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Data Article

Repeated stand structure inventory dataset in long abandoned deciduous forest reserves in Hungary

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A R T I C L E I N F O

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A B S T R A C T

Deeper understanding on natural forest dynamics requires long-term data series from forests that have not been affected by human interventions, which are often scarce especially in the Pannonian Bioregion. Unmanaged, but regularly inventoried forest reserves provide an opportunity to fill this gap.
The dataset provides repeated inventory data for 233 permanent plots situated in the core areas of six forest reserves selected from primary forests (Kékes), long abandoned forests (Kecskés-galya, Szalafő, Várhegy) and abandoned ones (Hidegvíz-völgy, Nagy Istrázsa-hegy). The sampled old stands represent the four most widespread hilly forest types in Hungary: Carpathian submountainous beech forest; sessile oak-hornbeam forest; Turkey oak and sessile oak forest; downy oak forest. In each plot, stand level attributes included main mensuration variables (canopy closure, stand height, tree density, basal area, living and dead volume, lying deadwood and admixture of the main tree species). Tree level attributes (diameter at breast height, height measured and estimated, crown position in the canopy, health status, tree history of all trees or shrubs having diameter larger or equal to 5 cm)

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were also measured in two inventories (after 6-16 years) for a total of 6,986 individual trees sampled in all plots. *Fagus sylvatica* L., *Quercus petraea* agg., *Q. cerris* L., *Q. pubescens* Willd., *Carpinus betulus* L., *Acer campestre* L. and *Cornus mas* L. were the most abundant. The individual tree history classification refers to regeneration ingrowth, growing phase, mortality, decaying phase and disappearance events, that can be used for calculation of various stand dynamics attributes.
The dataset offers valuable opportunities for quantifying changes in stand structures and tree population dynamic attributes after the abandonment of management. Inventory data can be integrated with environmental and climatic information to understand the drivers of forest stand dynamics under a changing climate.

Specifications Table

Subject	Agricultural science: Forestry
Specific subject area	Stand structure of long untouched forests, dendrometric measurement data, and tree population dynamic attributes derived from tree history
Type of data	Tables (excel format), Georeferenced plots (shape file format)
How the data were acquired	The dataset were based on field sampling at forest stand level (233 plots distributed in six strict forest reserves of Hungary); and living and dead tree attributes were acquired at tree level (6986 trees or shrubs of 5 cm diameter at breast height (DBH) or larger). GPS, Vertex, tape measuring and Bitterlich angle count sampling were applied.
Data format	Raw data
Description of data collection	We resurveyed 233 permanent sampling plots (PSPs) in six forest reserve's core areas, stratified by the main zonal forest types. Standard data acquisition procedure was applied that consists of three modules: i) general description of stand, ii) selecting representative tree individuals for the stand, iii) inventory of standing living or dead trees selected by a circular plot and a horizontal subsampling (according to Bitterlich), iv) volume estimation of lying deadwood by line intercept sampling method
Data source location	Three administrative regions (NUT2) of Hungary: Észak-Magyarország, Pest, and Nyugat-Dunántúl regions
Data accessibility	Repository name: Zenodo Data identification number: 10.5281/zenodo.7311384 Direct URL to data: https://zenodo.org/record/7311384#.Y20v0HbMKUk

Value of the Data

- This dataset can be used to analyse natural forest stand structure and population biology attributes of beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), sessile oak (*Quercus petraea*), Turkey oak (*Quercus cerris*) and downy oak (*Quercus pubescens*) dominating long untouched forest types in two periods of time (basic surveys of sites between 2004 and 2013, and resurvey in 2019–2020)
- Data derived from the core areas of strict forest reserves, which were set aside to secure spontaneous natural development for a long time [1]. Stands are considered mainly as 'long untouched' forests according to [2].
- Comparative analysis of this integrated survey-resurvey dataset on stand structure and tree history can reveal natural tree population and forest dynamic trends in details.

- Ecologists, forest researchers and managers, conservationist and ecosystem modellers can benefit from these data, which are lacking in a recent EU dataset [3]. It could partially fill this gap.
- Extending time span with further resurvey of these plots after about a ten years is highly recommanded.
- We encourage further collaboration and analysis by combining and/or extending this dataset with environmental, climatic or biodiversity data.

1. Objective

Our dataset contains information about the changes of stand structure between the two surveys. Through their comparative analysis we can study the natural changes in forest reserves after abandonment and it helps to understand tree population and stand dynamic processes.

2. Data Description

We provide an integrated dataset of two consecutive forest inventories, contains plot level, and individual tree level data [4].

The first provides the descriptions and measuring units (or categories) of plot level variables (Table 1). The plot level table contains 233 records (rows), one for each selected permanent plots of six strict forest reserves located in Hungary (Fig. 1). This dataset is georeferenced and contains information on inventories and basic stand structure attributes in MS Excel and ESRI shape

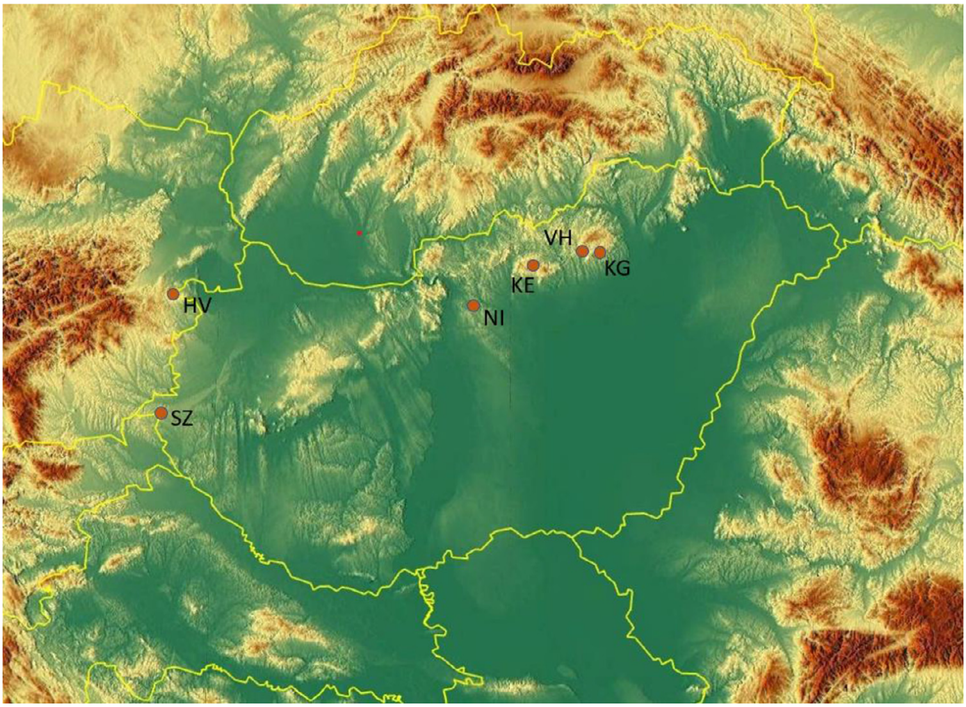

Fig. 1. Location of the strict forest reserve sites: KE – Kékes SFR, KG – Kecskés-galya SFR, VH – Várhegy SFR, NI – Nagy-Istrázsa-hegy SFR,HV – Hidegvíz-völgy SFR, SZ – Szalafő SFR.

	
Central European submountainous beech forest. Photo by Tamás Vig, Kékes SFR, 2021	Sessile oak–hornbeam forest. Photo by Márton Kovács, Szalafő SFR, 2020
This forest type can be found in the more humid and cool climatic areas of the mountainous regions of Hungary. These forests are mostly dominated by beech. The proportion of mesic forest species can be significant in each of the forest layers. Other main characteristic is the large amount of decaying wood and the diversity in age and size classes of living tree. Because of the light conditions, the shrub and herbaceous layers are usually poor. This type is represented by 49 PSPs from 3 sites.	Mixed stands of sessile oak and hornbeam, which zonal type's range can be found in the lower regions of mountains and hills. The upper canopy dominated by light-transmitting tree species, and the lower canopy contains shade-tolerant tree species. The shrub and regeneration layer can be significant in the more lighted patches, if the browsing of the games is not extremely notable. Generally the herb-layer is rich in species, This type is represented by 86 PSPs from 4 sites.
	
Turkey oak, sessile oak forest. Photo by János Bölöni, Mátra, 2016	Downy oak forest. Photo by Ákos Vig, Nagy-Istrázsa-hegy SFR, 2019
In the lower regions of mountain and hilly areas, xeric forests consist of sessile oak and turkey oak mixed stands. The natural-like stands have diverse structure, mosaic closure, varied height of canopy and shrub layers. The frequency of large living trees and standing dead trees gives high structural diversity for the forest stand and provides various micro-habitats for other species. This type is represented by 29 PSPs from 3 sites.	The thermophilous downy oak woodlands often low with open canopy. The dominant downy oak prefers warm climatic conditions and tolerate the xeric circumstances and shallow, stony soil conditions. Consequently the main sites of this forest type are on ridges and southern sides of the hills. The herb layer is also well-developed with very high plant diversity. This type is represented by 69 PSPs from 3 sites.

Fig. 2. Characteristic stand views and short descriptions of the main forest types.

format (file names: SZEGLETI_etal_2022_PLot_and_Tree_tables.xlsx, Table_1_Plots.shp). There are basic metadata of forest sites summarized in Table 4. The NUT2 regions, altitude ranges, sizes and descriptions of management regime of forest sites are not included in Table 1. Characteristic stand views and short descriptions help to visualize and recognize the four main forest types (Fig. 2) referred in Table 1 and Table 2. We also prepared a multiple circle chart to

Table 1
Plot identification and stand structure: variables, descriptions and units of plot-level, georeferenced dataset. Missing values represented by 'NA' (XLSX format), and by the code of '999' (ESRI shape attributum table).

Variable	Description	Unit or category
SiteName	name of the site (Strict Forest Reserve)	i.e. Vár-hegy SFR
SiteAcron	acronym of the site	VH: Vár-hegy SFR HV: Hidegvíz-völgy SFR KG: Kecskés-galya SFR KE: Kékes SFR NI: Nagy Istrázsa-hegy SFR SZ: Szalafő SFR
ForestType	European Forest Type (EFT) according to European classification [5], the stand repr esented by the sampled trees	BEECH: EFT 6.5 Carpathian submountainous beech forest OAK-HB: EFT 5.2 Sessile oak-hornbeam forest OAKTUR: EFT 8.2 Turkey oak and sessile oak forest DOWNY: EFT 8.1 Downy oak forest
Site_PlotID	unique identification code for each permanent plot (SiteAcron and PlotID combined)	i.e. VH_Jb-017
WGS_latitude	latitude coordinate of the plot centre	WGS 84 (latitude, decimal format)
WGS_longitude	longitude coordinate of the plot centre	WGS 84 (longitude, decimal format)
InventoryDate1st	date of the 1st inventory of the plot	dd.mm.year
InventoryDate2nd	date of the 2nd inventory of the plot	dd.mm.year
Surveyors1st	names of stand and tree surveyors at the 1st inventory	i.e. Mázsa, K - Horváth, F
Surveyors2nd	names of stand and tree surveyors at the 2nd inventory	i.e. Szegleti, Zs - Vig, Á
Closure1st	estimated closure of the canopy as all tree crown projection (<= 100%) at 1st inventory	%
Closure2nd	estimated closure of the canopy as all tree crown projection (<= 100%) at 2nd inventory	%
CoverUpper1st	estimated cover of the upper canopy trees (crown projection) at 1st inventory	%
CoverUpper2nd	estimated cover of the upper canopy trees (crown projection) at 2nd inventory	%
CoverLower1st	estimated cover of the lower canopy trees (crown projection) at 1st inventory	%
CoverLower2nd	estimated cover of the lower canopy trees (crown projection) at 2nd inventory	%
CoverShrub1st	estimated cover of the shrub layer at 1st inventory	%
CoverShrub2nd	estimated cover of the shrub layer at 2nd inventory	%
CoverHerb1st	estimated cover of the herb layer at 1st inventory	%
CoverHerb2nd	estimated cover of the herb layer at 2nd inventory	%
CanopyHeight1st	height of the canopy at 1st inventory	%

(*continued on next page*)

Table 1 (*continued*)

Variable	Description	Unit or category
CanopyHeight2nd	height of the canopy at 2nd inventory	%
GapCategory1st	gap classification at 1st inventory	NO: no gap occurs 1G: one dominant tree gap 23: two or three dominant tree gaps GX: larger gap
GapCategory2nd	gap classification at 2nd inventory	NO: no gap occurs 1G: one dominant tree gap 23: two or three dominant tree gaps GX: larger gap
OpenByGap1st	openness by gaps at 1st inventory (derived from gap category)	10%, 25%, 50% of openness are assigned to 1G, 23 and GX gap categories accordingly
OpenByGap2nd	openness by gaps at 2nd inventory (derived from gap category)	10%, 25%, 50% of openness are assigned to 1G, 23 and GX gap categories accordingly
Nlive_1st	number of trees/stems per hectar (density) at 1st inventory	number of tree / ha
Nlive_2nd	number of trees/stems per hectar (density) at 2nd inventory	number of tree / ha
BAlive_1st	basal area of live trees per hectar at 1st inventory	m^2/ha
BAlive_2nd	basal area of live trees per hectar at 2nd inventory	m^2/ha
Vlive_1st	volume of living trees per hectare at 1st inventory	m^3/ha
Vlive_2nd	volume of living trees per hectare at 2nd inventory	m^3/ha
Ndead_1st	number of standing dead trees/stems per hectar (density) at 1st inventory	number of tree / ha
Ndead_2nd	number of standing dead trees/stems per hectar (density) at 2nd inventory	number of tree / ha
BAdead_1st	basal area ofstanding dead trees per hectar at 1st inventory	m^2/ha
BAdead_2nd	basal area ofstanding dead trees per hectar at 2nd inventory	m^2/ha
Vdead_1st	volume of standing dead trees per hectare at 1st inventory	m^3/ha
Vdead_2nd	volume of standing dead trees per hectare at 2nd inventory	m^3/ha
Nstump_1st	number of stumps (dead broken stems) per hectar (density) at 1st inventory	number of tree / ha
Nstump_2nd	number of stumps (dead broken stems) per hectar (density) at 2nd inventory	number of tree / ha
BAstump_1st	basal area of stumps per hectar at 1st inventory	m^2/ha
BAstump_2nd	basal area of stumps per hectar at 2nd inventory	m^2/ha
Vstump_1st	volume of stumps per hectare at 1st inventory	m^3/ha

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Table 1 (*continued*)

Variable	Description	Unit or category
Vstump_2nd	volume of stumps per hectare at 2nd inventory	m^3/ha
V_lyingDead1st	volume of lying (downed) dead tree per hectare at 1st inventory	m^3/ha
V_lyingDead2nd	volume of lying (downed) dead tree per hectare at 2nd inventory	m^3/ha
AR_Fagussyl_1st	admixture rate of Fagus sylvatica at 1st inventory	%
AR_Fagussyl_2nd	admixture rate of Fagus sylvatica at 2nd inventory	%
AR_Quercpet_1st	admixture rate of Quercus petraea at 1st inventory	%
AR_Quercpet_2nd	admixture rate of Quercus petraea at 2nd inventory	%
AR_Querccer_1st	admixture rate of Quercus cerris at 1st inventory	%
AR_Querccer_2nd	admixture rate of Quercus cerris at 2nd inventory	%
AR_Quercpub_1st	admixture rate of Quercus pubescens at 1st inventory	%
AR_Quercpub_2nd	admixture rate of Quercus pubescens at 2nd inventory	%
AR_Carpibet_1st	admixture rate of Carpinus betulus at 1st inventory	%
AR_Carpibet_2nd	admixture rate of Carpinus betulus at 2nd inventory	%
AR_Acer_cam_1st	admixture rate of Acer campestre at 1st inventory	%
AR_Acer_cam_2nd	admixture rate of Acer campestre at 2nd inventory	%
AR_other_1st	admixture rate of other species at 1st inventory	%
AR_other_2nd	admixture rate of other species at 2nd inventory	%

visualize dispersal of permanent sampling plots by forest types per strict forest reserve sites to easy understand sampling design (Fig. 3).

The individual tree level datasets (Table 2) were acquired by the sampling procedure, detailed in section 2.2. Species, dendrometric attributes, relative crown position, health and decay status were documented for each tree belonging to the samples in MS Excel format. Table 2 provides the descriptions and measuring units (or categories) of tree level datasets in detail. Furthermore it provides a tree history classification based on the interpretation of tree status changes. According to a simple scheme of the life and dead history of a tree, it could be classified into four main phases: establishment/regeneration phase; developmental phase; death and gradual decay of the tree trunk; terminated in decomposed/disintegrated state. The main events along these phases are: ingrowth regeneration; death of tree (mortality); disaggregation and decomposition of deadwood. We classify each sampled tree individuals into tree history categories (events and

Table 2
Dendrometry and tree-history: variables, descriptions and units of individual tree-level dataset. Missing values represented by 'NA' (XLSX format), and by the code of '999' (ESRI shape attributum table).

Variable	Description	Unit or category
SiteName	name of the site (Strict Forest Reserve)	i.e. Vár-hegy SFR
SiteAcron	acronym of the site	VH: Vár-hegy SFR HV: Hidegvíz-völgy SFR KG: Kecskés-galya SFR KE: Kékes SFR NI: Nagy Istrázsa-hegy SFR SZ: Szalafő SFR
ForestType	European Forest Type (EFT) according to European classification [5], the stand represented by the sampled trees	BEECH: EFT 6.5 Carpathian submountainous beech forest OAK-HB: EFT 5.2 Sessile ok-hornbeam forest OAKTUR: EFT 8.2 Turkey oak and sessile oak forest DOWNY: EFT 8.1 Downy oak forest
Site_PlotID	unique identification code for each permanent plot (SiteAcron and PlotID combined)	i.e. VH_Jb-017
TreeID	unique technical identifications number of the tree specimens	i.e. 348
SpeciesName	latin name of tree or shrub species	i.e. *Quercus cerris*
SpecesAcron	acronym of tree or shrub species	i.e. QUERC_CER
TraitCat	trait category of tree or shrub specimen	UpperTree LowerTree Shrub
BelongsTo1st	belonging of the specimen to the sample at 1st inventory	YES or no
BelongsTo2nd	belonging of the specimen to the sample at 2nd inventory	YES or no
YearsBetween	number of vegetation years between 1st and 2nd inventories	year
DBH1st	diameter at breast height at 1st inventory	cm
DBH2nd	diameter at breast height at 2nd inventory	cm
HeightMeas1st	tree height measured at 1st inventory	m
HeightMeas2nd	tree height measured at 2nd inventory	m
HeightEstim1st	tree height estimated at 1st inventory	m
HeightEstim2nd	tree height estimated at 2nd inventory	m
CrownPos1st	relative crown position (simplified Kraft classification) in the canopy layer at 1st inventory	PR: pre-dominant tree, higher to the surroundings DO: dominant (well developed) crown forming the main canopy of stand CO: co-dominant (lower than the formers) crown SU: subordinated (overshadowed) position of the crown

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Table 2 (*continued*)

Variable	Description	Unit or category
CrownPos2nd	relative crown position (simplified Kraft classification) in the canopy layer at 2nd inve ntory	PR: pre-dominant tree, higher to the surroundings DO: dominant (well developed) crown forming the main canopy of stand CO: co-dominant (lower than the formers) crown SU: subordinated (overshadowed) position of the crown
ExtraLight1st	the crown gets additional sunlight due to canopy opening/gap nearby at 1st inventory	YES or no
ExtraLight2nd	the crown gets additional sunlight due to canopy opening/gap nearby at 2nd inventory	YES or no
AliveDead1st	alive or dead status of the tree or shrub at 1st inventory	LIVE or dead
AliveDead2nd	alive or dead status of the tree or shrub at 2nd inventory	LIVE or dead
HealthStatus1st	health status of the tree or shrub at 1st inventory	1-HE: healthy tree 2-TO: top-drying and/or crown damaged/diseased tree 3-ST: stem/stump damaged/diseased tree 23TS: top-drying AND stem/stump damaged tree 4-Dst: standing dead tree 4-Dbr: snag (broken dead tree, standing part) 4-Ddw: downed dead tree 4-Dct: stump cutted 4-Ddd: decayed or disappeared (dead) tree
HealthStatus2nd	health status of the tree or shrub at 2nd inventory	1-HE: healthy tree 2-TO: top-drying and/or crown damaged/diseased tree 3-ST: stem/stump damaged/diseased tree 23TS: top-drying AND stem/stump damaged tree 4-Dst: standing dead tree 4-Dbr: snag (broken dead tree, standing part) 4-Ddw: downed dead tree 4-Dct: stump cutted 4-Ddd: decayed or disappeared (dead) tree
HeightDsn1st	snag height at 1st inventory	m
HeightDsn2nd	snag height at 2nd inventory	m
DecayStage1st	decay stage category 4 of dead wood at 1st inventory	1: not decayed yet (died recently) 2: at the begenning of decay/decomposition 3: partly decayed/decomposed wood 4: highly decayed/decomposed wood 5: mostly decayed/decomposed wood 6: almost decayed/decomposed completely

(*continued on next page*)

Table 2 (*continued*)

Variable	Description	Unit or category
DecayStage2nd	decay stage category 4 of dead wood at 2nd inventory	1: not decayed yet (died recently) 2: at the begenning of decay/decomposition 3: partly decayed/decomposed wood 4: highly decayed/decomposed wood 5: mostly decayed/decomposed wood 6: almost decayed/decomposed completely
TreeHistory	tree history category/changes between the 1st and 2nd inventories	RegIngrowth: tree regeneration ingrowth event (overgrowth 5 cm at DBH) Growth: growing phase continuously Mortality: tree mortality event happens between inventories Decaying: decaying phase, biodegradation of deadwood DisApp: disappearance/disaggregation of a decaying deadwood
LargerTree1st	larger tree (DBH > 25,23 cm) sampled by Bitterlich angle counting (gauge constant k = 2, basal area factor = 2), at 1st inventory	YES or no
LargerTree2nd	larger tree (DBH > 25,23 cm) sampled by Bitterlich angle counting (gauge constant k = 2, basal area factor = 2), at 2nd inventory	YES or no
N_Quota1st	quota of the sampled tree (or shrub) to the number of trees/stems per hectar at 1st inventory	number of tree/ha
N_Quota2nd	quota of the sampled tree (or shrub) to the number of trees/stems per hectar at 2nd inventory	number of tree/ha
BA_Quota1st	quota of the sampled tree (or shrub) to the trees/stems per hectar at 1st inventory	m^2/ha
BA_Quota2nd	quota of the sampled tree (or shrub) to the trees/stems per hectar at 2nd inventory	m^2/ha
V_Quota1st	quota of the sampled tree (or shrub) to the volume of trees/stems per hectar at 1st inventory	m^3/ha
V_Quota2nd	quota of the sampled tree (or shrub) to the volume of trees/stems per hectar at 2nd inventory	m^3/ha

phases, Table 3) that can provide population dynamic aspects at stand level by appropriate tree aggregation functions.

Relational link can be set between the plot level and tree level datasets based on the unique indentification code of site and sampling plots (Site_PlotID).

Finally we present the graphical scheme of the combined tree selection methods (Fig. 4) for better understanding of circular plot subsampling and horizontal point subsampling. The logical value of LargerTree variables of Table 2 refer to this settings.

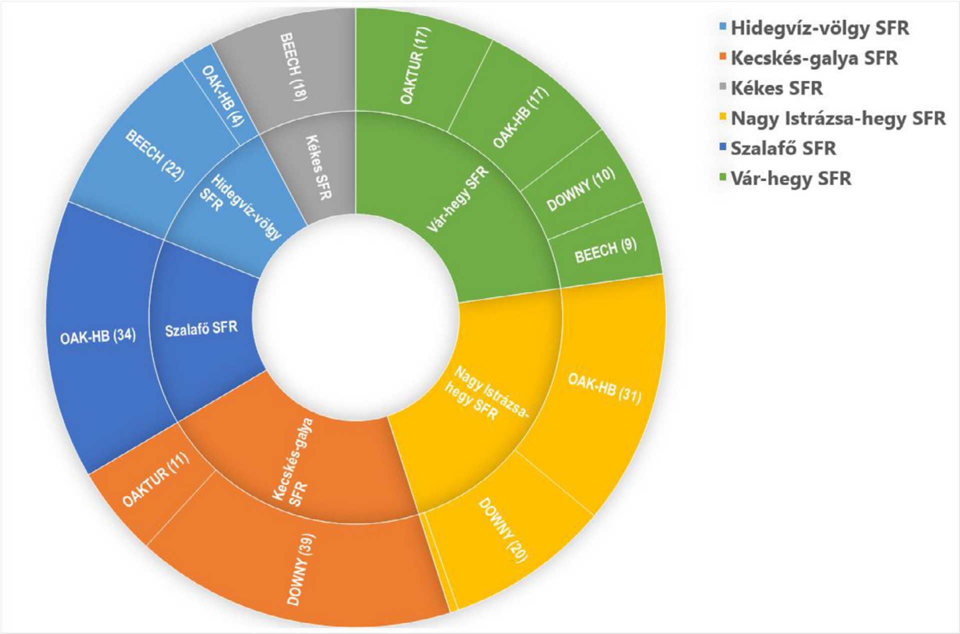

Fig. 3. Dispersal of permanent sampling plots by forest types per strict forest reserve sites. The numbers of PSPs are indicated in parenthesis.

Table 3
Main phases and events of a tree life/dead history.

Event	Phase	Description
–	Early development of a seedling/sapling	Establishment, survive and growth of seedlings/saplings, but it is out of sampling procedure due to the smaller diameter of 5 cm at DBH.
Ingrowth Regeneration	–	Saplings, which have reached and overgrown the size of 5 cm at DBH are considered as 'ingrowth' regeneration. The event counts as a regeneration occurence. The majority of trees sampled at the former survey survive and continue to grow.
–	Developmental growth	Younger trees invest in vertical growth mainly to reach the canopy layer, than it changes to mature growth to obtain a dominant position and produce seeds.
Death (mortality)	–	A tree which is living but ill or supressed at the time of the former survey, often die and deadwood decay/biodegradation begins. Dead trees can be categorized as standing deadwood, broken trunk, or lying deadwood.
–	Decaying	Dead trees recorded at the former survey still standing, or fall down, or break in half and decaying further or fully disintegrated and decomposed.
Disappearance/ disaggregation	–	disaggregation and gradual decomposition of an existing deadwood till it can be recognized as a remains of a separate tree

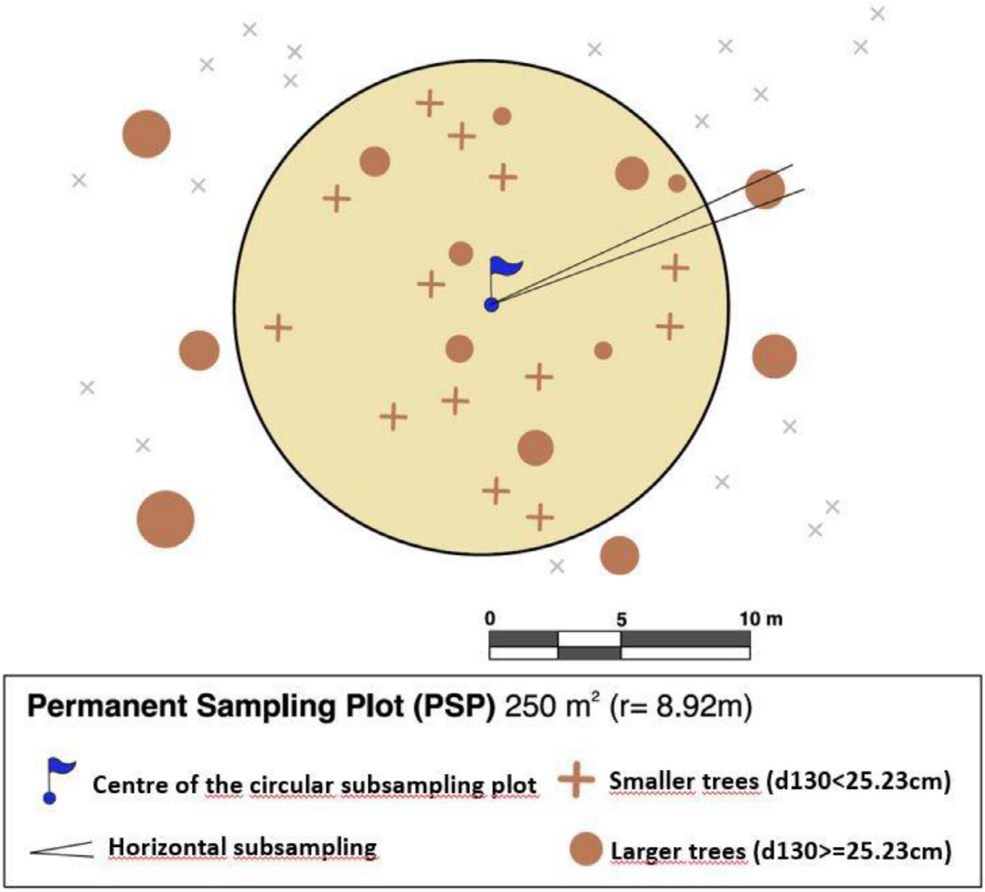

Fig. 4. Scheme of tree sampling by the combination of circular plot subsampling and horizontal point subsampling methods [9].

3. Experimental Design, Materials and Methods

3.1. Site description of the Strict Forest Reserves (SFR)

Kékes (KE) SFR: A beech and rocky slope forest remnant on the north-facing side of Kékes. The stand has developed free from any human intervention [6]. The structure shows the characteristics of a primeval forests, for example the varied age structure, the presence of old trees and the accumulation of standing and lying dead trees [7]. There were selected and resurveyed 18 PSPs from the 210 of the first inventory [7].

Hidegvíz-völgy (HV) SFR: This forest reserve has varied topography and mainly S-SW-facing exposure with beech forests and introduced patches of spruce. The destruction of several spruce trees caused by the gradation of bark beetles in the 1990-ies resulted in a high amount of dead wood, and in a diverse stand-structure [7]. There were selected and resurveyed 26 PSPs from the 75 of the first inventory [7].

Vár-hegy (VH) SFR: The core area, the forest reserve is characterized by the dominance of old oak and beech trees. There are four distinct age classes in the population, which consist of old and middle-aged trees, and significant presence of young regeneration under the canopy gaps. The topography and exposure of this site is very diverse, resulting different soil types and varied mesic and xeric forest types. A pest of oak decline decimated the trees in the 1970-ies [7,8]. There were selected and resurveyed 53 PSPs from the 373 of the first inventory [7].

Kecskés-galya (KG) SFR: In the core area, we can find mainly downy oak and turkey oak forest types alternating with patches of shrubs and open rocky grasslands facing mainly to South on limestone. Forests were traditionally exploited by lime-burning for centuries in this region till the 20th century. The habitat-types are diverse and make mosaic patches with each other. The amount of old and big dead trees are significant.

Nagy Istrázsa-hegy (NI) SFR: The hornbeam-sessile oak and turkey oak-sessile oak forest types are dominant in this area. Formerly it was a hunting estate for long centuries, under a very high browsing pressure of overpopulated games. The SFR was fenced in 2010, then red deer and wild boar populations were reduced and put under control. In the regeneration layer, field maple and flower ash are dominant.

Szalafő (SZ) SFR: It is scots pine mixed nemoral forest originating through a long spontaneous succession, where pedunculate oak has become dominant. The core area is rich in admixture tree species, mainly hornbeam, scots pine, birch and poplar. Due to the decline of early successional trees and the growth of oaks and hornbeam, the stand turn into a more closed and shaded forest. There were selected and resurveyed all PSPs of the first inventory[7].

The geographical disposition of sites in the Carpathian-basin showed on Fig. 1 along a West-East gradient, and further details are summarized in Table 4.

The Fig. 2 shows characteristic stand views of the four main forest types with short descriptions.

3.2. Distributions of the main forest types represented by plots

The main aim was to represent the forest types with minimum repetition of 30, distributed from the most sites possible. However the distribution of sampling plots according to the forest types is uneven, because of spatial constraints. The number of permanent sampling plots was dispersed among the sites and the main forest types intentionally in a balanced way according to the constraints of habitat distribution and size limitations of the strict forest reserve's core areas (Table 4). An easy recognizable multiple circle chart displays the dispersal of PSP's by forest types per sites (Fig. 3). The most outlier is the Turkey oak type (29 PSPs), that was hard to find enough area of stands to take more samples.

3.3. Data acquisition

Method of survey and resurvey of tree stands

We applied a standard data acquisition procedure for the stand survey [9, 10], with additional notes on tracking history of trees and quality checking. It consisted of four modules as follows:

(1) general description of the forest stand: assessment of canopy closure, coverage by layers, and gap extent within an area of 1–1.5 tree height radius around the center of PSP, but less or equal to 25 m. We completed the 1) paragraph with: "The vertical projection of tree crowns is estimated for canopy closure and distinct forest layers separately (upper tree canopy, lower tree canopy, shrub layer and herb layer). To describe the gap extent we applied a classification as follows: no gap occurs; open gap by one dominant tree; open gap by two or three dominant trees; larger open gap.

(2) Selecting tree individuals for the survey: living and standing trees or shrubs, and standing or down dead trees or shrubs were selected from the stands at each PSPs by the combination of complementary circular plot subsampling of set of smaller stems [where 5 cm <= diameter at breast height (DBH) < 25.2 cm, plot radius = 8.92 m, plot area = 250 m^2, tree factor = 40] and horizontal point subsampling for subset of larger stems [where

Table 4
Details of the forest sites.

Site	Kékes SFR	Hidegvíz-völgy SFR	Vár-hegy SFR	Kecskés-galya SFR	Nagy-Istrázsa-hegy SFR	Szalafő SFR
Acronym	KE	HV	VH	KG	NI	SZ
NUT2 region	Észak-Magyarország	Nyugat-Dunántúl	Észak-Magyarország	Észak-Magyarország	Pest	Nyugat-Dunántúl
Coordinates	WGS84 N:47°52'52" E: 19°59'55"	WGS84 N: 47°40'15" E:16°26'41"	WGS84 N:47°57'20" E: 20°26'05"	WGS84 N:47°58'20" E: 20°31'59"	WGS84 N: 47°36'05 E: 19°24'42"	WGS84 N: 46°52'10 E: 16°18'12"
Altitude (m)	760–980m	450-500m	300–669m	310-350m	200-280m	310-320m
Size	55 ha	21 ha	94 ha	87 ha	70 ha	12 ha
Year of the first inventory	2005	2005	2005	2011	2012-2013	2004, 2009
Year of the second inventory	2019	2020	2018 - 2019	2019	2018-2019	2020
Number of permanent sampling plots (PSPs)	18	26	53	50	52	34
European Forest Type (Barbati et al. 2014)	6.4 Central European submountainous beech forest (PSP: 18)	6.4 Central European sub-mountainous beech forest (PSP: 22)	6.4 Central European sub-mountainous beech forest (PSP: 9)	8.1 Downy oak forest (PSP: 39)	5.2 Sessile oak–hornbeam forest (PSP: 31)	5.2 Sessile oak–hornbeam forest (PSP: 34)
		5.2 Sessile oak–hornbeam forest (PSP: 4)	5.2 Sessile oak–hornbeam forest (PSP: 17)	8.2 Turkey oak, Hungarian oak and Sessile oak forest (PSP: 11)	8.1 Downy oak forest (PSP: 20)	
			8.2 Turkey oak, Hungarian oak and Sessile oak forest (PSP: 17)		8.2 Turkey oak, Hungarian oak and Sessile oak forest (PSP: 1)	
			8.1 Downy oak forest (PSP: 10)			
Management regime	Old primary forest; never used or exploited	Abandoned old stands with gaps by perished patches of spruce trees. Rotation forestry from the end of the 19th century. The last thinning or sanitary cutting was carried out in the end of the 1980-ies.	Long abandoned old stands left for free development. Rotation forestry from the end of the 19th century. The last thinning was carried out in the end of the 1960-ies.	Long abandoned very old dry oak stands left for free development. Rotation forestry from the end of the19th century (and long since grazed). Some cutting was carried out in the 1960-ies.	Abandoned stands under high pressure of games, but fenced since 2010. Rotation forestry from the end of the 19th century. The last thinning was carried out in the 1980-ies.	Long abandoned successional forest left for free development. Forest use was not allowed since the 1960-ies.

DBH >= 25.2 cm, gauge constant k = 2, basal area factor = 2] to estimate the local stand parameters (Fig. 1). The two subsets are complementary and additive:

a. Sample set of trees = Subset(trees in circular plot) + Subset(trees of horizontal point sampling)
b. The number of stems (N), basal area (BA), volume (V) per hectare and other stand characteristics can be estimated by addition as follows:
c. N(number/hectare) = N(circular plot subsampling) + N(horizontal point subsampling)
   BA(basal area/hectare) = BA(circular plot subsampling) + BA(horizontal point subsampling)
   V(volume/hectare) = V(circular plot subsampling) + V(horizontal point subsampling)

(3) Survey of trees in the sample: the following variables were recorded for each individual:
   a. Species identity of tree or shrub (where DBH >= 5 cm)
   b. DBH (cm) of living tree, and standing or down deadwood (calculated from tape measuring of girth or measured directly at down dead trunks). The diameter of an individual tree starts to decrease after they die, and continues to decrease during the further degradation and decay of the trunk. Checking the change of health status or the tree history category can inform about it.
   c. Further characteristics not evaluated in this article are as follows: crown position, health status, deadwood decay phase, extraordinary tree form, presumable origin of the trees, canopy height.
   d. Volumetric calculation fo individual trees is according to the two-variables-function (DBH and heigth) of prof. László Király described in [11].

(4) Volume estimation of lying deadwood per hectare with line intercept sampling method [12].

During the fieldwork newly measured data were recorded on the copies of the standard datasheets, filled out during the first survey (2005-2008). Local tree maps for each PSP, were created using ESRI ArcMap, based on the coordinates of individual trees and stored in a central database were also used. In this way, the exact location of each tree and shrub individual made possible the checking for completeness and consistency of the sampling within and between the two surveys. It also enabled the assessment of changes of data and tracking history of each trees. Tree ingrowth into the sample, death of trees and falling down of dead ones are normal events which can be well tracked by status changes. In case of erroneous, unlikely and inconsistent records, short explanations were taken to note the problem and the most probable cause(s) of changes (e.g. decrease of DBH due to bark loss, diminish of logs, false identification of species etc).

Ethics Statements

The authors declare that the present work did not include experiments on human subjects and/or animals.

CRediT Author Statement

Zsófia Szegleti; conceptualization, data gathering, data curation, writing. Ákos Vig; data gathering, data curation. Adrienne Ortmann-Ajkai; conceptualization, methodology, writing, review & editing. Gábor Szabó and Zita Zimmermann; gathering, data curation. Ferenc Horváth; conceptualization, methodology, writing, review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Stand structure and tree population dynamic attribute dataset of long abandoned strict forest reserves (Original data) (Zenodo)

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