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SHORT COMMUNICATION

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Current status of International Beech Provenance Trial in Ukraine (Bu19_19) from the 1993/95 series started by Institute of Forest Genetics, Großhansdorf

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Abstract

The European beech (*Fagus sylvatica* L.) is one of the most important tree species in Europe. In order to understand the breeding and biological aspects of the species, the Institute of Forest Genetics and Forest Tree Breeding (Großhansdorf, Germany) has carried out several series of provenance trials in collaboration with researchers throughout Europe. The most extensive series was the International Beech Provenance Trial 1993/95 (established in 1995). One of the provenance trials, Bu19_19 (Roztochja), involving 70 provenances from 10 European countries, was established in Ukraine at the north-eastern edge of the species' natural range. We investigated survival and DBH at this site in May 2023. The average survival rate was 38% (57 trees per provenance), while the number of surviving trees per provenance ranged from 37 to 76. The average DBH was 11.2 centimeters, with the DBH of some individual trees exceeding 30 centimeters. The Bu19_19 provenance trial remains a valuable resource for studying the performance of European beech populations and can provide important insights into their resilience and adaptation.

Key words

European beech, *Fagus sylvatica* L., provenance test trial, Roztochchia, Stradch

The European beech (*Fagus sylvatica* L.) is an important tree species in European forests that offers numerous benefits (Durrant et al. 2016; von Wühlisch 2008). Its wood is valued for its strength, and its fine grain has great economic importance. Moreover, beech serves as an important carbon sink, contributes to the

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reduction of greenhouse gas emissions, and increases the productivity of forest ecosystems through nutrient cycling and soil fertility. As the dominant species in many forest ecosystems, beech forests play a crucial role in maintaining biodiversity by providing a habitat for diverse flora and fauna. In addition, these forests provide recreational opportunities and are of cultural and historical importance, often as protected landscapes. Ensuring the protection and sustainable management of beech forests is essential for the promotion of resilient forest ecosystems and the well-being of people and the environment (Frýdl et al. 2011; Mühlethaler et al. 2011; Skrzyszewski 2012).

Dealing with the effects of climate change on tree species, including European beech, remains a major challenge for forest science (Alia et al. 2021; Mátyás et al. 2010). Common garden tests provide valuable insights into their adaptability to different climatic conditions (Robson et al. 2018). The broad ecological amplitude of beech makes it a valuable reference species for large-scale studies on plastic and adaptive responses in fitness-related traits to climate change.

Numerous provenance trials for European beech have been carried out throughout Europe (Muhs and von Wuehlisch 1993; von Wuehlisch 2004). These trials usually involve progenies from different populations (provenances, i.e., natural beech stands) at different experimental sites, where researchers carefully observe their growth, survival, and adaptability over time. Such experiments are important to understand

Table 1. General description of the international beech provenance tests of the 1993/95 series (adapted from information provided by the Institute for Forest Genetics and Forest Tree Breeding, Großhansdorf, Germany). ID – trial designation according to Figure 1, VersNr – official designation of the provenance trial, Ort – official name of the provenance test trial, LAT – latitude (degrees and minutes), LON – longitude (degrees and minutes), ALT – altitude (meters above sea level).

ID	VersNr	Ort	Country	LAT	LON	ALT
01	Bu19_01	Schädtbek	Germany	54° 18’ N	10° 18’ E	40
02	Bu19_02	Wesel	Germany	51° 39’ N	6° 23’ E	40
03	Bu19_03	Malter	Germany	50° 56’ N	13° 40’ E	360
04	Bu19_04	Navarra	Spain	43° 0’ N	1° 20’ W	910
05	Bu19_05	Vrchdobroc	Slovakia	48° 36’ N	19° 38’ E	840
06	Bu19_06	Bilogora	Croatia	45° 55’ N	16° 58’ E	220
07	Bu19_07	Gablitz	Austria	48° 15’ N	16° 7’ E	350
80	Bu19_08	Otterup	Denmark	55° 31’ N	10° 25’ E	5
09	Bu19_09	FD de Lyons	France	49° 29’ N	1° 36’ E	190
10	Bu19_10	Bologna	Italy	44° 6’ N	11° 6’ E	930
11	Bu19_11	Rathdnum	Ireland	52° 30’ N	6° 10’ W	106
12	Bu19_12	Chilterns FD	United Kingdom	51° 37’ N	0° 57’ E	180
13	Bu19_13	Loehlitz	Germany	49° 53’ N	11° 24’ E	430
14	Bu19_14	Benesov	Czech Republic	49° 21’ N	15° 1’ E	630
15	Bu19_15	Oleszyce	Poland	50° 10’ N	22° 55’ E	200
16	Bu19_16	Nedlitz	Germany	51° 59’ N	12° 19’ E	120
17	Bu19_17	Brasov	Romania	45° 33’ N	25° 45’ E	800
18	Bu19_18	Livadkite	Bulgaria	42° 40’ N	26° 50’ E	1150
19	Bu19_19	Roztochja	Ukraine	49° 55’ N	23° 42’ E	330
20	Bu19_20	Laski	Poland	51° 11’ N	18° 2’ E	234
21	Bu19_21	Ranna	Sweden	58° 27’ N	13° 50’ E	160
22	Bu19_22	Louschelt	Luxembourg	49° 53’ N	5° 47’ E	425
23	Bu19_23	Baia Mare	Romania	47° 35’ N	24° 4’ E	640

how the species adapts to different climates and soil conditions. The most extensive is the International Beech Provenance Trial 1993/95, which was established in 1995 (von Wuehlisch 2004). The aim of this experiment is to evaluate different geographical provenances of European beech in the gradient of climate conditions across Europe. The planning of the International Beech Provenance Trial 1993/95 was coordinated by researchers from the Institute for Forest Genetics and Forest Tree Breeding (Großhansdorf, Germany) in collaboration with the international trial site holders. All trials were conducted according to a standardized methodology. A total of 23 provenance trials were conducted in 18 countries (Tab. 1, Fig. 1). One such experiment, named Bu19_19 (Roztochja), was established in the western part of Ukraine, at coordinates 49°54'36" N, 23°38'20" E.

The provenance trial Bu19_19 comprised a total of 70 provenances from 10 European countries and is one of the largest trials of the 1993/95 series. While five larger trials with more than 100 provenances each were carried out in Germany (Bu19_01, Bu19_02, and Bu19_03), Spain (Bu19_04), and Slovakia (Bu19_05), a similar trial (Bu19_20) in Poland comprised 71 provenances. All other trials included 49 provenances or less (von Wühlisch 2004).

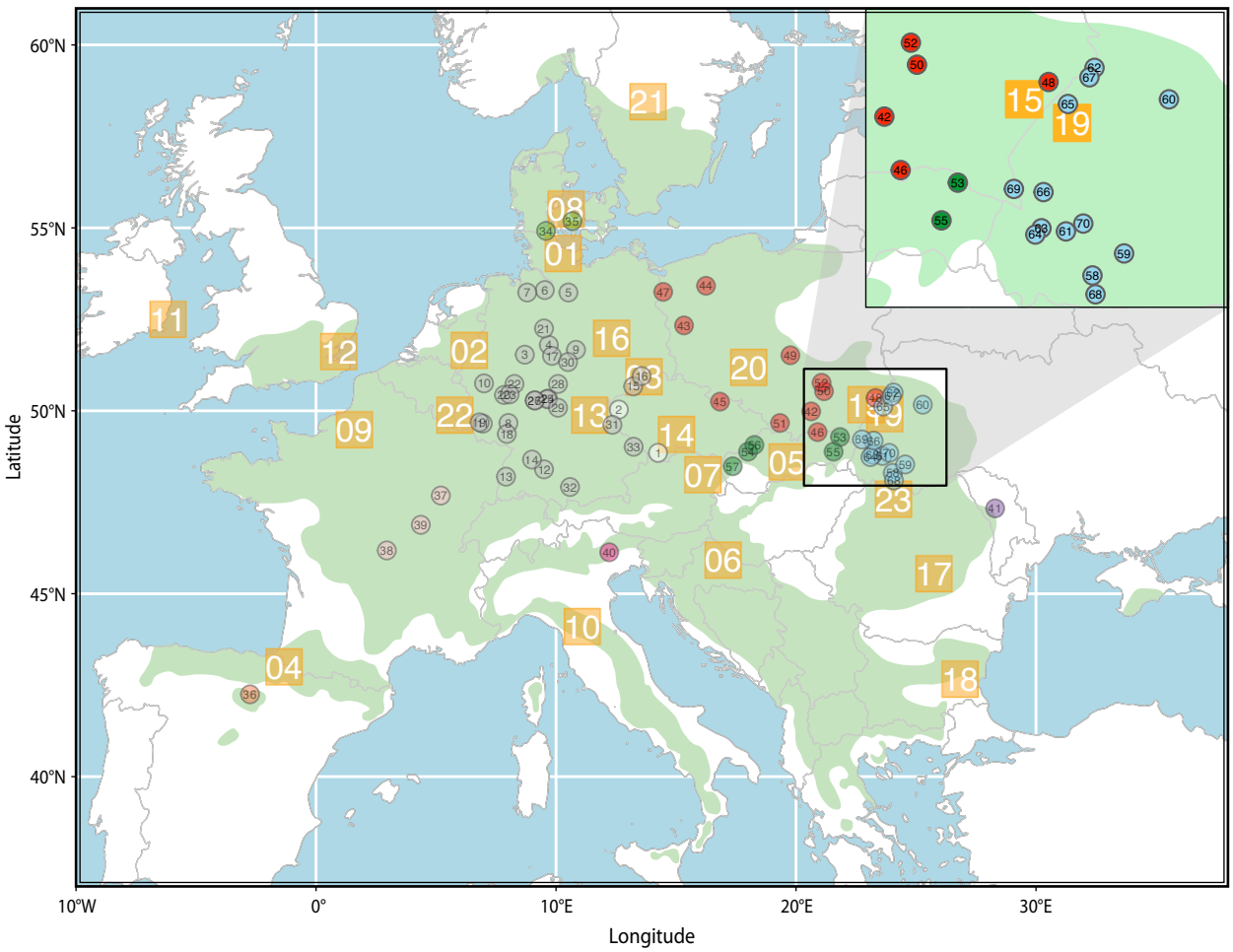

Figure 1. Map of provenance trials (orange squares) from the 1993/95 series. The numbers in the orange squares correspond to the ID column in Table 1, indicating that the provenance trial Bu19_19 is marked as 19 on the map. Circles on the map represent the provenances used for the Bu19_19 provenance trial, with numbers in the circles corresponding to the ID column in Table 2. The transparent green area denotes the natural distribution area of *Fagus sylvatica* L. in Europe (source: https://www.euforgen.org)

The provenances represented in the Bu19_19 trial cover a large part of the natural distribution area of beech, extending north-south from Italy to Denmark and east-west from Moldova to Spain (Fig. 1, Tab. 2). These provenances also have a wide range of altitudes, ranging from 25 m above sea level (Osterholz-Scharmbeck, Germany) to 1150 m above sea level (Vallorch, Italy). However, the areas outside Central Europe are rather underrepresented. Most provenances come from Germany (31), followed by Ukraine (13), Poland (11), and Slovakia (5). The remaining provenances come from France (3), Denmark (2), the Czech Republic (2), Italy (1), Spain (1), and Moldova (1).

Table 2. General description of provenances used at Bu19_19 provenance trial (adapted from information provided by the Institute for Forest Genetics and Forest Tree Breeding, Großhansdorf, Germany). CO – Country of origin (CZ – Czech Republic, DE – Germany, DK – Denmark, ES – Spain, FR – France, IT – Italy, MD – Moldova, PL – Poland, UA – Ukraine), ID – provenance designation according to Figure 1, Ort – Provenance (ecotype), VersNr – provenance designation according to documentation, LAT – Latitude (degrees and minutes), LON – Longitude (degrees and minutes), ALT – Altitude (meters above sea level).

CO	ID	Ort	VersNr	LAT	LON	ALT	CO	ID	Ort	VersNr	LAT	LON	ALT
1	2	3	4	5	6	7	8	9	10	11	12	13	14
CZ	1	Cesky serumlov	9001	48°51'N	14°15'E	750	ES	36	Anguiano	8984	42°15'N	2°45'W	950
	2	Kladska	9007	50°2'N	12°37'E	690		37	Val desmons	9018	47°41'N	5°12'E	440
DE	3	Glashutte	8771	51°32'N	8°42'E	440	FR	38	Colettes	9020	46°11'N	2°57'E	575
	4	Seelzerthurm	8786	51°48'N	9°42'E	360		39	Planoise	9021	46°53'N	4°22'E	535
	5	Busschewald	8938	53°14'N	10°31'E	75	IT	40	Vallorch	9049	46°8'N	12°13'E	1150
	6	Harsefeld	8939	53°18'N	9°32'E	43	MD	41	Ungeny MLD	M1	47°20'N	27°78'E	36
	7	Ostenholz-Scharmbeck	8940	53°14'N	8°48'E	25	PL	42	Brzesko, Tymowa	161	49°59'N	20°38'E	350
	8	Kirchheimbo-landen	8941	49°40'N	8°1'E	400		43	Swiebodzin PL-1	9051	52°20'N	15°20'E	170
	9	Oderhaus	8942	51°40'N	10°50'E	710		44	Swierczyna PL-9	9052	53°25'N	16°15'E	180
	10	Morbach	8951	50°45'N	7°0'E	660		45	Ladek Zdroj PL3/ PL2	9053	50°15'N	16°50'E	965
	11	Hermeskeil	8952	49°39'N	6°57'E	650		46	Krynica	9054	49°25'N	20°54'E	850
	12	Ehingen	8953	48°24'N	9°30'E	620		47	Gryfino	P2	53°15'N	14°28'E	37
	13	Ettenheim	8954	48°12'N	7°55'E	445		48	Narol	P4	50°21'N	23°19'E	273
	14	Herrenberg	8955	48°40'N	9°0'E	500		49	Mlynary	P5	51°31'N	19°46'E	183
	15	Heinzebank	8956	50°40'N	13°13'E	540		50	Staszow	P6	50°32'N	21°10'E	176
	16	Tharandt	8957	50°57'N	13°34'E	365		51	Sucha	P7	49°40'N	19°20'E	400
	17	Bovenden	8958	51°30'N	9°50'E	375		52	Lagow	P8	50°46'N	21°4'E	295
	18	Elmstein-Sud, Appenthal	8959	49°22'N	7°57'E	405	SK	53	Medzilaborce-kos	8943	49°17'N	21°50'E	426
	19	Osburg	8960	49°41'N	6°49'E	540		54	Trenk In	8945	48°53'N	18°0'E	144
	20	Montabaur	8961	50°26'N	7°50'E	313		55	Zamutov	8946	48°53'N	21°34'E	259
	21	Deister	8962	52°15'N	9°30'E	175		56	Lednike Rovne	8947	49°4'N	18°16'E	257
	22	Dillenburg	8963	50°44'N	8°16'E	500		57	Smolenice	8948	48°29'N	17°22'E	192

1	2	3	4	5	6	7	8	9	10	11	12	13	14
DE	23	Hadamar	8964	50°27'N	8°4'E	218	UA	58	Uholka	U1	48°18'N	23°62'E	353
	24	Schluchtern	8966	50°20'N	9°40'E	490		59	Ust-Chorna	U2	48°32'N	23°93'E	686
	25	Sinntal	8968	50°19'N	9°38'E	430		60	Brody	U3	50°10'N	25°17'E	253
	26	Budingen	8970	50°17'N	9°7'E	198		61	Svaliava – 1	U4	48°46'N	22°96'E	678
	27	Budingen	8971	50°17'N	9°7'E	225		62	Roztochchia	U5	49°90'N	23°64'E	330
	28	Bad Salzungen	8994	50°44'N	10°5'E	555		63	Mukachevo	U6	48°48'N	22°72'E	356
	29	Eisenach	8995	50°5'N	10°5'E	615		64	Svaliava – 2	U7	48°44'N	23°6'E	949
	30	Ebeleben	8996	51°20'N	10°30'E	315		65	Zavadiv	U8	50°7'N	23°38'E	245
	31	Vohenstrauss	8997	49°37'N	12°21'E	660		66	Volovets	U9	48°71'N	23°14'E	717
	32	Kaufbeuren	8998	47°55'N	10°35'E	700		67	Rava-Ruska	U10	50°24'N	23°59'E	260
	33	Zwiesel	8999	49°1'N	13°14'E	755		68	Kobyletska Poliana	U11	48°6'N	24°5'E	587
DK	34	Grasten, Buskmose	8974	54°55'N	9°35'E	50		69	Perechyn	U12	48°73'N	22°45'E	235
	35	Glorup	8975	55°11'N	10°41'E	70		70	Mizhhiria	U13	48°51'N	23°53'E	627

The plants of this series were sown in the spring of 1993, undercut during the first growing season for easier lifting, and lifted in the autumn of 1994 at two years of age (Von Wuehlisch G. et al. 1998; von Wuehlisch 2004). The establishment of the Ukrainian part of the trial was coordinated by I. Shvadchak and H.T. Krynytskii from the Institute of Forestry and Wood Technology in Lviv (now UNFU – Ukrainian National Forestry University). The provenance trial was established on the territory of the Stradch Educational-Industrial Forestry Complex of UNFU, which is located in Roztochchia (sometimes transliterated as Roztochia or Roztocja), a region in western Ukraine known for its high biodiversity.

European beech is a species that requires medium-fertile soils (Sułkowska et al. 2011). The site for the provenance trial was selected on a plateau 330 m above sea level within the 4-square of the Velykopilske forestry. In the winter of 1994/95, a monospecific beech forest (*Carpineto-Fageta*) was cleared at this site. The topography of the site is heterogeneous, with a surface slope of about 4–6° (Delehan 2005). The soils were originally characterized as turf podzolic soils of medium thickness, although studies by Grechanyk et al. (2004) describe them as gray forest podzolic soils. The plant cover includes species such as *Rubus caesius* L., *Rubus idaeus*, *Hypericum perforatum* L., *Pteridium aquilinum* L. Kuhn, *Chamaenerion angustifolium* Scop, and *Calamagrostis epigejos* L. The natural regeneration of *Betula pendula* Roth, *Carpinus betulus* L., *Salix caprea* L., *Populus tremula* L., *Acer pseudoplatanus* L., and *Frangula alnus* Mill. was observed at this site (Delehan 2005).

The seedlings were planted in spring 1995 with a spacing of 2 × 1 m, resulting in a density of 5000 seedlings per hectare. The experimental design is a randomized complete block with three replicates, which was used for all trials in this series (Fig. 2). One replicate of each provenance consisted of 50 plants planted in five rows of 10 planting sites (10 × 10 m plot; Fig. 2). Dead seedlings were not replaced in subsequent years. According to von Wuehlisch (2004), the plots are large enough to maintain the trials for 60 years.

After the establishment of the experiment, the investigations of the provenance test Bu19_19 were carried out by I.I. Delehan (Delegan and Skobalo 2010; Delehan 2005), who concluded that most of the provenances showed good adaptability. The five-year phenological observations from 2006 to 2010 (Delegan and Skobalo 2010) show that the provenances from Gryfino (Poland), Kaufbeuren (Germany), and Planoise (France) are the earliest to initiate budburst. The Polish provenance from Gryfino is the first to complete leaf

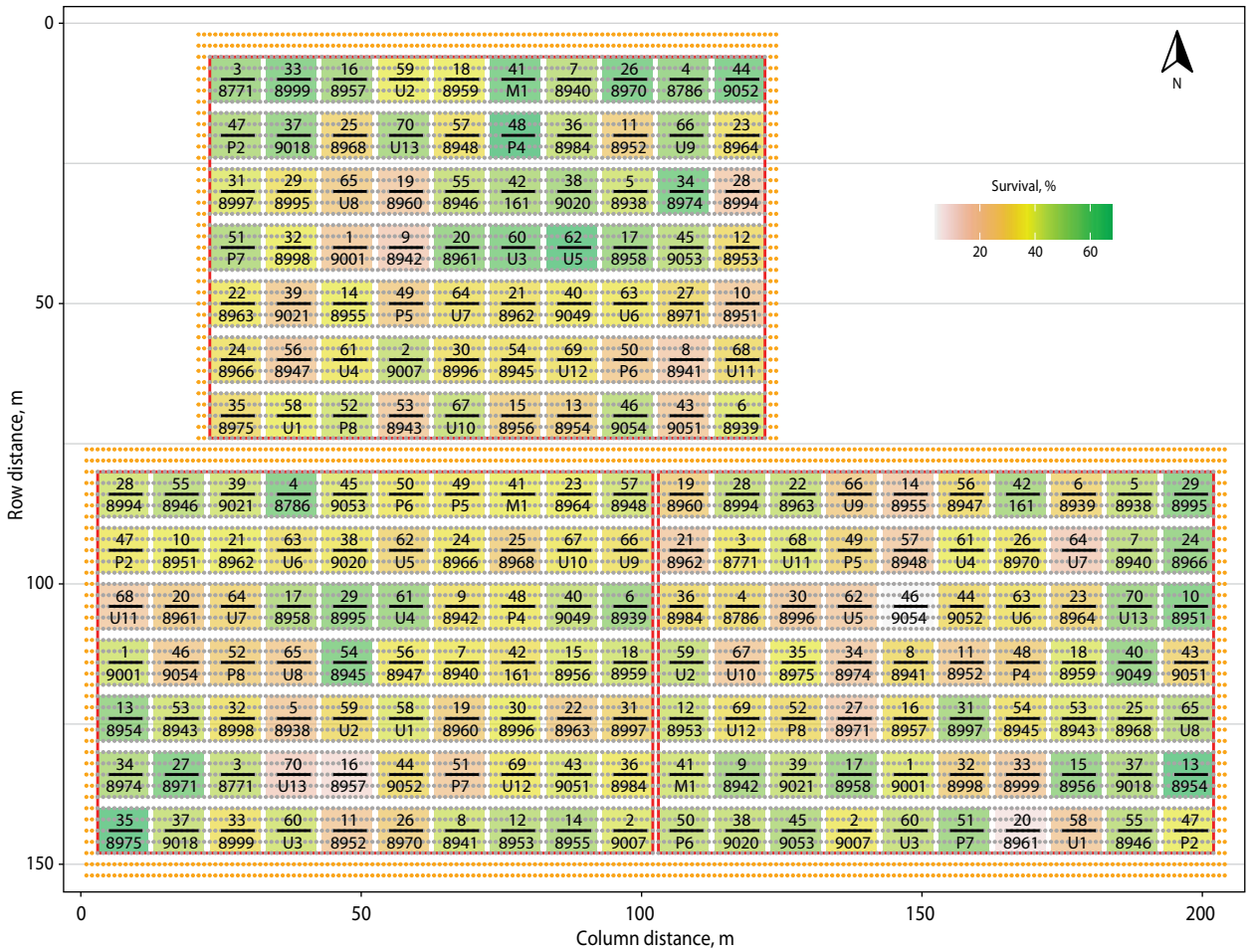

Figure 2. Plan of the provenance trial Bu19_19 established in 1995 in Stradch Educational-Industrial Forestry Complex. Fill color, according to the scale, denotes the survival rate of provenances after 28 years of growth. The numerator and denominator of each plot denote the provenances according to the columns ID and VersNr in Table 2. The red line denotes the borders of complete randomized blocks, and gray dots denote planting sites (orange dots around blocks denote bordering rows). Block one is on top, blocks two and three are bottom left and right, respectively.

senescence, while the provenance from Swierczyna (Poland) is the last to complete this phase.

The trial Bu19_19 has not been thinned since it was established. From May 22 to May 30, 2023, we measured the DBH of all alive trees at each plot of this site (Ivaniuk and Zaitsev 2024; Zaitsev and Ivaniuk 2023). The effects of the microenvironment on the survival of the population in each block are clearly

Figure 3. Plots with high (A) and low (B) survival rate at the Bu19_19 provenance test trial in Ukrainian Roztochchia

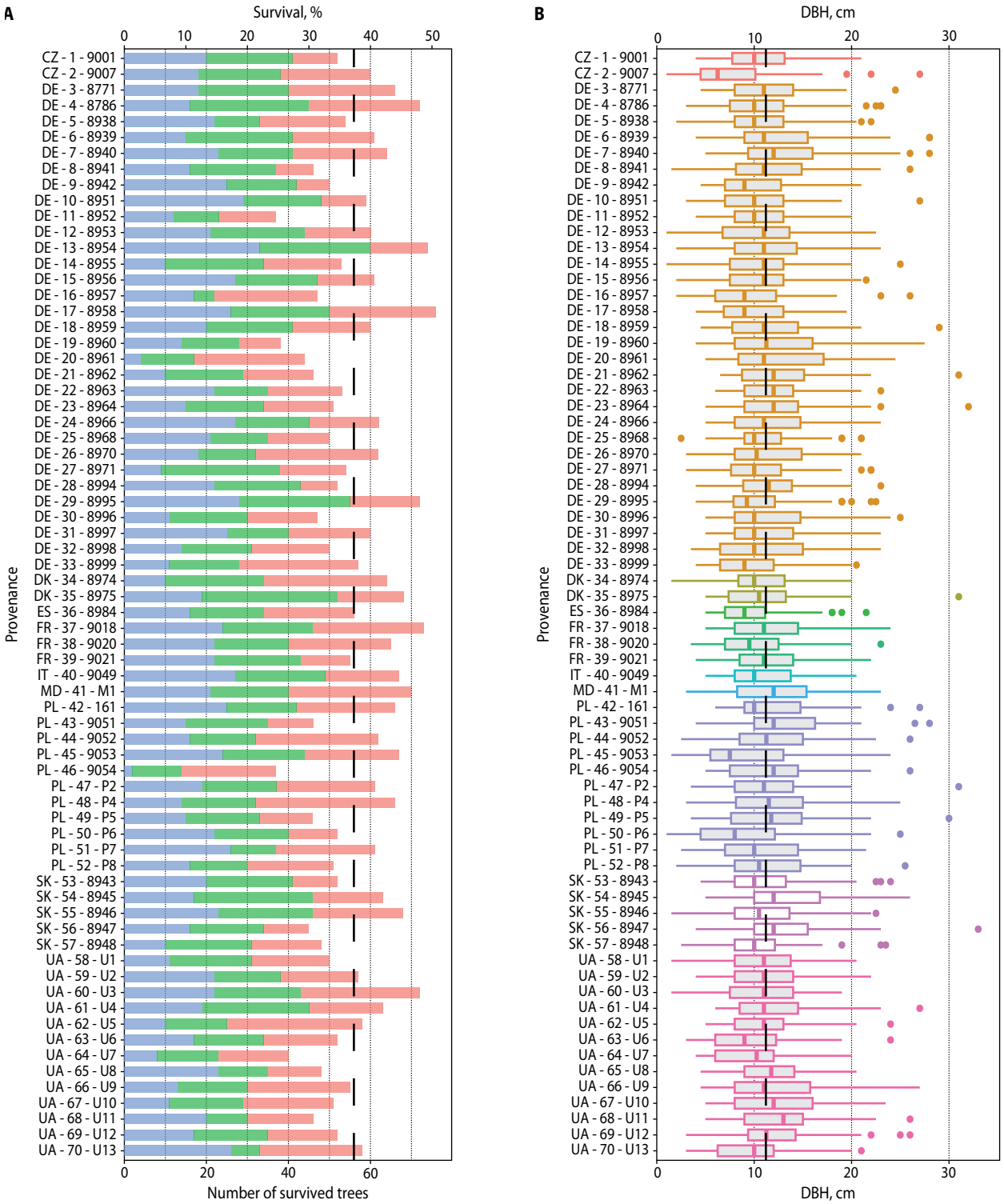

Figure 4. Survival rate (A) and DBH (B) at the Bu19_19 provenance trial 28 years after planting. Provenances are labeled according to columns CO, ID, and VersNr in Table 2. Vertical dashed lines indicate grand mean values. In panel A, the colors red, green and blue represent blocks 1, 2 and 3 respectively.

visible (Fig. 2). Thus, the number of alive trees per plot varies a lot (Fig. 3) due to both genetic and microenvironmental variability. Twenty-eight years after the trial was established, 3961 of the 10,500 trees planted are still present. The average survival rate is 38% or 57 trees per provenance (Fig. 4A). The number of surviving trees per provenance ranges from 37 (provenances 8952 and 9054 from Germany and Poland, respectively) to 76 (provenance 8958 from Germany). The average DBH of the trees at this site is 11.2 centimeters, while some provenances have trees with a DBH of more than 30 centimeters (Fig. 4B).

In conclusion, after almost three decades, the Bu19_19 provenance trial in Roztochchia demonstrates significant variability in survival and growth among European beech provenances. With a survival rate of 38%, the trial remains a valuable resource for investigating the performance of European beech populations and can provide crucial insights into their resilience and adaptation.

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