm)	%	
REQUIRED						
Bark	Bark pocket	10	10	1		Loose bark, still attached to the stem
	Bark loss	10	30			Wood exposed, no cavity
Crack	Crack	1	30			Shows exposed or rotting wood inside the crack (not re-closed)
Trunk cavities	Woodpecker breeding cavity					breeding cavity, not foraging cavity or 'cavity attempts'
	Trunk rot-hole	10				
Tree base cavities (0-50cm above ground level)	Base rot-hole	10				Rot-hole below 50cm above ground; mostly with soil contact
	Root buttress concavity	10	10	10		Living wood; stem base deformation due to root buttressing, forming a shelter
	Dendrotelms	10				At least temporarily water-holding; can be in living wood or rot-holes
Fungi	Perennial polypores	10				Living & dead fruit bodies of perennial species (=fruit body has woody texture and persistent for at least one year)
Crown damages	Dead crown				> 25	Over ¼ of the crown is dead
	Broken crown				> 25	at least ¼ of the crown has broken off (can be top-end or large limbs)
ADDITIONAL						
Bark	Exudates (sap, resin)		10			Crack/burst with active flow of sap or resin
Epiphytes	Mosses, lichens				30	At least 1/3 of the trunk up to 3m is covered
	Climbing plants/vascular plants				30	At least 1/3 of the trunk up to 3m is covered (ferns, Hedera, Clematis,...)
Cankers	Cankers	20				Deformations caused by an infection, dead or living (burrs),

REQUIRED:

record presence/absence per stem>20cm DBH (living and dead) for every of the required elements above. Always relate the recording to the individual tree (of which you also recorded at least its DBH, species, and living/dead status).

ADDITIONAL sampling:

- also sample dead branches, branch base rot, ...or use the 47 types of Larrieu et al., 2018;
- also sample tree crowns;
- also sample lying dead trees.

ADDITIONAL recording:

for ‘countable elements’: count the number of occurrences on every tree.

If additional elements are sampled, always make sure that you separate the results from the required protocol!

5.4.4. **Lying deadwood –lying [B, C]**

Lying deadwood normally consists of trunks -or parts of it- and branches that fell to the ground. In managed forests, it may also consist of harvest residues (crown wood) or even forgotten and abandoned piles of wood or logs.

Freshly cut trees, that are obviously destined for extraction, are normally not registered.

Also excluded are wooded structures (benches, …) and dead branches that are still attached to living trees.

Hanging dead trees are considered as ‘laying’ if the deviation from the vertical axis is more than 45° (other is assessed as standing)

Lying deadwood is registered if it meets the minimum size requirements. The registration will depend on the applied method (below).

Two sampling methods are applied to lying deadwood: Line intersect sampling (LIS) or Full-area sampling (FAS). The required measurements are described below for both methods separately.

5.4.4.1.Line intersect method

The ‘line intersect method’ is one option which is simple and time-efficient (Ritter and Saborowski, 2012), but is not precise for local deadwood volume estimations (no local estimator). The result becomes stable and reliable when combining data from at least 10-20 plots combined.

The line intersect method was originally developed in North America for the assessment of the hazard potential posed by flammable undergrowth (WARREN & OLSEN 1964; VAN WAGNER 1968). In this method, all lying deadwood that crosses one of the specified transect lines and meets the diameter threshold at this point is recorded (independent of their length). The crossing does not require the fragment to touch the ground: it can cross the line at several meters high (e.g. branches of a freshly fallen crown that cross the line). Dead hanging trees, with a deviation from the vertical axis of more than 45° are considered as ‘lying deadwood’ and recorded if their vertical projection crosses the transect line.

If a deadwood fragment crosses the transect line more than once (or crosses several transect lines), it will be recorded at every intersection.

Not recorded are fragments of which the central axis coincides exactly with the transect line (very rare), or which touch the transect line but do not cross it with their central axis.

REQUIRED length and position of intersect lines: at least 2 intersect lines oriented perpendicular to each other, and centred at the plot centre are required. A design of three transects in the orientation of 120° to each other and meeting in a central point is also applied (so-called 'fan-design'). The length of all transects together in one plot should be at least 80 m ((Fraver et al., 2018)).

On slopes, one transect is oriented parallel to the slope, the other one in the direction of the slope, facing downhill and uphill. In flat sites, the transects are oriented North-South and East-West.

Depending on the applied correction for the hillslope, the length of the transect will be 40 m exactly (when measuring along the slope) and corrected afterwards (for transformation to volumes per ha); or corrected in the field (for horizontal projection), resulting in slightly longer line length. In this case, it is **essential to record the precise length of the transect** that was recorded.

REQUIRED measurements: all lying deadwood fragments with a diameter >10cm at the point where the imaginary central axis of the logs crosses the transect line are registered. The following parameters are measured:

- Diameter (in cm) at the point of crossing (measured perpendicular to the stem axis)
- Decay stage in at least 3 classes
- Tree species (in higher decay stages: conifer, broadleaf, not assessable)

ADDITIONAL:

- Lower diameter threshold
- Decay stages in 5 classes (see Table 5)
- Origin: sawn, broken or windthrown

Windthrown is if the tree where the fragment originates from was uprooted (check for the presence of a root plate or exposed roots

A visualisation of a possible plot design, when applying line intersects is given below.

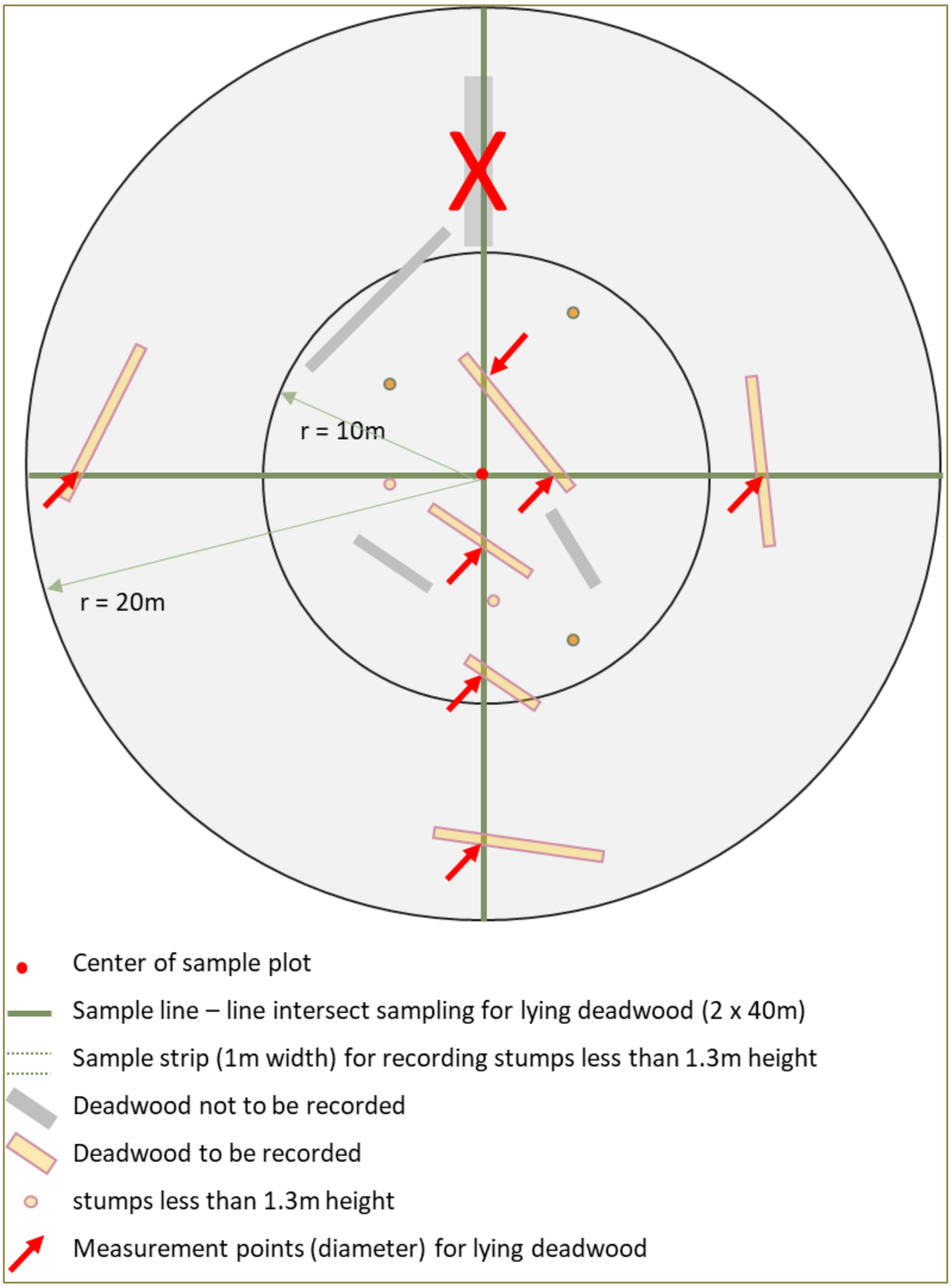


Figure 5: Proposed plot design for field teams who have no existent plot network. It shows the basic unit (circle with 10m and 20m radius), and the sample lines (2 x 40m).

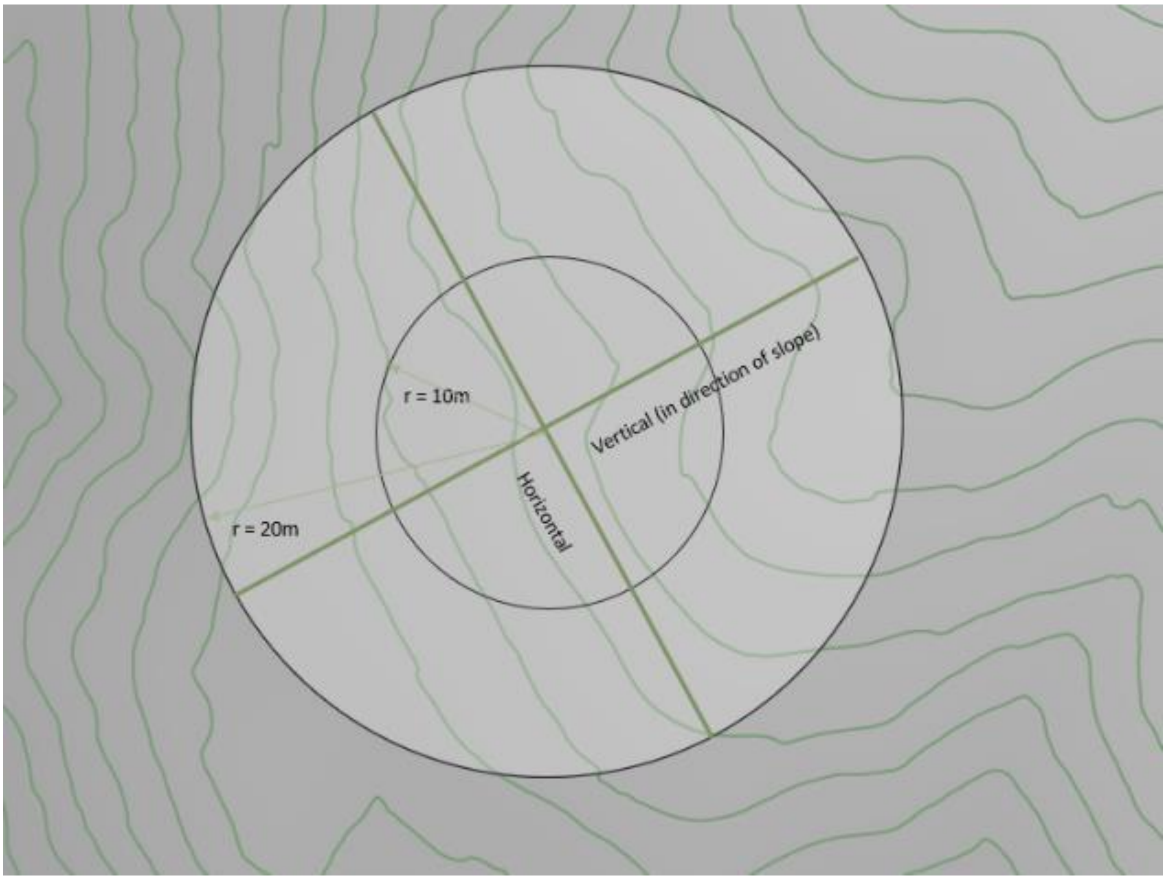


Figure 6: In sloped terrain, the transect is oriented in slope direction (vertical) and parallel to isohypses (horizontal).

5.4.4.2.Dead wood: full sampling

In this method, all lying deadwood units meeting the size requirements are measured. Also parts (e.g. crowns) not touching the ground are measured and considered lying deadwood if attached/part of a fragment or tree that is lying on the ground. Dead hanging trees, with a deviation from the vertical axis of more than 45° are classified as 'lying deadwood' and also recorded as such. Dead branches that are still attached to living trees are not recorded.

REQUIRED: all fragments or dead, lying tree sections with a diameter at the largest end of >10 cm and more than 1m length within the 10m plot are recorded. For every fragment, the following parameters are recorded:

- Diameter at both ends (in cm) and length of the fragment (in cm) Fragments or trees that cross the border of the plot are virtually 'cut-off' at this border: their diameter and length are measured at this point (or automatically generated if using specialized equipment).
- Decay stage in at least 3 classes
- Tree species (in higher decay stages: conifer, broadleaf, not assessable)

ADDITIONAL:

- Lower diameter threshold
- Decay stages in 5 classes (Table 5)
- Positioning of the fragments

- Origin (sawn, windthrown or broken)

Windthrown: the tree was uprooted (check for a root plate or exposed roots on the tree it originates from.

5.4.5. Rare elements (checked in the 20m radius plot)

Most forest structural features will be derived from the plot dendrometric data (R=10m). However, some specific elements are rare, also in primary and old-growth forests, but are essential features of these forests. This is especially true for Very Large Trees (VLT), Large deadwood and pit-and-mound structures. Densities of more than 10-20 per ha are seldom occurring, even in forests with a high degree of old-growthness. Using small sample plots (radius 10m), they have a high probability to be 'missed' by the sampling plot design.

That is why an additional assessment of the presence of these structures is needed, within a 20m radius plot. The minimum required recording is the presence/absence of these structures within the wider circle; additional measurements include their exact number and additional features such as size, species,…

For existing plot designs that do not have a 20m radius circle, the number of recorded plots per 'stratum' should be raised in order to cover the same surface (25 plots of 500 m² i.s.o. 10 plots of 1250 m²)

5.4.5.1.<u>Pit-and-mound structures</u>

Rootplates of uprooted trees (with soil attached) and pit/mound microrelief are important indicators of recent or past windthrow events of larger trees. They are important habitats and add microrelief to the site.

The relief differences between the sole of the pit and the summit of the mound where soil is still attached, should be at least 50 cm.

<u>REQUIRED</u>: Presence/absence of pit-and-mound structures in the 20m plot

ADDITIONAL: record their precise number and note if the structure is recent (uprooted tree still identifiable) or old (only microrelief with/without wood mould of the former stem)

5.4.5.2.<u>Very large trees and large deadwood</u>

The size thresholds of VLT and large deadwood is dependent on the local growth conditions (low, medium or high), assessed by estimating the upper canopy height of fully grown beech trees within or close to the plot (see before). Threshold values are given below :

Upper canopy height (mature trees)	**> 30 m**	**20-30 m**	**< 20 m**
Threshold DBH for VLT	80 cm	70 cm	60 cm
large deadwood – standing or lying	40 cm	35 cm	30 cm
Pit-and-mound structures/root plates	Root plates of uprooted trees and pit/mound microrelief: relief differences between the sole of the pit and the summit of the mound should be at least 50 cm.		

For standing trees (alive and dead), the in/out rules are according to the rules for the dendrometric circle (centre of the stem inside radius).

For large, lying deadwood: trees are considered 'in' if they meet the threshold diameter at the largest end, and this largest end is located within the 20m radius. (see Figure 7).

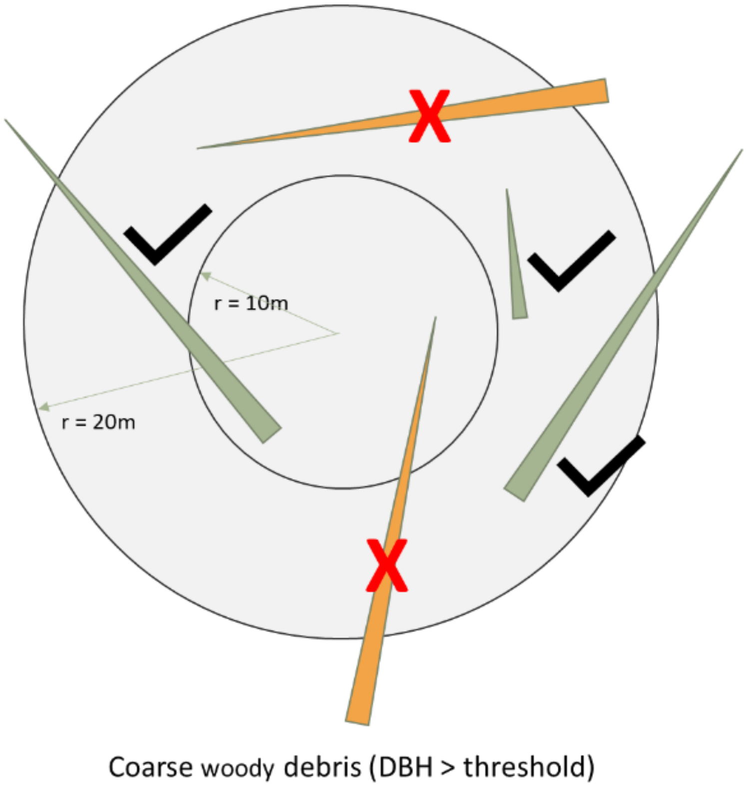


Figure 7: Trees are considered 'in' when their part with the largest diameter equals or exceeds the threshold diameter and is located within the plot.

<u>REQUIRED</u>:

- presence/absence of VLT within the 20m range
- Presence/absence of large deadwood within the 20m range

(if already present and recorded within the 10m range, no additional recordings are needed)

ADDITIONAL:

For a more precise and nuanced figure on the density and nature of these elements, it is recommended (but not mandatory) to record the individual elements and some additional features:

- DBH (for standing trees), diameter at the base end for lying large deadwood
- Species
- Status: living, dead standing, dead lying

For features that were already recorded within the 10m circle, these recordings should not be repeated but can be retrieved from the dendrometric data.

Trees broken into several pieces are only counted once and measured at the lower end.

5.5. OPTIONAL: assessment of current vs. natural tree species composition/shares

For those teams and sites where reliable PNFT maps or assessment methods exist, and the field teams have the required expertise, an additional estimation of the current vs. Potential (natural) species composition can be made for the most important tree species, using rough classes (dominant, co-dominant, admixed, sporadic or absent).

The PNFT types that can be applied and the method for assessment are described in the annex.

6. Assessing soil carbon content (Coordinated by UNITUS - Alfredo Di Filippo, Luca Di Fiore, Simone Priori)

An elaborate methodological report, summarizing the literature on above- and belowground carbon content in old-growth forests and describing the field method has been developed within the LIFE PROGNOSES project WP2.02 (Di Filippo et al. 2022a). We summarize below the proposed sampling protocol.

6.1. Glossary/definition of the terms used

- **Study Area**. Territory hosting the forests to be sampled (e.g. Parco Nazionale d'Abruzzo, Kalkalpen National Park).
- **Forest**. The ecosystems to be compared within each study area (e.g. old-growth vs. managed forest).
- **Plot**. Areas sampled for stand structure within each forest, of about 2,000 m2. The sites correspond to the study areas where local information/metadata will be collected, and where internal replicates of soil samples will be collected.
- **Sampling Area**. Location for collecting the soil cores in relation to the centre of each plot.
- **Sampling Points or Replicates**. The number of soil cores and place of collection at each sampling area. Three cores will be taken at each sampling area, and the content at the same depth from each replicate will be mixed to produce average data for each sampling area.
- **Soil Core**. Soil samples collected across the entire prescribed depth (see below) at each sampling area, by manual augering (drill) or pits (large holes of some decimeters, manually dug by a spade).
- **Depths**. Soil core is collected in sequential drills/excavations, thus dividing the whole soil sample into fixed, prescribed depths (see below).
- **Soil Sampling Sheet**. Pre-printed document for reporting the prescribed metadata and measures associated with every soil sample.

6.2. Forest Selection

In each study area, available maps of the strata will be used to select 20-30 plots (preferably paired plots) in managed and long unmanaged parts of the research site.

An effort must be made to select plots that clearly differ in terms of old-growth status but grow under comparable ecological conditions (bedrock, elevation range, aspect, slope).

The selected managed forest must preferably cover the full rotation cycle.

6.3. Locating the soil sampling areas within each forest

Available plot descriptions and metadata will be used to stratify the research site for collecting soil samples. The 'research site' encompasses both managed and unmanaged forest areas (e.g. UNESCO old beech forest and its managed buffer zone)

Within each forest, the candidate sampling areas for soil analysis will be extracted among plots within the different strata (see before) and selected using a stratified random approach based on local geomorphological conditions, i.e. plots falling in marginal or extreme conditions, like mountain tops, ridges, rocky outcrops, narrow valleys, gorges (Figure 8) will be excluded. The selection will be made possible using plot metadata on geomorphology, also including elevation, slope, exposure, rockiness and stoniness (%).

The number of sampling areas per site will be at least 2x10 (if possible 20-30, in accordance with the available budget).

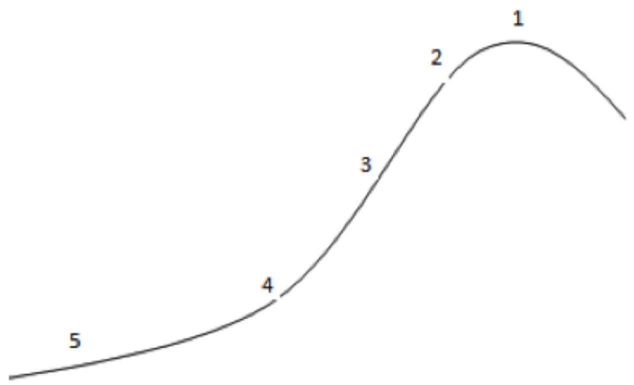


Figure 8: Potential slope position attributed in the metadata description of biomass plots. 1: mountain top/ridge; 2- upper slope; 3: mid-slope; 4: bottom slope; 5 valley/plain).

6.4. Locating the replicates within each sampling area

At each selected soil sampling area, three sampling points (replicates) will be collected.

Each replicate will be located along the azimuth directions 0°, 120° and 240°, at 2.5 m outside the border of the plot established for quantifying stand structure (Figure 9).

If the sampling point falls closer than 2 m to a tree's base, the first among any successive points falling along the same direction (outward from the plot centre) at intervals of 2.5 m will be used (i.e. at 15m, 17.5m, …).

A short description of vegetation cover and soil surface, using a reduced version of the metadata collection sheet used for stand structure, will be compiled for the surrounding of each sampling point.

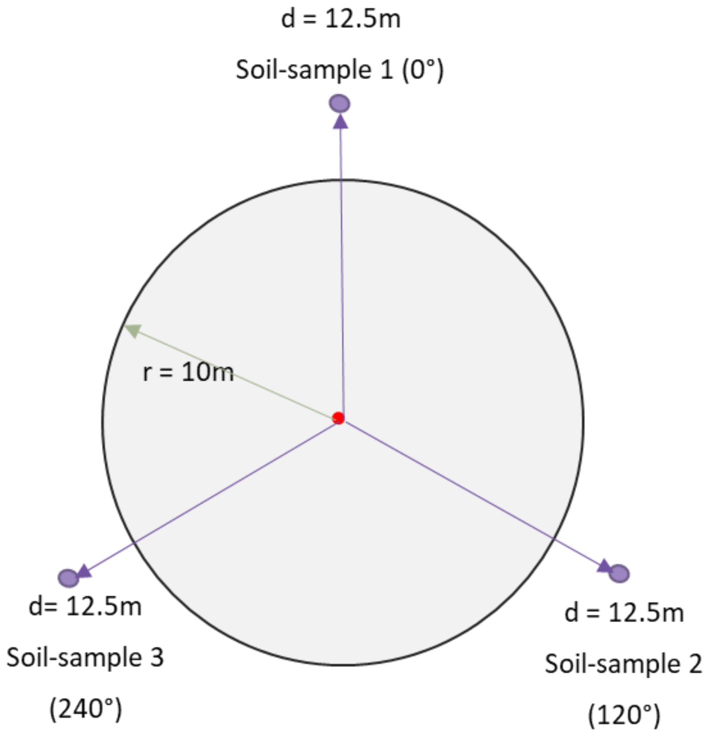


Figure 9: Location of soil sampling points within each selected sampling area (grey dots) with reference to plot centre.

6.5. Collecting litter and soil samples in the field at each replicate

Soil samples will be collected at each sampling point with different approaches regarding litter and organic horizon, versus mineral layers.

At each selected sampling plot, 3 replicate samplings are performed. At each point, both litter and soil samples are taken. For the soil, samples are taken at fixed depths (4 mineral horizon depths 0-10, 10-30, 30-60, and 60-100 cm; see below).

The tree replicates per fraction (organic, fixed depth of soil) are merged into one composite sample, and bagged. Whenever possible, the mixing of the samples and taking the subsample for chemical analysis is best performed in lab conditions. Only if the composite sample is too heavy, the sample is thoroughly mixed in the field and a subsample is bagged.

Add a waterproof label that describes the plot identity and the depth of sampling in the bag.

Sample analyses will be divided into two steps: a preparatory procedure performed in local laboratories (sample preparation); and laboratory analysis performed in a single selected soil laboratory (at INBO - Belgium) for density and chemical analyses.

6.5.1. Litter (OL + OF) and Organic Horizon (OH)

The organic layer combines the Litter layer (OL+OF), combined with the Organic horizon (OH). All three are sampled together, as the subdivision is not always straightforward, and is not essential for the assessment of the Carbon stock.
The organic horizon must clearly show that its organic matter content is higher than its mineral content (SOM > 70%). Usually, the O_H horizon can be easily divided from the lower mineral horizons.

Litter and organic layers are sampled together. They will be collected at each sampling point by using a circular or square sampling frame (side or diameter ≥ 25 cm; Figure 10). At each sampling point, the full organic layer thickness is measured with a ruler within the sampling frame and registered on the Soil Sampling Sheet.

All organic matter within the frame is now manually collected and bagged. The sample will include all dead leaves, fine woody debris with a diameter < 1 cm and decayed organic matter. Live roots, woody debris with a diameter ≥ 1 cm, rocks, and all fruits (cones, acorns) and bark > 1cm diameter will be removed.

The litter samples at the three sampling points are compiled into one sample (3 replicates) in an airtight plastic bag (LDPE plastic), adding a plastic label with the sample code and, after removing most of the air, will be taken to the local laboratory.

Figure 10: Example of a frame for collecting litter.

6.5.2. Mineral Horizons (A)

Samples from the mineral horizons will be collected at fixed depths:

- 0-10 cm
- 10-30 cm
- 30-60 cm
- 60-100 cm (only in optimal cases, in deeper soils, without stones; in case the core is stopped between 60 to 100 cm, mark the maximum depth you reached)

Mineral horizons could be sampled using a soil auger (Figure 11) or excavating pit.

- Manual augering generates semi-undisturbed sampling. For bulk density, the core diameter should be between 50- and 100 mm to avoid excessive soil compression. Alternatively, the rotative auger (root auger or traditional auger) can also be used, with particular attention to determining the right sampling depth. Alternatively, an excavation pit will be dug (if possible/allowed), necessary under those soil conditions not appropriate for the auger (e.g. rocky soils or dry sands).

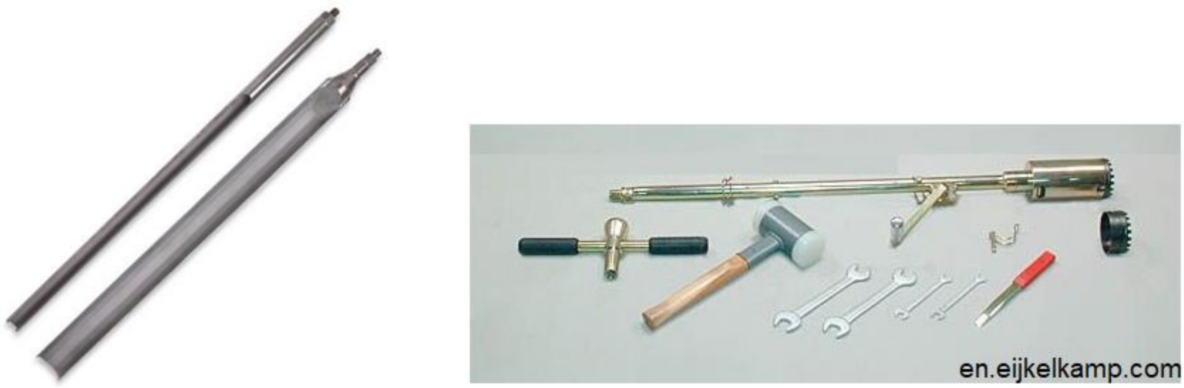


Figure 11: Root augers, with accessories.

Figure 12: Examples of ring samplers for bulk density.

When using the auger, 3 samples are taken at fixed depths :
0-10 cm
10-30 cm
30-60 cm
60-100 cm.
At one of the auger samples, an additional sample for bulk density is taken at mid-depth (approx. 5 cm, 20cm, 45 cm and 80cm) using a ring at known volume (usually Kopecky rings, 100 or 110 cm^3). Try to fill the whole cylinder avoiding compaction of the soil. To avoid compaction, use a ring sampler that pushes into the soil only the border of the ring (AVOID WOOD TABLES, because the risk to compact the soil into the ring is high!)

The fixed-depth soil samples of the 3 corings are combined into one sample, bagged and labelled. The bulk density samples are bagged and labelled separately.

What if the full depth is not reached?

This is noted on the sampling document, mentioning the depth that was attained and the reason for not reaching the full depth (e.g. hitting bedrock)
If one or two of the corings is not reaching full fixed depth, the remaining sample(s) is/are selected and bagged as the sample for this depth. Do not (!) add a sample that did not reach the full depth of a fixed-depth section (as you will oversample the upper part of that fixed depth, and you don't know whether you reached bedrock, or just a large stone).

In the case of a profile pit
You dig one pit, carefully separating the different fixed depths. If full depth is not reached, note the depth achieved, and, if you reached bedrock, you can still consider a non-complete depth sample (carefully noting bedrock depth). Take the soil samples that are relevant depending on this reached depth. Depending on the fraction of the horizon reached, a soil sample may or may not be taken.

e.g; depth reached = 48 cm: sample for 30-48 cm is relevant; if the depth is 34cm, insufficient material can be sampled, so this makes no sense

Take the bulk-density samples in the profile-side of the pit at depths of 5, 20, 45 and 80 cm, by pushing in a Kopecky ring horizontally.

6.6. Pre-processing of the samples (in each country)

Each soil sample (litter, organic horizon, up to 4 mineral horizon depths 0-10, 10-30, 30-60, 60-100 cm) from each sampling area will be carried to a local laboratory for preliminary treatment, before being further shipped to the laboratory for chemical analyses.

6.6.1. Pre-processing of the organic layer – samples

Organic layer samples are weighed (fresh weight) upon arrival in the office/lab. They are inserted in the oven at 105°C for 24 h or until the weight is stable, and weight (dry litter). Both values are carefully recorded.

The samples are reinserted in a sealed bag, labelled and sent to the central lab for further analysis.

6.6.2. **Pre-processing of the mineral layer- samples.**

First, the composite samples are weighed (fresh weight), and sieved through a 1-cm sieve, to separate stones and coarse roots with a diameter >1 cm. Each separated fraction will be weighted again and the % volume occupied within the soil sample will be estimated (Figure 13).

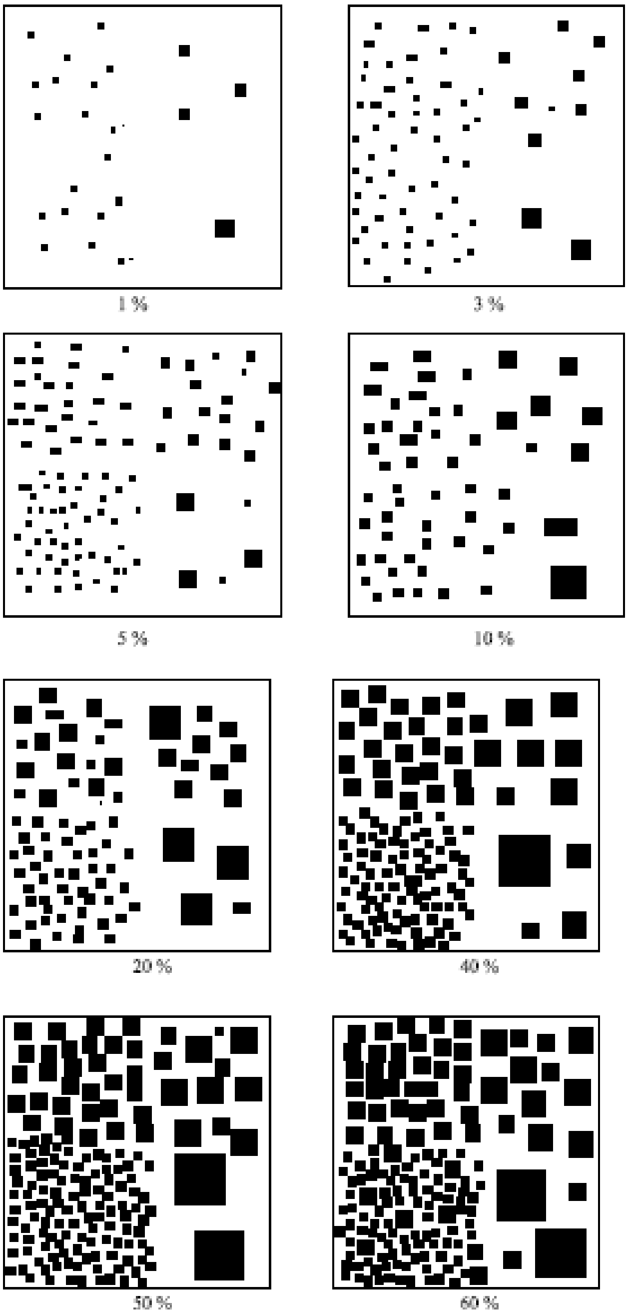


Figure 13: Examples of volume percentages occupied by the coarse fraction within the soil.

The sieved samples will be air dried (alternatively at 30°C for 24h in an oven with a fan), labelled and sealed in plastic bags and sent to the analytical lab.

If the sample is too large or heavy, a subsampling will be performed first: the sample is mixed intensely and then subsampled using the quartering method (Figure 14), a representative aliquot of 150 g will be sent to the laboratory selected for chemical analyses. The rest may be preserved in each local laboratory. For **Bulk density** (BD), the fresh samples are weighed, then dried in the oven at 105°C for 24h and then weighted again (dry weight).

6.7. Laboratory analyses

6.7.1. mineral layers

6.7.1.1. ***<u>Organic layer and litter:</u>***

The dried litter/organic layer samples are cut-up in a cutting mill (RetschSM2000) or knife mill (GRINDOMIX GM 200), until a size of <0.2mm is reached and homogenized. A subsample is taken (using a splitter), and ready for analysis. Total Carbon (TC), inorganic C (TIC) and total nitrogen (N) are determined through combustion methods. The total organic carbon (TOC) is then the difference between TC and TIC.

6.7.1.2. ***<u>Chemical analysis in the selected laboratory</u>***

The air-dried samples are further dried until stable weight (in the oven at 40°C) and ground to fraction sizes of < 2mm using a 'jawbreaker-mill'. For further milling to sizes < 0.02 mm (needed for total inorganic carbon content) a planetary ball mill (type Pulverisette 6 classic line) is used.

Total, organic, and total nitrogen (N) is determined through combustion methods on the fine earth fraction (soil materials passing a 2 mm sieve), and for inorganic C, the pulverised sample is used. Total Carbon (TC), inorganic C (TIC) and total nitrogen (N) are determined through combustion methods. The total organic carbon (TOC) is then the difference between TC and TIC.

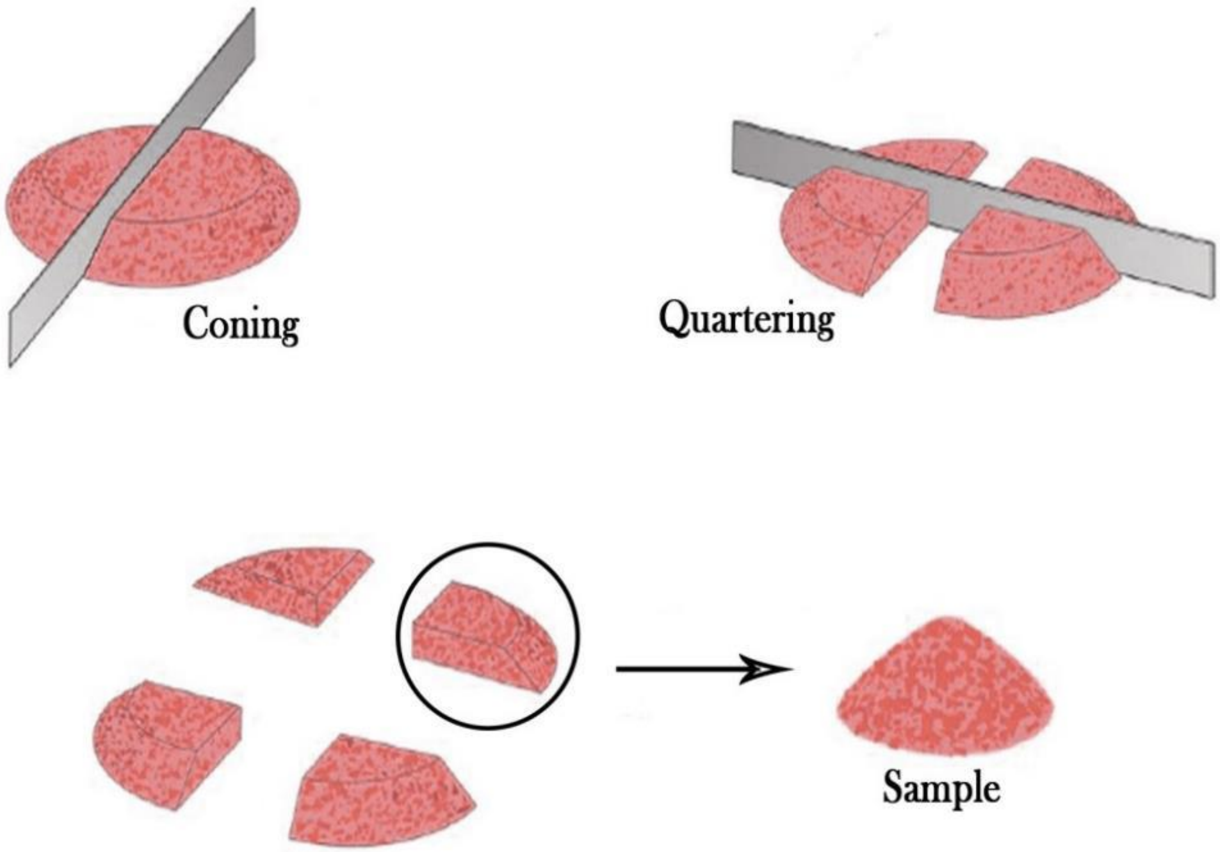


Figure 14: The quartering method for subsampling soil samples.

6.8. Tree cores collection – Summary Guidelines

Tools: increment borer, borer starter, plastic tubes or straws, tree core ejector.

Which trees to select? 5 trees of the dominant species per plot, one for each DBH class.

How many trees to core? At least 25-30 per forest.

Number of cores to collect: at least 25-30 per forest.

What to collect? Tree cores and tree-related information.

How to collect? Trees will be sampled with an increment borer, storing the samples in plastic tubes or straws.

Notes

Not all plots may have trees in all DBH classes (< 20 cm, 20-39 cm, 40-59 cm, 60-79 cm, >80 cm). In that case, additional plots will be selected for additional sampling. Trees may be randomly selected within the plot, or immediately outside the plot (closer to the plot border).

6.8.1. Steps for a correct tree coring

1. **Inspect the tree.** Cored trees must have a regular shape (i.e. straight stem) and do not show signs of decline/dieback or heart rot.

2. **Sample the tree stem radially**, considering both stem shape and crown geometry (Fig. 1). A starter can facilitate the borer insertion and avoid that too much pressure is exerted on the external tissues of the stem.

3. **Turn the borer clockwise** until it reaches and then exceeds the estimated pith of at least 10 cm. Ensure that the entire wood radius is represented to the pith, or sufficiently close to it.

4. **Insert the extractor in the borer** and then turn the borer counterclockwise for one complete rotation. Pull carefully the extractor ensuring that the tree core is complete.

5. **Store both bark and wood** in plastic tubes or straws to avoid breakage (Fig. 2).

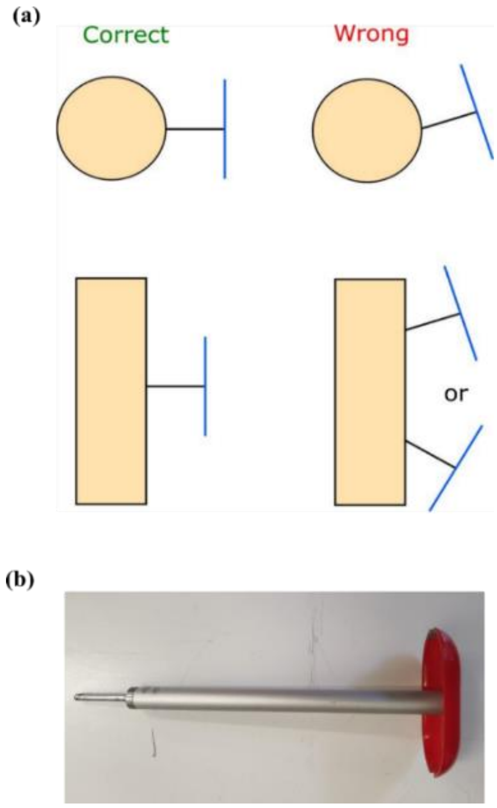


Figure 15. (a) Some frequent mistakes in collecting tree cores with an increment borer, with view on the transverse (above) and longitudinal (below) stem sections. (b) Increment borer starter.

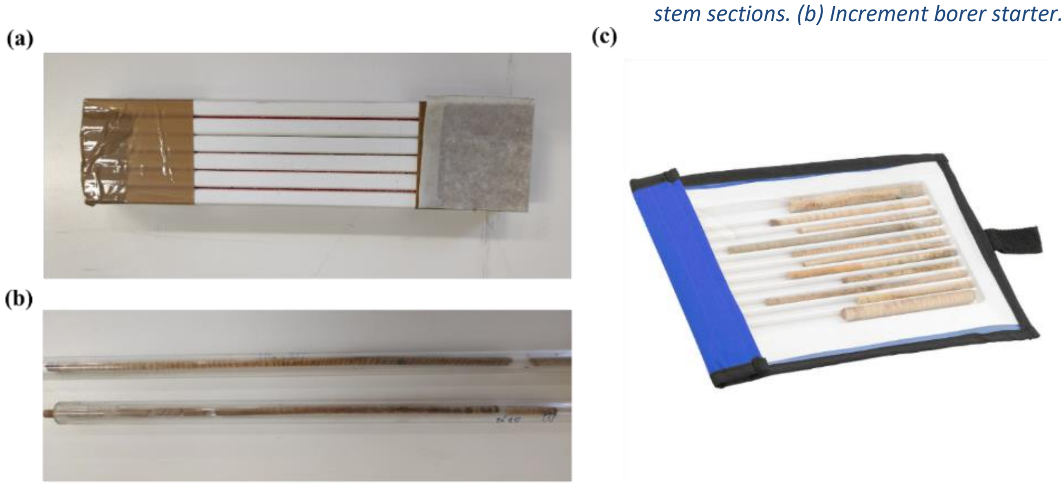


Figure 16. Possible ways to store wood samples. (a) Plastic tubes. (b) Straws. (c) Plastic core case (source: Forestry Suppliers).

6. **For each cored tree measure**:
- DBH (two orthogonal measures, along isolines and maximum slope);
- height;
- crown extent measuring the length of 4 radii along the cardinal directions considering only the sun-exposed portion of the crown;

- metadata regarding species, plot number, tree ID (if available), and GPS position. At least Tree ID should be written with a permanent marker on the plastic tube which contains the core (Fig. 3).

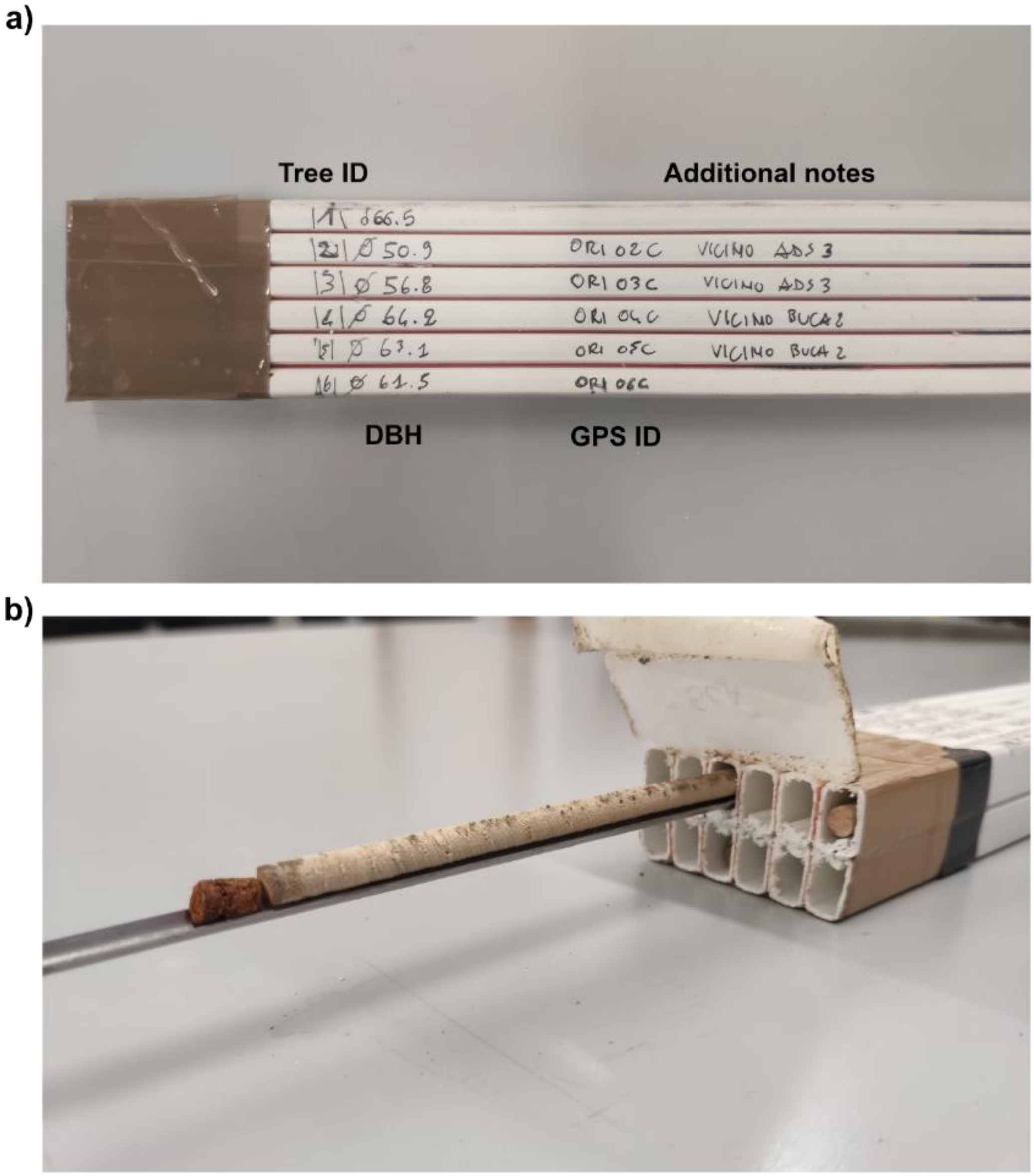


Figure 17: (a) Example of metadata data written on the plastic tube. (b) Tree core and bark inside the plastic tube.

6.8.2. Possible problems during coring

- **Rotten cores.** A sudden decrease in the wood resistance when coring is frequently related to decay inside the tree. In this case, stop immediately the coring and pull out the borer from the tree. Tree rings in rotten wood are not measurable and the increment borer is hardly removable from the tree.
- In case of **cores broken** in more than 2 pieces and cores that **missed getting close to the stem pith**, another one must be collected from the closest tree pertaining to the same DBH class. If pieces are lost during the coring process, another core must be collected below (approx. 10 cm) the first one.
- **Bark broken in several pieces.** collect another bark sample 5 cm above the first core.

- **Borer stuck into the tree**. Try to turn the borer counterclockwise and pull it out at the same time.
- Pay attention to keeping the **borer screw away from stones** or the ground. It can be easily damaged.
- **Tree core stuck into the borer**. A special ejector should be used (Fig. 4), inserting it into the screw. Do not use sticks.

Figure 18: Tree core ejector.

ANNEX

A. Forest typology (EEA)

Table 7: European forest types classes – EAA typology, FFH beech forest habitats and potential natural forest types for mapping.

Lowland beech forest		**Relationship to Annex I, Habitat Directive**	**Mapping PNFT**
6.1	Lowland beech forest of southern Scandinavia and north-central Europe	9120 — Atlantic acidophilous beech forests with Ilex and sometimes also Taxus	Pure beech forest
		9130 — Asperulo-Fagetum beech forests	Pure beech forest
		9150 — Medio-European limestone beech forest of the Cephalanthero-Fagion	Pure beech forest
6.2	Atlantic and Subatlantic lowland beech forest	9120 — Atlantic acidophilous beech forests with Ilex and sometimes also Taxus	Pure beech forest
		9130 — Asperulo-Fagetum beech forests	Pure beech forest
6.3	Subatlantic sub-mountainous beech forest	9110 — Acidophilous (Luzulo-Fagetum) beech forests	Pure beech forest
		9130 — Asperulo-Fagetum beech forests	Pure beech forest
6.4	Central European sub-mountainous beech forest	9110 — Acidophilous (Luzulo-Fagetum) beech forests	Pure beech forest
		9130 — Asperulo-Fagetum beech forests	Pure beech forest
		9150 — Medio-European limestone beech forest of the Cephalanthero-Fagion	Pure beech forest
6.5	Carpathian sub-mountainous beech forest	9130 — Asperulo-Fagetum beech forests	Pure beech forest
		9110 — Acidophilous (Luzulo-Fagetum) beech forests	Pure beech forest
6.6	Illyrian sub-mountainous beech forest	91K0 — Illyrian Fagus sylvatica forests (Aremonio-Fagion)	Pure beech forest
6.7	Moesian sub-mountainous beech forest	91W0 Moesian beech forests	Pure beech forest
Mountainous beech forest		**Relationship to Annex I, Habitat Directive**	
7.1	South-western European mountainous beech forest (Cantabrians, Pyrenees, central Massif, south-western Alps)	9120 — Atlantic acidophilous beech forests with Ilex and sometimes also Taxus	Pure beech forest/Mixed beech forest with spruce/fir
		9130 — Asperulo-Fagetum beech forests	Pure beech forest/Mixed beech forest with spruce/fir
		9140 — Medio-European subalpine beech forests with Acer and Rumex arifolius	
7.2	Central-European mountainous beech forest	9110 — Acidophilous (Luzulo-Fagetum) beech forests	Pure beech forest/Mixed beech forest with spruce/fir
		9130 — Asperulo-Fagetum beech forests	Pure beech forest/Mixed beech forest with spruce/fir
		9140 — Medio-European subalpine beech forests with Acer and Rumex arifolius	Pure beech forest/Mixed beech forest with acer/ash
7.3	Apennine-Corsican mountainous beech forest	9210 — *Appenine beech forests with Taxus and Ilex	Pure beech forest/Mixed beech forest with spruce/fir
		9220 — *Appenine beech forests with Abies alba and beech forests with Abies nebrodensis	Pure beech forest/Mixed beech forest with spruce/fir
7.4	Illyrian mountainous beech forest	91K0 — Illyrian Fagus sylvatica forests (Aremonio-Fagion	Pure beech forest/Mixed beech forest with spruce/fir
7.5	Carpathian mountainous beech forest	9130 — Asperulo-Fagetum beech forests	Pure beech forest/Mixed beech forest with spruce/fir
		9110 — Acidophilous (Luzulo-Fagetum) beech forests	Pure beech forest/Mixed beech forest with spruce/fir

7.6	Moesian mountainous beech forest	91W0 Moesian beech forests	Pure beech forest/Mixed beech forest with spruce/fir
7.7	Crimean mountainous beech forest	-	Pure beech forest/Mixed beech forest with spruce/fir
7.8	Oriental beech and hornbeam-oriental beech forest	-	Mixed beech forest with oak/hornbeam

B. ADDITIONAL: option for assessing the tree species composition (not mandatory)

For those teams and sites where reliable PNFT maps or assessment methods exist, and the field teams have the required expertise, an additional estimation of the current vs. Potential (natural) species composition can be made for the most important tree species, using rough classes (dominant, co-dominant, admixed, sporadic or absent).

When addressing the actual tree species combination, the proportions of tree species were determined without differentiating between native and non-native tree species (see Table 8). The assessment should be done on the 20m radius circle.

Table 8: Table of dominance classes for actual and potential tree cover.

Code	***Description***	***Percentage ot total coverage***
0	*Tree species absent*	
1	*Dominant*	*> 50%*
2	*Subdominant*	*26 – 50%*
3	*Admixed*	*5 – 25%*
4	*Sporadic*	*< 5%*
5	*Non-native (only for potential natural cover)*	*various*
7	*Pioneer tree species of current vegetation; absent from potential natural vegetation (PNV) (only for potential natural cover)*	*various*

	curre	pot.		curre	pot.		curre	pot.		curre	pot.		curre	pot.		curre	pot.
F. sylvatica			A. pseudopl.			Q. petraea			F. excelsior			U. glabra			P. sylvestris		
A. alba			A. platan.			Q. robur			T. cordata			U. minor			P. nigra		
P. abies			A. campest.			C. betulus			T. platyph.								
1	= dominant (>50% of crowncover						3	= admixed (5-25%)				5 = not native (only pot.)					
2	= subdominant (25-50%)						4	= spradic (< 5%)				7 = Pioneer tree species (only pot.)					

The assessment of the potential natural tree species: For the evaluation of the potential natural tree species composition, the current site factors from the site survey of the sample area and the potential natural forest type as well as the ecological requirements of the tree species were to be taken into account.

In the estimation of the species coverage, a distinction was made between native and non-native tree species and neophytes. The expected tree species of the PNV were assigned to classes 1 to 4, currently, existing neophytes and non-native tree species were assigned to class 5. Pioneer tree species of the current vegetation, which are absent in the PNV but may occur in the course of short-term succession, were assigned to class 7 (pioneer tree species) and will not be rated as a negative deviation from the potential natural tree species composition.

Assessed are:

- *Current and natural dominance class for each tree species (even those, which are not present but would be expected in the potential natural forest type*

Optional

- *Name of the potential natural forest type phytosociological forest association*

C. ADDITIONAL: Assessment of Human impact intensities

For the following human impacts, the intensity and the time frame can be assessed by visible indicators of anthropogenic influence. The assessment is done on an area equal to or larger than 1000m² (e.g. 20m radius circle).

These indicators can be important co-variables to counter-check the structural indicators with the absence or presence of human interventions of different origins or intensities.

a) Time since the last intervention

Table: categories of time period for human impact intensity.

Code	Description
current	Up to a maximum of 10 years before recording.
historic	More than 10 years ago.
current & historical	Both cases apply.

b) Forestry harvesting activities

Intensity	Description
low	* Single stem use or plentering distributed on the sample area or on parts of it. * Selective cutting: irregular removal of a part of the trees on an approximately round area with a diameter that corresponds approximately to the stand height (max. 1000 m²). * Uses in the course of a release and expansion of regeneration cores (max. 1000 m²). * Shelterwood cutting: Removal of so many trees that only a more or less loosely, uniform crown cover remains over the area (in pure beech stands). The use takes place in an area up to 0.5 ha.
moderate	* Small-scale clear-cutting: total removal of trees on an area of 0.1 to 0.5 ha. * Small-scale clear-cutting of fallen timber up to an area of 0.5 ha * Coppice * Shelterwood cutting on an area > 0.5 ha * Clearcutting on an area of 0.1 to 0.5 ha - Clearcutting of fallen timber on an area < 0.5 ha
strong	* Large-scale clearcutting: total removal of trees on an area > 0.5 ha. * Large-scale clearcutting of fallen timber on an area of > 0.5 ha

c) Intermediate treatment (e.g. thinning)

Intensity	Description
No visible	No impact visible
weak	* Weak thinning measures (<10% of stems bevor thinning) * Single stem removal in the course of an initial use
medium	* Moderate selective thinning (< 50% of stems) * Mechanical maintenance measures (thinning < 10% of stems, removal of branches)
strong	* Chemical measures in young stands/thicket (removal of the herb or shrub layer and pioneer plants) * Strong selective or schematic thinning (> 50% of stems before thinning)

d) Soil cultivation / road construction

Intensity	Description
No visible	No impact visible
low	* Minor changes in topsoil and humus layer due to timber harvesting activities on less than 50% of the sample plot.

moderate	* Weak to moderate impact on topsoil. Concentrated on parts of the sample plot or weak on the whole area. Caused by timber harvesting activities (tractor tracks, distinct grinding marks, etc.). * No impairment of tree roots evident. * Preparatory measures of shelterwood cutting by superficial soil wounding. Soil compaction only locally. * Humus removal in the area of logging trails and drag roads.
strong	* Intensive degradation of more than 50% of the sample plot. Humus, topsoil and deeper soil layers are affected. Significant soil compaction by forwarders or by truck-accessible roads. Recognizable damage to the root system of trees. * Surface damage to the topsoil by ploughing or harrowing in the course of regeneration measures. * Drainage of wetlands and boggy and marshy areas (with subsequent reforestation). Drainage ditches or drainage systems.

e) Agro-pastoral uses

Intensity	Description
low	* Area freely accessible to grazing livestock, but only poorly accepted due to locally unfavourable vegetation conditions (e.g. dwarf shrubs) * Sporadic droppings (cowpats,…),
moderate	* Many droppings in the sample plot * Isolated trampling damage and soil wounding
strong	* On the whole sample plot many droppings and/or strong soil wounding. * Significant trampling damage visible on the relief. * Browsing damage with clear assignment to grazing livestock (e.g. at a height of more than 1.5 m)

f) Browsing influence

In the case there is regeneration present, the browsing impact is assessed:

Intensity	Description
No	No impact of game browsing visible
low	Impact of browsing on < 10% of terminal sprouts or 30% of lateral sprouts
moderate	Impact of browsing on 10-49% of terminal sprouts or 30-80% of lateral sprouts
strong	> 50% of the trees in regeneration are showing browsing impact on their terminal sprout or >80% of the lateral sprouts.

g) Recreation and tourism

Intensity	Description
low	*Up to two footpaths (hiking trails) less than 1 meter wide on the sample area.
moderate	*1 Footpath or bike path more than 1m wide; signs or trail markers present. *Physical damage by skies to regeneration evident, but not frequent. *Surface erosion due to tourist activities
strong	*Multiple footpaths or bike paths > 1m wide; tourist signage, rest areas (benches, trash cans, etc.) present; trampling damage also visible adjacent to trails. *The sample area is touched by the following facilities: playgrounds, fitness facilities, ski trails, golf courses, etc. *Frequent shear damage to regeneration.

h) Use of litter raking

Intensity	Description
low	*Pruning or pollarding of less than 5% of the trees.
moderate	*5 – 20% of the trees are pruned or pollarded *Historical litter use recognizable.
strong	*Pruning or pollarding of more than 20% of the trees. *Significant litter use on more than half of the sample area (current).

i) Other use

If there are any uses or impairments that have not yet been defined, the type, intensity and duration of use must be recorded verbally.

j) Natural disturbance regime

The historic patterns (frequency and extent) of natural processes such as fire, insects, wind, and mass movement are drivers of forest structure and composition.

Indicate which of the following factors are relevant to the forest area (visible or from different sources (e.g. meteorological information, historical documentation, evidence from old-growth remnants and salvage logging data from National forest inventories). Estimation of the time of impact for each disturbance: 0-10 /10-30/>30 years

- Drought
- Thunderstorm wind
- Ice storm
- Heavy snow
- Forest fire
- Insect pests
- Avalanches
- Landslides