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Characterization of Core Areas following the methodology of LIFE RedBosques (LIFE15 GIE/ES/000809)

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WP3 – Tools for CNF management

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Purpose of the document

In the protocol for the identification of Core Areas, their characterisation using the Index of Biodiversity Potential (IBP) is proposed. Alternatively, their characterisation can be carried out more accurately, following the methodology implemented within LIFE project Redcapacita 2015 (LIFE15 GIE/ES/000809, also named LIFE RedBosques) for the identification of old-growth (or near-old-growth) forests. This methodology, applied for the characterisation of Core Area, would allow the Core Areas to be attributed their degree of naturalness.

This document describes the methodology proposed and implemented within the framework of LIFE Redcapacita for the identification of old-growth (or near-old-growth) forests, as a methodological proposal for the characterisation of Core Areas.

This procedure requires field measurements by means of survey plots, and calculations to obtain the indicators. Assigning scores to indicators allows the subsequent assessment of the naturalness of each Core Area. Assuming that Core Areas represent portions of forest with characteristics very close to those of mature forests, the RedBosques methodology is well suited to the description of Core Area characteristics.

The implementation of the RedBosques protocol for the identification of old-growth (or near-old-growth) forests is divided in 2 stages, with a gradual increase in complexity is proposed: an **initial phase to identify potential mature stands *in situ***, and a **second phase for their characterisation by means of a set of indicators**.

The methodology here reported concerns this second phase, and it's synthesized and translated from the document "Manual for assessing the naturalness of reference stands. REDBOSQUES tool. Phase II: Identification through plots"[1].

[1] FUNGOBE, 2024. Manual de evaluación de la naturalidad de rodales de referencia. Herramienta REDBOSQUES. Fase II: Identificación mediante parcelas. Fundación Fernando González Bernáldez, Madrid.

Introduction to the method

Quantitative indicators about the forest's structural properties and human impacts are proposed to characterize the stand. (Please remember that within LIFE GoProForMED, the stand will coincide with the Core Area).
This work involves taking measurements on the field.
The method is based on sampling plots.
In the related field manual, and here reported, indications are given about:

- the procedure for locating the sampling plots, and its requirements concerning shape and size
- the specific protocol for sampling of trees, regeneration, vertical strata and dead wood
- indicators to be collected at the sampling plot scale are described in full detail,
- the procedure for integration of the results of the different sampling plots into stand-scale information.

The process for the assessment of the naturalness of each stand consists of 2 steps:

1. Field sampling for the collection of data on variables relating to the stand forest structure and the presence of evidence of anthropogenic uses at the local scale. Other landscape-scale variables are calculated using mapping and GIS tools from stand boundaries.
2. Calculation of simple indicators that can be appropriately standardized and hierarchically aggregated into criteria and domains (maturity, human footprint and spatial integrity) to construct the composite naturalness index.

Variables are collected in:

1) a field form for the stand: summary document for the identification of the stand from the data obtained in the sampling plots. It also includes the variables necessary for the stand assessment, for each of the forest plots surveyed and for the synthetic data at stand level of these same variables.
2) a field form for sampling plots: it contains the basic data per sampling unit (inventory plots and deadwood transects). It will be necessary to fill in one for each plot and therefore to print as many copies as needed.

Then, all the information necessary to construct the naturalness indicator of the stands, based on field data, are provided. For this purpose it is necessary to:

1. calculate the indicators, on the basis of field or cartographic data;
2. normalize the indicators (which is the process of scaling them to values that are comparable between them);
3. aggregate the indicators into a composite index.

Overview of all the variables to be measured

Variables are measured at stand scale and at plot scale.

DOMAIN	CRITERIA	VARIABLES	SAMPLING UNITS
Maturity	Composition	N° tree species	Stand
	Structural complexity	Basal area	Plot
		N° diametric classes	Plot
		Volume of living trees	Plot
		N° vertical layers	Plot
	Senescence	Densità arborea eccezionale	Plot
		Volume medium/large deadwood	Plot
		Ratio medium/large deadwood	Plot
	Microhabitat	Types of TreMs	Plot
	Dymanic	Silvogenetics phases	Stand
Human footprint	Past human footprint	Temporal continuity	Stand
		Agro-pastoral uses	Stand
		Forest uses	Stand
	Recent human footprint	Forest uses	Stand
		Invasive species	Stand
		Causes of fragmentation	Stand
		Hunting activity	Stand
		Grazing herbivores	Stand
		Frequentation	Stand
		Duration of use	Stand
Spatial integrity	Stand extension	Stand extension	Cartography
	Forest continuity	Forest surface area	Cartography
	Edge effect	Surrounding forest area	Cartography
	Connectivity	Degree of isolation	Cartography

Field sampling

Positioning of sampling plots

The aim is to sample representative areas of exceptional (reference) values with a relatively low number of plots, but of large size. Sampling plots should be placed in areas with obvious maturity attributes (larger living and standing dead trees, abundant dead wood, and other maturity attributes). In this way, we ensure that the areas chosen are representative of the most outstanding areas of the stand.

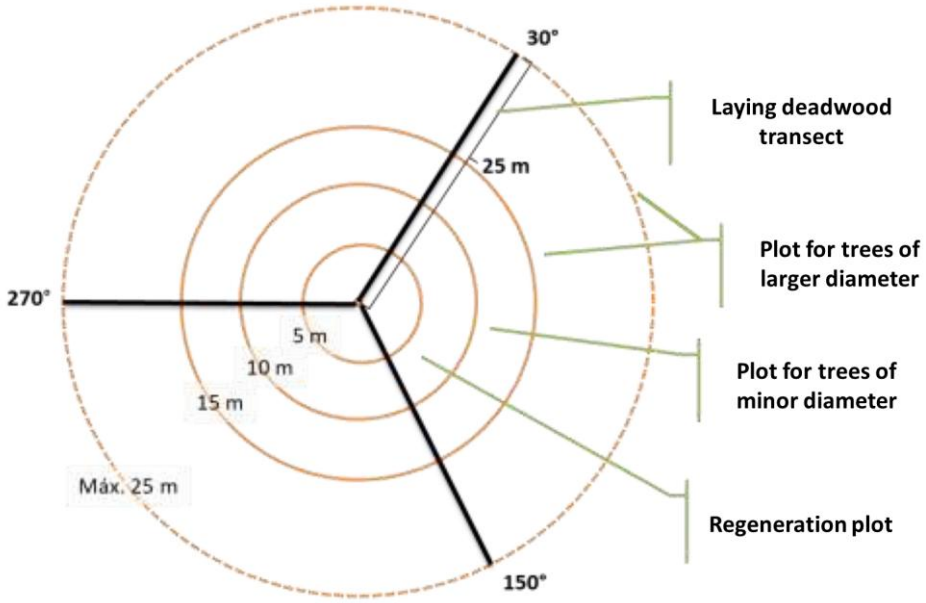
Sampling effort

Fixed radius (m)	Sampling plot surface (m^2)	Stand surface (ha) Number of sampling plots				
		<1	1-5	5-25	25-50	50-100
15	707	2	4	5	6	7
20	1257	1	2	4	5	6
25	1963	1	2	3	4	5

For stands larger than 100 hectares, one sampling plot is added for every additional 50 hectares.

Size of sampling plot

It is proposed to sample in fixed, but variable radius plots, to include in each sampling plot a minimum number of large trees to be measured. Be sure to sample **at least 15 living trees with a diameter at breast height (DBH) ≥ 17.5 cm**. It may be necessary to adjust the plot size if the number of living trees does not reach the minimum number of 15 at the end of the sampling. The measurement of the trees is what defines the plot size.



Shape

Circular, square or rectangular, with field correction according to slope. If no field correction is made, then measure the maximum slope and indicate that no correction has been made.

- **Circular**: mark the centre, record the coordinates of the centre, measure the radius with the hypsometer, which already includes the slope correction
- **Rectangular/square**: alternative for larger sampling plots, but more laborious to mark and correct the slope.

Stand fieldsheet

The variables obtained directly at the stand scale and those resulting from the aggregation of the sampling plot data are collected in this fieldsheet, so that the stand fieldsheet is a summary of the information from all the sampling plots.

General stand data

What to record

- Sensitive data: tick if you consider that the data should not be disclosed
- Name: name of the stand or site where it is located, and which uniquely identifies it
- Region/Province/Municipality
- Owner: if public, indicate the managing body

Sampling data

What to record

- Date
- Surveyors

Habitat

What to record

- Corine: Indication of forest habitat type according to CORINE coding. Indicate code and habitat name.
- Community interest: Enter the code and name of the habitat of Community interest. Enter the 4-digit code corresponding to the habitat type of Directive 92/43/EEC. In the case of a mixed stand, this must be specified in the comments section. In the case of a priority habitat, an asterisk (*) must be entered at the end of the code.
- Biogeographical region: Please refer to the map proposed within the DH [Biogeographical regions in Europe - EEA (europa.eu)]

EVALUACIÓN DE LA NATURALIDAD DE RODALES DE REFERENCIA
Fase II – Identificación mediante parcelas | Versión 2024

FICHA DE RODAL

RODAL | Datos restringidos: indicar si los datos no susceptibles de ser publicados con precisión. | **Nombre:** nombre representativo del rodal. | **Comunidad autónoma, provincia y termino municipal:** dónde se encuentra el rodal. | **Propietario:** organismo o administración propietaria. No indicar en caso de propiedad privada

☐ **Datos restringidos**	**Nombre:**
Comunidad autónoma:	**Provincia:**
Termino municipal:	**Propietario:**

MUESTREO | Fecha: fecha de muestreo. | **Equipo**: nombre del personal que desarrolla (o al menos el responsable del equipo de campo).

Fecha _ _ /_ _ /_ _ _ _	**Equipo**

HÁBITAT | CORINE/LPEHT: código y/o nombre del hábitat según la clasificación CORINE y de acuerdo con la lista preestablecida. | **Interés comunitario** (HIC)**:** código y/o nombre del hábitat de interés comunitario al que corresponde. | **Región biogeográfica:** indicar a que región corresponde según su localización geográfica. || **Especie arbórea principal y acompañante (acompañ.)** ⇒ **Especie:** código y/o nombre de la especie arbórea principal (en FCC) y la primera acompañante del dosel del rodal. | **FCC:** fracción de cabida cubierta del conjunto del rodal, en %. | **Ho:** altura dominante media en las parcelas, en metros.

CORINE/LPEHT código/nombre 4 __.__ __ __							
Interés comunitario (HIC) código/nombre 9 __ __ __							
Región biogeográfica	☐ Alpina	☐ Atlántica		☐ Mediterránea		☐ Macaronésica	
Especie arbórea principal	**Especie** código/nombre	**FCC** %	**Ho** m	**Especie arbórea acomp.**	**Especie** código/nombre	**FCC** %	**Ho** m

Indicators

In this section of the stand fieldsheet, the data for obtaining the maturity and anthropogenic use indicators from the sampling plots, and their corresponding aggregate value for the stand under each of the assigned and numbered cells of the sampling plots, will be given. These are in turn grouped into the following maturity criteria: composition, structural complexity, senescence, microhabitat and dynamics; and anthropogenic use: past and recent.

This section of the sheet is completed once plot data is available. The description of this block is developed in the 'Naturalness Index' chapter. In this chapter, each indicator is described by explaining its rationale, the source of the data, how its value for the stand is determined, as an aggregate form of plot data (if applicable), and how it was calculated and normalized.

INDICADORES | Anotación de los valores de los indicadores, calculadas o directas, por parcela y/o rodal. | **Parcela** ⇒ Dato del indicador para cada parcela. | **Agreg.:** forma de agregación de los datos de parcela en el rodal. | **Rodal:** Dato resultante de rodal. | **CP: composición, CE: complexidad estructural, SE: senectud, MH: microhábitats, DN: dinámica, HH: huella humana.**

Indicador ⇓		Parcela ⇒	1	2	3	4	5	6	7	8	9	10	Agreg.	Rodal
MADUREZ	CP	Especies arbóreas n											*Difer*	
	CE	Área basal m²/ha											*Media*	
		Volumen de árboles m³/ha											*Máx.*	
		Clases diamétriques n											*Difer.*	
		Estratos verticales n											*Media*	
	SE	Arboles excepcionales n/ha											*Media*	
		Volumen de MM en pie m³/ha											*Máx.*	
		Volumen de MM en suelo m³/ha											*Máx.*	
		Abundancia de MM m³/ha											*Máx.*	
		Proporción de MM %											*Máx.*	
	MH	Dendromicrohábitats n											*Difer.*	
	DN	Fases silvogenéticas valor											*Valor*	

HH									
	ANTIGUA		Rodal	RECIENTE		Rodal	Actividad cinegética valor máximo		
	Continuidad temporal valor	*Valor*		Usos forestales valor	*Máx.*		Herbivoría i/o ramoneo valor	*Valor*	
	Usos agropastorales valor	*Máx.*		Especies invasores valor	*Valor*		Frecuentación valor	*Máx.*	
	Usos forestales valor	*Media*		Causas de fragmentación valor	*Máx.*		Durabilidad de los usos valor	Mín.	

Not all the elements listed in the table are indicators as such. The 'Volume of trees', 'Volume of standing dead wood (MM)' and 'Volume of laying dead wood' are indicators that are used in the construction of other simple indicators, but do not enter directly into the construction (aggregation) of the naturalness index. These are also explained in the chapter on indicators.

What to record

- Samplig plot (*Parcela*): field data for each indicator and variable, calculated if necessary, for each sampling plot
- Stand (*Rodal*): stand data for each indicator and variable, calculated if necessary from the plot data aggregation function, or directly, if it is the stand value.

Additional information

What to record

- Other relevant species: relevant species because they are exotic, protected, threatened, important to the community
- Habitats of community interest: Please complete the list of habitats of community interest, whether forest habitat or not.
- Other relevant information: lithology, soils (according to USDA classification), climate (mean annual temperature in degrees, mean annual precipitation potential evapotranspiration in mm), bioclimatic plan
- Attachments: stand plan, at least on a scale of 1:25,000, and an orthophoto of the stand with the most recent possible information, descriptive photographs of the stand.

Tree species

What to record

- Tree species: code and/or name of the tree species is noted.

Silvogenetic phases

What to record

- Presence: Indicate which phases of the silvogenetic cycle are present in the stand. For the collapsing and regeneration phases, it is important to determine whether their origin is natural or artificial, due to silvicultural actions. The presence of each phase must be noted provided that the area occupied is at least 200 m^2, except for the regeneration phase, which may be smaller, minimum 100 m^2. The value of the indicator is the sum of the values in [] (square brackets) corresponding to the different phases noted in the stand to be used for normalizing the indicator.

FASES SILVOGENÉTICAS | Fase: tipos de fase del ciclo silvogenético. Para considerar que está presente una fase es necesario que ésta ocupe al menos 200 m^2, excepto los claros y regeneración. Éstas pueden medir 100 m^2, y hay que diferenciar si el origen es natural (**N**) o de corta (**C**). | **Pres.:** presencia de la fase en el rodal.

Claros: FCC de A < 30%, R < 50%, restos de MM de etapas anteriores. / **Regeneración (Reg.)**: FCC de A < 30%, R > 50%, restos de MM de etapas anteriores / **Ocupación**: ≈ latizal; FCC de A > 30%, Dn < 20 cm, restos de MM de fases anteriores y nueva de pequeñas dimensiones. / **Exclusión**: FCC de A > 30%; a) ≈ fustal bajo, 20 < Dn ≤ 30-35 cm; b) ≈ fustal medio, 30-35 < Dn ≤ 40-50 cm; c) ≈ fustal alto, Dn > 40-50 cm; MM < 25%. / **Maduración**: FCC de A > 30%, Dn > 40-50 cm, Ho > 85% Hmax, MM < 25%. / **Senescencia**: 30% < FCC de A < 65%, Dn > 20 cm, Ho > 85% Hmax, MM > 25%. / *A: arbolado; R: regeneración; FCC: fracción de cabida cubierta; MM: madera muerta; Ho: altura dominante; Hmax: altura máxima, Dn: diámetro normal.*

Fase								
Pres.	☐ Claros N [2]	☐ Claros C [0]	☐ Reg. N [1]	☐ Reg. C [0]	☐ Ocupación [1]	☐ Exclusión [2]	☐ Maduración [3]	☐ Senescencia [4]

Phase	Forest	Regeneration	Deadwood
Collapse	FCC <30%	FCC <50%	Residues of the previous phase
Regeneration	<30%	FCC >50%	Residues of the previous phase
Occupation	FCC >30%; Dn <20 cm		Residues of the previous phase and new deadwood of small dimension
Exclusion	a) **Early phase** FCC >30%; 20 < Dn ≤ 30-35 cm b) **Medium phase** FCC >30%; 30-35 < Dn ≤ 40-50 cm c) **Late phase** FCC >30%; Dn > 40-50 cm		Remain < 25% of total deadwood
Maturity	FCC >30% Dn > 40-50 cm Ho > 85% Hmax		Remain < 25% of total deadwood
Senescence	30% < FCC < 65% Dn > 20 cm Ho > 85% Hmax		Remain < 25% of total deadwood

FCC is the fraction of area covered

Dn is the dominant mean DBH

Past human footprint

This section of the stand's fieldsheet indicates the elements and/or traces of old utilisations of the stand (eg, Italy: before 1954-55, GAI flight; Spain: before 1956-57, American flight), mainly centered on forest, agricultural and livestock activities. The temporal continuity of the forest is surveyed in the office with the help of reference and thematic cartography, while the rest is surveyed in the field.

What to record

- Temporal continuity: the percentage (according to the proposed occupancy scale) of tree cover in the stand estimated from orthophotographs (eg, Italy: before 1954-55, GAI flight; Spain: before 1956-57, American flight).
- Agro-pastoral uses: Traces and indications of agropastoral use of the stand prior to 1956 shall be recorded, in most cases by the presence of signs (such as old bridle paths, walls, terraced areas, shelters, ruins, debris, pasture trees), or in other cases due to the probability that agro pastoral use took place and if it is certain that it is prior to 1956. In case of strong presumption of use without field confirmation note 'No signs, but probable use'. The case 'No use' shall only be noted in case there is a corroborating historical record. The location by photo-interpretation of the 1956 aerial photographs can be of great help to complement the field observations.
- Past forest uses: there are also traces of old logging, prior to the mid-20th century (mainly felling of timber, firewood and resinous trees). Unmistakable signs are a rough forest structure (stumps with shoots), the presence of resinous trees, cork oaks with old decortication marks. If no signs are seen, note 'No sign, but probable'. Only if there is confirmation from some historical document, note 'No use'.

Recent human footprint

This section of the stand's fieldsheet indicates the elements and/or traces of recent utilisations of the stand (e.g. Italy: after 1954-55, GAI flight; Spain: after 1956-57, American flight), mainly focused on forestry, agricultural, livestock and management activities. More modern activities related to the establishment of invasive species, fragmentation, hunting activity, tourist use and the legal nature of their protection status are also identified. Typical signs or evidence for identification are proposed for each use, the most common to be identified. The duration of the uses, linked to their current legal protection status, is recorded in the office with the help of references and thematic mapping, while the others are surveyed in the field.

What to record

- Recent forest uses: <u>Timber and/or firewood harvesting</u>: the number of years since the last harvest must be recorded. The exact date of the last cut can be obtained from the management plan or by consulting an expert. An estimate based on the age of the stumps can also be attempted. <u>Stump density</u>: if stumps exist, estimate their number per hectare. A quick estimate of stump density per hectare can be obtained by calculating the average distance between stumps per hectare. This can be obtained by calculating the average distance between 2 stumps from different measurements. The number of stumps for coppice is counted from a minimum diameter of 7.5 cm and from 17.5 cm for high forests.
- Invasive species: Fraction of tree canopy cover (FCC in %) occupied by invasive species. Neophyte species are those introduced after 1500, when world trade intensified (and have continued to grow since then). Nor should we forget the active policies of introducing exotic tree species at various times in more recent history (19th and 20th centuries), such as *Pseudotsuga menziesii, Robinia pseudoacacia, Ailanthus altissima, Eucalyptus, Pinus radiata*, ecc.)

- Causes of fragmentation: fragmentation and its impact on biodiversity and ecosystem functioning are assessed by analyzing the type of use causing the fragmentation. A stand is considered fragmented and isolated when the logging distance around its periphery is more than 100 m. In the office, based on recent orthophotography, the type of fragmentation around the study area is assessed. If there are several types of fragmentation, the minimum value will be assigned, on the understanding that, whatever the type, any species will be able to move through the most permeable area.
- Hunting activities: the intensity of hunting practices is assessed according to the different types and signs of hunting activities. Signs of punctual activity refer to the presence of used cartridges on the ground, marker boards (hunting reserve), hunting area, hunting licenses, etc.; permanent hunting infrastructure refers to lookouts, feeders, hunting posts.
- Grazing herbivores: it is assessed through signs of herbaceous consumption and damage caused by the grazing of young trees (regeneration), the debarking of older trees or indirect damage caused by soil disturbance by ungulates.
- Frequentation: the data measure the potential pressure of use based on the ease of access as measured by the distance to roads and the degree of knowledge of the access route. A 'known path' corresponds to those that are signposted and integrated into path networks for the promotion of hiking. The category 'road over 100' m refers to a road that is passable by car and open to the public.
- Duration of use: Indirectly measured by the protection category according to the IUCN classification, which estimates the degree of protection and ultimately the likelihood of change in use.

Sampling plot fieldsheet

For plot detection, it will be necessary to have a fieldsheet for each plot. A detailed description of how to collect information in sampling plots is given below.

General sampling plot data

Sampling data

What to record

- Date
- Surveyors

Trees

All living or dead trees with a DBH ≥ 17.5 cm should be measured. Larger standing dead trees may be whole, with branches or without branches, with or without crown, rooted, even partially in the ground, and generally standing. Otherwise, it is considered laying dead wood. Stumps and snags are also included, provided they are ≥ 1.30 m high.

Sampling is carried out completely within the plot radius, according to the sampling methodology for living trees. It is advisable to sample living trees at the same time as standing dead trees and to use the same numbering. Suckers from the same stump or bifurcated trees below 1.3 m are considered separately. The criterion used to determine whether or not a tree falls within the plot is the position of the center of the tree at the height of its diameter measurement. For this it is necessary to set the horizontal distance of the plot size as the reference distance, and not the distance following the slope.

The methodology is as follows:

1. Make an approximate count of the 15 to 20 living trees with a diameter greater than or equal to that of the reference tree and closest to the center of the plot, to determine the value of the radius (or

side, depending on shape) of the sampling plot. This radius, in circular plots, must be between 15 and 25 m. If the required minimum number of trees is not reached, the sampling radius must be increased until the required sample size is reached;

2. Measure for each tree with a DBH ≥ 17.5 cm, the distance from the center of the plot to determine whether or not it falls to the plot and therefore whether it should be measured. Correct all measurements on the basis of the horizontal distance from the center of the plot if they are taken following the slope. Use the center point of the stem at diameter height (130 cm) to determine whether or not the tree falls within the plot;
3. Measure and record all stand attributes.

If at the end of the living tree sampling the number of 15-20 trees has not been reached, the sampling size should be increased until the required number of trees is reached. To obtain plot structure indicators, the best option is to measure all tree heights. This simplifies subsequent calculations because it is not necessary to directly determine the height of unmeasured trees. And finally, the value of the dominant height can be obtained easily.

What to record

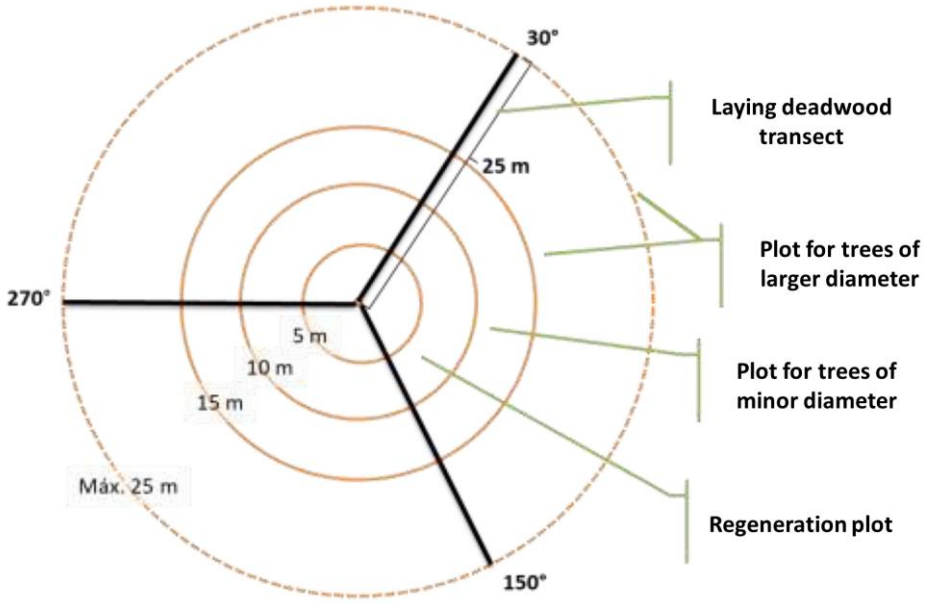
- Plot radius
- Tree: Identification number (both living and standing dead trees)
- Distance (Dist.) *optional: Distance between tree and plot center, in meters
- Orientation *optional: Orientation north of tree from plot center, in degrees
- Species: code assigned to the tree species
- Tree type: Assign the code to indicate the tree category, whether it is a whole tree, a pole or a stump. This classification will depend on whether or not the tree is broken and the height to which it is broken. This is necessary in order to be able to calculate the volume of the stand differently from how it is done for whole trees. The categories are as follows:
    - A = Tree: whole tree. H > 130 cm; DBH > 17.5 cm
    - S = Snag: tree without top part due to natural breakage. H > 130 cm; DBH > 17.5 cm
- Living (V/M): Assignment of tree vitality status. Living trees (V) have sufficient foliage to remain alive (have a living gearbox). Otherwise they are dead (M)
- DBH (Dn in the sheet): Diameter at 130 cm (with an approximation of 0,1 cm)
- Height (H)
- Tree microhabitats: No. of tree microhabitats, for each type, found in each tree. The classification refers to Larrieu et al., 2018.

Regeneration and trees of minor diameter

What to record

- Seedlings: seedlings are counted and measured in a subplot concentric to the central point of the sampling plot (subplot of 5 m radius). The seedlings to be measured are those with H > 30 cm, and diameter < 2.5 cm
- Advanced regeneration: Advanced regeneration is counted and measured in a portion of the plot concentric to the central point (subplot of 5 m radius). Trees to be measured are those with diameters between 2.5 and 7.5 cm
- Diameter class 10 (DC 10): all trees of diameter class 10 (between 7.5 and 12.5 cm in diameter) are counted and measured in a subplot concentric to the central point of the sampling plot (subplot of 10 m radius).

- Diameter class 15 (DC 15): All trees in diameter class 15 (with dimensions between 12.5 and 17.5 cm in diameter) are counted and measured in a subplot concentric to the central point of the sampling plot (subplot of 10 m radius).



Laying deadwood

The aim is to determine the volume of medium/large laying deadwood or Coarse Woody Debris (CWD), by decay class and size.

Laying deadwood is considered to be whole trees or parts thereof, above ground, at any stage of decay, with a diameter greater than 17.5 cm (or equivalent cross-section) at the point of intersection with the central axis of the sampling transect, not 'standing' and uprooted. Dead but rooted trees and trunks are considered 'standing' and are part of the larger category of standing deadwood, which is measured in the 'Trees' section.

Deadwood includes:

- all pieces, including thick branches, at least 17.5 cm in diameter (or an equivalent area of 44.2 cm^2 measured perpendicular to their length in pieces of irregular shape at the intersection with the transect) where their central axis intersects with the vertical projection of the transect (Figure)
- pieces of deadwood laying on nearby living or dead trees, other pieces, with or without roots, that intersect with the vertical projection of the transect, either above or below.
- stumps of dead trees on the ground or suspended, with or without roots, but uprooted;
- trees on the ground that still have green foliage, but no roots in the ground to keep the stem alive,
- rootless cuttings over 17,5 cm in diameter at the crossing point and any roots over 17,5 cm in diameter at the crossing point with the transect
- broken tops of fallen trees in a horizontal or leaning position, or large branches;
- freshly cut logs.

Deadwood does not include:

- dead branches still attached to standing trees;
- stumps still standing;
- exposed tree roots;
- living or dead (rooted) trees that remain standing;

- "Ghost" deadwood: material that is buried in organic or mineral soil layers or has decomposed sufficiently to form part of the forest soil (it is more decomposed Class 5 material). The distinguishing characteristics of 'ghost' deadwood are: the wood is soft throughout the piece, breaks easily in the hand and is sufficiently decomposed to be considered organic soil material; the piece is well buried and covered with moss and leaf litter, just above the forest floor level.

Laying deadwood will be measured in 3 radial 25m long transects, from the centre plot, but discarding the first metre from the centre (in total 24m x 3 = 72 m) separated by 120° angles, placing the first transect at 30° north. The second and third transects will be at 150° and 270° respectively. Several transects of equal length may be added if there is a shortage of dead wood on the ground, in directions such that the angles between transects are equal. For square/rectangular areas, parallel transects can be placed, always separated by the same distance and covering a large part of the sampling area. The slope of each transect must be measured so that the transect length horizontally is 25 m.

If transects pass through very abundant accumulations of deadwood such as those produced by landslides, windstorms, piles, etc., the wood will be measured in parts of the transects in alternating sections. When, for safety reasons, precise measurements are not possible, it will be necessary to make a rough estimate of the number of pieces and their diameters.

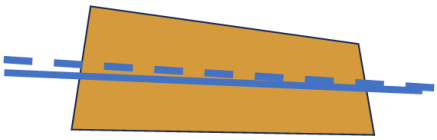
The protocol is as follows:

1. Identify the first transect of the plot, following the azimuth of 30° from the center of the plot relative to the sampling of the largest trees.
2. Measure the distance of 25 m from the center of the plot and, if necessary, correct the distance according to the slope.
3. Attach the ends of the tape measure.
4. Identify the second transect at azimuth 150° and the third at azimuth 270° following the same procedure.
5. Start sampling at a distance of one meter from the center of the plot.
6. Walk through the first transect and select the deadwood pieces to be measured that have a diameter of at least 17.5 cm at the point of intersection with the transect. Take care not to step on or crush the deadwood.
7. For each deadwood element that meets the definition, record the corresponding attributes.
8. If for some reason the entire transect cannot be sampled, the sampled horizontal distance must be measured and the reason noted.

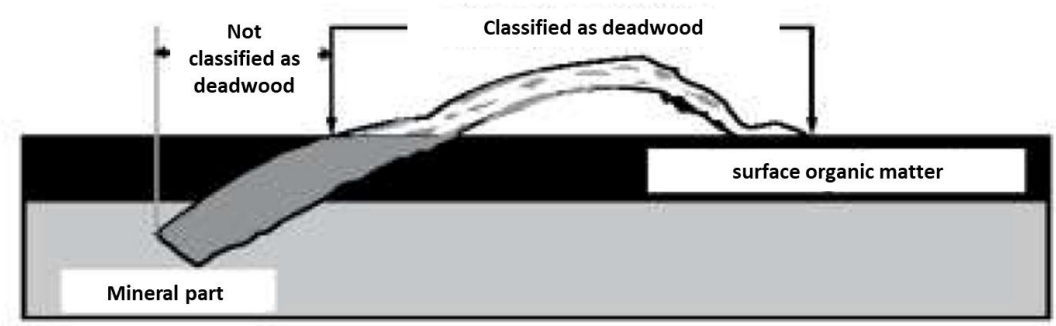
Some rules to keep in mind when considering whether to sample a piece of deadwood are as follows:

- ➔ if the transect intersects some deadwood, the portion of the piece that is above the ground at the point of intersection must be measured. Some parts of the deadwood may be suspended above the transect. If measurement is not possible, proceed with an estimate of the deadwood suspended at the crossing point.
- ➔ deadwood must be greater than 17.5 cm in diameter (or equivalent) at the point of intersection with the transect.
- ➔ if the transect almost coincides with the center axis of the part, it is necessary to decide whether the transect crosses the axis of the part and where, and to measure the diameter at the point where both lines intersect (figure below).

Transect (full line) near the centre axis of the piece (dotted line)
(view from above)



➔ Only deadwood that protrudes above the ground counts. A piece is not above ground when it is buried by a layer of organic or mineral matter. The equivalent diameter must be estimated based on the portion of the piece that remains when part of the wood has detached and is on the ground



➔ Accumulations of cut logs are sampled, even if the material is later removed.

What to record

- Species: Record the code assigned to the species, both native and naturalized and cultivated (code taken from the European Flora).
- Diameter: Record the diameter of the deadwood perpendicular to its length at the point of intersection with the transect. Use the tree diameter tape, or in case of difficulty in measuring, tree caliper. Measure the diameter (or equivalent) to the nearest 0.1 cm. If the piece is hollow inside, retaining part of the outermost wood, estimate the equivalent diameter required to approximate it to the volume of the remaining wood. If a piece crosses the transect more than once, measure each intersection as a separate record. If the diameter cannot be measured, it is estimated.
- Inclination: It refers to the angle of the individual log with respect to the horizontal, regardless of the slope of the terrain. The angle of the log with respect to the horizontal (in degrees) is measured with a clinometer placed on the surface of the piece at the point of intersection with the transect.

Vertical layers

The vertical stratification of the sampling plot must be measured in an area of 15 m radius, which is the minimum size of the tree measurement area, and concentric to it, indicating which layers of tree species are present, including undergrowth and regeneration. For this purpose, the total height of the vertical profile must be imaginatively divided into four equal parts, indicating how many of them are occupied by foliage, even of the same trees. The total height is the dominant height of the species occupying the upper canopy. The lower layers contain any tree species, regardless of its stage of development.

What to record

- Presence: Each layer is only counted if its fraction of area covered is at least 20% of the total area. In some cases, it may be the case that an additional emergent stratum has to be taken into account that corresponds to relatively isolated stands that exceed the dominant tree cover (e.g. mixed forests with scattered and isolated stands of Aleppo pine above a dominant holm oak forest below)

- 1) 0≤H<¼: from the ground to a quarter of the dominant height,
- 2) ¼≤H<½: from a quarter to half of the dominant height,
- 3) ½≤H<¾: from half to three quarters of the dominant height,
- 4) ¾≤H<Ho: from three quarters of the dominant height,
- 5) H emerg. >Ho: crowns that exceed the dominant height.

Summary of the procedure

Sampling can be carried out by two people, but three are recommended. The sequence of field sampling steps using plots is as follows:

1. **Complete reconnaissance and sampling of the stand**, in which locations are chosen for plot placement:
   a. visit the entire stand, so that you can choose the areas with the greatest maturity. If the stand is small, examine it all.
   b. if the stand is very heterogeneous and different aspects of maturity can be distinguished (e.g. in one area there is abundant deadwood and in another there are very mature trees with microhabitats or trees of exceptional diameter), separate it into several stands and fill in as many fieldsheets as there are different stands identified.
   c. identify or correct stand boundaries
   d. collect general stand data and those relating to tree species, silvogenetic cycle phases, human footprint..., and take representative photographs. Use the field sheet for the stand (except the 'indicators' section).
2. **Plot sampling and related data collection**:
   a. determine the number of plots, based on the area of the stand, and the size of each one, based on the number of living trees.
   b. data collection in each plot (trees, abundance of standing and laying deadwood, microhabitat, regeneration and vertical layers). Use the field sheet for the sampling plot.
3. **Calculation of indicators**: processing of data at plot level to obtain an aggregate value representative of the entire stand. Use of the 'indicators' section of the field sheets for the stand.

Necessary material

- Fieldsheets and field manual, folder, pencil…
- Spare batteries and charged batteries, for instruments that require them.
- GPS, or mobile phone with application and corresponding detailed cartography (topographic and orthophotographic is also recommended) for delimiting and surveying the coordinates of the stand.
- Paper maps of the stand on a detailed scale (at least 1:1,000) topographical and orthophotographic if not available in digital format.
- Digital distance meter type Haglof Vertex IV. This makes it possible to measure whether trees, dead or alive, enter the ground and the dominant height of the crown.
- Clinometer or mobile application, to measure the dominant height (and if a distance meter is not available).
- Tree diameter tape, or tree caliper, to measure diameters.
- Metric tape measure, at least 25-30 m, for developing transects of laying deadwood.
- Camera or mobile phone.

INDEX OF NATURALNESS

The naturalness of a stand is assessed on the basis of **3 different domains**: maturity, human footprint and spatial integrity. Each of these is quantified through a series of objective **indicators (grouped into criteria)**, which allow their systematic application on the territory for the identification of stands in the field.

Therefore, for the quantitative assessment of stand naturalness, a **composite indicator** has been developed based on the selection and combination of a set of variables that provide information on the properties of the forest stand to be assessed (indicators), organizing them hierarchically into domains and criteria and finally arriving at a grouped or synthetic value by means of a weighting method.

Maturity indicators

It is assessed with indicators based on structural attributes associated with natural dynamic processes and the age of the stand.

Composition criterion

This criterion is measured by a single indicator that reports the diversity of tree species present in the stand. This criterion includes the variable 'volume of trees', which is used to calculate the percentage of deadwood (senescence criterion), but is not an indicator as such.

Tree species: Number of native tree species

- Calculation: This is the value of the species count in the stand.
- Normalization: Linear with thresholds

Structural complexity criterion

This criterion is measured by three indicators reporting different aspects of the vertical and horizontal distribution of the forest.

Basal area: Basal area of larger native tree species

- Calculation: the following formula is used for the calculation

$$\text{AB } (m^2/ha) = \sum_{i=1}^{n} \pi \cdot \left(\frac{Dn_i}{2}\right)^2 \cdot Eq$$

where Dn is the DBH of the stand (in m), and Eq is the factor to change the plot area to the value per hectare.

Plot radius (m)	10	15	20	25
Surface (m2)	314,15	706,86	1256,64	1963,49
Eq	31,83	14,15	7,96	5,09

To calculate the various indicators, it is necessary to transform the data obtained in the plot into area values, in hectares. For this purpose, the best method is to multiply by a parameter, an equivalence of the value according to the sampled plot, which transforms the data into values relative to the hectare. The table shows the Eq values for various radii (if circular) or sides (if square) of the plot. When the tree diameter is measured with two calipers, it is calculated from the arithmetic mean of

the two measured diameters. The value for the stand will be the average value of the data over the basal area of the plots.

- Normalization: Linear with thresholds

Volume of living trees: volume of living native tree species

- It is not a true indicator and is used to calculate the indicator 'Proportion of deadwood'.
- Calculation: the total volume of living trees is as follows, where Dn is the DBH (in m), Ht is the tree height (in m), up to the tip if it is a whole tree (tree type A) or up to the fragmentation point if it is a stump (tree type E), Kf is the shape coefficient (different depending on whether it is type A or E) and Eq is the equivalent value for calculating the reference to the hectare of land from the plot data (see criterion 'basal area').

$$\text{VCC}\ (m^3/ha) = \sum_{i=1}^{n} \pi \cdot \left(\frac{Dn_i}{2}\right)^2 \cdot Ht \cdot Kf \ \cdot Eq$$

The shape coefficient is the ratio between the volume of a cylinder of equal height and radius and the volume of a cone of the same dimensions. The value of 0.441 can be used for whole, type A trees. For trees with a broken top (type E), the volume is estimated by measuring their DBH and estimating or measuring their height, and applying a shape coefficient of 0.8. The value for the stand is the maximum value among the plot tree volume data.

- Normalization: not necessary, it's not an indicator

Diametric Classes: Number of distinct diametric classes of the largest living trees of any native tree species

- Calculation: The data for the plot is the number of distinct diametric classes detected in the whole plot
- Normalization: Linear with thresholds

Vertical layers: Number of vertical layers occupied by tree vegetation

- Calculation: direct count of the tree layers in the plot, which fulfill the stratification criteria. The value for the stand is the mean value of the data from the plot vertical layers.
- Normalization: Linear with thresholds.

Senescence criterion

This criterion is measured by three indicators reporting different aspects peculiar to the more mature stages of the natural forest cycle. This criterion includes the variables 'standing dead trees' and 'laying deadwood', which are used for the calculation of 'deadwood abundance', but are not indicators as such.

Exceptionally large trees: density of exceptionally large living trees.

- Calculation: The value for each plot will be the sum of the density of exceptional trees of any species in relation to the hectare, where n_{De} is the number of trees of exceptional diameter (De) and Eq is the equivalent value for the calculation in relation to the hectare (same table reported for "Basal Area). The value for the stand will be the average value of the exceptional tree data of the plots.

$$AE\ (pies/ha) = n_{De} \cdot Eq$$

- Normalization: Linear with thresholds

Volume of standing dead trees: volume of standing dead trees of medium and large size.

- Calculation: The calculation of the volume of standing dead trees is similar to the calculation of the volume of living trees (see indicator 'Volume of living trees'). Take into account the shape coefficient according to the type of tree (whole tree or snag) (A and E, respectively). The value for the stand is the maximum value of the standing deadwood data of all plots.
- Normalization: not necessary, it's not an indicator

Volume of laying deadwood: volume of laying deadwood of medium and large size.

- Calculation: If the area to be represented is one hectare (10,000 m^2) and 3 transects of 24 m whose total sum is 72 m, the equation of the volume per hectare is simplified as follows, where MM means Laying Deadwood, Dt is the diameter of the part at the point of intersection with the transect (in cm) and In is the inclination of the part on the ground:

$$MMs(m^3/ha) = 0{,}017 \cdot \sum_{j=1} \frac{Dt_j^2}{cosIn_j}$$

The presence of this angle in the formula is due to the fact that, if the part is not in a position in the horizontal plane, its actual projected length must be calculated from the multiplication with the cosine of the inclination at which the part lies with respect to the horizontal. And when 6 transects are made instead of 3:

$$MMs(m^3/ha) = 0{,}0085 \cdot \sum_{j=1} \frac{Dt_j^2}{cosIn_j}$$

This formula is derived from Marshall, Davis & LeMay, 2000. The value for the stand is the maximum value of deadwood for all plots

- Normalization: Linear with thresholds

Abundance of deadwood: Total volume of medium and large standing and laying deadwood

- Calculation: The value for each plot is the sum of the volume of standing laying deadwood. The value for the stand is the maximum value of the total deadwood data of all plots.
- Normalization: Linear with thresholds

Proportion of deadwood: Ratio of the total volume of deadwood (standing and laying) to the volume of living trees.

- Calculation: The way to calculate the deadwood ratio is the total volume of deadwood divided by the volume of living trees, both in m^3/ha. The value for the stand will be the maximum value among the deadwood ratio data of all plots.
- Normalization: Linear with thresholds.

Tree microhabitat criterion

This criterion is measured by an indicator showing the characteristic habitats of mature trees and the associated biodiversity, unique for each stage.

Trees microhabitat: Number of distinct tree microhabitats present on living trees.

- Calculation: The measurement of microhabitats on living trees will be expressed as the number of microhabitats of the 10 types proposed in Kraus et al. (2016)[2] (classification of 10 types) in the entire stand. This classification is slightly different from that proposed for field sampling (Larrieu et al. 2018)[3] (classification of 15 types). To be counted, a tree microhabitat type must be found on at least 2 trees in the plot. Note that if a stand has 2 different microhabitat types, it must be recorded twice in the corresponding boxes. The calculation for the stand must be expressed as the number of distinct types recorded among all plots of values for each plot.
- Normalization: Linear with thresholds.

Dynamic criterion

Silvogenetic phases: Phases of the silvogenetic cycle present in the stand

- Calculation: Sum of the values, from 0 to 4, assigned to each phase of the silvogenetic cycle. The data is directly the value of the stand.
- Normalization: A value is associated with each phase of the silvogenetic cycle, so that the presence of all phases takes on a value of 10.

[2] KRAUS, D., BÜTLER, R., KRUMM, F., LACHAT, T., LARRIEU, L., MERGNER, U., PAILLET, Y., RYDVIST, T., SCHUCK, A. WINTER, S., 2016. Catalogue of tree microhabitats - Reference field list. . S.l.:

[3] LARRIEU, L., PAILLET, Y., WINTER, S., BÜTLER, R., KRAUS, D., KRUMM, F., LACHAT, T., MICHEL, A.K., REGNERY, B. y VANDEKERKHOVE, K., 2018. Tree related microhabitats in temperate and Mediterranean European forests: A hierarchical typology for inventory standardization. Ecological Indicators, vol. 84, no. October, ISSN 1470160X. DOI 10.1016/j.ecolind.2017.08.051. Disponible en: http://dx.doi.org/10.1016/j.ecolind.2017.08.051.

Human footprint indicators

The incidence of human activity in the stand, both past and recent, is assessed. The basic premise for assessing the maturity of a given forest or stand is that two requirements must be met: that the stand has always been a forest, or at least since historical times, and that there has been no cutting for a sufficient period of time to recover the ecological processes associated with maturity. In contrast, in relation to the other assessment areas, these indicators assess anthropogenic use, the more recent and intense the more distant from the natural state.

Past human footprint criterion

It groups together indicators of signs of anthropogenic land use before the 1950s.

Temporal continuity: Proportion of tree cover in the 1950s

- Calculation: The indicator value must be reported as the percentage of tree cover in the categories 0-10, 11-25, 26-50, 51-75, 75-90 and 91-100. Only one option can be selected.
- Normalization: Classification of cover categories in values from 0 to 10. Section 'Past anthropic use' of the stand fieldsheet.

Agropastoral uses: Intensity of agro-pastoral uses before the 1950s.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Past anthropogenic use' section of the stand fieldsheet. Only one option 'Possibilities' and one option 'Signs of' can be selected.
- Normalization: Ranking of the 'Possibility' and 'Signs of' categories in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Past forest uses: Intensity of forest uses before the 1950s.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Past anthropogenic use' section of the stand fieldsheet. Only one option 'Possibilities' and one option 'Signs of' can be selected.
- Normalization: Ranking of the 'Possibility' and 'Signs of' categories in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Recent human footprint criterion

It groups together indicators of signs of anthropogenic land use after the 1950s and is easy to identify through field observation.

Recent forest uses: Intensity of forest uses after the 1950s.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Recent anthropogenic use' section of the stand fieldsheet. Only one option for each section of the indicator can be selected.
- Normalization: Ranking of the categories 'Years since last cut' and 'Stump density' in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Invasive species: Relative abundance of tree crowns occupied by alien and invasive or potentially invasive tree species.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Recent anthropogenic use' section of the stand fieldsheet. Only one option can be selected.
- Normalization: Ranking of the categories 'Abundance' in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Causes of fragmentation: Degree of fragmentation according to the type of use or type of cover in the stand or its immediate perimeter.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Recent anthropogenic use' section of the stand fieldsheet. As many options can be selected as are recognised in the stand.
- Normalization: Ranking of the categories 'Causes of fragmentation' in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Hunting activities: Intensity of hunting practices according to different types and signs of activity.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Recent anthropogenic use' section of the stand fieldsheet. As many options can be selected as are recognised in the stand.
- Normalization: Ranking of the categories 'Evidences of hunting activities' in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Grazing herbivores: Impact of grazing damage by wild or domestic animals on woody vegetation and soil.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Recent anthropogenic use' section of the stand fieldsheet. Only one option for each section of the indicator can be selected.
- Normalization: Ranking of the categories 'Evidences of grazing' in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Frequentation: Measure of human use calculated on the basis of accessibility by distance from roads and degree of knowledge of the access route.

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Recent anthropogenic use' section of the stand fieldsheet. Only one option for each section of the indicator can be selected.
- Normalization: Ranking of the categories 'distance from roads and paths' in values from 0 to 10. The normalized value of the indicator is the maximum of all those marked.

Duration of use: Indirect measure of duration of use according to protection category (IUCN classification and other state and regional protection categories).

- Calculation: The value of the indicator is recorded by indicating which options are recognised in the stand from those proposed in the 'Recent anthropogenic use' section of the stand fieldsheet. As many options can be selected as are recognised in the stand.
- Normalization: Ranking of the categories of protection in values from 0 to 10. The normalized value of the indicator is the minimum of all those marked.

Spatial integrity indicators

It characterizes the spatial context in which a stand is located, through forest continuity, the edge effect, connectivity between mature stands or the extent of the stand itself, and which directly influences the ability to perpetuate in space all the ecological processes inherent to the dynamics of a mature forest and all the associated biodiversity.

Extension: stand surface.

- Calculation: Direct calculation using the GIS tool.
- Normalization: Linear with thresholds

Forest continuity: Continuous forest area of the stand

- Calculation: The indicator is the average of the pixel values within the population boundaries
- Normalization: Linear with thresholds

Forest density (Edge effect): Percentage of forest around the stand within 5 km..

- Calculation: The indicator is the average of the pixel values within the population boundaries
- Normalization: Linear with thresholds

Distance from central area (Connectivity): Degree of isolation or interconnection based on distance from other forest areas and the characteristics of these surrounding areas.

- Calculation: The indicator is the average of the pixel values within the boundaries of the stand and is expressed in km and as the opposite distance from 27 km (which is taken as a reference for the value 0), where $\vec{d}$ is the average of the pixel values within the stand. (which is taken as a reference for the value 0), where $\vec{d}$ is the average of the distance values, expressed in km: $Dc(Km) = 27 - (\frac{\bar{d}}{1000})$
- Normalization: Linear with thresholds.

NORMALIZATION OF INDICATORS

The values calculated for the indicators from the cartography and field data are normalized so that they can be combined hierarchically to obtain the composite naturalness index. With this process, all indicators take on values between 0 and 10. For this purpose, and depending on the interpretation of the indicator, different forms of normalization are proposed:

(a) **Direct assignment**: for indicators of dynamics and anthropogenic use, the normalized value of the indicator is a value from 0 to 10 assigned to the elements detected, or a combination thereof, in the stand. The methods of normalization are described in the previous chapter, while the field sheet describes the values assumed by each option.

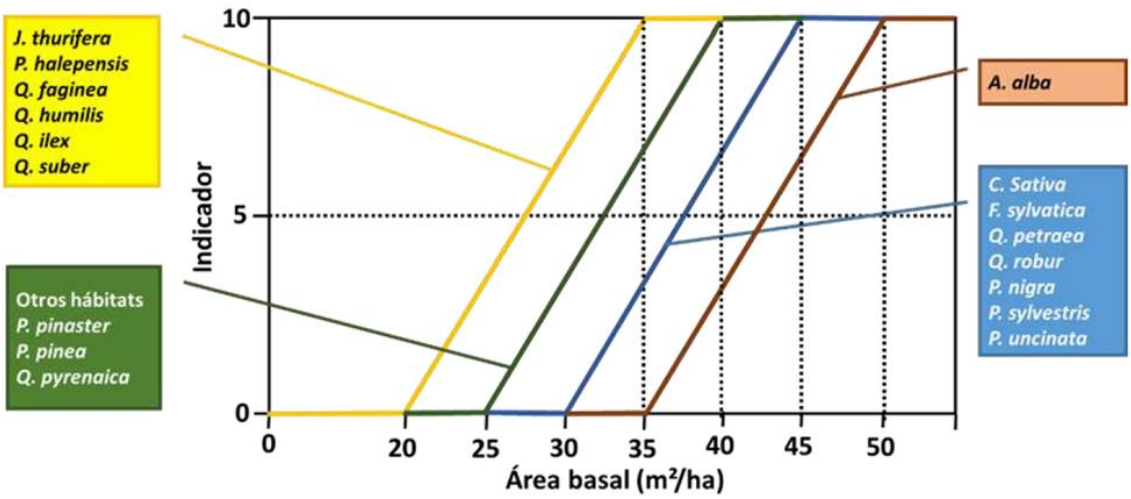
b) **Linear with thresholds**: In the rest of the maturity indicators and the spatial integrity indicators, a variant of Min-Max normalization (OECD/European Union/EC-JRC 2008) is applied, but with thresholds determined for minimum and maximum values.

Linear with thresholds

Linear normalization with thresholds is formulated as follows, where Vi is the indicator value for the population, $Umin$ is the minimum threshold and $Umax$ is the maximum threshold determined for each indicator:

$$I = \frac{(V_i - U_{min})}{(U_{max} - U_{min})} \cdot 10$$

For the maturity indicators (except the silvogenetic phases indicator) and spatial integrity, these two threshold values were determined for each indicator. These thresholds define the values that the indicator can take in each case, the lower threshold being the variable data from which the value is 0 and the upper threshold the data from which the value is 10. These thresholds may be different for different forest habitat types (based on their dominant tree species), or for groups of them. For example, for the yellow habitat group in the figure below, 20 is the lower threshold for which the basal area indicator value is 0 and 35 is the upper threshold from which it takes the value of 10.



The thresholds for normalizing these indicators are shown in the following table.

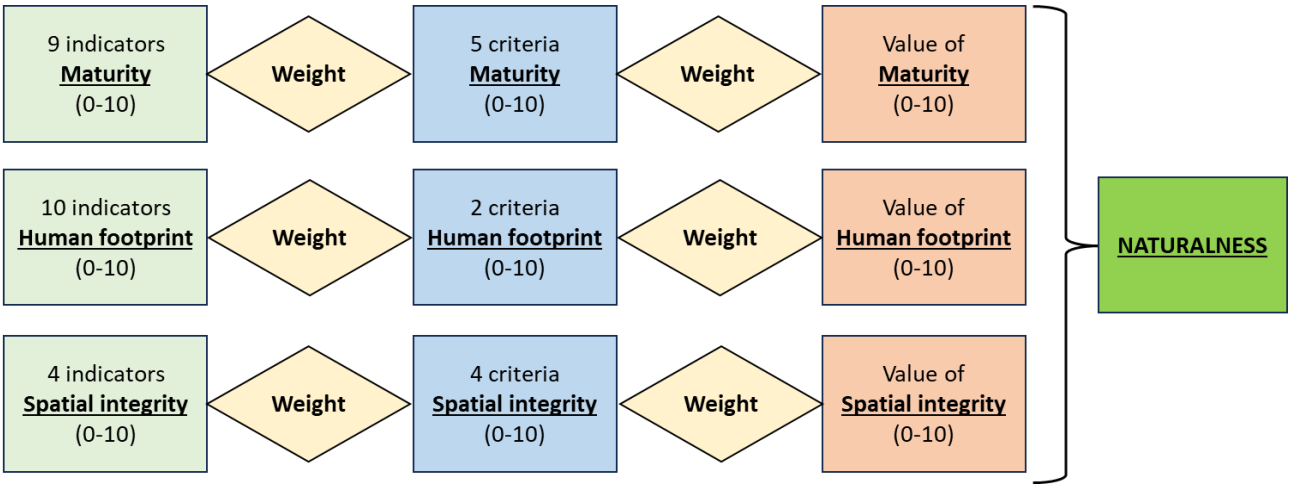
Indicator	Tresholds	
	Umin	***Umax***
Vertical layers (n)	1	4
Proportion of deadwood (%)	5	30
Tree microhabitat (n)	2	10
Stand surface (ha)	1	100
Continuity of forest cover (ha)	1	30.000
Distance from central areas (km)	1	10
Forest density (%)	1	90

AGGREGATION

Aggregation in the construction of composite indicators refers to the process of combining several individual indicators to form a single synthetic indicator. This synthetic indicator is a combination of its component indicators. For the construction of the naturalness index, weighting is used as a method at all hierarchical levels.

Indicators are grouped by weighted averages, first into criteria and then into domains, with weights assigned to each indicator and criterion according to their relative importance to what is being assessed. Finally, the domains are grouped by naturalness.

The three domains described above are developed hierarchically in a scheme of criteria and indicators for each domain (Figure).



The generic aggregation form of criteria, scopes and indicators is as follows, where p_a is the weighting of the corresponding indicator I_1:

$$Level = \frac{p_a \cdot I_1 + p_b \cdot I_2 + \ldots + p_x \cdot I_x}{10}$$

The assignment of each weight depends on the relative importance of each level. The sum of the weights for each level is always 10.

List of indicators, criteria and domains with aggregation weights for each of them.

Indicators	Weight	Criterion	Weight	Domain	Weight	Index
Tree species	10	Composition	0,5	Maturity	5	Naturalness
Basal area	2	Structural complexity	2,5			
Diametric classes	4					
Vertical layers	4					
Exceptional trees	4	Senescence	4,0			
Deadwood abundance	2					
Deadwood proportion	4					
Tree microhabitats	10	Microhabitat	1,0			
Silvogenetic phases	10	Dynamics	2,0			
Temporal continuity	5	Past human footprint	3,0	Human footprint	3	
Agropastoral uses	3					
Past forest uses	2					
Recent forest uses	3	Recent human footprint	7,0			
Invasive species	1					
Causes of fragmentation	1					
Hunting activity	1					
Grazing	1					
Frequentation	1					
Duration of uses	2					
Stand extention	10	Surface	4,0	Spatial integrity	2	
Continuity of forest cover	10	Forest continuity	2,0			
Forest density	10	Edge effect	2,0			
Distances from central areas	10	Connectivity	2,0			

So:

$$Senescence = \frac{4 * \text{Exceptional trees} + 2 * \text{Deadwood abundance} + 4 * \text{Deadwood proportion}}{10}$$

And:

$$Maturity = \frac{0{,}5 * \text{Composit.} + 2{,}5 * \text{Struct. Compl.} + 4 * \text{Senescence} + 1 * \text{Microhabitat} + 2 * \text{Dynamics}}{10}$$

Finally:

$$Naturalness = \frac{5 * \text{Maturity} + 3 * (10 - \text{Human footprint}) + 2 * \text{Spatial integrity}}{10}$$

For the combination of the 3 domains to be consistent, the human footprint must be transformed into its opposite value by subtracting 10.

Annex 1 Stand fieldsheet

Translated English version of the stand fieldsheet of LIFE project Redcapacita_2015 (or RedBosques, LIFE15 GIE/ES/000809)

Versión 2024 | Ficha rodal: Redbosques_EvalRodalReferencia_Ficha_v24.240117

EVALUATION OF THE NATURALITY OF REFERENCE STANDS
Phase II – Identification through plots | 2024 version

STAND FIELDSHEET

STAND | Restricted data: indicate if the data cannot be published. | **Name:** representative name of the stand. | **Region, province and municipality:** where the stand is located. | **Owner**: organization or administration owning the stand. Do not indicate in case of private property

☐ **Sensitive data**	**Name**
Region	**Province**
Municipality	**Owner**

SAMPLING | Date: date of sampling. | **Team:** name of the personnel carrying out the sampling (or at least the person responsible for the field team).

Date _ _/_ _/_ _/	**Team:**

HABITAT | CORINE/LPEHT: code and/or name of the habitat according to the CORINE classification | **Community Interest:** code and/or name of the habitat of Community interest to which it corresponds. | **Biogeographical region:** indicate which region it corresponds to according to its geographical location. || **Main tree species and companion tree species (comp.) → Species:** code and/or name of the main tree species (in FCC) and the first canopy companion tree species. | **FCC:** fraction of canopy cover of the whole stand, in %. | **Ho:** mean dominant height in the plots, in metres.

CORINE/LPEHT: code/number 4 _._ _ _

Community Interest: code/number 9_ _ _

Biogeographical Region ☐ Alpine ☐ Atlantic ☐ Mediterranean ☐ Continental ☐ Macaroniesian ☐ Other (speficy)

Main tree species	Species: code/number	FCC %	H_o m	Comp. tree species	Species: code/number	FCC %	H_o m

INDICATORS | Annotation of indicator values, calculated or direct, per plot and/or stand. | **Plot** → Indicator data for each plot. | **Aggr:** form of aggregation of plot data in the stand.| **Stand:** Resulting stand data. | **CP**: composition, **SC**: structural complexity, **SE**: senescence, **MH**: microhabitats, **DN**: dynamics, **HF**: human footprint.

Indicator ⇓		Plot ⇒	1	2	3	4	5	6	7	8	9	10	Aggr	Stand
MATURITY	CP	**Tree specie** n											*Difer*	
	SC	**Basal area** m^2/ha											*Aver*	
		Tree volume m^3/ha											*Máx.*	
		Diametric classes n											*Difer.*	
		Vertical layers n											*Aver*	
	SE	**Exceptional trees** n/ha											*Aver*	
		Standing dead trees volume m^3/ha											*Máx.*	
		Layin deadwood Volume m^3/ha											*Máx.*	
		Deadwood abundance m^3/ha											*Máx.*	
		Deadwood proportion %											*Máx.*	
	MH	**Tree microhabitats** n											*Difer.*	
	DN	**Silvogenetic phases** value											*Value*	

HF	PAST		STAND	RECENT		STAND	**Hunting activity** maximum value		
	Temporal continuity value	*Value*		**Forest uses** value	*Máx.*		**Grazing** value	*Value*	
	Agropastoral uses value	*Máx.*		**Invasive species** value	*Value*		**Frequentation** value	*Máx.*	
	Forest uses value	*Aver*		**Causes of fragmentation** value	*Máx.*		**Duration of uses** value	Mín.	

SUPPLEMENTARY INFORMATION | Other accompanying flora species: the accompanying flora, selecting the most relevant (because they are indicators of the biological season, because they define the plant formation, etc.). | **Habitats of Community Interest:** other HCI identified within the stand, whether forested or not. | **Other relevant information:** also any other information on the stand that is considered relevant for the assessment of the naturalness: fauna present, golden position of the stand, etc. **Other relevant information**: also any other information on the stand that is relevant to the assessment of naturalness: fauna, geology, hydrography, lithology, history... The information on the sheet can be completed with maps, photographs or documents with information on the stand.

Community Interest: (exotic, protected, threatened, indicator species...)

Habitats of Community Interest: (Other forest habitat or not even forest

Other relevant information

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TREE SPECIES | Tree species: code and/or name of the species found in the stand at any stage of development, even if under-represented. Special care should be taken to include those not detected in the plots.

Tree species: code/number

SILVOGENETIC PHASES : Phase: types of phase in the silvogenetic cycle. To consider that a phase is present, it must occupy at least 200 m^2, except for clearings and regeneration. These can measure 100 m^2 , and it is necessary to differentiate whether the origin is natural **(N)** or cut **(C).** | **Pres.:** presence of the phase in the stand.

Clearing (Clear.): FCC of A < 30%, R < 50%, remnants of DW from previous stages / **Regeneration (Reg.):** FCC of A < 30%, R > 50%, remnants of DW from previous stages / **Occupation**: FCC of A > 30%, DBH < 20 cm, remnants of DW from previous stages and new of small dimensions / **Exclusion**: FCC of A > 30%; a) ≈ low forest, 20 < DBH ≤ 30-35 cm; b) ≈ medium forest, 30-35 < DBH ≤ 40-50 cm; c) ≈ high forest, DBH > 40-50 cm; DW < 25%. / **Maturity**: FCC of A > 30%, DBH> 40-50 cm, Ho > 85% Hmax, DW < 25%. / **Senescence**: 30% < FCC of A < 65%, DBH > 20 cm, Ho > 85% Hmax, DW > 25%. / *A: tree stand; R: regeneration; FCC: fraction of canopy cover; DW: deadwood; Ho: dominant height; Hmax: maximum height, DBH: diameter at breast height.*

Fase						
Pres.	☐ Clear. N **[2]** ☐ Clear. C **[0]**	☐ Reg. N **[1]** ☐ Reg. C **[0]**	☐ Occupation **[1]**	☐ Exclusion **[2]**	☐ Maturity **[3]**	☐ Senescence **[4]**

PAST HUMAN FOOTPRINT| Signs and evidence of forest use and harvesting in the stand over 60 years old. The value of each case is identified in square brackets [ ].

Temporal continuity

Portion of forest area in the 1950s

- ☐ 91-100% **[0]**
- ☐ 76-90% **[3]**
- ☐ 51-75% **[5]**
- ☐ 26-50% **[7]**
- ☐ 11-25% **[9]**
- ☐ 0-10% **[10]**

Agro-pastoral uses

Possibilities

- ☐ Absence **[0]**
- ☐ Absence, but possible use **[2]**
- ☐ Soil favourable to cultivation (slope < 30% and altitude < 2000 m) **[10]**

Signs of

- ☐ Old roads **[2]**
- ☐ Livestock trails **[5]**
- ☐ Grazing signs **[5]**
- ☐ Shelter, hut, ruins **[5]**
- ☐ Walls, terraces **[10]**
- ☐ Pollard trees **[5]**
- ☐ Other signs:

Past forest uses

Possibilities

- ☐ Absence **[0]**
- ☐ Absence, but possible use **[2]**
- ☐ Other signs

Signs of

- ☐ Resin, debarking **[4]**
- ☐ Stumps with suckers > 60 years old **[8]**
- ☐ Wire rope, cables, charcoal **[10]**
- ☐ Other signs:

RECENT HUMAN FOOTPRINT| Signs and evidence of forest use and harvesting in the stand less than 60 years old. The value of each case is identified in square brackets [ ].

Recent forest uses

Years since the last harvest

- ☐ More than 60 years or no cut **[0]**
- ☐ De 25 a 60 **[6]**
- ☐ Less than 25 **[10]**

Stump density (n/ha) (DBH ≥ 7.5 cm for cutting from below, and DBH ≥ 17.5 CM, in cutting from above)

- ☐ 0 stumps **[0]**
- ☐ de 1 a 10 **[2]**
- ☐ de 11 a 50 **[4]**
- ☐ de 51 a 100 **[6]**
- ☐ de 101 a 400 **[8]**
- ☐ más de 400 **[10]**

Invasive species

Abundance

- ☐ Absence **[0]**
- ☐ Punctal presence (FCC < 10%) **[7]**
- ☐ Abundant presence (FCC ≥ 10%) **[10]**

Causes of fragmentation

- ☐ No discontinuity **0]**
- ☐ Natural discontinuities (streams, rivers, …) **[0]**
- ☐ Matorral **[5]**
- ☐ Plantations **[7]**
- ☐ Flush cutting **[7]**
- ☐ Crops, pastures, meadows **[9]**
- ☐ Urbanised areas, roads **[10]**

Hunting activities

Evidence of activities

- ☐ Prohibited **[0]**
- ☐ Permitted, but poor accessibility **[3]**
- ☐ Permitted, but no signs of activity **[5]**
- ☐ Signs of occasional activity **[7]**
- ☐ Permanent hunting facilities **[10]**

Grazing

Intensity

- ☐ No visible marks or damage **[0]**
- ☐ Scattered signs or damage **[3]**
- ☐ Damage to tree regeneration (< 50% trees) **[5]**
- ☐ Damage to tree regeneration (≥ 50% of trees) **[10]**

Frequentation

Accessibility

- ☐ Path at ≥ 100 m **[0]**
- ☐ Not well-known path **[2]**
- ☐ Known path **[5]**
- ☐ Road at < 100 m **[10]**

Duration of uses

- ☐ IUCN Site I-II (National park, nature reserve, wilderness area) **[0]**
- ☐ Nature park **[4]**
- ☐ N2000 site **[6]**
- ☐ Listed forest **[6]**
- ☐ IUCN V (less restrictive) **[8]**
- ☐ Without protection **[10]**

STAND AND PLOT(s) SKETCHES

Annex 2 Sampling plot fieldsheet

Translated English version of the sampling plot fieldsheet of LIFE project Redcapacita_2015 (or RedBosques, LIFE15 GIE/ES/000809)

Versión 2024 | Ficha rodal: Redbosques_EvalRodalReferencia_Ficha_v24.240117

EVALUATION OF THE NATURALITY OF REFERENCE STANDS
Phase II – Identification through plots | 2024 version

SAMPLING PLOT FIELDSHEET

PLOT | Num: unique alphanumeric identifier of the plot **| Stand**: name of the stand to which the plot belongs **| Coordinates:** geometric coordinates of the central point of the plot, in metres and indicating the zone. **| Rockyness:** measure of the amount of rocks and/or stones in the plot (radius 15 m) according to categories.

1. no rocks, surface completely covered by vegetation / **2. slightly rocky,** surface covered by coherent rocks < 25% / **3. rocky,** rocky surface between 25% and 50% / **4. very rocky**, rocky surface between 50% and 75% / **5. rocky**, rocky surface > 75%

Num.	**Stand**	
Coordinates	Huso __ __ UTM X m __ __ __ __ __ __ UTM Y m __ __ __ __ __ __ __	**Rockyness** ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

SAMPLING | Date: date of sampling**. | Team:** name of the personnel carrying out the sampling (or at least the person responsible for the field team).

Date _ _/_ _/_ _/	**Team:**

TREES : Live or dead trees of DBH ≥ 17,5 cm | Plot of variable radius | Plot size (m): plot radius size, between 15 m and 25 m (exceptionally 10 m). Sampling of at least 15-20 living trees of DBH ≥ 17,5 cm

Plot radius (m): ☐ 10 ☐ 15 ☐ 20 ☐ 25

For each tree → Id: Tree number **| Dist.** (distance, in m): horizontal distance of the tree to the plot centre. Optional data **| Rum.** (in º). Orientation of the tree from the plot centre to the stem. Optional data. **| Sp:** species code. **| Tip:** type depending on whether it is A (entire tree), or E (with broken top). It allows to apply different cubing functions and thus to refine the calculation of the volume). **| Liv:** dead (D) or alive (A). **DBH:** diameter at breast height, in cm, either dead (D) or alive (A). **| Ht:** height of the tree, in m.

Id	Dist.	Rum.	Sp	Tip.	Liv.	DBH	Ht	Tree microhabitats														
Núm.	m	º	Code	A/E	A/D	Cm	m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1																						
2																						
3																						
4																						
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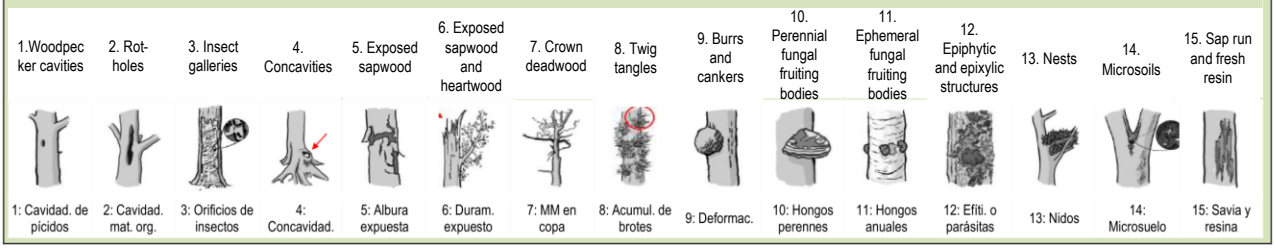
For each tree → Tree microhabitat: types of microhabitats present in living trees of DBH ≥ 17.5 cm.



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Continuation…

Id	Dist.	Rum.	Sp	Tip.	Liv.	DBH	Ht	Tree microhabitats														
Núm.	m	°	Code	A/E	A/D	Cm	m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
27																						
28																						
29																						
30																						
31																						
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REGENERATION | 5 m radius plot | Number of living trees (seedlings and advanced regen. of any species in the plot of 5 m radius concentric to the tree plot

Seedlings *(Ht≤30/Diam≤2,5):* **Adv. Reg (***Diam=[2,5-7[):*

MINOR TREES | 10 m radius plot | Number of living minor trees of any species in the 10 m radius plot concentric to the tree plot.

CD10 (*Dbh=[7,5-12,5[):* **CD15** *(Diam=[12,5-17,5[):*

LAYNG DEADWOOD | Pieces of Dt ≥ 17.5 cm | 3 or 6 transects of 25 m | Logs or pieces of laing deadwood of Dt ≥ 17.5 cm, crossing the axis of the transect. At least 3 transects at 30, 150 and 270°. In case of low abundance of deadwood, also sample transects at 90, 210 and 330°. Transect length horizontally corrected for slope of the transect**. For each piece | Sp**.: code and/or name of the tree species of any piece of wood that intersects with the corresponding transect, in any state of decay | **Dt:** diameter of the piece of wood at the intersection, in cm | **Incl:** inclination of the piece in relation to the horizontal, in degrees.

Transect 30°			Transect 150°			Transect 270°			Transect *90°*			Transect *210°*			Transect *330°*		
Sp	Dt	Incl.	Sp	Dt	Incl.	Sp	Dt	Incl.	Sp	Dt	Incl.	Sp	Dt	Incl.	Sp	Dt	Incl.
Code	cm	°	Code	cm	°	Code	cm	°	Code	cm	°	Code	cm	°	Code	cm	°

TREE LAYERS | 15 m radius plot | Layer: living tree vegetation (of tree species and at any stage of development). They are mentally established in 4 strata of equal height taking into account the dominant height. A 5th emergent stratum is that of those relatively isolated trees that surpass the dominant canopy. | **For each stratum Presence (20%):** of the stratum with at least 20% cover of each stratum.

Layer					
Presence (20%)	☐ **1** (0 < H ≤ ¼)	☐ **2** (¼ < H ≤ ½)	☐ **3** (½ < H ≤ ¾)	☐ **4** (¾ < H ≤ H_0)	☐ **5** ($H_{em.}$ > H_0)

OBSERVATIONS: anything else deemed appropriate.