LIFE4FIR – Project LIFE18 NAT/IT/000164

"Decisive in situ and ex situ conservation strategies to secure the critically endangered Sicilian fir, Abies nebrodensis"

Report on: Updated census and mapping of the natural regeneration of *Abies nebrodensis*
Action C1.4

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Consiglio Nazionale delle Ricerche
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REPUBBLICA ITALIANA
REGIONE SICILIANA
ASSESSORATO REGIONALE
DELL'AGRICOLTURA, DELLO SVILUPPO RURALE
E DELLA PESCA MEDITERRANEA

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1. Introduction

This Deliverable concerns activities and results of the survey carried out in situ in the natural population of *Abies nebrodensis* aimed at the identification, census and mapping of the natural regeneration. These activities fall within those provided for by action C1.4 planned in the LIFE4FIR project (LIFE18 NAT/IT/000164).

Surveys were conducted for the detection and identification of the natural regeneration of *Abies nebrodensis* in the relic population. Census and mapping of the young plants were carried out using a GPS, to track the purported mother tree and to follow their evolution in the future and to optimize the protective function of the new fences that are going to be installed in 2021.

To carry out exhaustive surveys in the field, survey tables were prepared containing the parameters to be recorded: no. of the mother tree (MP), seedling Id, distance from MP, azimuth, height (cm), age, vegetative and health state, any notes. The collected data were used for the implementation of a comprehensive database and 15 maps, one for each mother plant.

2. Procedure followed to detect and track plants of the natural regeneration

Surveys were carried out to detect the young plants growing in the natural population site that originated from seed. To this end, numerous inspections were carried out during summer and fall 2020 in the vicinity of the mature trees of the natural population that had borne fruits in the past years. To make the surveyed natural regeneration traceable, a survey protocol was developed. It was based on measuring the distance in meters and the azimuth angle from each plant or seedling to its respective mother tree, through the use of a professional compass. This tracking procedure allowed to carry out future monitoring of the natural regeneration surveyed. For each plant or seedling identified, height, age (estimated with by counting the number of whorls), and information on the vegetative and phytosanitary state were recorded. Considering the experiences of previous surveys, among which the last dated back to 2014, pegs with labels were not used as signals of young plants. Infact, those used in the previous surveys detached and were chewed by deers after a few weeks as they entice these animals to approach.

3 Results

3.1 Consistency and localization of the natural regeneration

The survey of natural regeneration allowed to census a total of 484 plants and seedlings of *Abies nebrodensis*, subdivided among fifteen mother trees. This data is extremely significant considering that in the previous survey conducted in 2014, eleven mother trees with 274 accessions were recorded. In fact, new reports concern the mother tree no. 2, in the vicinity of which three established young plants with an estimated age of about 13 years have been recorded (Fig. 1).

Fig 1 – Young plant of the natural regeneration detected near the mother tree no. 2.

Fig. 2 - Plant about 25 years of age detected near the mother tree no. 13.

The mother tree no. 13 has four accessions, three young seedlings under 5 years of age and one 25 years-old plant (Fig. 2), probably not found in the previous monitoring.
Even for the mother tree no. 20, four 4-years-old seedlings were surveyed for the first time in 2020; and new plants (thirty-one) were also reported for the mother tree no. 11, located a few meters from the

Fig 3 – Mother trees no. 10 (left) and 11 (right)

Fig 4 – Newly reported plants detected in the 2020 survey (10/18 and 10/21) whose growth is protected by the pillow-shaped *Juniperus hemisphaerica*.

mother tree no. 10 (Fig. 3). The actual origin of these plants should be verified with genetic analysis. For this purpose, samples were collected and processed by the University of Seville involved in the population genetics task within the project.

With 169 accessions recorded, the mother tree no. 10 currently represents the individual of the *Abies nebrodensis* population with the highest number of plants of the natural regeneration. These have an age varying between 6 months and 22 years (of which twenty-six seedlings do not exceed 2 years) and are located at varying distances from their mother tree, from 6 to 71 meters (Fig. 4). Some plants over twenty years of age were found for the first time in the survey of 2020.

Comprehensive tables containing the data collected from of all plants of the natural regeneration registered in the 2020 survey are reported in the following pages (Tab. 2 and 3).

Table 2 – Main parameters recorded on the plants of the *Abies nebrodensis* natural regeneration.

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
1	1/1	x			5.50	258	12	9	very good
1	1/2	x			2.74	328	13	10	very good
1	1/3	x			7.80	52	14	14-16	fair
1	1/4	x			4.40	85	30	18	good
1	1/5	x			3.60	93	20	17	very good
1	1/6	x			5.50	95	11	10	very good
1	1/7	x			5.40	108	11	10	very good
1	1/8	x			6.05	118	13	17	good
1	1/9	x			5.23	119	16	14	very good
1	1/10	x			4.23	228	27	24	good
1	1/11		x	x	5.80	82	14	12-14	good
1	1/12	x			5.90	100	10	10	very good
1	1/13	x			5.00	108	12	9	very good
1	1/14	x			6.40	108	11	9	very good
1	1/15		x		3.14	110	12	7-8	very good
1	1/16		x		6.20	255	13	7-8	very good
1	1/17		x		6.10	260	12	7-8	very good
1	1/18		x		6.20	113	9	7-8	very good
1	1/19		x		1.65	18	8	6	good
1	1/20		x		4.50	110	6	4-5	very good
1	1/21		x		7.65	112	6	4-5	very good
1	1/22		x		8.90	102	6	4-5	very good
1	1/23		x		6.50	268	10	4-5	good
1	1/24		x		5.70	115	9	4-5	very good
1	1/25		x		3.80	285	3	1-2	fair
1	1/26		x		0.80	18	3	1-2	fair
1	1/27		x		6.40	108	2	1-2	very good
1	1/28		x		8.90	103	5	1-2	very good
1	1/29		x		0.80	252	4	<1	good
2	2/1		x		27.50	202	12	12-15	good
2	2/2		x		25.10	202	12	12-15	very good
2	2/3		x		25.90	206	14.5	12-15	very good

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
6	6/1	x			5.40	128	28	24-26	good
6	6/2	x			8.00	118	22	13	good
8	8/1	x			7.30	285	58	20-26	very good
8	8/2	x			4.15	280	48	16-17	very good
8	8/3		x		20.00	135	10	9	very good
8	8/4		x		14.80	138	8.5	6	very good
8	8/5		x		18.00	144	8	5-6	good
8	8/6		x	x	13.20	145	6	4-5	very good
8	8/7		x		16.60	130	11	4-5	very good
8	8/8		x		17.20	1285	7	4-5	very good
8	8/9		x	x	9.45	282	11.5	4-5	very good
8	8/10		x		16.85	162	8	4-5	very good
8	8/11		x		18.30	162	8	4-5	very good
8	8/12		x		17.60	156	6	4-5	very good
8	8/13		x		20.20	133	6.5	4-5	good
8	8/14		x		10.13	282	7	3	very good
8	8/15		x		9.58	286	5	1-2	good
8	8/16		x		4.40	311	5	1-2	poor
8	8/17		x		6.10	230	5	1-2	good
8	8/18		x		15.40	151	4	1-2	very good
8	8/19		x		14.90	160	5	1-2	very good
8	8/20		x		17.50	152	3.5	1-2	good
8	8/21		x		18.00	144	4	1-2	good
8	8/22		x		19.00	141	4	1-2	very good
8	8/23		x		65.00	92	4	1-2	very good
8	8/24		x		13.20	148	3	<1	good
8	8/25		x		13.20	148	2	<1	good
8	8/26		x		16.00	145	1	<1	good
8	8/27		x		18.00	175	3	<1	fair
10	10/1	x			9.10	64	19	20	fair
10	10/2	x			10.30	62	44	20-22	poor
10	10/3	x			11.15	74	32	20	poor
10	10/4	x			12.00	68	23	14	good
10	10/5	x			12.90	75	22	12	poor
10	10/6	x			14.07	76	34	14	good
10	10/7	x			9.00	62	29	16-18	fair
10	10/8	x			5.10	77	15	13-14	good
10	10/9	x			10.86	72	32	15	poor
10	10/10	x			22.20	68	34	16-18	poor
10	10/11	x			24.50	72	35	16-18	good
10	10/13	x			39.00	93	8	7-8	good
10	10/14			x	7.70	61	30	16-18	fair
10	10/15	x			13.90	67	16	16	poor
10	10/16	x			16.60	57	22	15	good
10	10/17	x			17.60	37	30	18-20	very good
10	10/19	x			7.65	69	12	8-9	good
10	10/20	x			6.10	66	17	13	good
10	10/22	x			28.20	87	7	6-7	good
10	10/23	x			30.30	87	5	6-7	good
10	10/24	x			14.90	73	8	7-8	very good
10	10/18		x	x	12.50	279	25	16-18	very good
10	10/21		x	x	12.10	278	28	16-18	very good
10	10/12		x	x	15.50	144	19	16-18	fair
10	10/25		x		13.60	64	20	15-16	good
10	10/26		x		14.20	75	40	15-16	fair

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
10	10/27		x		27.00	67	27	15-16	fair
10	10/28		x		13.10	74	24	14-16	good
10	10/29		x		17.50	101	20	11-12	very good
10	10/30		x		18.80	70	11.5	9-10	very good
10	10/31		x		9.10	94	11	8-9	good
10	10/32		x		57.00	102	9	8-9	good
10	10/33		x		57.00	120	12	8-9	very good
10	10/34		x		68.00	108	8	8-9	fair
10	10/35		x		6.00	67	7	7-8	good
10	10/36		x		11.90	65	4	7-8	fair
10	10/37		x		11.90	65	8	7-8	fair
10	10/38		x		12.00	69	7.5	7-8	good
10	10/39		x		13.20	74	8	7-8	good
10	10/40		x		13.60	60	9	7-8	fair
10	10/41		x		13.80	50	12	7-8	very good
10	10/42		x		14.90	72	10	7-8	very good
10	10/43		x		15.06	70	11	7-8	very good
10	10/44		x		15.34	54	6.5	7-8	very good
10	10/45		x		19.80	93	10	7-8	good
10	10/46		x		21.50	77	8	7-8	good
10	10/47		x		57.00	102	10	7-8	very good
10	10/48		x		10.50	61	7.5	6-7	very good
10	10/49		x		42.00	94	6	6-7	good
10	10/50		x		7.50	78	4	5-6	fair
10	10/51		x		7.65	71	8	5-6	good
10	10/52		x		7.80	73	8	5-6	good
10	10/53		x		7.80	61	7	5-6	good
10	10/54		x		8.30	69	7	5-6	good
10	10/55		x		8.40	68	9	5-6	good
10	10/56		x		9.50	71	9	5-6	very good
10	10/57		x		9.70	70	9	5-6	good
10	10/58		x		10.20	61	8	5-6	good
10	10/59		x		10.30	75	9	5-6	very good
10	10/60		x		11.40	71	7	5-6	fair
10	10/61		x		11.50	105	5	5-6	fair
10	10/62		x		12.10	73	8	5-6	good
10	10/63		x		12.10	73	6	5-6	good
10	10/64		x		13.50	66	8	5-6	poor
10	10/65		x		13.60	68	8	5-6	good
10	10/66		x		13.65	70	5	5-6	good
10	10/67		x		14.00	68	7	5-6	very good
10	10/68		x		14.30	67	7.5	5-6	good
10	10/69		x		14.45	69	5	5-6	very good
10	10/70		x		15.06	70	9	5-6	very good
10	10/71		x		15.70	94	6	5-6	very good
10	10/72		x		15.73	77	6	5-6	good
10	10/73		x		16.00	72	10	5-6	good
10	10/74		x		16.00	72	10	5-6	good
10	10/75		x		16.10	77	8	5-6	fair
10	10/76		x		16.70	68	6	5-6	good
10	10/77		x		17.00	83	10	5-6	very good
10	10/78		x		23.80	80	5	5-6	good
10	10/79		x		29.00	87	5	5-6	good
10	10/80		x		29.50	87	5	5-6	good
10	10/81		x		33.70	81	7	5-6	very good

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
10	10/82		x		73.00	103	11.5	5-6	good
10	10/83		x		7.65	75	5	4-5	good
10	10/84		x		9.60	71	7	4-5	very good
10	10/85		x		11.20	74	6	4-5	good
10	10/86		x		15.20	56	7	4-5	very good
10	10/87		x		16.10	99	11	4-5	good
10	10/88		x		16.50	74	6	4-5	good
10	10/89		x		17.15	93	7	4-5	very good
10	10/90		x		5.90	66	5	3-4	fair
10	10/91		x		7.00	63	6	3-4	good
10	10/92		x		7.50	78	8	3-4	good
10	10/93		x		8.30	63	5	3-4	good
10	10/94		x		8.50	66	9	3-4	good
10	10/95		x		8.50	66	6	3-4	good
10	10/96		x		8.90	80	7	3-4	good
10	10/97		x		9.00	79	5	3-4	good
10	10/98		x		9.00	70	5	3-4	good
10	10/99		x		9.20	68	7	3-4	good
10	10/100		x		9.20	68	6	3-4	good
10	10/101		x		9.30	68	8	3-4	good
10	10/102		x		9.60	70	4	3-4	fair
10	10/103		x		10.00	56	6	3-4	fair
10	10/104		x		10.10	61	5	3-4	fair
10	10/105		x		10.45	55	8	3-4	fair
10	10/106		x		10.70	71	5	3-4	good
10	10/107		x		10.80	72	6	3-4	fair
10	10/108		x		10.90	56	10.9	3-4	fair
10	10/109		x		11.30	69	3	3-4	poor
10	10/110		x		11.50	104	7	3-4	good
10	10/111		x		11.50	104	3	3-4	poor
10	10/112		x		11.50	69	5	3-4	very good
10	10/113		x		11.80	104	7	3-4	good
10	10/114		x		11.90	67	7	3-4	good
10	10/115		x		13.70	60	5	3-4	good
10	10/116		x		14.90	73	5	3-4	very good
10	10/117		x		15.20	91	5	3-4	very good
10	10/118		x		15.20	91	4	3-4	very good
10	10/119		x		15.78	88	6	3-4	very good
10	10/120		x		15.88	92	4	3-4	very good
10	10/121		x		16.80	55	6	3-4	very good
10	10/122		x		16.80	75	5	3-4	good
10	10/123		x		17.20	95	6	3-4	good
10	10/124		x		17.30	95	5.5	3-4	good
10	10/125		x		17.32	86	4	3-4	very good
10	10/126		x		17.45	96	4	3-4	good
10	10/127		x		17.82	93	6	3-4	very good
10	10/128		x		18.20	90	6	3-4	poor
10	10/129		x		18.30	78	5	3-4	good
10	10/130		x		18.37	86	4	3-4	very good
10	10/131		x		18.40	90	6.5	3-4	very good
10	10/132		x		18.45	96	4.5	3-4	very good
10	10/133		x		18.70	87	7	3-4	very good
10	10/134		x		19.30	86	5	3-4	very good
10	10/135		x		20.00	93	4	3-4	good
10	10/136		x		23.00	87	7	3-4	very good

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
10	10/137		x		40.00	96	4	3-4	good
10	10/138		x		40.70	93	5	3-4	good
10	10/139		x		40.70	94	4	3-4	good
10	10/140		x		47.00	102	8	3-4	good
10	10/141		x		48.00	98	6	3-4	good
10	10/142		x		53.00	104	5	3-4	very good
10	10/143		x		58.00	102	3.5	3-4	good
10	10/144		x		7.10	63	3	1-2	fair
10	10/145		x		8.90	95	3	1-2	good
10	10/146		x		8.90	70	5	1-2	good
10	10/147		x		8.95	81	3	1-2	good
10	10/148		x		9.50	70	5	1-2	good
10	10/149		x		10.20	104	5	1-2	good
10	10/150		x		10.70	71	4	1-2	good
10	10/151		x		11.20	74	3	1-2	good
10	10/152		x		12.10	74	3	1-2	good
10	10/153		x		16.50	83	3	1-2	very good
10	10/154		x		16.80	75	3	1-2	good
10	10/155		x		17.50	95	2	1-2	good
10	10/156		x		20.20	85	3	1-2	good
10	10/157		x		27.20	85	3.5	1-2	good
10	10/158		x		27.50	86	2.5	1-2	good
10	10/159		x		33.40	91	6	1-2	good
10	10/160		x		38.00	110	4	1-2	very good
10	10/161		x		44.00	107	3	1-2	good
10	10/162		x		47.00	107	4	1-2	good
10	10/163		x		47.00	100	3	1-2	good
10	10/164		x		50.00	100	3	1-2	good
10	10/165		x		52.00	98	3	1-2	good
10	10/166		x		27.00	85	2	1	good
10	10/167		x		38.50	93	3	1	good
10	10/168		x		50.00	100	2	1	good
10	10/169		x		54.00	104	3	1	good
11	11/1		x		13.30	113	6	7-8	good
11	11/2		x		19.10	111	9	7-8	very good
11	11/3		x		19.50	97	8	7-8	good
11	11/4		x		21.50	97	10	7-8	good
11	11/5		x		22.80	98	10	7-8	good
11	11/6		x		10.80	87	12	5-6	very good
11	11/7		x		10.80	87	11	5-6	very good
11	11/8		x		18.90	107	7	5-6	fair
11	11/9		x		21.90	107	7	5-6	very good
11	11/10		x		26.70	115	6	5-6	very good
11	11/11		x		27.50	115	6	5-6	very good
11	11/12		x		41.00	102	7	5-6	good
11	11/13		x		41.50	99	7	5-6	good
11	11/14		x		46.00	98	6	5-6	good
11	11/15		x		52.00	97	7	5-6	very good
11	11/16		x		52.00	98	8	5-6	very good
11	11/17		x		22.40	114	5	4-5	good
11	11/18		x		37.00	98	6	4-5	very good
11	11/19		x		19.40	111.5	6.5	4	very good
11	11/20		x		21.50	107	5	4	good
11	11/21		x		29.50	113	6	4	very good
11	11/22		x		37.00	105	7.5	4	good

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
11	11/23		x		46.50	97	7	4	good
11	11/24		x		54.00	96	3.5	4	good
11	11/25		x		10.80	87	6	3	good
11	11/26		x		19.80	98	5	3	good
11	11/27		x		21.40	114	5	2	very good
11	11/28		x		22.80	98	7	2	good
11	11/29		x		25.50	115	3	2	good
11	11/30		x		41.00	98	4	2	good
11	11/31		x		45.00	101	3	2	good
13	13/1		x		18.74	191	11	5	very good
13	13/2		x		18	244	35	21	very good
13	13/3		x		28	242	5	3	very good
13	13/4		x		27.5	240	3	1-2	good
17	17/1	x			17.00	200	5	6	good
17	17/2	x			17.00	205	5	6	good
17	17/3	x			20.00	192	4	6	pessimo
17	17/4	x			26.00	184	5	6	good
18	18/1		x	x	13.50	259	12	15	good
18	18/2		x	x	5.50	40	8	6-7	good
18	18/3		x	x	5.50	115	6	6	good
18	18/4		x	x	6.90	108	6	2	good
18	18/5	x			2.25	149	15	18	good
18	18/6		x	x	6.05	100	7	3	good
18	18/7		x	x	5.00	115	4	2	good
18	18/8		x	x	2.00	172	5	2	good
18	18/9	x			2.60	195	13	20	good
18	18/10	x			2.53	200	12	16	fair
18	18/11	x		x	3.50	202	12	12	good
18	18/12	x			4.30	195	16	12	good
18	18/13	x			5.70	202	18	12	good
18	18/14	x			6.20	201	9	11	good
18	18/15	x			6.10	194	15	15	good
18	18/16		x	x	1.80	121	5	3	good
18	18/17	x			5.60	191	10	10	good
18	18/18	x			13.00	205	32	20	very good
18	18/20	x			9.20	118	24	18	very good
18	18/23	x			6.40	133	12	19	good
18	18/24	x			5.80	144	10	16	fair
18	18/24bis	x			5.80	144	7	13	good
18	18/27	x			4.28	125	6	10	good
18	18/28	x			4.38	115	5	9	good
18	18/29	x			5.08	125	7	10	good
18	18/30	x			5.00	115	14	17	poor
18	18/32	x			5.60	105	7	12	good
18	18/33	x			5.30	100	5	11	good
18	18/34	x			7.80	95	9.5	11	good
18	18/35	x			6.20	256	9	14	poor
18	18/36	x			9.55	289	12	16	good
18	18/37	x			12.21	63	12	17	good
18	18/38	x			11.46	70	18	17	good
18	18/39	x			13.10	74	22	20	good
18	18/40	x			8.25	76	15	20	good
18	18/41	x			14.00	95	9	9	poor
18	18/42	x			10.54	101	27	24	very good
18	18/44	x			12.70	192	15	20	fair

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
18	18/45	x			13.50	188	14	12	very good
18	18/46	x			11.15	89	12	17	good
18	18/47	x			8.25	75	8	8-9	fair
18	18/48	x			8.40	70	7	8-9	good
18	18/49	x			12.93	65	12	16	good
20	20/1		x		5.00	355	8	3	good
20	20/2		x		5.00	356	7	3	good
20	20/3		x		4.80	355	5	3	good
20	20/4		x		6.00	5	5	3	good
21	21/1		x	x	7.03	305	10.5	4-6	good
21	21/2		x	x	9.00	105	4	3-4	good
21	21/3	x			10.35	95	5	8	good
21	21/4		x		13.00	80	3	1-2	good
21	21/5		x		13.00	80	3	1-2	good
21	21/6		x		13.00	80	3	1-2	good
21	21/7		x		13.00	80	3	1-2	good
21	21/8		x		13.00	80	3	1-2	good
21	21/9		x		12.80	85	2	1-2	good
21	21/10		x		12.33	94	3	1-2	good
21	21/11		x		12.33	94	3	1-2	good
21	21/12		x		12.33	94	3	1-2	good
21	21/13		x		12.33	94	3	1-2	good
21	21/14		x		11.77	96	2	1-2	good
21	21/15		x		11.77	96	2	1-2	good
21	21/16		x		11.77	96	2	1-2	good
21	21/17		x		9.90	99	3	1-2	good
21	21/18		x		9.90	99	3	1-2	good
21	21/19		x		9.90	99	3	1-2	good
21	21/20		x		10.35	96	2	1-2	good
21	21/21		x		10.35	96	2	1-2	good
21	21/22		x		10.35	96	2	1-2	good
21	21/23		x		13.00	80	3	1-2	good
21	21/24		x		13.00	80	3	1-2	good
21	21/25		x		16.80	80	3	1-2	very poor
21	21/26		x		20.83	85	2	1-2	fair
21	21/27		x		20.83	85	2	1-2	fair
21	21/28		x		20.83	85	2	1-2	fair
21	21/29		x		8.46	200	3	1-2	fair
21	21/30		x		8.18	305	3.5	1-2	good
21	21/31		x		0.90	140	2	1-2	good
21	21/32		x		1.55	140	5	1-2	good
21	21/33		x		0.60	140	3	1-2	good
21	21/34		x		2.77	145	3	1-2	good
21	21/35		x		2.74	115	2	1-2	good
21	21/36		x		2.74	115	3	1-2	good
21	21/37		x		2.45	122	3	1-2	good
21	21/38		x		7.30	60	4	1-2	good
21	21/39		x		7.94	70	3	1-2	good
21	21/40		x		7.98	70	3	1-2	good
21	21/41		x		7.24	72	2	1-2	good
21	21/42		x		7.84	72	2	1-2	good
21	21/43		x		7.84	72	2	1-2	good
21	21/44		x		7.71	72	2	1-2	good
21	21/45		x		8.44	78	3	1-2	good
21	21/46		x		9.42	78	3	1-2	good

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
21	21/47		x		10.24	78	2	1-2	good
21	21/48		x		10.24	81	2	1-2	good
21	21/49		x		10.24	78	2	1-2	good
21	21/50		x		10.91	83	2	1-2	good
21	21/51		x		10.91	83	2	1-2	good
21	21/52		x		10.91	83	2	1-2	good
21	21/53		x		12.00	81	4	1-2	good
21	21/54		x		12.00	81	4	1-2	good
21	21/55		x		12.00	81	4	1-2	good
21	21/56		x		12.60	78	3	1-2	good
21	21/57		x		12.60	78	3	1-2	good
21	21/58		x		12.60	78	3	1-2	good
22	22/A	x			4.52	165	25	35	good
22	22/B	x			6.10	178	50	36	very good
22	22/C	x			7.15	192	41	32	very good
22	22/D	x			8.50	313	48.5	29	very good
22	22/1	x			6.40	164	13	11	good
22	22/2		x	x	11.50	198	17	16	good
22	22/3	x			6.40	252	8	9	good
22	22/4	x			10.00	37	16	16	good
22	22/5	x			8.80	60	15	13	good
22	22/6	x			10.90	37	12	16	good
22	22/7		x	x	7.00	145	12	11	good
22	22/8	x			9.40	184	20	17	good
22	22/9		x	x	9.20	70	10.5	9	good
22	22/10		x	x	45.00	13	18	11	good
22	22/11		x	x	4.60	188	5.5	7	good
22	22/12		x	x	5.00	182	5	7	good
22	22/13	x			5.00	257	6	8	good
22	22/14	x			10.70	38	25	23	good
22	22/15	x			11.43	45	16	10	good
22	22/16	x			12.30	38	10	15	good
22	22/17	x			12.60	39	12	10	good
22	22/18	x			12.30	43	11	15	very good
22	22/19	x			5.54	345	18	16	good
22	22/20	x			12.10	46	21	16	very good
22	22/21	x			12.70	48	16	14	good
22	22/22	x			13.00	48	18	14	good
22	22/23	x			14.35	45	28	14	very good
22	22/24	x			13.40	35	10	10	good
22	22/25	x			13.80	35	17	13	good
22	22/26	x			14.20	35	11	11	good
22	22/27		x	x	46.00	5	16	7	good
22	22/28	x			10.20	56	11	11	good
22	22/29	x			11.20	190	16	10	good
22	22/30	x			13.00	170	21	15	very good
22	22/31	x			19.10	14	19	15	good
22	22/32	x			18.60	13	18	16	good
22	22/33		x	x	46.00	10	20	7	good
22	22/34	x			34.25	350	12	12	good
22	22/35		x	x	46.00	10	12	5	good
22	22/36	x			18.00	82	15	16	good
22	22/37		x	x	42.40	10	8	5	good
22	22/38	x			15.20	32	14	10	good
22	22/39	x			11.30	330	12	8	good

Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
22	22/40		x	x	45.50	10	6	5	good
22	22/41		x	x	45.00	5	9	5	good
22	22/42	x			5.30	180	11	10	good
22	22/43	x			4.80	190	8	9	good
22	22/44	x			12.70	42	9	9	good
22	22/45	x			13.00	143	15	12	fair
22	22/46	x			13.70	141	14	12	good
22	22/47		x		4.80	215	8	5	good
22	22/48		x		10.33	68	7.5	5	good
22	22/49		x		10.82	40	6	5	good
22	22/50		x		11.33	44	7.5	5	good
22	22/51		x		15.20	32	6.5	5	good
22	22/52		x		17.10	7	12	5	good
22	22/53		x		19.30	21	10	5	good
22	22/54		x		19.30	21	7	5	good
22	22/55		x		19.36	20	11	5	good
22	22/56		x		20.70	17	10	5	good
22	22/57		x		10.10	50	7.5	4	good
22	22/58		x		10.80	68	7	4	good
22	22/59		x		17.60	24	9	4	good
22	22/60		x		18.00	10	7	4	good
22	22/61		x		18.00	20	8	4	good
22	22/62		x		5.20	13	7	3	good
22	22/63		x		10.94	42	4	3	good
22	22/64		x		11.80	70	10	3	good
22	22/65		x		14.20	45	6	3	good
22	22/66		x		14.30	45	4.5	3	good
22	22/67		x		14.30	39	6.5	3	good
22	22/68		x		14.40	38	3.5	3	good
22	22/69		x		18.50	8	6	3	poor
22	22/70		x		10.48	45	5	2	good
22	22/71		x		12.60	38	3	2	good
22	22/72		x		32.50	350	6	1-2	good
22	22/73		x		46.00	10	5	1-2	good
22	22/74		x		4.60	215	4	1-2	good
22	22/75		x		5.00	182	2	1-2	good
22	22/76		x		5.00	183	2	1-2	good
22	22/77		x		5.00	181	2	1-2	good
22	22/78		x		5.10	257	3	1-2	good
22	22/79		x		5.50	257	3	1-2	good
22	22/80		x		7.00	146	3	1-2	good
22	22/81		x		7.00	144	2	1-2	good
22	22/82		x		10.95	42	3	1-2	good
22	22/83		x		14.40	37	4	1-2	good
23	23/1				7.20	210	21	16	very good
27	27/1				9.80	276	34	19-20	very good
27	27/2				10.00	271	35.5	19-20	very good
27	27/3				11.00	276	30	16	very good
29	29/1	x			6.80	172	33	22	good
29	29/2	x			2.95	229	9	10	poor
29	29/3		x	x	3.10	320	5	4	poor
29	29/4	x			3.10	225	7	8	poor
29	29/5	x			5.70	225	10	9	good
29	29/6	x			3.10	229	7	8	good
29	29/10	x			3.50	229	9	9	good

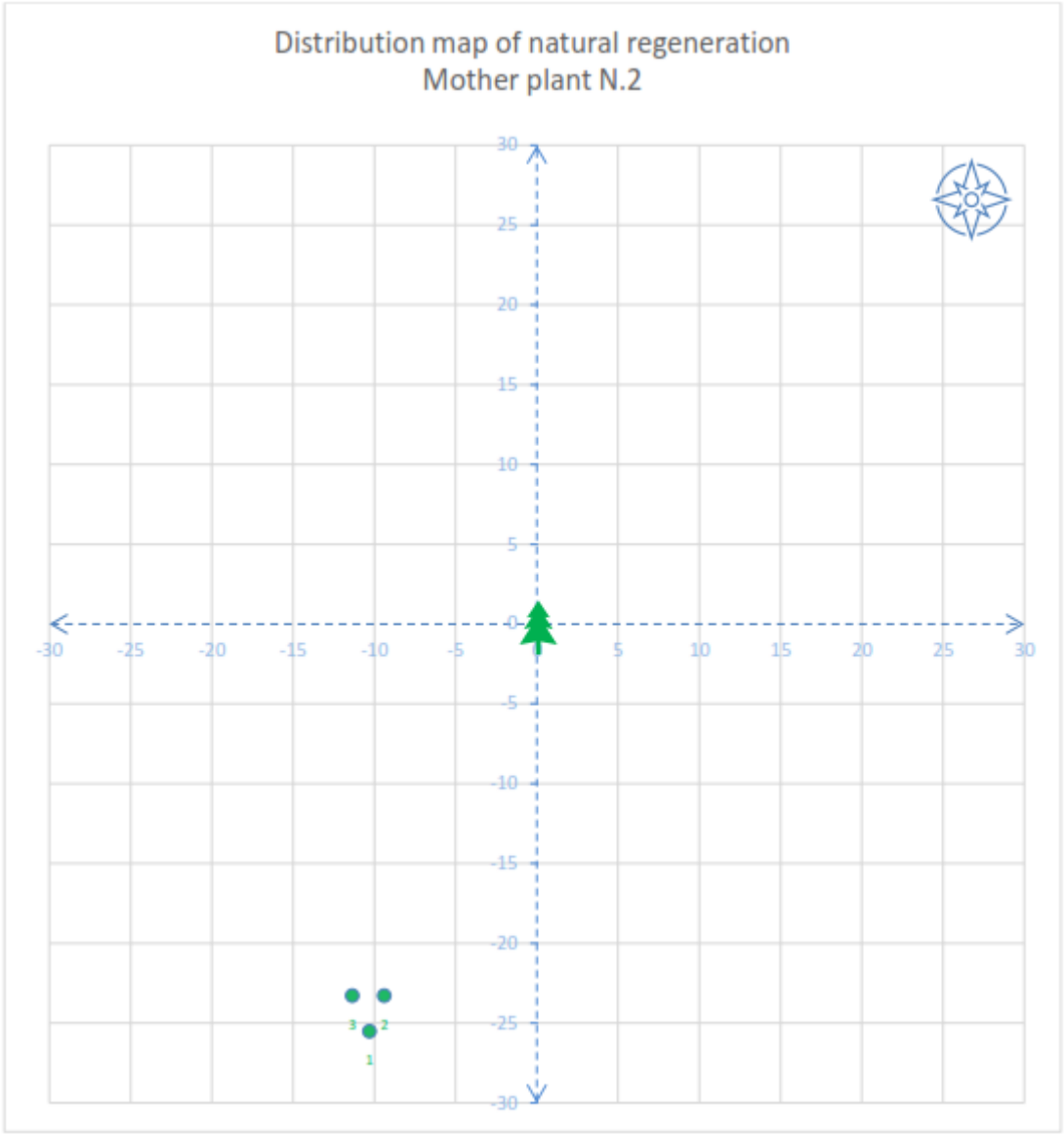
Mother Plant Id	Natural regeneration plant Id	Surveyed in 2014	New detection (2020)	Replacement	Distance from the MP (m)	Azimuth (degree)	Height (cm)	Age	Growth and health conditions
29	29/11	x			3.00	205	9	7	good
29	29/7		x		3.10	320	5	2	good
29	29/8		x		3.10	320	5	2	good
29	29/9		x		3.10	320	5	2	good
29	29/12		x		3.10	320	5	2	good
29	29/13		x		3.10	320	5	2	good
29	29/14		x		3.30	190	4	2	good
29	29/15		x		2.45	190	5	2	good
29	29/16		x		2.10	210	4	2	good
29	29/17		x		2.90	215	4	2	good
29	29/18		x		3.10	320	3	1	good
29	29/19		x		2.40	35	3	1	good

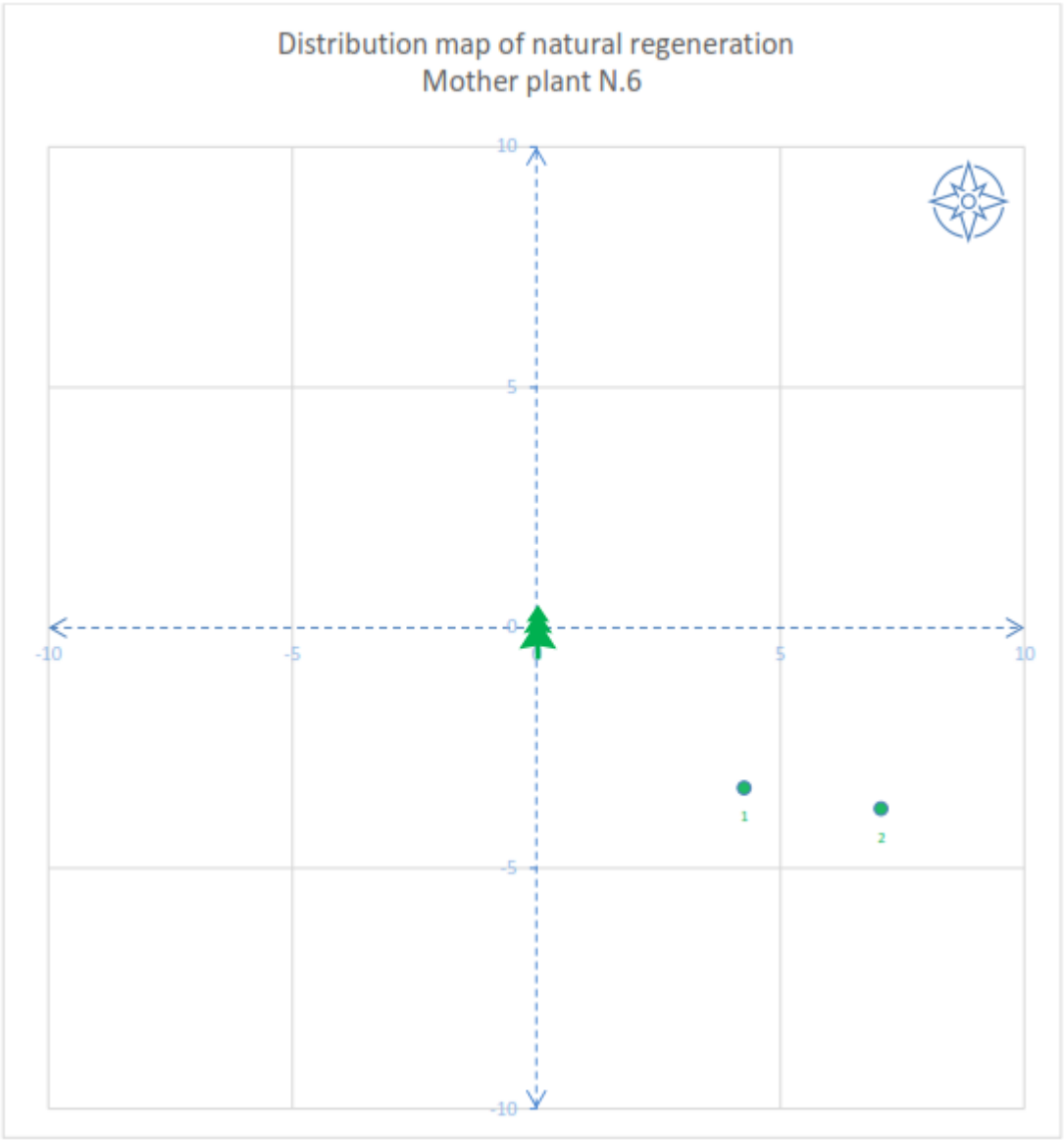
Mother tree (no.)	No. plants of the natural regeneration	No. of seedlings (age < 2 years)	No. tot natural regeneration	Plants already surveyed in 2014	Plants newly reported in the 2020 survey
1	24	5	29	13	16
2	3		3		3
6	2		2	2	
8	14	13	27	2	25
10	143	26	169	21	148
11	26	5	31		31
13	3	1	4		4
17	4		4	4	
18	40	3	43	35	8
20	4		4		4
21	3	55	58	1	57
22	73	14	87	38	49
23	1		1	1	
27	3		3	3	
29	8	11	19	7	12
Tot.	**351**	**133**	**484**	**127**	**357**

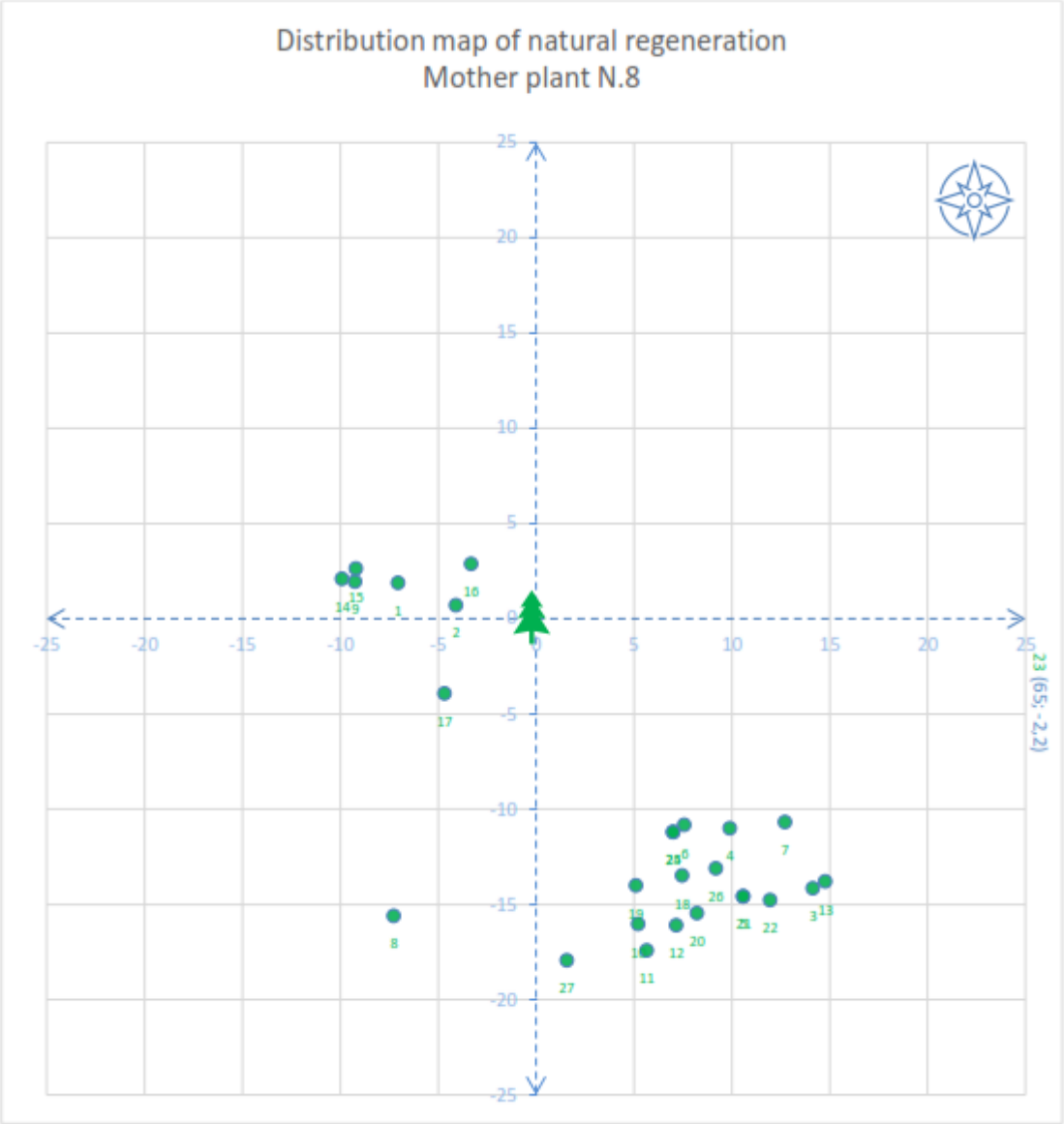
Table 3 – Summary table of the amount of the natural regeneration for each mother tree

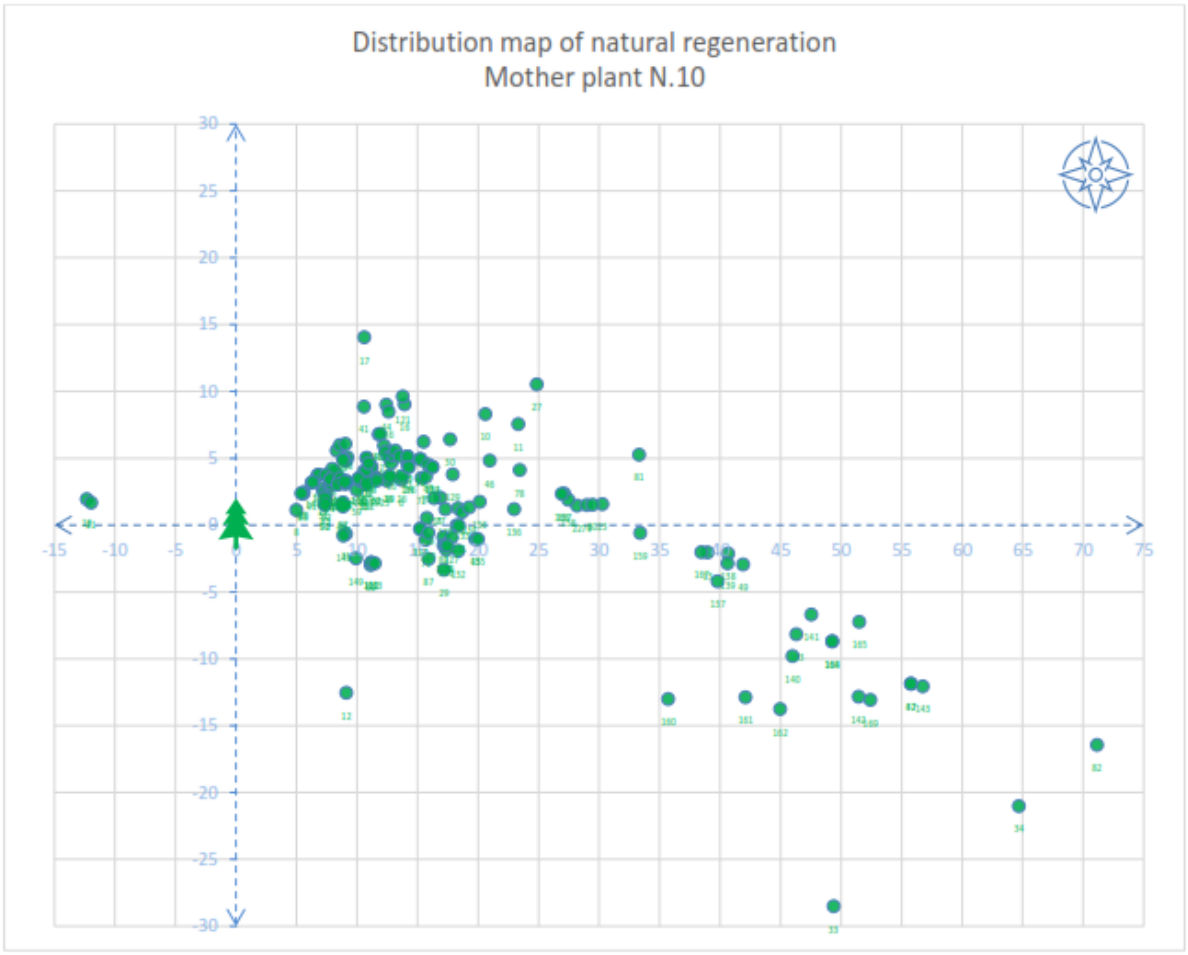
3.2 Distribution maps of the *Abies nebrodensis* natural regeneration

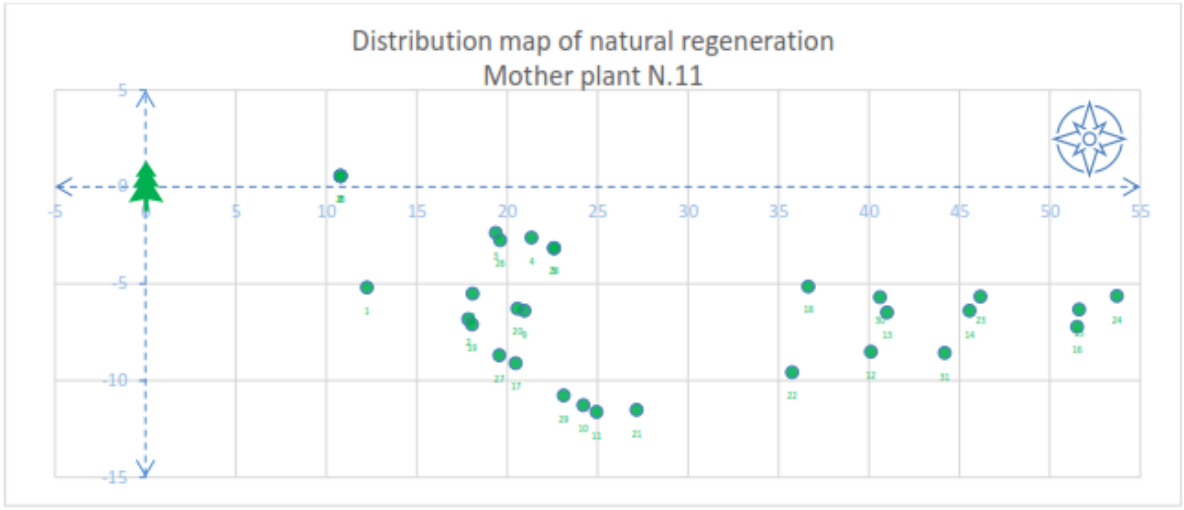
The distribution maps of the natural regeneration were elaborated for each mother tree based on the azimuth coordinates and the distance measured for each accession referred to its purported mother tree. Both axes report linear metric measurements.

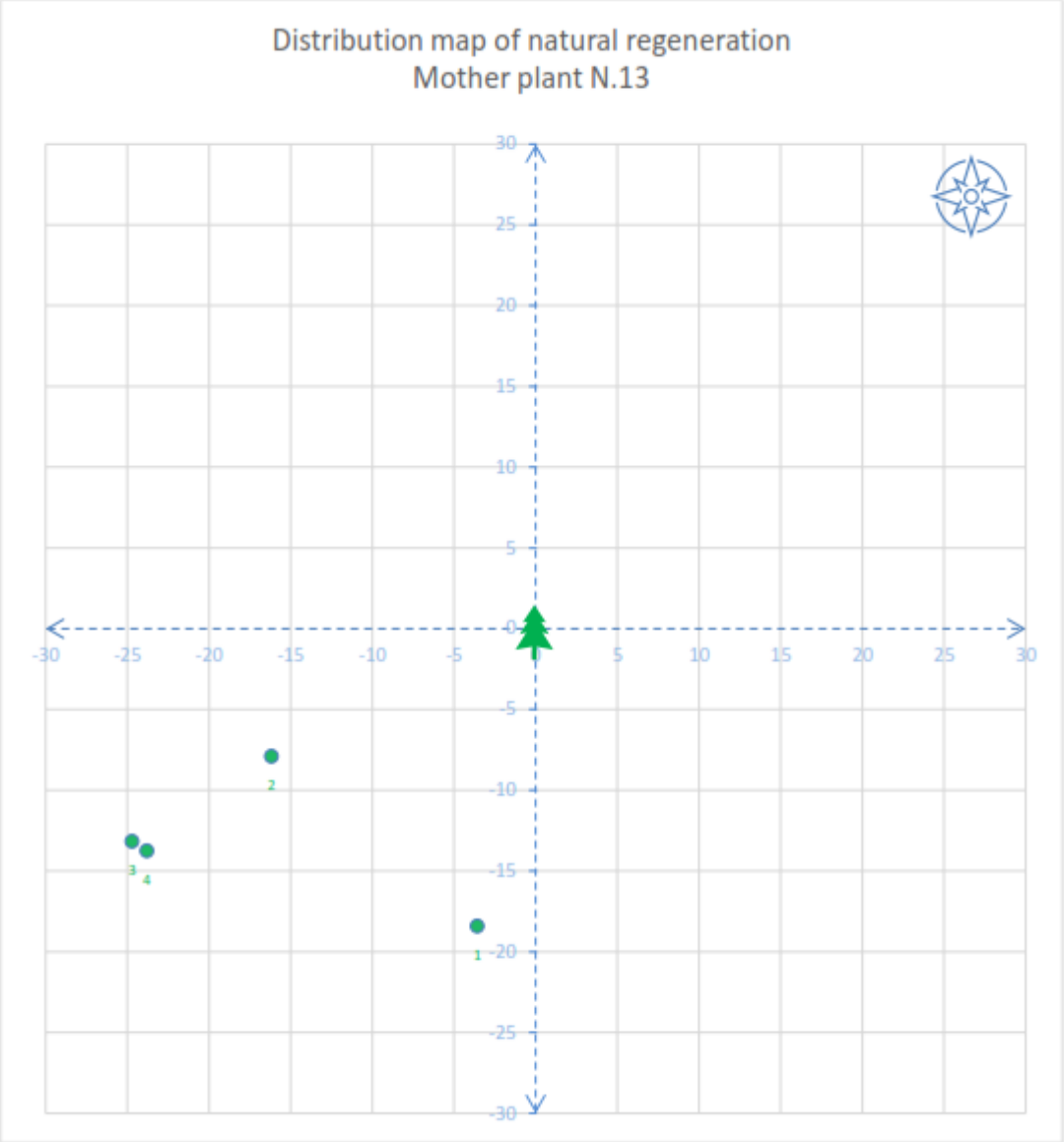



Distribution map of natural regeneration
Mother plant N.6
10
5
0
-5
-10
-10
-5
5
10
1
2


Distribution map of natural regeneration
Mother plant N.8
25
20
15
10
5
0
-5
-10
-15
-20
-25
-25
-20
-15
-10
-5
0
5
10
15
20
25
23 (65; -2,2)


Distribution map of natural regeneration
Mother plant N.10


Distribution map of natural regeneration
Mother plant N.11


Distribution map of natural regeneration
Mother plant N.13
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
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-25
-20
-15
-10
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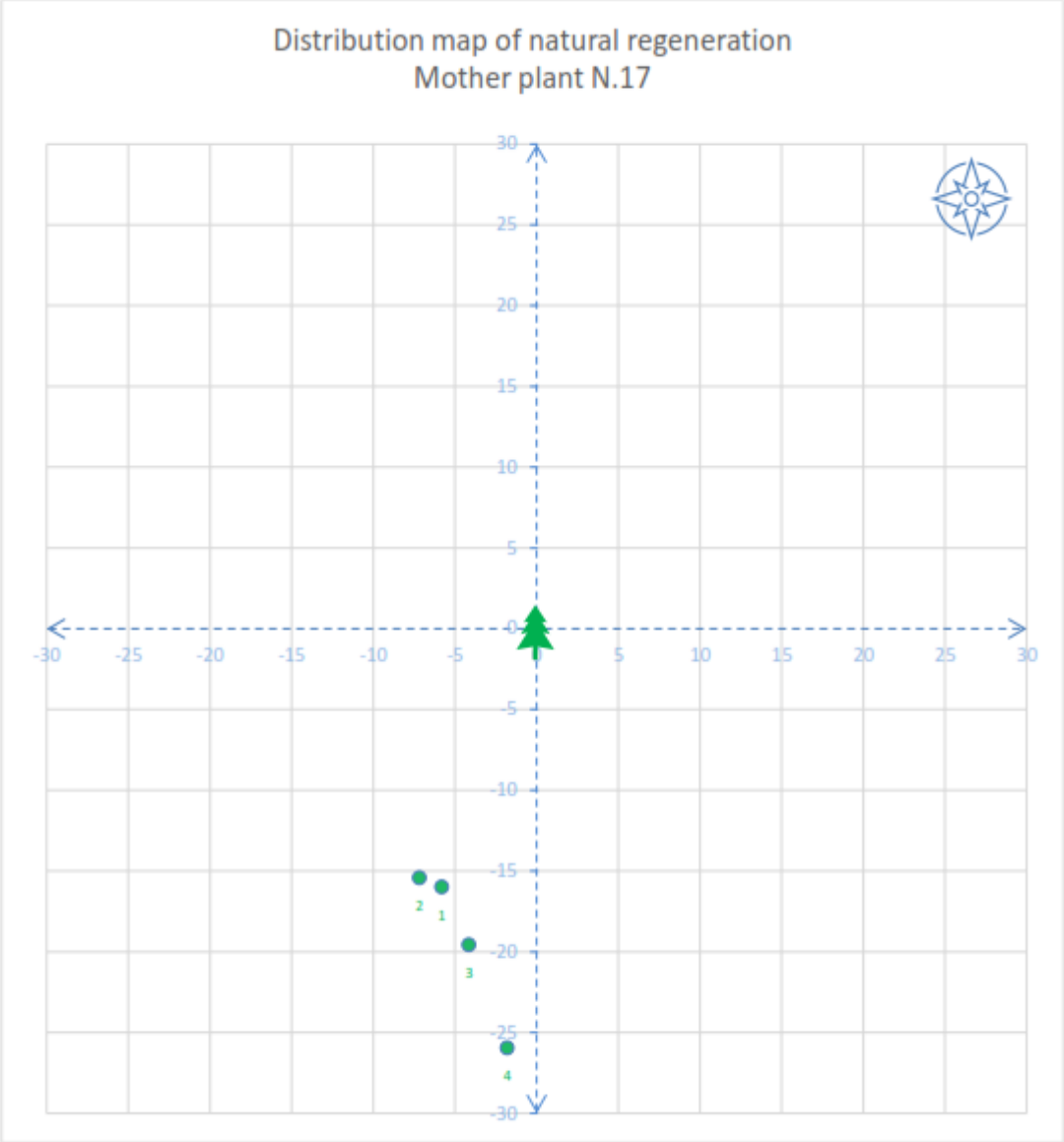
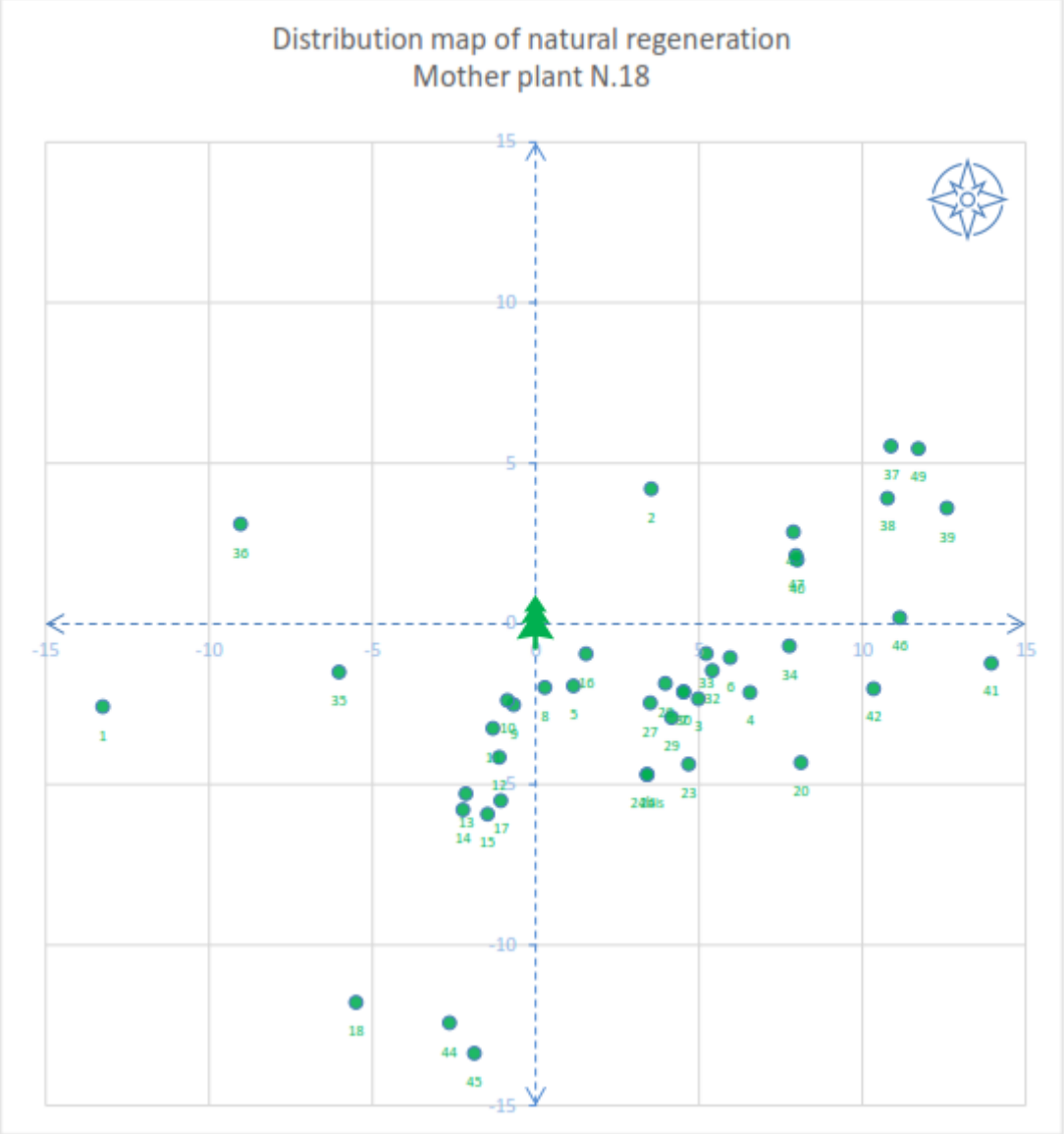
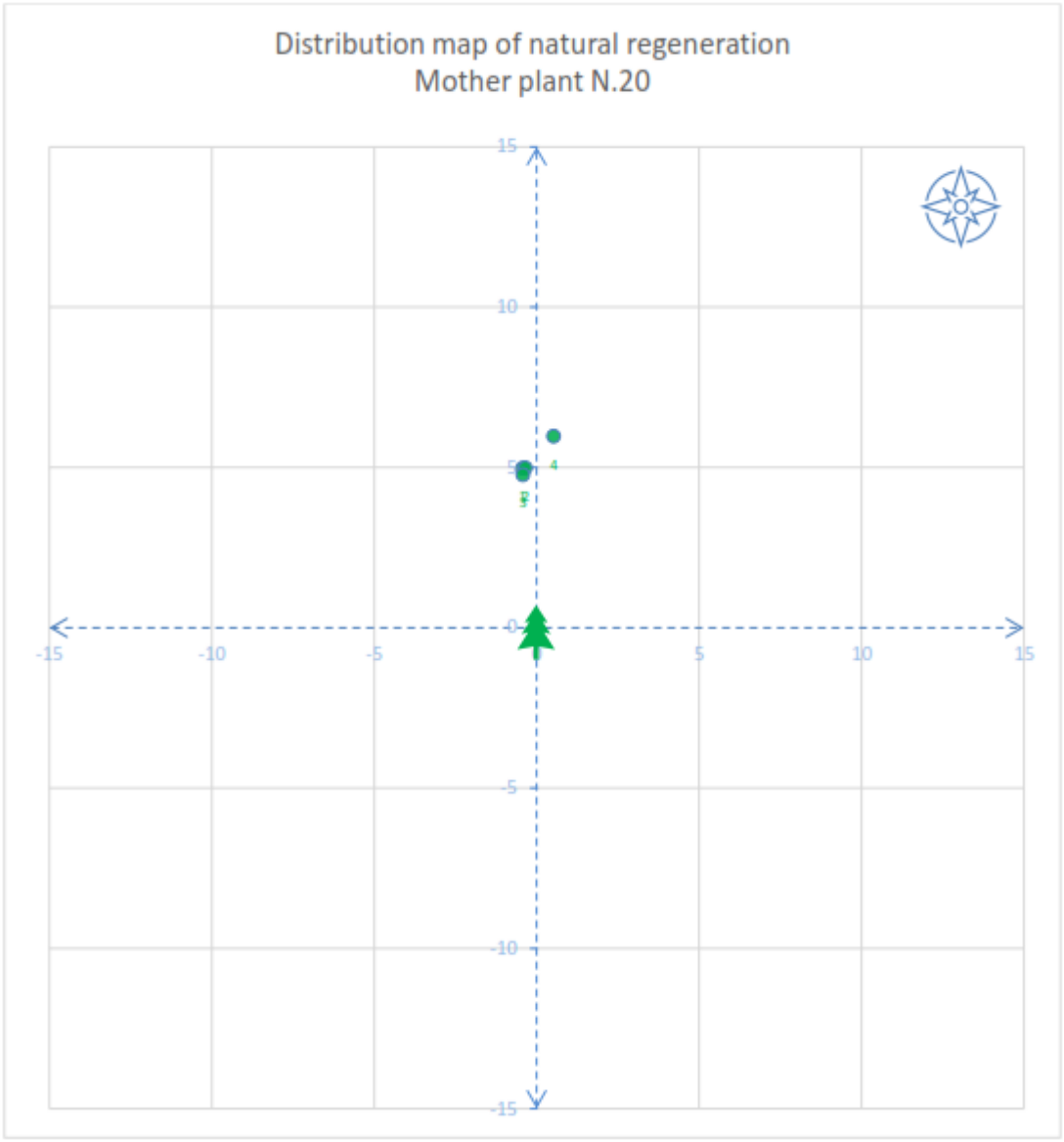
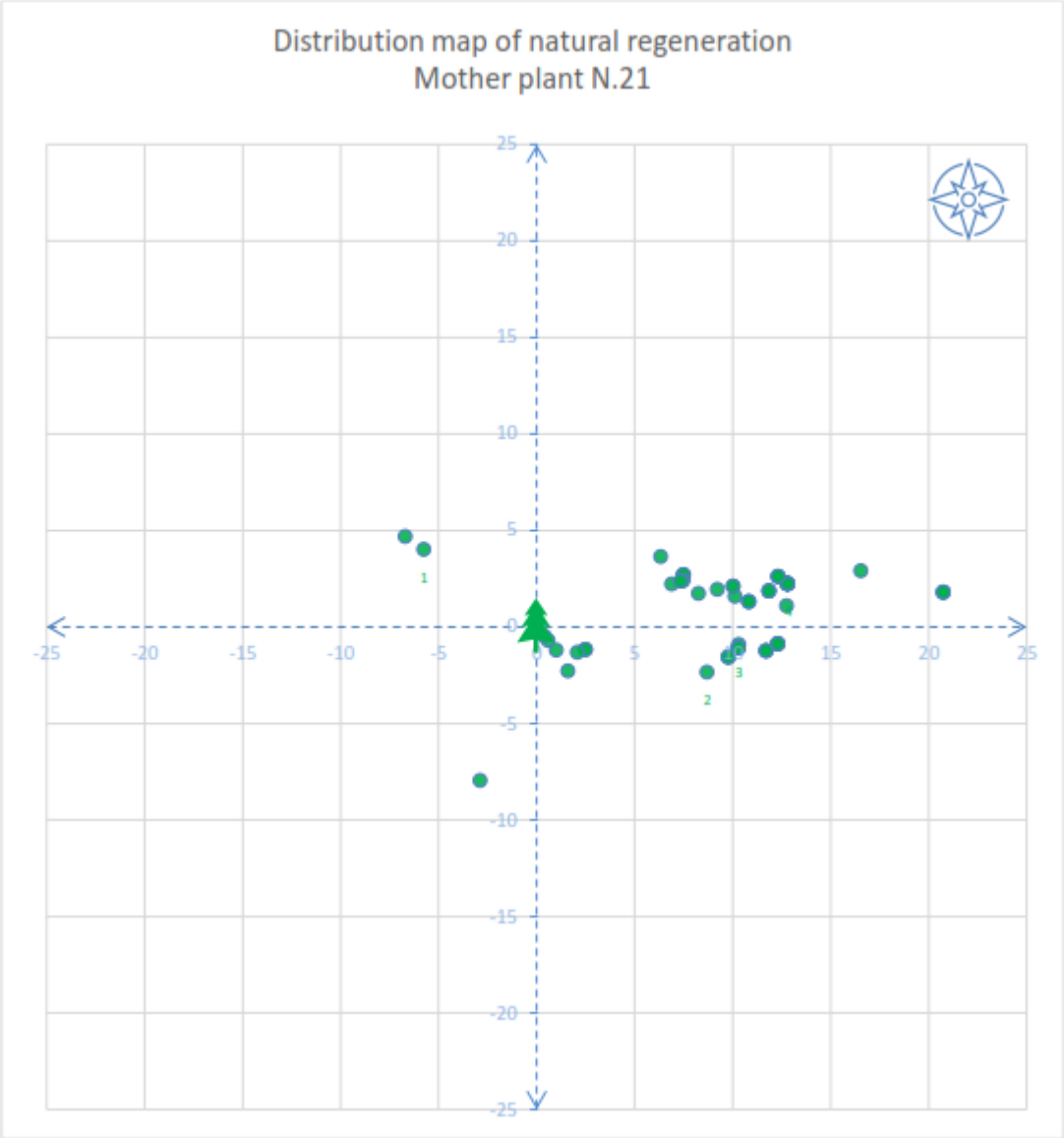
5
10
15
20
25
30
1
2
3
4


Distribution map of natural regeneration
Mother plant N.17
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
2
1
3
4


Distribution map of natural regeneration
Mother plant N.18
15
10
5
0
-5
-10
-15
-15
-10
-5
0
5
10
15


Distribution map of natural regeneration
Mother plant N.20
15
10
5
0
-5
-10
-15
-15
-10
-5
5
10
15
4
3


Distribution map of natural regeneration
Mother plant N.21
25
20
15
10
5
0
-5
-10
-15
-20
-25
-25
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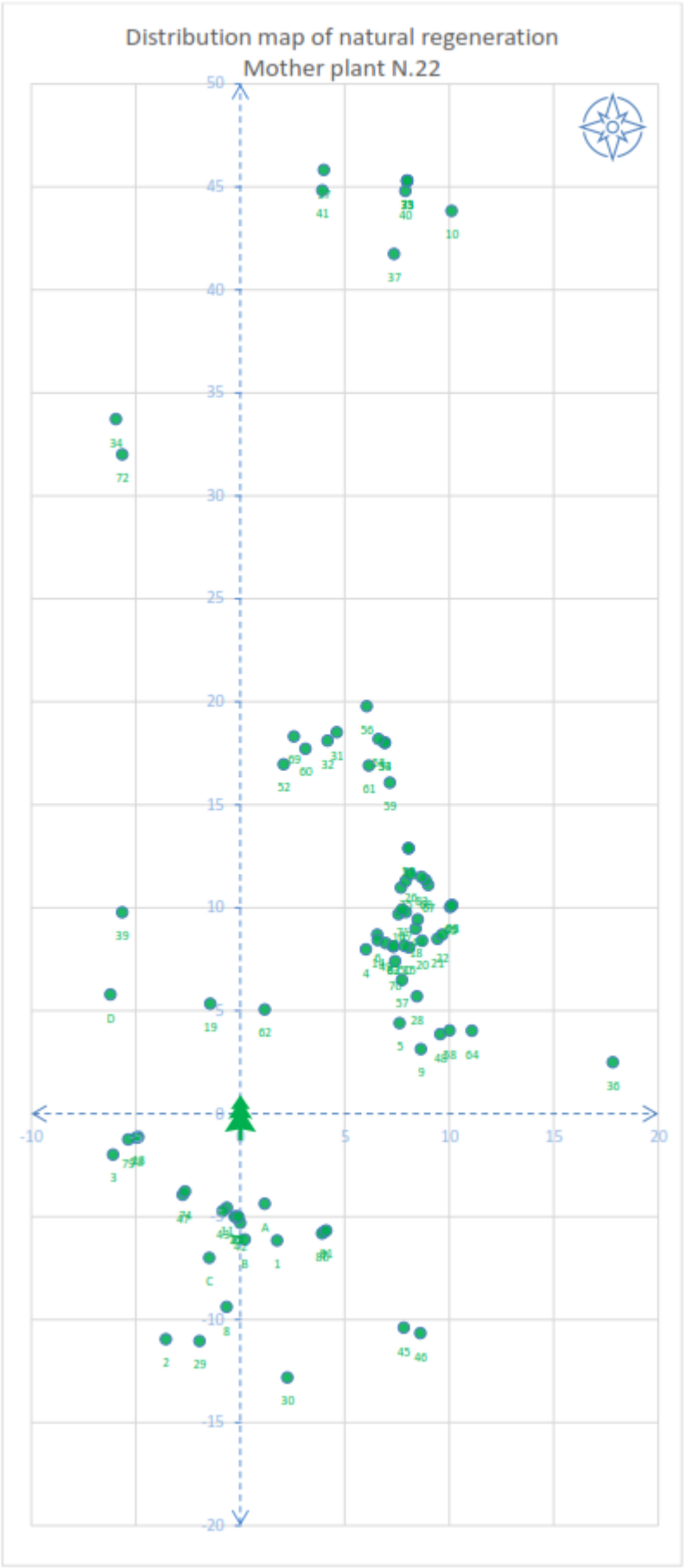
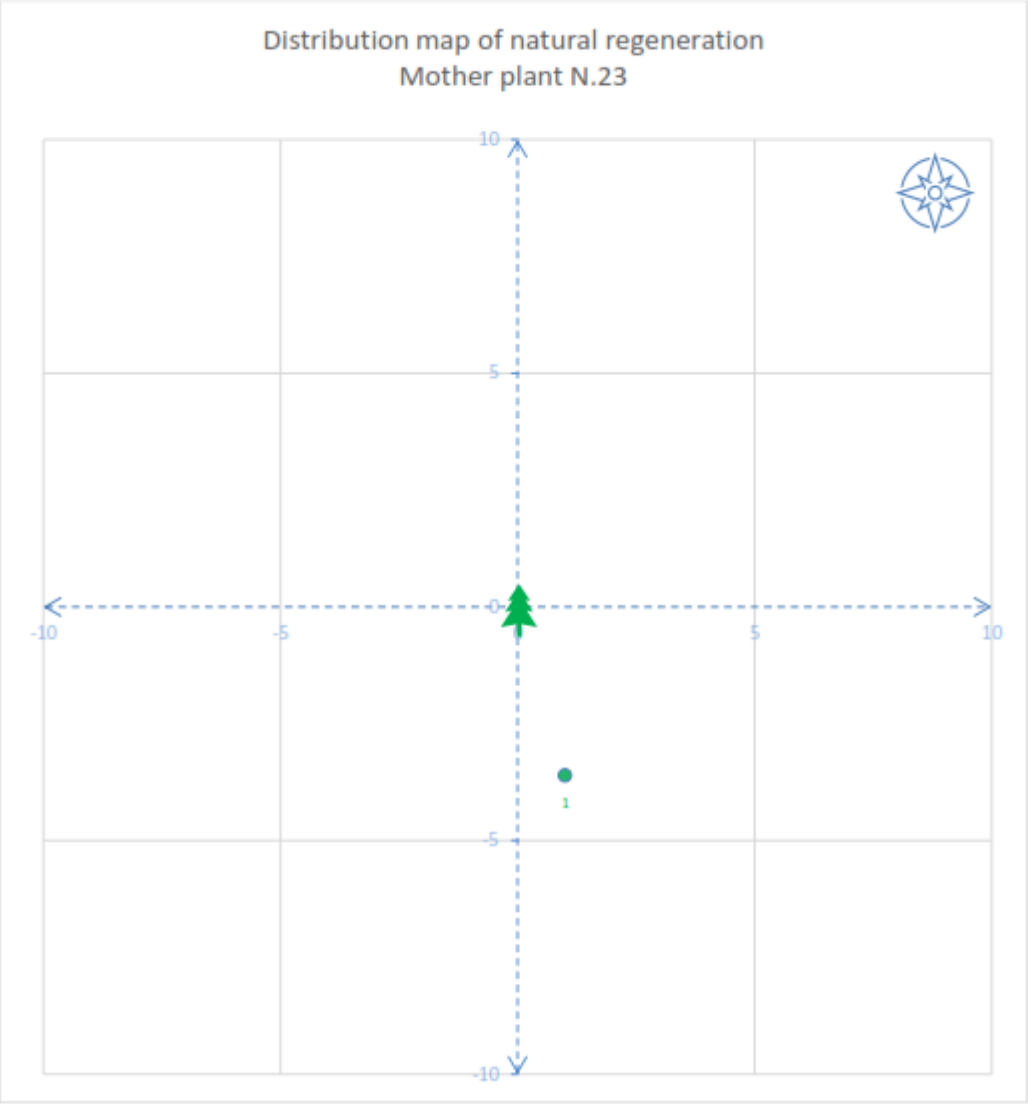
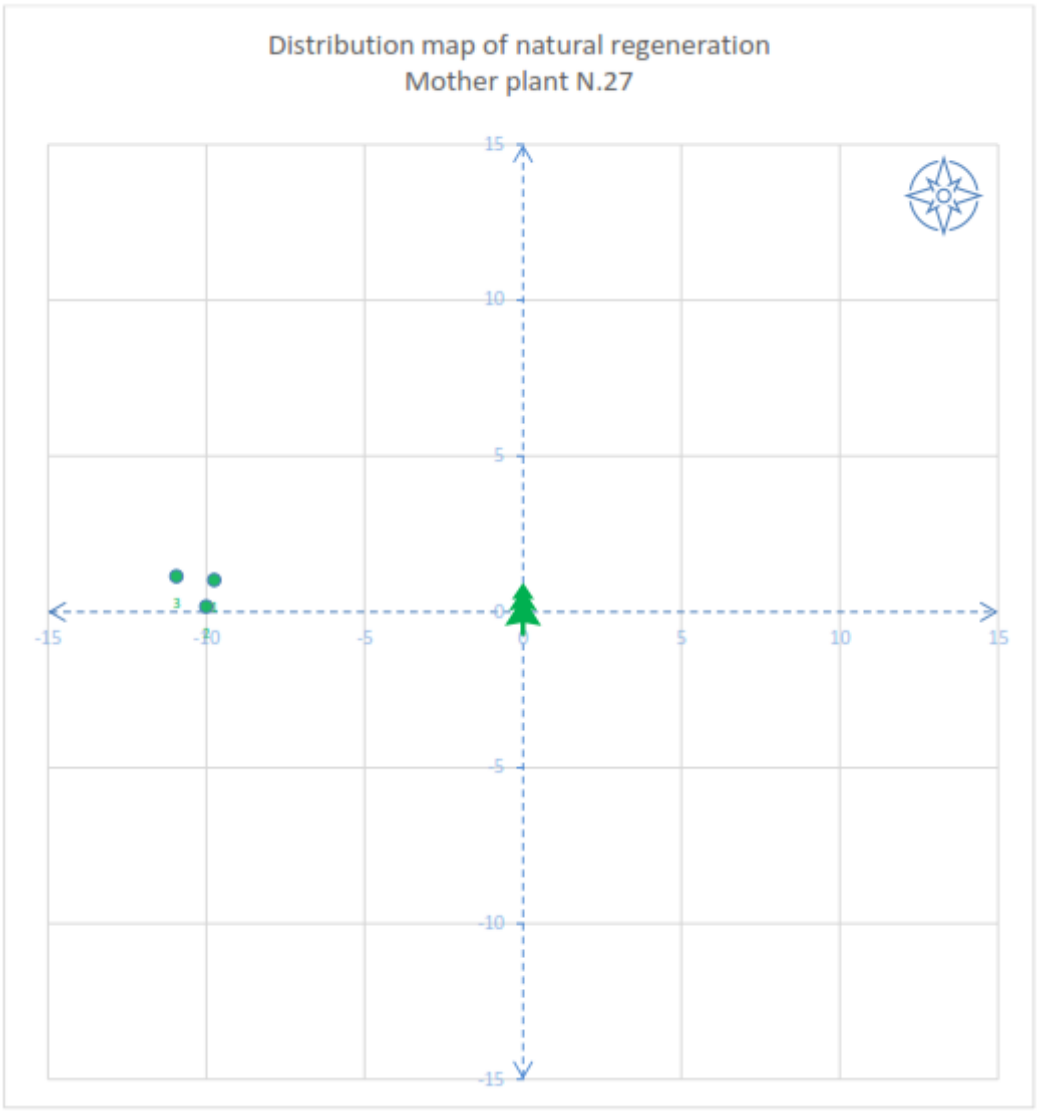
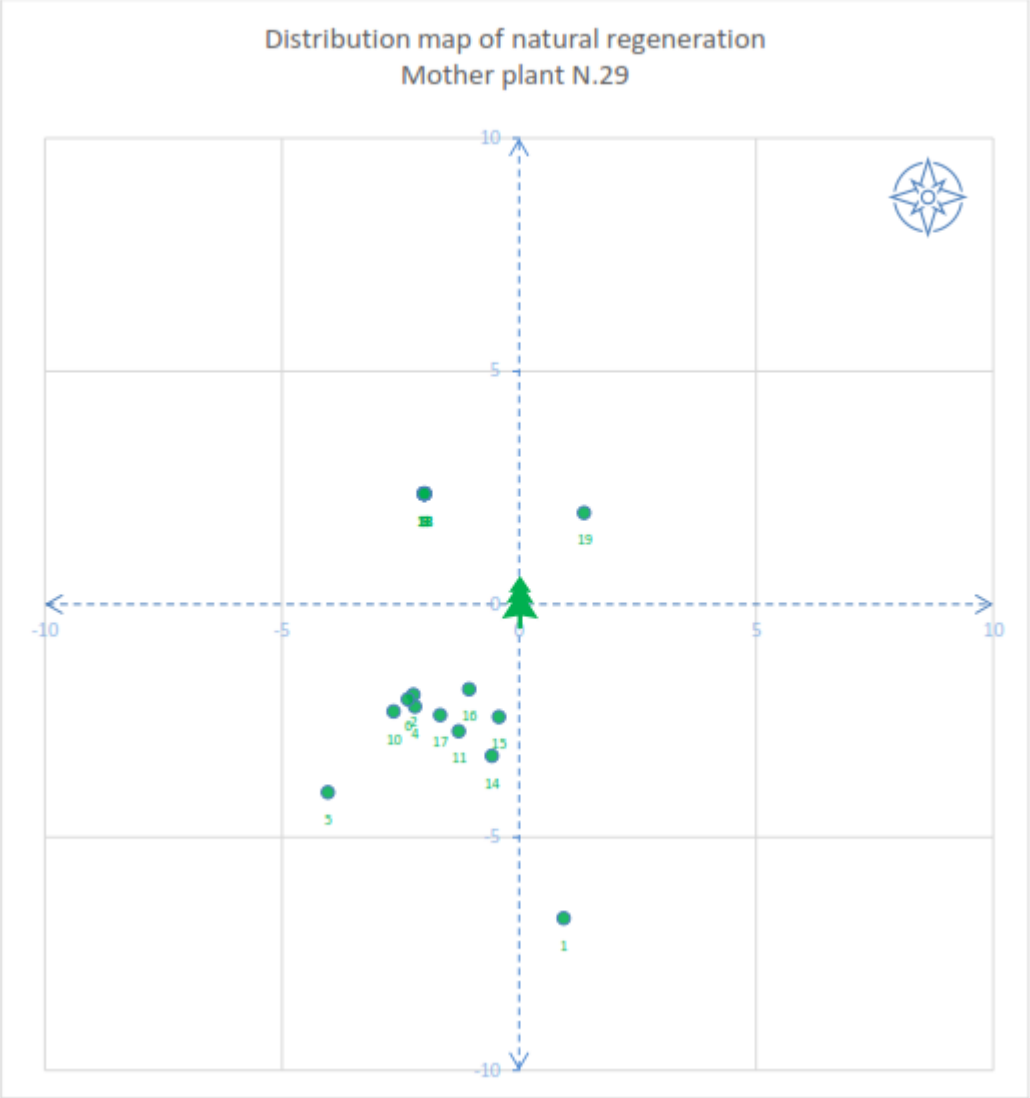
-10
-5
0
5
10
15
20
25
1
2
3


Distribution map of natural regeneration
Mother plant N.22
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-10
-5
0
5
10
15
20


Distribution map of natural regeneration
Mother plant N.23
10
5
0
-5
-10
-10
-5
5
10
1


Distribution map of natural regeneration
Mother plant N.27
15
10
5
0
-5
-10
-15
-15
-10
-5
0
5
10
15
3



The analysis of the distribution maps showed that a slow growing natural regeneration of *Abies nebrodensis* has been established around most mature mother trees, preferring protected sites with greater ease of rooting, such as shady and humid sites near beech, oak or holm oak groves, or pillow-shaped juniper shrubs, or Rowan shrubs, moss layers and ledges of cliffs facing north. Natural regeneration was found up to distances as far as seventy meters from a mother tree. For example, the 10/82 seedling was found 71 meters southeast of mother tree no. 10 (Fig. 5) and the seedling 8/23 was found at 65 meters near a beech stump, along the path located upstream the mother tree no. 8 (Fig. 6).

A comparison with the data collected in the previous survey of 2014, highlight that the seedlings of *Abies nebrodensis* are subjected to a relevant mortality rate. For example, in the

case of the mother tree no. 22, fourty-seven one-year-old seedlings were reported in 2014, whereas only 21 plants with a compatible age (5/7 years) were found in 2020, showing a mortality rate of 55%.

Fig. 5 – Accession 10/82: the plant of the natural regeneration for which the distance from its purported mother tree was the longest (71 m).

Fig. 6 – Plantlet of the natural regeneration (accession 8/23) located far away from its purported mother tree (65 m).

For the mother tree no. 29, 28 seedlings of about one year of age (scattered between 5 and 34 m apart) were detected in 2014, in addition to 8 well established plants. Today 7 out of the 8 established plants were found, but none of the seedlings recorded in 2014. Instead, 12 new seedlings less than two years old were found. Therefore, in this case a 100% mortality of seedlings occurred.

4. Conclusions

Despite the high mortality rate of seedlings, the overall increase of the natural regeneration shows a trend of growth (though slow) and gradual expansion of *Abies nebrodensis* in its habitat in recent years, despite the worn fences have not adequately protected the mother trees and the young plants growing in their surroundings. The actual origin of natural regeneration, especially the plantlets and seedlings found at a great distance from the closest mother tree, can be assessed only with the genetic analyses. Nevertheless, the correct census of the natural regeneration as well as the updating the consistency of the population of *A. nebrodensis* will allow to address the management choices for the conservation of this species. As part of this project, the knowledge of the correct location of each single accession is of considerable importance, as the removal of the old fences and re-installation of new traditional and electric fences can be carried out without causing damage and interference to plants and seedlings, absolutely not visible to personnel not used to looking for them. The same fences can be installed to include as much as possible the seedlings of natural regeneration, to protect them from wild herbivores and visitors.

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