THE FRENCH SERIES OF *Quercus petraea* PROVENANCE TESTS.

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Starting in the early eighties, INRA and Office National des Forêts (ONF) joined their efforts to conduct a range wide investigation of the genetic variation of *Quercus petraea*, a highly valuable broadleaved tree in French forestry. Earlier studies have been conducted in other countries, but were usually limited to regional issues (Kleinschmit, 1993 for review). There are severe biological constraints to carry out provenance research in oaks, as uneven fruiting across the distribution range of a species, and lack of acorn storage ability. These constraints explain why earlier efforts were usually conducted on a regional scale, and why research organizations were reluctant to support research in oak genetics. The motivation for implementing a large scale genetic survey in *Q. petraea* in the early 80s came from the decline of oak species observed during that period as a result of very severe summer drought in 1975 and 1976. Furthermore, sessile oak was increasingly used in plantations and recommendations about the choice of seed sources was urgently needed in operational forestry. Clearly these two issues were the rationale to start a large scale research project on oak genetic variation. The preferential choice for carrying out research in *Q. petraea* was also due to a large interest in planting this species rather than *Q. robur*. This was also the time where the first research framework programmes were launched by the European Union, thus providing opportunities to extend and support research at a range wide scale. The basic objectives of the provenance research experiment installed in France jointly by INRA and Office National des Forêts were twofold

(1) To identify the best seed sources for operational plantation. This was the applied focus, as previously assigned to provenance project of other tree species.
(2) To provide estimates of the level and distribution of genetic variation across the distribution range of the species. This was a more basic issue underlying the needs for genetic indicators in conservation and management strategies. As such provenance research was a significant component of the large scale genetic investigations in the white oak complex that was implemented at the same time.

These two objectives underpin the background and rationale of provenance sampling, and setting up of the experimental plantations that are described in this note.

1. Seed collection

The whole project started in summer 1986, when an exceptional seed crop could be foreseen the next fall. INRA and ONF launched together a nationwide collection operation, that was repeated over the next years in France and in nearby countries (thanks to EU support). Finally these operations were completed by Søren Madsen initiative to install a multisite provenance network in Europe in the fall of 1989.

1.1. Collection in France.

INRA and ONF constructed a collection protocol that was repeatedly used over the years. From the beginning the protocol accommodated for collections implemented over successive years to cope with uneven fruiting of oaks across the distribution of the species.

A collection unit was defined as a forest compartment of 15 to 20 ha, in the case of a pure stand of *Quercus petraea*. Contiguous compartments could also be selected as collection unit, if a single compartment was not of sufficient size. In the case of a mixed stand (the other associated species not being another white oak), for example in the case of a mixed *Q. petraea – Fagus sylvatica* stand, a larger collection area encompassing one or more contiguous compartments was recommended (30 to 40 ha). However in this case, *Q. petraea* should represent at least 50% of the stems. The density of the stand may vary between 70 to 400 *Q. petraea* stems/ ha, meaning that the age of the stand was older than 80 years.

Additional selection criteria for the collection were:

- No presence of other white oaks neither in the collection unit, nor in the immediate neighbouring compartments to the collection unit.
- The harvest of acorns is implemented only if half of the *Q. petraea* trees are fruiting in the stand.
- Oak trees of the collection unit should be of autochthonous origin.

The collection protocol consisted in bulk ground harvests of acorns on 50 collection spots separated at least by 50 meters between each other. Most of the time, this was done on a 50 m grid system. Each collection spot is an approximate circle of 10 to 15 meters. There is no necessary matching of one collection spot with the canopy ground projection of a single tree. It can overlap more than one tree. About 2 kgs of seed are collected at each collection spots. All seeds collected are bulked in one seed lot per collection unit.

The collections were done by the personnel of Office National des Forêts (ONF), and supervised by the Direction technique de l'ONF (Michel Buffet). A protocol was distributed to the field stations of ONF, with a proposed list of stands to be harvested, if the seed crop was sufficient. The proposed list comprised 55 stands classified as seed stands and distributed across the different provenance regions, and 33 stands that were selected due to their peculiar ecological or geographical location. They were situated either at the margins of the distribution, or on unusual soil conditions. The former list was intended to encompass as much as possible the genetic variation of the species; it was built after discussions with colleagues at INRA and with ONF staff. All stands originated from public owned and managed forests. The final outcome after the collection was completed in 1992 is 69 French populations of sessile oak. Among the 69, 48 originate from registered seed stands located in 41 different forests and 21 originate from non-registered stands located in 20 forests. In addition, 4 French populations of pedunculate oak were collected that are all registered seed stands and located in 4 different forests.

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The collections started in the fall of 1986, due to the very good acorn crop, and were repeated in 1987, 1989 and 1992. Missing years were due to poor seed crop. A collection was indeed conducted in the fall 1988 in French stands, but the seed crop was very poor (only 15 populations collected with many overlaps with 1987). The same list of suggested stands was repeatedly distributed every year, but the outlier stand list was slightly completed over the years. Repeated collections in the same compartment were organized on purpose so that a subsample of populations is included in at least two collection years. Such repeated collected populations are considered as "cross-over populations" in plantations that are established each year (see paragraph 4.2). Repeated collections were only organized in French oak stands

1.2.Seed Collection in other countries.

The seed collections procedures and protocol were the same as those used in France except that the seed quantities requested were of much lower amount. It was recommended to collect acorns on 50 collection spots separated by at least 50 m. Acorns were ground collected on collection spots distributed over an area of 5 to 30 ha. Seed lots consisted of 10 to 30 kgs of seed. There was also more variation in the level of fruiting. Collections were made in the fall of 1987, 1989 and 1992. No repeated collections in the same locations were organized. Collections were made by staff of research organizations, or of national forest services in the different countries, following a protocol that was distributed by circular mail.

Due to shipping problems generating germination failures (see paragraph 2), a collection trip was organized by Alexis Ducousso and Antoine Kremer in Eastern countries (Poland, Tchecoslovakia, Hungary, Rumania) in October-November 1992. Collections could be made in a limited time period thanks to the help of local forest organizations, and transportation duration was also limited.

1.3.The Søren Madsen collection

Dr Søren Madsen, scientist at the Danish Forest and Landscape Research Institute, initiated in the fall of 1989 a collection of provenances across the distribution range of *Quercus petraea*, with the aim to establish a network of multiple provenances tests. The original plan was to collect 19 populations selected from the better growing indigenous stands in the following countries: Belgium, Denmark, France, Germany,, Hungary, Norway, Poland, Turkey and United Kingdom. And these populations were further planted in 27 test sites (including the 4 French sites, see paragraph 4). The collections were carried out in 19 European sessile oak stands including Turkey by local forest research institutes, covering large parts of the natural area of distribution. The institutes taking part in the seed collection and/or the establishment of field provenance experiments were i) Danish Forest and Landscape Research Institute, Hoersholm, Denmark (earlier: Danish Forest Experiment Station, Lyngby, Denmark); ii) Niedersächsische Forstliche Versuchsanstalt, Abt. Forstpflanzenzüchtung, Escherode, Germany; iii) INRA, Centre de Recherches de Bordeaux, Cestas, France; iv) Institut für Forstgenetik und Forstpflanzenzüchtung, Grosshansdorf, Germany; v) Forestry Commission, Northern Research Station, Roslin, Great Britain; vi) Forest Research Institute, Ankara,

Turkey; vii) Polish Academy of Sciences, Institute of Dendrology, Kórnik, Poland; viii) Station de Recherches Forestières et Hydrobiologiques, Groenendaal-Hoeilaart, Belgium (seed coll. only); ix) Forest Research Institute, Botanikus Kert, Sárvár, Hungary (seed coll. only); x) Norwegian Forest Research Institute, Ås, Norway (seed coll. only).

Collections were made in mature stands (more than 80 years old) and collection areas varied between 3 to 40 ha (only 4 collection units were smaller than 10ha). Seed were generally collected on at least 100 mother trees, in three cases they were done according to commercial rules. The majority of mother stands was declared to be autochthonous or of natural origin, only the three British stands were of unknown origin, and no information was given on the Polish provenance. The stands showed variation in species composition, ranging from pure sessile oak stands, eventually having undergrowth of beech or hornbeam, to more or less mixed stands in the upper layer of oak, beech, spruce, larch, and pine. The seed crop was generally described as good or above average, in four cases it was fair, below average, or poor. The harvested acorns in a given provenance was thoroughly mixed and subdivided in lots of 12 kg and shipped by the collector to each institutional participant.

Finally these collections were completed by a few *Quercus robur* populations, that were harvested with the same procedures and protocols

Table 1 Number of populations collected per species, and year

Crop year	*Quercus robur*		*Quercus petraea* ssp *petraea*		*Quercus petraea* ssp *iberica*		Madsen collection	
	France	Other countries	France	Other countries	France	Other countries	France	Other countries
1986	2	0	19	0	0	0	0	0
1987	4	3	27	8	0	0	0	0
1989	1	0	39	24	0	3	4	9 + 1[a]
1992	1	7	18	7	0	0	0	0

[a]The Madsen collection was constituted of 9 populations of *Q. p.* ssp. *petraea* and one of *Q. p*. ssp. *iberica*.

Table 2 Number of populations collected per species, and country

Species	Countries	Number of populations
Quercus robur		15
	Czech Republic	2
	France	4
	Germany	2
	Great Britain	2
	Latvia	1
	Poland	4
Quercus petraea ssp petraea		104
	Austria	2
	Czech Republic	1
	Denmark	2
	France	69
	Germany	17
	Great Britain	3
	Hungary	2
	Ireland	3
	Poland	4
	Slovakia	1
Quercus petraea ssp *iberica*		4
	Georgia	3
	Turkey	1
Total		123

2. Seed treatments

After harvest seed were transferred to the ONF tree seed centre (Sécherie de la Joux - 39300 SUPT – FRANCE), located in Jura, eastern part of France. The transfer was done either by car transportation in France (by ONF personnel), or shipped via ground surface (usually postal service) from other countries. The quality of seed may have suffered from long lasting transportation as it may have happened via the postal service.

Seeds were subjected to thermotherapy treatment (soaking for 3 hours in 41 °C hot water, in a double boiler) to prevent infestation by *Ciboria batschiana* during seed storage prior to seeding. *Ciboria batschiana* is a fungus that is likely to grow on acorns, which nned to maintain a high water content. Soaking in water allowed also to remove floating acorns, that are assumed to have lost germination ability. At this stage a subset of seed (approximatively 500) were retrieved from each seed lot for implementing a population survey of genetic diversity with isozymes. After thermotherapy, acorns were stored in cold rooms at -1°C, before sowing in the spring.

3. Sowing and nursery

Seed lots were transported during late winter at the Pépinière Experimentale de Guéméné Penfao (RDI-PNRGF, Office National des Forêts, Route de Redon, 44290 Guéméné-Penfao), which is a state owned nursery, located in Brittany, west of France. Sowing of the seed lots in the nursery was done according to a complete block design (5 blocks), in late winter, early

spring of the year following seed collections. Each provenance seed lot was subdivided in 5 sublots. Sublots were sown in 5 seed beds that corresponded to the 5 blocks. Seed bed was 1.10 m wide and composed of 5 sowing rows (one row approximatively every 20cm).
Raising in the nursery lasted 3 years so that the slowest growing provenances would be of sufficient height for transplantation. Mechanical root pruning was carried the 2nd year in February.

After three years in the nursery, seedlings were lifted in late winter and assembled in lots of 24 bare root plants, which correspond to the size of a field plot in the plantation. Each lot of 24 seedlings was composed of seedlings originating from the 5 replicates of each provenance in the seedbeds. The assemblage of the 24 seedling lots did not involve any severe screening of seedlings. Only seedlings less than 10 cm high or heavily damaged were discarded. Subdivision in lots of 24 seedlings was carried out in the nursery and each lot was labelled according to its future position in the test plantation. All lots were maintained in a cold room prior to transportation to the test site.

4. Plantations

4.1. Choice of plantation sites

From the beginning, it was decided to install from 4 to 6 plantations in order to assess the differential responses of provenances to environmental conditions, given the resources available at this time for the plantations. Forest hosting test sites were preferentially selected within the area where *Quercus petraea* was likely to be planted, along a geographical gradient from West to East of France. Unusual test sites, based mainly on peculiar soil conditions, were also explored. With the help of the Direction technique of ONF a circular letter was sent to field stations of ONF asking for potential sites, where plantations were foreseen in the next four years. Various forests and potentials sites were visited and the final selection was made for Forêt Domaniale de la Petite Charnie, Forêt Domaniale de Vincence, Forêt Domaniale de Sillégny, as representatives of favorable sites of *Q. petraea*. The unusual soit type site was in Forêt Domaniale de Vierzon; the site is indeed characterized a podzol like type of soil. The whole network is therefore composed of 4 sister plantations, that were installed using the same procedures.

A framework agreement between INRA and ONF was signed by the two institutions, indicating the sharing of activities and costs related to the installation and management of the plantations. Briefly, it was indicated that INRA would provide the plants and supervise the installation of the experimental plantation, while ONF would take in charge the site preparation, plantation, fencing and cleaning. Extra operations, like measurements due to the experimental feature of the plantation would be taken in charge by INRA and ONF. Finally there was also a training component in the agreement, recommending that research operations and results conducted by INRA should be disseminated within the ONF staff through jointly organized training sessions.

Table 3 Main features of the test sites

	La Petite Charnie	Vierzon	Vincence	Sillegny
Latitude	48°05'12''N	47°15'44''N	46°58'12''N	48°59'24''N
Longitude	0°9'40''W	2°07'55''E	3°38'7''E	6°07'56''E
Altitude	146-154 m	154-173 m	235-240 m	200-212 m
Topography	Flat with small valleys	Flat	Flat with small valleys	Flat
Total number of populations tested Sessile (pedunculate)	94 (8)	90 (7)	103 (11)	103 (15)
Total area (experimental area)	24.54 ha (19.26 ha)	43.58 ha (20.36 ha)	28.60 ha (23,80 ha)	27.26 ha (23,29 ha)
Spacing	1.75 X 3 m	1.75 X 3 m	1.75 X 3 m (except tranche 2 2 x 3 m)	1.75 X 3 m
Total number of plants (experimental plants)	44,478 (36,672)	61,199 (38,784)	50,621 (43,200)	54,777 (44,064)
Soil	Brown soil Sand, silt and clay	Podzol sand	Brown soil Silt and clay	Brown soil Silt and clay
Annual Mean Temperature	10.8°C	11.22°C	10.85°C	9.65°C
Warmest month mean temperature	18.4°C	19.15°C	18.95°C	18.1°C
Coldest month mean temperature	3.55°C	3.15°C	2.7°C	1.1°C
Rainfall	710 mm	688 mm	747 mm	739 mm
Rainfall during growing season	329 mm	351 mm	408 mm	392 mm
Potential EvapoTranspiration (PET)	813 mm	868 mm	852 mm	786 mm
PET during growing season	625 mm	640 mm	628 mm	598 mm

4.2.Overall plantation design

The protocol of installation and experimental design of the plantation is the same in the four sister plantations. There are some slight differences in population composition among the 4 sister plantations, as a result of sample sizes differences among populations at the nursery stage, and the available place in each test site. Given that seeds could not be stored, the whole plantation at a given site was installed in 4 yearly tranches. A tranche corresponds to the set of populations collected a given year.

Table 4 Collection, sowing and plantation years

	Seed collection year	Sowing season	Plantation season
Tranche 1	1986	Spring 1987	Spring 1989
Tranche 2	1987	Spring 1988	Spring 1990
Tranche 4	1989	Spring 1990	Spring 1993
Tranche 5	1992	Spring 1993	Spring 1995

A given plantation is therefore composed of 4 tranches. Tranches are contiguous portions of the plantation, and are not intermixed. We recall that some populations have been repeatedly collected at least over two years. These populations provide therefore links across tranches that allow to compare a given population planted in tranche *i* with another population only planted in tranche *i'*. These populations are called "Cross-over populations"

Table 5 Number of sessile oak populations per tranche (diagonal) and cross-over populations between tranches (off diagonal)

La Petite Charnie

Tranche	1	2	4	5
1	19	6	8	4
2		32	18	7
4			54	7
5				20

Vierzon

Tranche	1	2	4	5
1	19	6	8	4
2		31	18	7
4			56	8
5				16

Vincence

Tranche	1	2	4	5
1	19	6	8	4
2		34	19	7
4			62	8
5				23

Sillegny

Tranche	1	2	4	5
1	19	6	8	4
2		35	20	7
4			63	8
5				24

The overall plantation at each site was entirely fenced to prevent from game browsing. Two plantation rows at the edges of the plantation were considered as neutral "zones" and were planted with *Q. petraea* seedlings not included in the experimental layout. No neutral rows were installed at edges between contiguous tranches.

4.3.Experimental layout

Prior to the plantation of the first tranche an ecological survey was conducted based on soil descriptions and on botanical composition of plant communities over the whole area. This survey was based on soil core extractions on a grid system every 20 meters. It was conducted by forestry students of the Ecole Nationale des Ingenieurs des Travaux des Eaux et Forêts (Enitef) for the Petite Charnie, Vincence and Vierzon sites as a tutorial class (practical field study). Colleagues from the Ecological group in INRA Nancy (Jean Luc Dupouey and colleagues) implemented a similar work at the Sillegny site.

Each tranche was subdivided in 5 or 10 ecological zones, of approximate equal size, based on the ecological survey. These zones were called macro-blocks. Micro-blocks with random composition of 8 population-plots were nested within macro-blocks. Each plot is composed of 24 seedlings belonging to the same population. The 24 trees of a population-plot are planted in 4 rows (3m*4=12m) and 6 trees on a row (1.75m*6=10.5m) (approximate square plots). Within a macro-block, each population is replicated in two different micro-blocks (in three micro-blocks for cross-over populations). Overall this means that a given population is represented by 240 trees in a given tranche (2 plots in 5 macro-blocks, eg 2*5*24=240 trees, 360 plants for cross-over populations).

Beyond, statistical accuracy, the rationale underlying the experimental layout was to secure for the durability of the experimental plantation:

(1) Initial Plot size (n) was set to 24 so that at the end of the rotation (in between 120 and 180 years), there would be at least 1 tree per plot, after all systematic thinnings have been carried out. The final tree density of the stand would then be 80 stems/ha. At that stage the population sample size over the whole tranche would be 10 trees (15 trees for a cross over population). These figures suggest that the plantation would give reliable results at least until 60-80 years when there will still be 3 trees per plot (30 trees per population, 45 for a cross-over population).

(2) The subdivision of each tranche into macro-blocks was not only to account for soil differences, but also to secure for unexpected events (storms, fire..) that may cause partial destruction over the life time of the plantation. Along the same lines, the nested micro-block within macro-block design allows a more homogeneous spatial distribution of a given population, should an extreme event occur.

Table 6 Detailed description of the experimental layout

Experimental layout La Petite Charnie

Tranche	**1**	**2**	**4**	**5**
Number of sessile + pedunculate oak populations (t)	19+4	32+6	54+1	20+1
Number of macro-blocks (b)	5	5	5	1
Number of micro-blocks (q)	30	60	85	16
Number of plots/ micro-block (k)	8	8	8	8
Number of trees/plot (n)	24	24	24	24
Number of replicated plots for a given pop/macro-block (for a given cross-over pop) (r)	2	2 (3)	2 (3)	2 (3)

Experimental layout Vierzon

Tranche	**1**	**2**	**4**	**5**
Number of sessile + pedunculate oak populations (t)	19+2	31+6	56+2	16+1
Number of macro-blocks (b)	5	10	5	1
Number of micro-blocks (q)	30	60	85	27
Number of plots/ micro-block (k)	8	8	8	8
Number of trees/plot (n)	24	24	24	24
Number of replicated plots for a given pop/macro-block (for a given cross-over pop) (r)	2	1 (2)	2 (3)	2 (3)

Experimental layout Vincence

Tranche	**1**	**2**	**4**	**5**
Number of sessile + pedunculate oak populations (t)	19+2	34+7	62+1	23+3
Number of macro-blocks (b)	5	10	5	5
Number of micro-blocks (q)	30	60	98	40
Number of plots/ micro-block (k)	8	8	8	8
Number of trees/plot (n)	24	24	24	24
Number of replicated plots for a given pop/macro-block (for a given cross-over pop) (r)	2	1 (2)	2 (3)	2 (3)

Experimental layout Sillegny

Tranche	**1**	**2**	**4**	**5**
Number of sessile + pedunculate oak populations (t)	19+2	35+7	63+1	24+7
Number of macro-blocks (b)	5	5	5	5
Number of micro-blocks (q)	30	60	95	35+25
Number of plots/ micro-block (k)	8	8	8	8
Number of trees/plot (n)	24	24	24	24
Number of replicated plots for a given pop/macro-block (for a given cross-over pop) (r)	2 (3)	2 (3)	2 (3)	2 (3)

Annexe 1

Summary table of the origin of provenances and their location in the different tranches

Forest	Compartment	Departement or Region	Latitude	Longitude	altitude	INRA Codes	Tranche
Quercus petraea ssp iberica							
Georgia							
Mtskheta		Kakhetia	41,9569	44,7894	740	183	4
Gourdjani		Kakhetia	41,7167	45,8000	700	182	4
Telavi		Kakhetia	41,8833	45,4667	700	184	4
Turkey							
Bolu (Ayikayasi)	48	Bolu	40,9167	31,6667	1200	249	4
Quercus petraea ssp petraea							
Austria							
Hainback		Salzburg	48,2307	16,2072	320	247	4
Klostermarienberg		Burgenland	47,4125	16,5525	310	248	4
Czech Republic							
Doubrava	911 D2 - 912 A2	Karlovy Vary	49,9014	13,4325	400	325	5
Denmark							
Hørbylunde	6k, 7f	Midtjylland	56,1333	9,4217	80	181	4
Løndal Naes	naesset 7a,b	Jutland	56,0713	9,5971	25	180	4
France							
Adé	7	Hautes Pyrénées	43,1467	-0,0158	450	117, 314	2, 5
Allogny	67	Cher	47,2119	2,3400	260	99, 232, 307	2, 4, 5
Bareilles	33-34-35-37	Hautes Pyrénées	42,8994	0,4311	1300	313	5
Bellême	68	Orne	48,3953	0,5383	225	330	5
Bellême	3	Orne	48,3978	0,5928	230	36, 242	1, 4
Bellême	67	Orne	48,3989	0,5339	220	35, 241	1, 4
Bercé	113, 119	Sarthe	47,8131	0,3906	165	1, 2, 41, 42, 217, 315	1, 2, 4, 5
Bercé	113	Sarthe	47,8131	0,3906	165	1, 41	1, 2
Bercé	119	Sarthe	47,8064	0,3764	160	2, 42	1, 2
Bertranges	253 (ex 53)	Nièvre	47,1731	3,1583	295	93, 212	2, 4
Bézange	26, 27	Moselle	48,7589	6,4933	275	204	4
Blois	136	Loir et Cher	47,5606	1,2606	115	5	1
Blois	33	Loir et Cher	47,5792	1,2803	125	4	1
Bommiers	126	Indre	46,8061	1,9044	166	92	2
Boulogne	120, 121	Loir et Cher	47,5681	1,5389	94	317	5
Bride	116, 117	Moselle	48,8269	6,6103	300	229	4
Bride	95, 96, 97, 99, 100, 101, 116, 117, 119, 120, 121, 122	Moselle	48,8269	6,6103	300	309	5

Bussières	58, 59, 60	Haute Marne	47,7614	5,4867	360	89, 235	2, 4
Chandelais	51	Maine et Loire	47,5236	-0,0469	90	3	1
Chateauroux	51, 53	Indre	46,7281	1,6842	180	98	2
Compiègne	4	Oise	49,3997	2,9114	65	121	2
Dreuille	37 & 41	Allier	46,4567	2,9022	290	105, 220	2, 4
Etangs	5,6, 7	Saöne et Loire	46,9206	4,9325	200	100, 245	2, 4
Fontainebleau 544	544	Seine et Marne	48,3586	2,6947	130	17, 39, 208, 305	1, 2, 4, 5
Fontainebleau 853	853	Seine et Marne	48,4664	2,6608	83	18, 40, 207, 306	1, 2, 4, 5
Grésigne	75	Tarn	44,0431	1,7489	310	97	2
Guerigny	39	Nièvre	47,0947	3,2311	240	108, 206	2, 4
Hagueneau	230	Bas Rhin	48,8783	7,8297	157	303	5
Hagueneau	259	Bas Rhin	48,8911	7,8303	152	304	5
Haslach	33	Bas Rhin	48,5581	7,3772	265	226	4
La Haie Renaut	31 et 32	Haute Marne	48,6728	4,9444	175	201	4
La Neuville en Hez	71	Oise	49,3800	2,2697	65	301	5
Lembach	51b et 52b	Bas Rhin	48,9914	7,8083	260	224	4
Longchamp	54	Côte d'Or	47,2636	5,3103	235	94, 218	2
Montargis	211	Loiret	48,0253	2,8419	127	16	1
Montécot et Senonches		Eure et Loire	48,4539	1,0800	240	243	4
Moulière	251	Vienne	46,6208	0,4792	115	11	1
Nicey	22, 23, 24, 25	Côte d'Or	47,8433	4,2778	280	238	4
Orléans Fay	868	Loiret	48,0194	2,2269	130	21	1
Orléans Ingrannes	807p, 808p et 767	Loiret	48,0167	2,2856	139	110	2
Parc Saint Quentin	23	Oise	49,4556	2,0319	115	14	1
Perseigne	168	Sarthe	48,3778	0,2022	200	37, 43	1, 2
Pontigny	108, 109	Yonne	47,9422	3,6817	160	120, 213	2, 4
Prémery	8	Nièvre	47,1986	3,2775	300	102, 211, 311	2, 4, 5
Prieurés Grosbois	7	Allier	46,5381	3,0575	320	107, 222	2, 4
Prieurés Moladier	12	Allier	46,5125	3,2672	270	106, 221	2, 4
Réno Valdieu 118 - 119	118, 119	Orne	48,4747	0,6831	210	33, 236	1, 4
Réno Valdieu 4-5	4, 5	Orne	48,5408	0,6681	230	38, 237	1, 4
Romersberg	13, 14	Moselle	48,8167	6,7956	220	230	4
Russy	37	Loir et Cher	47,5339	1,3369	100	316	5
Saint Germain	141	Yvelines	48,9403	2,1194	60	201, 302	4, 5
Saint Jean	155	Moselle	48,7786	6,7283	225	228, 308	4, 5
Serqueux	54, 52 et 69	Haute Marne	48,0150	5,7675	470	103, 240	2, 4
Soudrain	115	Cher	46,9200	2,3650	178	91, 194, 231	2, 4, 5
Soulongis	22p, 23p	Allier	46,5194	2,7631	260	104	2
St Aubin du Cormier	34,36, 38, 40, 42, 44, 46, 48, 50, 81, 83, 84, 80, 82	Ille et Vilaine	48,2792	-1,4944	70	205	4
St Sauvant	35	Vienne	46,3800	0,1244	155	9	1

Steinbach	102	Bas Rhin	49,0408	7,7447	480	223	4
Still	28, 29	Bas Rhin	48,5828	7,2619	688	225	4
Sturzelbronn	151, 152	Moselle	49,0317	7,4983	390	209	4
Temple	50, 51	Aube	48,3064	4,4608	165	96	2
Ternes	51-52	Vosges	48,3789	6,3814	340	310	5
Traconne	164 et 165	Marne	48,6386	3,6461	200	29	1
Tremozey et Fontenoy		Vosges	47,9511	6,2681	395	234	4
Tronçais	132	Allier	46,6814	2,7047	235	90	2
Tronçais 89	89	Allier	46,6803	2,8289	245	219	4
Vachères	1	Alpes de Haute Provence	43,9833	5,6325	650	233	4
Vincence	89-92	Nièvre	46,9714	3,6472	235	312	6
Vouillé	34	Vienne	46,6042	0,1781	130	10	1
Westhoffen	63	Bas Rhin	48,5986	7,3953	395	227	4
Germany							
Bad Hersfeld	571	Hesse	50,8817	9,6603	285	259	4
Cochem	13	Rhineland-Palatinat	50,0842	7,0519	380	250	4
Elmstein Nord	XVII 1b1	Rhineland-Palatinat	49,3608	7,8717	450	190, 254	4
Farchau	55	Schleswig-Holstein	53,6656	10,7233	40	251	4
Gelnhausen	124	Hesse	50,2307	9,2969	200	246	4
Göhrde	84a	Lower Saxony	53,1000	10,8458	85	253	4
Johanneskreuz	2a1, 2b2 et 2c2	North Rhine-Westphalia	49,3142	7,7978	470	252	4
Lappwald	Danndorf 1139	Lower Saxony	52,2972	10,9769	160	45	2
Lappwald	Danndorf 1084	Lower Saxony	52,2569	10,9883	180	256	4
Lüss	108c1 & 128b1	Schleswig-Holstein	52,8316	10,3005	110	191	4
Mölln (Büffelskopf)	16	Schleswig-Holstein	53,6250	10,7528	36	260	4
Peine	Wolfenbüttel 3133/3139)	Lower Saxony	52,4025	10,2431	80	48	2
Rantzau	83A	Schleswig-Holstein	53,7071	9,7617	10	192	4
Recklinghausen	202	Rhineland-Palatinat	51,7708	7,1805	75	193	4
Riedenburg	Essing 2	Bavaria	48,9192	11,7397	450	244	4
Sprakensehl	201b	Lower Saxony	52,8000	10,6000	115	255	4
Wolfgang	Hanua-Wolfgang 47a	Hesse	50,1500	9,0461	160	257	4
Great Britain							
Blakeney	402	Gloucestershire	51,7831	-2,4981	76	127, 185	2, 4
Dymock	309, 310, 311, 325	Herefordshire	51,9467	-2,4497	70	126, 187	2, 4
Suttom Bottom	446	Gloucestershire	51,8217	-2,4883	120	130, 186	2, 4
Hungary							
Nagybotany	26 A, 26 B	Heves	47,9439	19,8511	400	328	5
Pilismarot	127 B	Komárom-Esztergom	47,7239	18,8647	500	327	5

Ireland							
Coolgreany	257b, 258t, 259o, 260H	Wexford	52,7607	-6,2607	100	128	2
Delgany	156H, 157C, 158U, 154P	Wicklow	53,1367	-6,1172	120	125	2
Killarney	028b, 029t, 030m et adjoining Muckross Estate	Kerry	52,0133	-9,5044	50	124	2
Poland							
Kozienice		Masovia	51,5456	21,4828	150	320	5
Krzyz	191j et 192d	Greater Poland	52,9592	15,9886	70	323	5
Pionki	76	Masovia	51,5144	21,3882	150	319	5
Syców	97bc, 98c, 99bc, 126c, 127b, 128a	Lower Silesia	51,1818	17,9284	210	179	4
Slovakia							
Obora		Banská Bystrica	48,6106	19,0767	350	326	5
Quercus robur							
Czech Republic							
Chudenice	353 A 5	Plzen	49,44278	13,169444	435	340	5
Tvrdonice	942-A1-4	Moravia	48,7053	16,9856	150	339	5
France							
Compiègne 0021	21	Oise	49,3400	2,8231	47	13	1
Lisle	15 (ex 15, 16)	Meuse	48,9264	5,0008	165	119	2
Mées	5, 6, 7 et 8	Landes	43,6917	-1,0950	5	22, 118, 239, 318	1, 2, 4, 5
Temple	35, 36, 37, 38, 39	Aube	48,3050	4,4472	154	101	2
Germany							
Fallersleben	Danndorf 64d	Lower Saxony	52,3803	10,6933	64	47	2
Wienhausen	Fuhrberg 2296	Lower Saxony	52,6089	10,0389	38	46	2
Great Britain							
Drummond castle	Policy Woods	Perthshire	56,3431	-3,8489	50	129	2
New Forest Hursthill	16	Hampshire	50,8417	-1,5953	17	123	2
Latvia							
Liepaja		Kurzeme	56,689	21,159	27	343	5
Poland							
Hajnowka	389 b	Podlaskia	52,7132	23,6797	170	335	5
Kozienice		Masovia	51,51667	21,433333	150	334	5
Niepolomice	430 e, 431, 432, 462	Lesser Poland	50,1028	20,3711	185	336	5
Pszczyna		Silesia	50,0453	18,9972	243	337	5

Annexe 2

Summary table of the occurrence of the provenances in the different test sites and tranches (number in columns indicated tranches)

INRA code	Forest	Countries	Espèce	PC	VZ	VC	SI
1	Bercé 113	France	*Q.p. ssp p.*	1	1	1	1
2	Bercé 119	France	*Q.p. ssp p.*	1	1	1	1
3	Chandelais	France	*Q.p. ssp p.*	1	1	1	1
4	Blois 33	France	*Q.p. ssp p.*	1	1	1	1
5	Blois 136	France	*Q.p. ssp p.*	1	1	1	1
9	St Sauvant	France	*Q.p. ssp p.*	1	1	1	1
10	Vouillé	France	*Q.p. ssp p.*	1	1	1	1
11	Moulière	France	*Q.p. ssp p.*	1	1	1	1
13	Compiègne 0021	France	*Q.r.*	1	1	1	1
14	Parc Saint Quentin	France	*Q.p. ssp p.*	1	1	1	1
16	Montargis	France	*Q.p. ssp p.*	1	1	1	1
17	Fontainebleau 544	France	*Q.p. ssp p.*	1	1	1	1
18	Fontainebleau 853	France	*Q.p. ssp p.*	1	1	1	1
21	Orléans Fay	France	*Q.p. ssp p.*	1	1	1	1
22	Mées	France	*Q.r.*	1	1	1	1
29	Traconne	France	*Q.p. ssp p.*	1	1	1	1
33	Réno Valdieu	France	*Q.p. ssp p.*	1	1	1	1
35	Bellême 67	France	*Q.p. ssp p.*	1	1	1	1
36	Bellême 3	France	*Q.p. ssp p.*	1	1	1	1
37	Perseigne	France	*Q.p. ssp p.*	1	1	1	1
38	Réno Valdieu 4-5	France	*Q.p. ssp p.*	1	1	1	1
39	Fontainebleau 544	France	*Q.p. ssp p.*	2	2	2	2
40	Fontainebleau 853	France	*Q.p. ssp p.*	2	2	2	2
41	Bercé 113	France	*Q.p. ssp p.*	2	2	2	2
42	Bercé 119	France	*Q.p. ssp p.*	2	2	2	2
43	Perseigne	France	*Q.p. ssp p.*	2	2	2	2
45	Lappwald 139 a 1	Germany	*Q.p. ssp p.*			2	2
46	Wienhausen	Germany	*Q.r.*	2	2	2	2
47	Fallersleben	Germany	*Q.r.*	2	2	2	2
48	Peine	Germany	*Q.p. ssp p.*			2	2
89	Bussières	France	*Q.p. ssp p.*	2	2	2	2
90	Tronçais	France	*Q.p. ssp p.*	2	2	2	2
91	Soudrain	France	*Q.p. ssp p.*	2	2	2	2
92	Bommiers	France	*Q.p. ssp p.*	2	2	2	2
93	Bertranges	France	*Q.p. ssp p.*	2	2	2	2
94	Longchamps	France	*Q.p. ssp p.*	2	2	2	2
96	Temple	France	*Q.p. ssp p.*	2	2	2	2
97	Grésigne	France	*Q.p. ssp p.*	2	2	2	2

98	Chateauroux	France	*Q.p. ssp p.*	2	2	2	2
99	Allogny	France	*Q.p. ssp p.*	2	2	2	2
100	Etangs	France	*Q.p. ssp p.*	2	2	2	2
101	Temple	France	*Q.r.*	2	2	2	2
102	Prémery	France	*Q.p. ssp p.*	2	2	2	2
103	Serqueux	France	*Q.p. ssp p.*	2	2	2	2
104	Soulongis	France	*Q.p. ssp p.*	2	2	2	2
105	Dreuille	France	*Q.p. ssp p.*	2	2	2	2
106	Prieurés Moladier	France	*Q.p. ssp p.*	2	2	2	2
107	Prieurés Grosbois	France	*Q.p. ssp p.*	2	2	2	2
108	Guerigny	France	*Q.p. ssp p.*	2	2	2	2
110	Orléans Ingrannes	France	*Q.p. ssp p.*	2	2	2	2
117	Adé	France	*Q.p. ssp p.*	2	2	2	2
118	Mées	France	*Q.r.*	2	2	2	2
119	Lisle	France	*Q.r.*	2	2	2	2
120	Pontigny	France	*Q.p. ssp p.*	2	2	2	2
121	Compiègne	France	*Q.p. ssp p.*	2	2	2	2
123	New Forest Hursthill	Great Britain	*Q.r.*			2	2
124	Killarney	Ireland	*Q.p. ssp p.*	2	2	2	2
125	Delgany	Ireland	*Q.p. ssp p.*	2	2	2	2
126	Dymock	Great Britain	*Q.p. ssp p.*	2	2	2	2
127	Blakeney	Great Britain	*Q.p. ssp p.*	2		2	2
128	Coolgreany	Ireland	*Q.p. ssp p.*	2	2	2	2
129	Drummond castle	Great Britain	*Q.r.*	2	2	2	2
130	Suttom Bottom	Great Britain	*Q.p. ssp p.*				2
179	Syców	Poland	*Q.p. ssp p.*	4	4	4	4
180	Løndal Naes	Denmark	*Q.p. ssp p.*	4	4	4	4
181	Hørbylunde	Denmark	*Q.p. ssp p.*	4	4	4	4
182	Gourdjani	Georgia	*Q.p. ssp i.*		4		4
183	Mtskheta	Georgia	*Q.p. ssp i.*				4
184	Telavi	Georgia	*Q.p. ssp p.*	4	4	4	
185	Blakeney	Great Britain	*Q.p. ssp p.*	4		4	
186	Suttom Bottom	Great Britain	*Q.p. ssp p.*	4		4	4
187	Dymock	Great Britain	*Q.p. ssp p.*			4	
190	Elmstein Nord	Germany	*Q.p. ssp p.*		4	4	4
191	Lüss	Germany	*Q.p. ssp p.*	4	4		4
192	Rantzau	Germany	*Q.p. ssp p.*		4		4
193	Recklinghausen	Germany	*Q.p. ssp p.*	4		4	4
194	Soudrain	France	*Q.p. ssp p.*		4	4	4
201	La Haie Renaut	France	*Q.p. ssp p.*	4	4	4	4
204	Bézange	France	*Q.p. ssp p.*	4	4	4	4
205	St Aubin du Cormier	France	*Q.p. ssp p.*	4	4	4	4
206	Guérigny	France	*Q.p. ssp p.*	4	4	4	4
207	Fontainebleau 853	France	*Q.p. ssp p.*	4	4	4	4
208	Fontainebleau 544	France	*Q.p. ssp p.*	4		4	4

209	Sturzelbronn	France	*Q.p. ssp p.*	4	4	4	4
210	Saint Germain	France	*Q.p. ssp p.*	4	4	4	4
211	Prémery	France	*Q.p. ssp p.*	4	4	4	4
212	Bertranges	France	*Q.p. ssp p.*	4	4	4	4
213	Pontigny	France	*Q.p. ssp p.*	4	4	4	4
217	Bercé	France	*Q.p. ssp p.*	4	4	4	4
218	Longchamp	France	*Q.p. ssp p.*	4	4	4	4
219	Tronçais 89	France	*Q.p. ssp p.*	4	4	4	4
220	Dreuille	France	*Q.p. ssp p.*	4	4	4	4
221	Prieurés Moladier	France	*Q.p. ssp p.*	4	4	4	4
222	Prieurés Grosbois	France	*Q.p. ssp p.*	4	4	4	4
223	Steinbach	France	*Q.p. ssp p.*	4	4	4	4
224	Lembach	France	*Q.p. ssp p.*	4	4	4	4
225	Still	France	*Q.p. ssp p.*	4	4	4	4
226	Haslach	France	*Q.p. ssp p.*	4	4	4	4
227	Westhoffen	France	*Q.p. ssp p.*	4	4	4	4
228	Saint Jean	France	*Q.p. ssp p.*	4	4	4	4
229	Bride	France	*Q.p. ssp p.*	4	4	4	4
230	Romersberg	France	*Q.p. ssp p.*	4	4	4	4
231	Soudrain	France	*Q.p. ssp p.*	4	4	4	4
232	Allogny	France	*Q.p. ssp p.*	4	4	4	4
233	Vachères	France	*Q.p. ssp p.*	4	4	4	4
234	Tremozey et Fontenoy	France	*Q.p. ssp p.*	4		4	4
235	Bussières	France	*Q.p. ssp p.*	4	4	4	4
236	Réno Valdieu 118 - 119	France	*Q.p. ssp p.*	4	4	4	4
237	Réno Valdieu 4-5	France	*Q.p. ssp p.*	4	4	4	4
238	Nicey	France	*Q.p. ssp p.*	4	4	4	4
239	Mées	France	*Q.r.*	4	4	4	4
240	Serqueux	France	*Q.p. ssp p.*	4	4	4	4
241	Bellême 67	France	*Q.p. ssp p.*	4	4	4	4
242	Bellême 3	France	*Q.p. ssp p.*	4	4	4	4
243	Montécot et Senonches	France	*Q.p. ssp p.*	4		4	4
244	Riedenburg	Germany	*Q.p. ssp p.*				4
245	Etangs	France	*Q.p. ssp p.*	4	4	4	4
246	Gelnhausen	Germany	*Q.p. ssp p.*		4	4	4
247	Hainback	Austria	*Q.p. ssp p.*	4	4	4	4
248	Klostermarienberg	Austria	*Q.p. ssp p.*	4	4	4	4
249	Bolu (Ayikayasi)	Turkey	*Q.p. ssp i.*	4	4	4	4
250	Cochem	Germany	*Q.p. ssp p.*	4	4	4	4
251	Farchau	Germany	*Q.p. ssp p.*		4	4	4
252	Johanneskreuz	Germany	*Q.p. ssp p.*	4		4	4
253	Göhrde	Germany	*Q.p. ssp p.*	4	4	4	4
254	Elmstein Nord	Germany	*Q.p. ssp p.*		4	4	4
255	Sprakensehl	Germany	*Q.p. ssp p.*	4	4	4	4
256	Lappwald 84a	Germany	*Q.p. ssp p.*		4	4	4

257	Wolfgang	Germany	*Q.p. ssp p.*	4	4	4	4
259	Bad Hersfeld	Germany	*Q.p. ssp p.*		4	4	4
260	Mölln (Büffelskopf)	Germany	*Q.p. ssp p.*	4	4	4	4
301	La Neuville en Hez	France	*Q.p. ssp p.*	5	5	5	5
302	Saint Germain	France	*Q.p. ssp p.*	5	5	5	5
303	Hagueneau	France	*Q.p. ssp p.*	5	5	5	5
304	Hagueneau	France	*Q.p. ssp p.*		5	5	5
305	Fontainebleau 544	France	*Q.p. ssp p.*	5	5	5	5
306	Fontainebleau 853	France	*Q.p. ssp p.*	5	5	5	5
307	Allogny	France	*Q.p. ssp p.*	5	5	5	5
308	Saint Jean	France	*Q.p. ssp p.*	5	5	5	5
309	Bride	France	*Q.p. ssp p.*	5	5	5	5
310	Ternes	France	*Q.p. ssp p.*				5
311	Prémery	France	*Q.p. ssp p.*	5	5	5	5
312	Vincence	France	*Q.p. ssp p.*	5		5	5
313	Bareilles	France	*Q.p. ssp p.*	5		5	5
314	Adé	France	*Q.p. ssp p.*	5		5	5
315	Bercé	France	*Q.p. ssp p.*	5	5	5	5
316	Russy	France	*Q.p. ssp p.*	5	5	5	5
317	Boulogne	France	*Q.p. ssp p.*	5	5	5	5
318	Mées	France	*Q.r.*	5	5	5	5
319	Pionki	Poland	*Q.p. ssp p.*		5	5	5
320	Kozienice	Poland	*Q.p. ssp p.*	5	5	5	5
323	Krzyz	Poland	*Q.p. ssp p.*				5
325	Doubrava	Czech Republic	*Q.p. ssp p.*	5		5	
326	Obora	Slovaquie	*Q.p. ssp p.*	5		5	5
327	Pilismarot	Hungary	*Q.p. ssp p.*			5	5
328	Nagybotany	Hungary	*Q.p. ssp p.*	5		5	5
330	Bellême	France	*Q.p. ssp p.*	5	5	5	5
334	Kozienice	Poland	*Q.r.*			5	
335	Hajnowka	Poland	*Q.r.*				5b
336	Niepolomice	Poland	*Q.r.*				5b
337	Pszczyna	Poland	*Q.r.*				5b
339	Tvrdonice	Czech Republic	*Q.r.*			5	5b
340	Chudenice	Czech Republic	*Q.r.*				5b
343	Liepaja	Latvia	*Q.r.*				5b