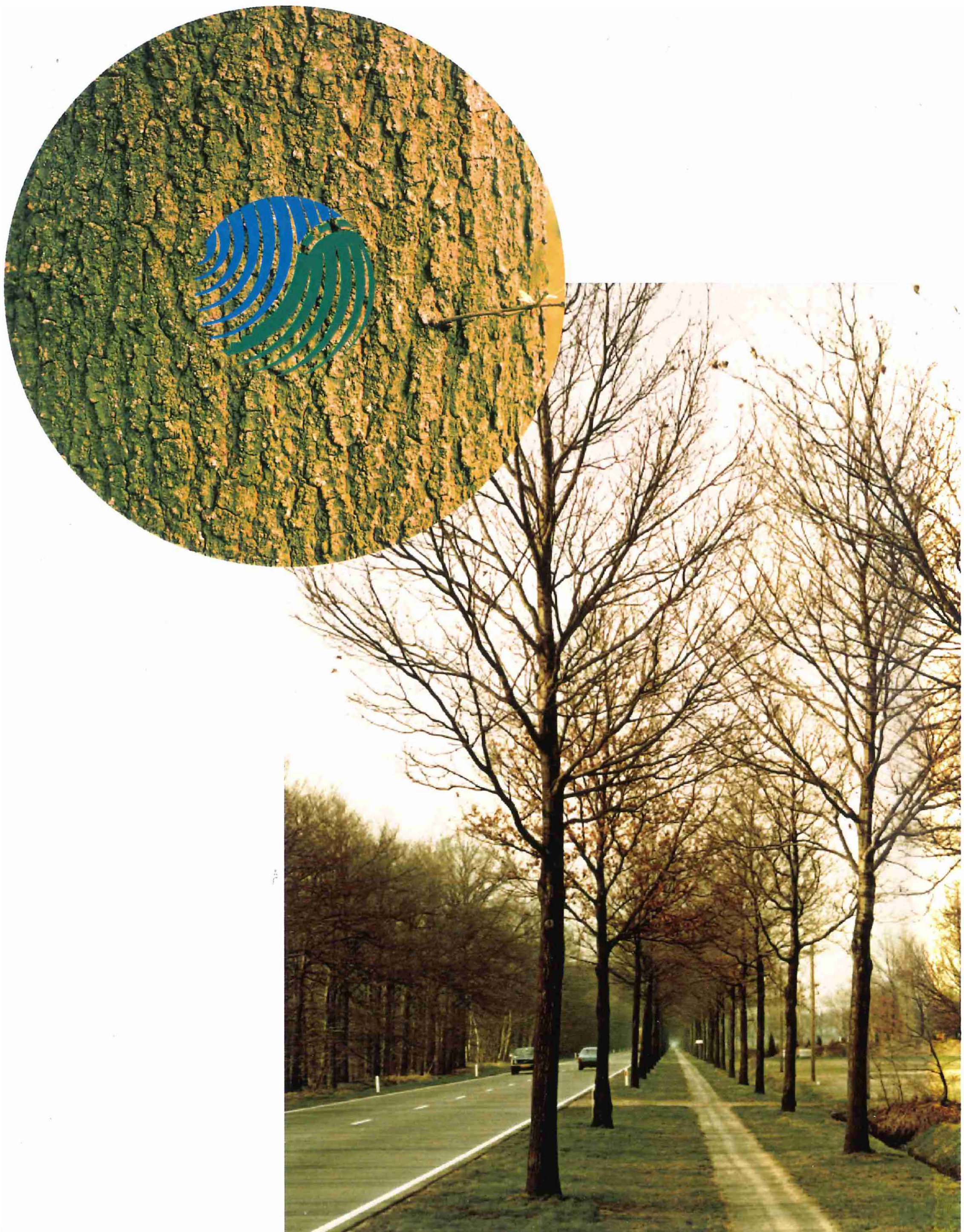
Provenance research Quercus robur in De Rips

K.G. Kranenborg
S.M.G. de Vries

ibn-dlo

Institute for Forestry and Nature Research



IBN-REPORT 99/4, ISSN: 0928-6896

Provenance research Quercus robur in De Rips

K. G. Kranenborg
S. M. G. de Vries

ibn-dlo

Institute for Forestry and Nature Research

Wageningen 1999, The Netherlands

IBN-REPORT 99/4, ISSN: 0928-6896

Contents

1. Summary

In the provenance trial of Quercus robur in De Rips the features height growth , flushing date, growth cessation, stem form and survival are reported. The best suitable provenances should combine all the good features as good growth, late flushing, a good stem form and a high survival rate. Most of these provenances originate from selected seed stands in the Netherlands and are listed in the National Catalogue as selected seed stands. The best provenances that combine the preferred features in this trial are: ZE 132 St.Oedenrode-02, ZE 161 Stadskanaal-01, ZE 145 Nuenen-02, ZE 141 Mierlo-01, ZE 67 Hapert-01, ZE 75 Vaals and ZE 80 Waalwijk -01. From these seven provenances there were five already listed in the National Catalogue as selected seed stand. The provenance ZE 75 was not listed because of too few trees. The provenance ZE 132 once was listed in the National Catalogue as seed stand, but was rejected some years ago because of strong crown pruning. Now after some years the crowns are strongly rejuvenated again and in the next version of this Catalogue this plantation will be listed again. These six provenances will be listed in the next National Catalogue in the higher category of 'tested', because of proven better genetic quality.

2. Introduction

Quercus robur is a very important forest tree species in the Netherlands. It is the most spread and planted generatively grown indigenous broad leave species in the country. At the moment about 16 % of the total forested area is covered with Oak as main tree species. Together with this about 25 % of line- and roadside plantations are planted with Oak, which is all together about 82.000 km. (de Vries and van Dam 1998.) Dutch seed stands of Q. robur contribute significantly to Oak afforestation and reforestation in large parts of Western Europe. Annually an average of about 400.000 kg. of acorns is harvested, from which half in selected stands and stands that have been tested for the basic material they produce. From the total of 400 tons, about half is exported as seed and the other half is sown in Dutch nurseries. From the 20 to 30 million plants that are raised this way in the Netherlands again a majority is exported to other countries as Germany, Denmark, Great Britain, Ireland, France and Sweden. (Jager a. o. 1993 and Jensen a. o. 1997). For this reason it is very important to bring and keep the genetic quality on a high level. This is why through the years a number of steps in selection have been made towards a sound system of administration and control and it is therefore quite relevant what kind of criteria are used in the Dutch selection programme of Oak (Jager a. o. 1993 and Jensen a. o. 1997).

Following a systematic phenotypic selection of seed stands it is important to find out more about their genetic quality by comparing the offspring with a certain standard or with the mean of the trial (Jensen a. o. 1997). Testing procedures are described in EC-directives and incorporated in Dutch law (Seed and Plant Act ; Zaaizaad- en Plantgoedwet, 1966).

A great number of comparative trials have been established from 1978 on by IBN-DLO, former Forest Research Institute 'De Dorschkamp'. By now almost all selected seed stands of Oak included in the National Catalogue are represented in one or more comparative provenance trials. For inheritance studies these trials are of great importance and the first results of these trials are already included in the Sixth list of recommended varieties and provenances of trees 1996-2000 (Commissie etc., 1996). Growth characters like height, diameter, flushing and form can be measured relatively easy.

The original origin of most of the selected seed stands in the National Catalogue is unknown. In order to find out more about the origin of these stands it seems this could be achieved by DNA techniques and international co-operation. (de Vries en van Dam 1998).

In the framework of the EU Oak project: 'Synthetic maps of gene diversity and provenance performance for utilisation and conservation of Oak resources in Europe' the provenance trial of Quercus robur in De Rips was subject of study of characteristics as height, phenology, form, survival and DNA analyses. This report represents the results of height growth, phenology , form and survival of the 39 provenances in this trial. On the basis of these results a selection of the provenances was made with proven good qualitative features to be listed in the category tested basic material in the next National Catalogue. The category tested basic material is of a higher standard than the category selected basic material.

3. Selection of Oak in the Netherlands

Already in 1949 a first selection took place by the Foundation for Improvement of Forest stands (Stichting Verbetering Houtopstanden, SVH). Individual trees were selected in order to be propagated vegetatively and to be evaluated for the use as clones.

Improvement of generatively propagated material of Oak was initiated by the Netherlands Inspection Service for Floriculture and Arboriculture (NAKB) first in 1958. This service created a list of recommended seed stands.

A more specific list on the basis of assessments of individual trees within stands was carried out by the Forest Research Institute "de Dorschkamp" in 1976. Subject of assessment was a number of relevant phenotypic characters from which was assumed they had a high rate of heritability. (de Vries en van Dam 1998). This list was published by a Commission installed in 1971 by the Dutch Government in order to create a National Catalogue, the so called Rassenlijst (Commissie etc., 1977). This Catalogue has been revised several times since then and nowadays it is issued at 5 year intervals, the last issue dates from 1996 (Commissie etc., 1996).

In 1984 a new selection was carried out by "de Dorschkamp"(nowadays IBN-DLO) on the basis of a far bigger number of features, 25 in total from which after statistical analysis seven features turned out to be of discriminating value. The list of recommended seed stands of Oak resulting from this selection was published in 1990 (Commissie etc., 1990).

By order of the NAKB a new selection took place by the IBN-DLO in 1994 in order to fully cover the possibilities of seed harvest of genetically good material. The selection criteria used in 1994 were based on the same seven features found to be of discriminating value in 1984.

Basicly a first impression of a stand is decisive whether a further evaluation on basis of an at random test is carried out or that the stand is rejected because of bad quality at first sight. In the case of continuation an at random sample is taken of 1/3 of the total amount of trees with a minimum of 50 trees and a maximum of 150 trees.
On the sampled trees a first inspection takes place judging on three features:
- form of the trunk underneath the crown
- form of the trunk within the crown
- branching habit

For the three different features three gradations are given: 1, 2 and 3.
For the trunk the numbers 1 to 3 have the following meaning:
1. straight; deviation < 10%
2. slightly curved; deviation 10-25%
3. curved; deviation > 25%

For the branching habit the numbers 1 to 3 have the following meaning:
1. no forks nor thick branches
2. one fork or one thick branch
3. more forks or thick branches

The total amount of grade 1 is added up in percentages for the three features. The total amount of grade 3 for the three features is taken away from the total of grade 1. In case this score is below 90 the stand is rejected as unfit for seed harvest at all. In case the score is above 90 a second inspection takes place judging on four more features:
- spiral grain
- lumps
- grooves
- epicorms

For these four features also three gradations are given which stand for:
1. not present
2. hardly present
3. moderate

Again the total amount of grade 1 is added up in percentages for the four features in the second round. When the total of grade 3 is taken away from the total of grade 1 and the outcome is above 300 the stand is considered to be positively selected for seed harvesting. In case the outcome is below 300 the stand is in this second round still rejected as unfit for seed harvest (Jager, 1994).
The seed stands from which the provenances in the trial De Rips are derived were selected according to this system. Also some provenances from not selected stands were included in this trial.

4. Material

Review of the provenances of Oak in De Rips. Besides the selection number and the registration number also the provenance name in the National Catalogue is mentioned. All the selected seed stands from which the provenances in this trial are derived are road side plantations. Three stands not selected for seed collection are small plantations in a village.
* = Provenance not listed in the National Catalogue. In figure 1 the partition of the Netherlands for seed collection is given and the locations of the provenances.

Sel. Nr.	Ze-nr.	Provenance name	Local name
220	ZE 101	Renswoude-02	Renswoude, Renswoude-Scherpenzeel.
221	ZE 14	Baarn-01	Baarn, Torenlaan.
222	ZE 38	Duiven-02	Duiven, Duiven-Westervoort.
223	ZE 35	Zevenaar-01	Zevenaar, Zevenaar-Babberich, Babberichseweg.
224	ZE 123	Hummelo-02	Hummelo en Keppel, Doesburg-Doetinchem.
225	ZE 129	Heeswijk-01	Heeswijk-Middelrode, Gouveneursweg.
226	ZE 132	*	St. Oedenrode, Ollandseweg.
227	ZE 161	Stadskanaal-01	Stadskanaal, Hoofdstraat-Ooststraat.
228	ZE 157	*	Zuidlaren, Brink-oostzijde.
230	ZE 164	*	Beek en Donk, Brandstraat-Koppelstraat.
231	ZE 159	*	Bakel en Milheeze, Bakel-Deurne, Overschot.
232	ZE 160	*	Bakel en Milheeze, Bakel-Deurne, kmp. 1.1-2.7
233	ZE 142	Helmond-01	Helmond, Stiphout, Jan van Brabantlaan.
234	ZE 143	Helmond-01	Helmond, Stiphout, Pres. Rooseveltlaan.
235	ZE 144	Nuenen-01	Nuenen, Boordseweg.
236	ZE 145	Nuenen-02	Nuenen, Nuenen-Gerwen, Broekdijk.
237	ZE 141	Mierlo-01	Mierlo, Eikendreef-Bekelaar-Goorsedijk.
238	ZE 138	Heeze-02	Heeze, Kasteel Heeze, Boschlaan.
239	ZE 162	Someren-01	Someren, Vaarselstraat.
240	ZE 57	Princenhage-02	Breda, Princenhage, Landgoed Zoudtland.
241	ZE 149	*	Zundert, Achtmaalseweg.
242	ZE 78	*	Oost-, West- en Middelbeers, .
243	ZE 76	Esbeek-01	Esbeek, Landgoed De Utrecht, Kinderlaan.
244	ZE 67	Hapert-01	Bladel en Netersel, Hulsel-Bladel.
245	ZE 158	Oirschot-02	Oirschot, Spoordonkseweg.
246	ZE 163	Best-01	Best, Koningin Julianaweg.
247	ZE 169	Horn-02	Heythuisen, Biesstraat.
248	ZE 127	Amstenrade-01	Schinnen, Amstenrade, Hommerterallee.
249	ZE 75	*	Vaals, Vaals-Gulpen, Hotel De Piethaan.
250	ZE 74	Bocholtz-01	Wittem, Simpelveld-Nijswiller.
251	ZE 94	*	Dwingeloo, Brink.
252	ZE 95	*	Diever, Brink.

253	ZE 102	Baarn-03	Baarn, Amsterdamsestraatweg.
254	ZE 80	Waalwijk-01	Waalwijk, Olympiaweg.
255	ZE 125	Zeist-01	Zeist, Koelaan.
256	ZE 43	Helvoirt-02	Helvoirt, De Dijk, Oude Rijksweg en Torenstraat
257	ZE 79	Helvoirt-03	Helvoirt, Vught-Tilburg.
258	ZE 30	Wageningen-01	Wageningen, Grintweg.
259	ZE 96	*	Wolfheze, Wolfhezerweg.

5. Trial data.

De Rips

Establishment:	Spring 1988.
Plant material:	2 years old (2+0)
Spacing:	1.50 x 1.50 m.
Plot size:	4 x 5 = 20 plants; 6 x 7.5 m.
Layout:	39 provenances in 6 blocks.
Soil:	Pzn21, gooreerdgrond; Gt III/V.
Soil preparation:	Completely ploughed.

6. Assessments.

First height measurements were carried out in spring of 1990 at the age of two years after establishment. At the end of 1994 a second height measurement was carried out at the age of seven years after establishment. With these two measurements all trees in 6 blocks were measured. Within the framework of subtask 2.3 of the EU Oak project: 'Synthetic maps of gene diversity and provenance performance for utilisation and conservation of oak genetic resources in Europe' a third and fourth height measurement was carried out in spring and autumn of 1997 at the age of nine and ten years after establishment. The measurement in spring of 1997 was carried out on all trees in the blocks 1, 2 and 3. The measurement in autumn of 1997 was carried out on all trees only in block 1. Flushing of all trees was recorded once in 1992 and once in 1994. Also within the framework of the EU Oak project flushing was recorded three times in May 1997 with intervals of one week on all trees in block 1. Growth cessation was recorded three times in autumn of 1997 with intervals of two weeks on 10 trees per plot in block 1. At the end of the growing season in 1997 survival of all oak trees per plot of 20 trees in block 1 was assessed. Also in 1997 tree form was assessed on 10 trees per plot in block 1.

7. Results

7.1 Growth

First height measurements were carried out in spring of 1990 at the age of two years after establishment. At the end of 1994 a second height measurement was carried out at the age of seven years after establishment. With these two measurements all trees in 6 blocks were measured. A third and fourth height measurement was carried out in spring and autumn of 1997 at the age of nine and ten years after establishment. In spring of 1997 all trees in blocks 1, 2 and 3 were measured. In autumn of 1997 all trees in block 1 only were measured as these measurements were carried out in the framework of the EU-Oak project. In table 1 and figure 2 results of these height measurements are summarised. According to subtask 1.2. of the EU-Oak project: 'CpDNA analysis of populations established in provenance tests' in this trial 5 at random chosen trees per plot in block 1 were sampled to identify the haplotypes present in the provenance. Height from these five trees measured in spring and autumn of 1997 are separately listed. With the analysis of variance significant differences in height between the provenances were shown at all the four measurements. In 1990 two years after establishment mean height of all provenances was 1.19 m. with a variation per provenance from 0.92 to 1.39 m. In 1994 mean height of all provenances was 3.82 m. varying per provenance from 3.21 to 4.27 m. In spring of 1997 nine years after establishment mean height of all provenances in block 1 was 5.52 with a variation from 4.04 m. to 6.63 m. At the end of 1997 mean height of all provenances in block 1 was 6.05 m. with a variation from 4.72 to 7.27 m. Mean annual increment of all provenances between 1990 and 1994 was 0.66 m. Mean annual increment of all provenances between the end of 1994 and spring of 1997 was 0.53 m. Mean annual increment of all provenances in block 1 in 1997 was also 0.53 m.

In table 7 an evaluation is given of the height growth in a ranking from 1 to 4, where 1 is the preferred best height growth and 4 is considered to be poor in height growth. The provenances with best height growth are the selected stands 223 Zevenaar-01, 236 Nuenen-02, 240 Princenhage-02 and 247 Horn-02 and another four stands that are because of different reasons not listed anymore in the National Catalogue. These four provenances are 226, 230, 232 and 249. The provenance 226 was rejected because of strong crown pruning some years ago and for this reason no crop of acorns could be expected. However after some years the crowns are strongly rejuvenated and in the next version of the National Catalogue this plantation will be listed again. The provenance 230 was cut in 1995. The provenance 232 was rejected from the list because of traffic circumstances for collecting acorns were considered to be too dangerous. The provenance 249 was not listed because the majority of the trees were cut down. Besides these mentioned eight provenances with best height growth another 14 provenances showed a height growth better than the mean of all provenances in the trial. The four provenances with poorest growth are 248 from the selected stand ZE 127 Amstenrade-01 and three provenances 241, 251 and 259 from the stands not selected for seed collection ZE 149 Zundert, Achtmaalseweg, ZE 94 Dwingeloo, Brink and ZE 96 Wolfheze.

7.2 Phenology

7.2.1 Flushing

Flushing may be used as a feature to determine the suitability of a provenance for Dutch circumstances. Late frosts often occur in the Netherlands in April and May, causing severe damage to the newly flushed shoots. Provenances that flush late have less chance of suffering damage from late night frosts than provenances that flush early. The variation in flushing date between species and between populations within species is substantial. Flushing seems to be under strong genetic control (Jensen, 1999 and 1999). This confirms earlier observations made by Burger (1921), Kleinschmit & Svolba (1979) and Kleinschmit (1993). In order to obtain a better insight into the flushing behaviour of the various provenances flushing was recorded in spring 1992 and 1994 on all trees in the 6 blocks in the trial. Six stages of flushing were distinguished From 0 = not yet any activity of the buds to 5 = complete leave development. Within the framework of the EU Oak project flushing was recorded three times in May 1997 with intervals of one week on all trees in block 1. With these assessments 5 stages of flushing were distinguished according to the NFV-Bonitur (EU-Project Fair 1, 1995). See figure 3 for the different flushing stages. Distinguished were 1 = start of the bud burst to 5 = complete leave development. The flushing was evaluated on the terminal bud of the leader or on buds in the rosette just below the terminal bud. The first bud was selected for the scoring. Table 2 and figure 4 show the mean flushing values from each selection number in 1992, 1994 and 1997. In all these three years significant differences were shown between the provenances. Figure 5 shows flushing behaviour of the three recordings in 1997. According to these flushing values the provenances can be classified from early to late flushing. In Table 7 an arrangement of the mean flushing behaviour in 1992, 1994 and 1997 is given. Four classes are distinguished: 1 = very late flushing, 2 = late flushing, 3 = early flushing and 4 = very early flushing. Six provenances in class 1 are very late flushing. Twelve provenances in class 2 are late flushing and sixteen provenances in class 3 are early flushing. The remaining five provenances are very early flushing. In 1992 and 1994 only one assessment was carried out. These assessments give a comparative result of flushing values of the provenances. In 1997 three recordings of flushing were carried out. On the basis of the results of the first and second recording an assessment of the difference in time of flushing of the provenances can be made. Assuming that all the provenances progress the flushing stages with the same speed the difference in time of flushing between the earliest and latest flushing provenance was 23.2 days. The mean mutual difference in time of flushing between all provenances was 12.8 days, while the smallest difference in time of flushing between two provenances was 3 days. For a better insight in the speed of progress of the flushing values in relation to the assessment of the exact time difference in flushing stage more flushing recordings are required than three recordings. At the moment of the third recording almost all trees were already in stage 5 which means a complete leave development. More recordings for that reason were not necessary. The relation between flushing behaviour of the provenances in 1992, 1994 and 1997 can be expressed by the correlation coefficients between the flushing values in those years. In Table 3 these results are summarised. Correlation coefficients between the mean flushing value of the provenances in 1992 with those in 1994 and 1997 are 0.8967 and 0.6815 and the correlation coefficient between the mean flushing value in 1994 and 1997 is 0.7487. These values show a strong significant relation between flushing behaviour of the provenances in the different years. This confirms other research results (Burger, 1921. Kleinschmit & Svolba, 1979. Kleinschmit, 1993 and Jensen 1999, 1999.) that flushing behaviour is genetically controlled. In table 7 an evaluation is given of flushing time in a ranking from 1 to 4, where 1 is the preferred late flushing date and 4 is considered to be flushing early.

7.2.2 Growth cessation

Growth cessation was recorded three times in the autumn of 1997 with intervals of three weeks on 10 trees per plot in block 1. Calculated was the percentage of oak trees having the majority of leaves of the terminal leader, not being Lammas shoots, with yellow tints. Results are summarised in table 4. At the time of the first assessment on 30-09-1997 the mean percentage of all provenances with the majority of leaves of the terminal leader with yellow tints was 9.7 % with a variation between the provenances of 0 to 60 %. At the second and third assessment these values were 51.8 % varying from 10 to 100 % and 88.7 % varying from 70 to 100 % respectively. With the analysis of variance no significant differences could be found between the provenances in growth cessation at the three moments of assessment.

7.2.3 Growth and phenology

Significant differences were found between the provenances in height growth and flushing values in different years. No significant differences were found in growth cessation at the end of 1997. The mean difference in flushing time between the provenances is 12.8 days, with the smallest difference between two provenances of 3 days and the largest difference in time of flushing of 23.2 days. This means that the length of the vegetation period of the different provenances is not the same. In order to analyse whether height growth could be related to the length of the vegetation period correlation coefficients were calculated between flushing values and height growth. Between these two features no significant correlation was found. Correlation coefficients between height in autumn of 1994 and flushing values in spring of 1994 and height in autumn of 1996 and flushing values in spring of 1997 were 0.5263 and 0.1326 respectively. Two examples of this contradictory behaviour are for instance the sel. nr. 249 that is one of the best growing provenances, but at the same time it is flushing very late and the sel. nr. 248 that shows very poor height growth, while at the same time it is flushing very early.

7.3 Form

At the end of the growing season in 1997 ten years after establishment tree form was assessed on 10 trees per plot in block 1 according to the NFV- Bonitur (EU-Project Fair 1, 1995). See figure 6 for the different scoring classes. Distinguished were six tree forms: 1 = straight, 2 = slightly curved, 3 = badly curved, 4 = no straight leader, 5 = repeated forking and 6 = shrubby. In table 5 the results of these assessments are summarised. As the trees were only twelve years old from seed these results must be considered as being preliminary. The mean scoring value of all provenances was 3.5 with a variation per provenance of 2.4 to 5.0. The mean percentage of straight trees in class 1 is 6.7 % with a variation per provenance of 0 - 30 %. The mean percentage of slightly curved trees in class 2 is 30.8 % with a variation per provenance of 0 - 70 %. In class 3 the mean percentage of badly curved stems is 16.2 % with a variation per provenance of 0 - 40 %. The percentage of trees in class 4, no straight leader, and class 6, shrubby, is low with a mean percentage of 3.3% and 2.6 % respectively. The mean percentage of trees class 5, repeated forking, is with 40.5 % rather high. Per provenance this percentage varies from 0 - 100 %. The provenances with the best stem form are 242, 246, 248 and 250 with 30 %, 30 %, 20% and 20 % straight stems (1) and 20%, 30%, 60% and 40% slightly curved stems (2) respectively. The provenance 242 was a former selected stand, but this stand was rejected because of dangerous traffic situations for collecting acorns. The provenances 246, 248 and 250 are selected seed stands. The provenance 230, that is not a stand selected for seed collection, shows poorest stem form with 100 % repeated forking. In table 7 an evaluation is given of the average stem form in a ranking from 1 to 4, where 1 is the preferred straight and good stem form and 4 is considered to be poor in stem form. Besides the already mentioned provenances with a good stem form also the following provenances show a good stem form: 236, 237, 254 and 255 derived from selected seed stands and the provenances 241and 249 derived from stands not selected for seed collection.

7.4 Survival

At the end of the growing season after cessation of growth in 1997, 10 years after establishment, survival of all oak trees per plot of 20 trees in block 1 was calculated. The results are summarised in table 6. The mean number of remaining trees of all provenances was 17.9 trees per plot with a variation per provenance of 14 to 20 trees per plot. This is a rather good score since the plantation was not beaten up after establishment. Four provenances showed a survival of 100 % while only one provenance showed the lowest survival of 70 %.

8. Conclusions

On the basis of the results of height growth, phenology, form and survival the following conclusions can be drawn.
Significant differences in height growth between provenances at the age of two, seven, nine and ten years after establishment were shown. In 1990 two years after establishment mean height of all provenances was 1.19 m. with a variation per provenance from 0.92 to 1.39 m. In 1994 mean height of all provenances was 3.82 m. varying per provenance from 3.21 to 4.27 m. In spring of 1997 nine years after establishment mean height of all provenances in block 1 was 5.52 with a variation of 4.04 m. to 6.63 m. At the end of 1997 mean height of all provenances in block 1 was 6.05 m. with a variation from 4.72 m. to 7.27 m. Mean annual increment of all provenances between 1990 and 1994 was 0.66 m. Mean annual increment of all provenances between 1994 and 1997 was 0.53 m. In the year 1997 annual increment was also 0.53 m.
Significant differences in flushing values between the provenances were shown in 1992, 1994 and 1997. Assuming that all provenances progress the flushing stages with the same speed the difference in time of flushing between the earliest and latest flushing provenance was 23.2 days. The mean mutual difference in time of flushing between all provenances was 12.8 days, while the smallest difference in time of flushing between two provenances was 3 days. Correlation coefficients between the flushing values in the years 1992, 1994 and 1997 show a strong significant relation between flushing behaviour of the provenances in the different years. This confirms other research that flushing behaviour is genetically controlled.
No significant differences were found in the time of growth cessation in autumn of 1997. However significant differences were shown in height growth and flushing time. Therefore the length of the vegetation period of the provenances is not the same. Still no significant correlation was found between height growth and flushing values that indicate the length of the growing season.
At the end of 1997 ten years after establishment tree form was assessed. As the trees were only twelve years old from seed these results must be considered as being preliminary. The mean percentage of straight trees was 6.7 % with a variation per provenance of 0 to 30 %. The mean percentage of slightly curved trees was 30.8 % with a variation per provenance of 0 to 70 %. The mean percentage of badly curved stems is 16.2 % with a variation per provenance of 0 to 40 %. The percentage of trees with no straight leader and shrubby is low with a mean percentage of 3.3 % and 2.6 % respectively. The mean percentage of trees with repeated forking is with 40.5 % rather high. Per provenance this percentage varies from 0 to 100 %. From the total of 39 provenances in this trial 10 provenances show a good to rather good stem form. The other 29 provenances have a low score on more negative features as badly curved stem, no straight leader, repeated forking or a shrubby form.
Survival at the end of 1997 10 years after establishment is considered to be high. The mean survival of all provenances was 89.5 % with a variation per provenance of 70 to 100 %. This is a rather good result because the trial has not been beaten up after establishment.

The best suitable provenances should combine all the preferred features as good growth, late flushing, a good stem form and a high survival rate. The best provenances that combine these preferred features in this trial are: ZE 132 St. Oedenrode-02, ZE 161 Stadskanaal-01, ZE 145 Nuenen-02, ZE 141 Mierlo-01, ZE 67 Hapert-01, ZE 75 Vaals and ZE 80 Waalwijk-01. From these seven provenances there were five already listed in the National Catalogue in the category selected seed stand. The provenance ZE 75 was not listed because of too few trees. The provenance ZE 132 once was listed in the National Catalogue as selected seed stand, but was rejected some years ago because of strong crown pruning. However after some years the crowns are strongly rejuvenated again and in the next version of this Catalogue this plantation will be listed again. These six provenances will be listed in the next version of the National Catalogue in the higher category of 'tested', because of proven better genetic quality.

Literature

Burger, H. 1921.

Über morphologische und biologische Eigenschaften der Stiel- und Traubeneichen und ihre Erziehung in Forstgarten. Mitt. D. Schweiz. Anst. F. das Forst. Versuchsvesen 11: 306-377.

Commissie voor de samenstelling van de Rassenlijst voor Bosbouwgewassen. 1977.

Rassenlijst voor naald- en loofbomen voor bos- en landschapsbouw in Nederland. Stichting Bosbouwproefstation "De Dorschkamp", Wageningen.

Commissie voor de samenstelling van de Rassenlijst voor Bosbouwgewassen. 1990.

Vijfde Rassenlijst voor Bomen. "De Dorschkamp", Instituut voor Bosbouw en Groenbeheer, Wageningen. Leiter-Nypels, Maastricht. 160 pp.

Commissie voor de samenstelling van de Rassenlijst voor Bosbouwgewassen. 1996.

Zesde Rassenlijst voor Bomen. Uitgever de Boer Mailing Service. 304 pp.

EU-Project Fair 1 CT95 0297. 1995.

Synthetic maps of gene diversity and provenance performance for utilization and conservation of oak genetic resources in Europe.

Jager, K. 1994.

Genetische verbetering van zomereik (Quercus robur L.). Selectie van zaadopstanden.
IBN-rapport 119. 153 pp.

Jager, K., K. G. Kranenborg and S. M. G. de Vries.

Genetische verbetering van zomereik (Quercus robur L.) en wintereik (Quercus petraea lieblein). Rapport IBN-DLO in preparation.

Klaas Jager, Lars Holmgaard og Jan Svejgaàrd Jensen. 1993.

Hollandske stilkegeprovenienser. Dansk kovbrugs Tidsskrift 78(2): 37-68.

Jensen, J. S., H. Wellendorf, K. Jager, S.M.G. de Vries & V. Jensen. 1997.

Analysis of a 17-year old Dutch open-pollinated progeny trial with Quercus robur (L). Forest Genetics 4 (3) : 139-147.

Jensen, J. S. 1999.

Provenance variation of phenotypic traits in Quercus robur (L.) and Q. petraea (Matt.) Liebl. In Danish provenance trials. Scandinavian Journal of Forest Research.

Jensen, J. S. 1999.

Rapport for projekt adaptive egenskaber pa eg. Forkningscentret for Skov og Landskab & Arboretet. Internal report from project "Adaptive traits on oaks".

Kleinschmit, J. & J. Svolba. 1979.

Möchlichkeiten der züchterischen Verbesserung von Stiel- und Traubeneichen. III. Nachkommenschaftsprüfung von Eichenzuchtbaümen. All. For. u. Jagdz. 150: 111-120.

Kleinschmit, J. 1993.

Intraspecific variation of growth and adaptive traits in European oak species. Ann. Sci. For. 50
Suppl 1: 166-185.

Vries, S.M.G. and B.C. van Dam 1998.

Selection Programme of Oak in the Netherlands. In: Diversity and Adaptation in Oak Species. Proceedings of the second meeting of Working Party 2.08.05, Genetics of Quercus, of the International Union of Forest Research Organizations. October 12-17, 1997 University Park (State College), Pennsylvania, U.S.A. edited by Kim C. Steiner: 201-208.

Zaaizaad- en Plantgoedwet. 1966.

Wet van 6 oktober 1966, Stb. 455, houdende een nieuwe regeling van het kwekersrecht alsmede van het verkeer met teeltmateriaal van landbouw- en tuinbouwgewassen.

Annexes: tables, figures

Figure 1

Partition of The Netherlands for seed collection
Provenances of Oak
in De Rips
Zuidlaren
01 Stadskanaal
Diever
Dwingelo
05 Baarn
07 Zeist
16 Renswoude
Wageningen
15 Wolfheze
14 Hummelo
Duiven
13 12 Zevenaar
26 Waalwijk
15 Heeswijk
20 Helvoirt
St. Oedenrode
Nuenen
Bakel
10 Breda
Zundert
Oirschot 05 32 Best
04 Esbeek
10 29 Helmond
28 Mierlo
18 Heeze 31 Someren
07 Hapert
Middelbeers
Beek en Donk
06 Horn
07 Amstenrade
06 Bochholtz
Vaals
1-8 = Subregions
1, 2, etc.= Districts
01 etc. = Provenance(s)

Table 1. Results of height measurements in 1990, 1994 and 1997 at the age of 2, 7, 9 and 10 years after establishment. Average of all trees (all t.) and of 5 trees (5t.) per selection number measured in blocks 1 to 6 (Bl.1/6); blocks 1 to 3 (Bl.1/3) and in block 1 (Bl.1).

Sel. nr.	*H in m 2 j. Bl. 1/6 All t.*	*H in m 7 j. Bl. 1/6 All t.*	*H in m 9 j. Bl. 1/3 All t.*	*H in m 9 j. Bl. 1 All t.*	*H in m 9 j. Bl. 1 5 t.*	*H in m 10 j. Bl. 1 All. t.*	*H in m 10 j. Bl. 1 5 t.*
220	1.31	3.91	4.97	5.40	5.42	6.09	6.02
221	1.15	3.77	4.72	5.49	5.36	6.06	5.98
222	1.20	3.92	5.32	5.89	5.72	6.28	6.08
223	1.35	4.27	5.73	6.35	6.72	6.95	6.92
224	1.36	4.05	4.86	5.76	6.38	6.13	6.90
225	1.30	3.90	5.23	5.78	6.06	6.25	6.48
226	1.39	4.19	5.42	5.76	5.48	6.19	5.84
227	1.18	3.94	5.16	5.93	6.24	6.41	6.82
228	1.19	3.85	4.75	5.99	6.42	6.42	6.92
230	1.31	4.02	5.01	6.28	6.40	6.61	6.84
231	1.34	3.91	4.65	5.73	6.46	6.04	6.76
232	1.33	4.09	5.02	6.63	6.64	7.27	7.16
233	1.10	3.79	4.68	5.68	5.66	6.38	6.32
234	1.17	3.93	4.80	4.64	4.62	5.36	5.40
235	1.29	3.73	4.99	5.65	6.16	6.20	6.72
236	1.22	4.04	5.29	6.39	6.60	6.93	7.46
237	1.28	3.91	4.92	5.78	5.80	6.38	6.54
238	1.10	3.60	4.82	5.35	6.12	5.70	6.76
239	1.20	3.79	4.78	5.86	6.00	6.29	6.58
240	1.29	3.91	5.35	6.41	6.28	6.81	6.88
241	1.14	3.60	4.25	4.04	4.78	4.72	5.82
242	1.12	3.76	4.79	4.68	5.46	5.44	6.24
243	1.12	3.71	4.83	5.48	5.46	6.18	6.02
244	1.16	3.84	5.05	5.51	5.30	5.96	5.76
245	1.10	3.60	4.39	5.05	5.40	5.46	6.18
246	0.97	3.26	4.25	5.31	5.04	5.91	5.84
247	1.27	4.14	5.29	5.72	5.28	6.21	5.66
248	1.03	3.48	4.23	4.52	5.06	5.18	5.78
249	1.14	3.61	4.97	6.08	5.98	6.83	6.76
250	0.92	3.42	4.51	4.77	5.34	5.44	5.96
251	1.03	3.65	4.09	3.88	4.04	4.74	4.92
252	1.23	4.21	5.17	5.55	6.02	5.98	6.54
253	1.22	3.82	4.74	5.37	5.68	6.03	6.22
254	1.33	3.91	5.00	5.91	6.06	6.15	6.44
255	0.98	3.59	4.57	4.82	5.30	5.51	5.96
256	1.20	3.74	5.32	5.75	6.62	6.21	7.44
257	1.18	3.73	4.92	5.47	5.46	5.95	6.06
258	1.39	4.06	4.80	5.72	6.20	6.27	6.94
259	0.94	3.21	4.19	4.83	5.28	5.21	5.58
Mean:	1.19	3.82	4.87	5.52	5.75	6.05	6.35

Figure 2

Height Quercus robur De Rips in 1990, 1994 and 1997.

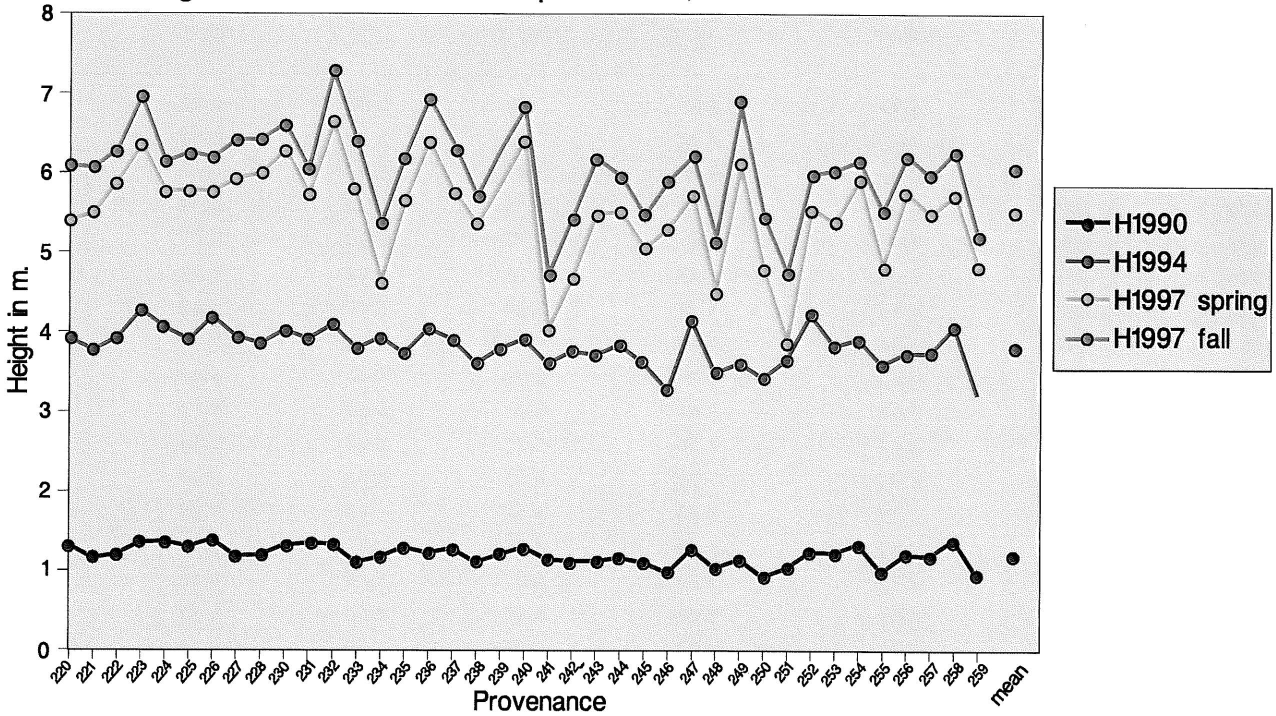


Figure 3. Flushing values of Oak according to NFV-Bonitur.

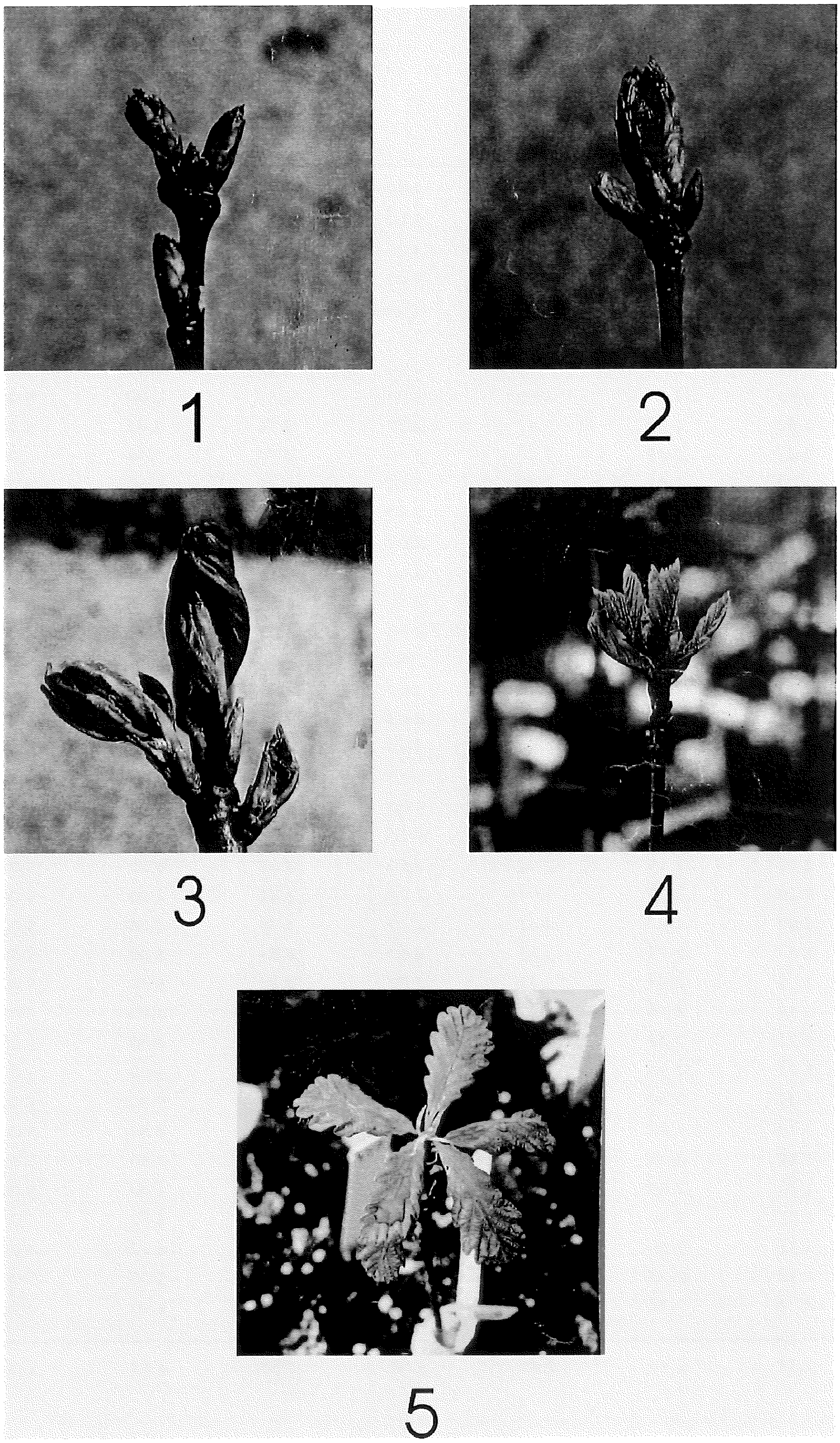


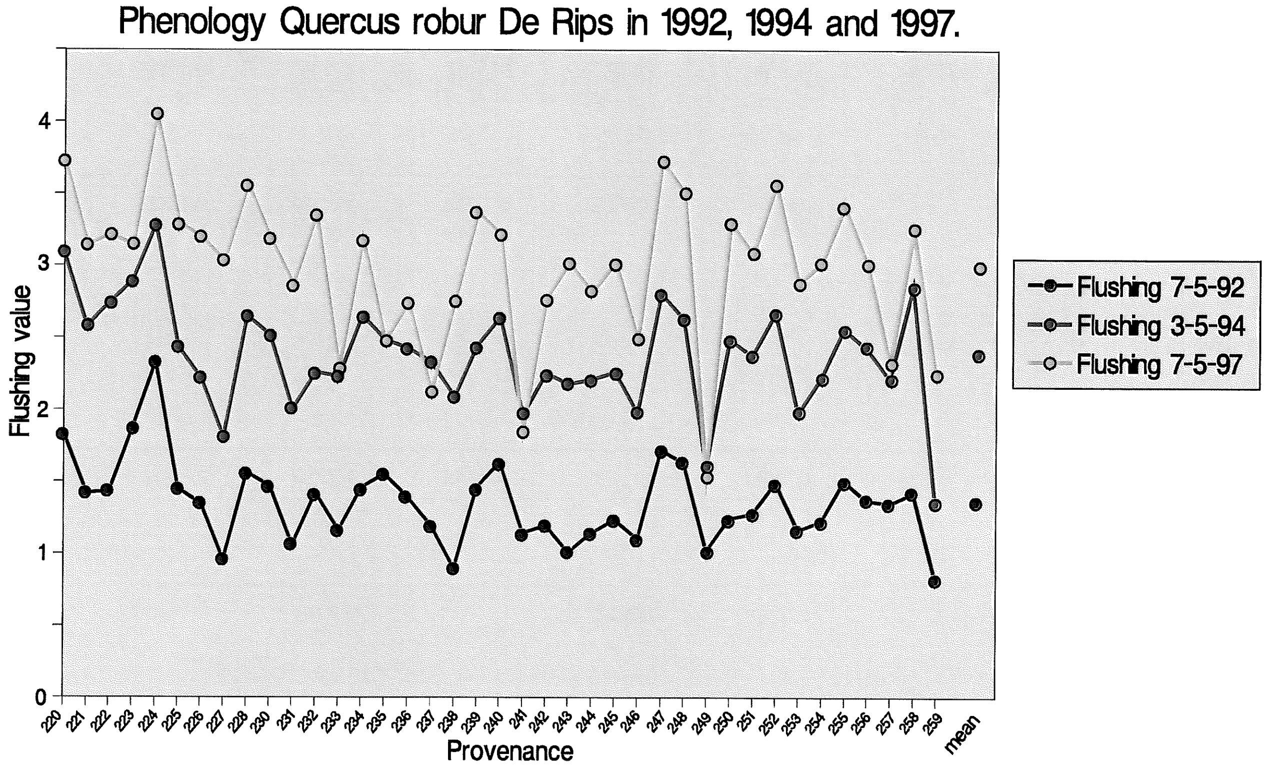
Table 2. Results of phenology in mean values from each selection number recorded at 7-5-1992 and 3-5-1994 on all trees and at 7-5-1997, 14-5-1997 and 21-5-1997 on all trees and on 5 trees in block 1.

Sel. Nr.	*Flushing value:*							
	7-5-92 Bl. 1/6 All t.	*3-5-94 Bl. 1/6 All t.*	*7-5-97 Bl. 1 All t.*	*7-5-97 Bl. 1 5 t.*	*14-5-97 Bl. 1 All t.*	*14-5-97 Bl. 1 5 t.*	*21-5-97 Bl. 1 All t.*	*21-5-97 Bl. 1 5 t.*
220	1.78	3.01	3.63	3.80	4.84	5.00	5.00	5.00
221	1.38	2.51	3.06	2.20	4.67	4.20	5.00	5.00
222	1.39	2.67	3.13	3.20	4.56	4.80	5.00	5.00
223	1.82	2.82	3.06	3.00	4.71	4.80	5.00	5.00
224	2.27	3.20	3.95	4.00	4.95	5.00	5.00	5.00
225	1.41	2.37	3.21	2.60	4.50	4.20	5.00	5.00
226	1.31	2.16	3.11	3.40	4.50	4.80	5.00	5.00
227	0.93	1.76	2.95	3.00	4.53	4.60	5.00	5.00
228	1.52	2.58	3.47	3.40	4.79	4.60	5.00	5.00
230	1.43	2.45	3.10	3.40	4.70	5.00	5.00	5.00
231	1.03	1.95	2.79	3.00	4.37	4.60	4.95	5.00
232	1.38	2.20	3.27	2.80	4.87	4.80	5.00	5.00
233	1.13	2.17	2.22	2.00	4.06	4.20	5.00	5.00
234	1.42	2.58	3.10	3.40	4.55	4.80	5.00	5.00
235	1.51	2.42	2.41	2.80	4.53	4.40	5.00	5.00
236	1.35	2.36	2.67	3.60	4.50	5.00	5.00	5.00
237	1.16	2.27	2.06	1.80	4.00	3.80	5.00	5.00
238	0.87	2.03	2.68	2.60	4.00	4.40	4.95	5.00
239	1.42	2.38	3.28	4.00	4.50	4.80	5.00	5.00
240	1.59	2.57	3.13	3.40	4.67	5.00	5.00	5.00
241	1.11	1.91	1.80	1.40	3.85	3.60	5.00	5.00
242	1.16	2.19	2.70	3.00	4.10	4.40	5.00	5.00
243	0.98	2.12	2.94	3.20	4.78	5.00	5.00	5.00
244	1.11	2.15	2.74	2.60	4.47	4.20	5.00	5.00
245	1.20	2.20	2.94	2.20	4.41	4.00	5.00	5.00
246	1.07	1.92	2.41	2.40	4.24	4.60	5.00	5.00
247	1.67	2.73	3.63	4.00	4.81	5.00	5.00	5.00
248	1.59	2.56	3.41	4.00	4.82	5.00	5.00	5.00
249	0.99	1.56	1.50	1.40	3.89	4.80	5.00	5.00
250	1.21	2.42	3.21	3.60	4.58	4.60	5.00	5.00
251	1.24	2.31	3.00	3.20	4.79	5.00	5.00	5.00
252	1.45	2.60	3.47	4.00	4.79	5.00	5.00	5.00
253	1.13	1.92	2.80	2.80	4.20	4.40	5.00	5.00
254	1.19	2.16	2.94	3.20	4.38	4.40	5.00	5.00
255	1.46	2.49	3.32	3.60	4.84	5.00	5.00	5.00
256	1.33	2.36	2.93	3.60	4.47	4.80	5.00	5.00
257	1.31	2.15	2.25	2.80	3.80	4.20	4.95	5.00
258	1.38	2.78	3.16	3.40	4.58	5.00	5.00	5.00
259	0.79	1.31	2.18	2.60	4.00	4.20	4.94	5.00
Mean:	1.32	2.32	2.91	3.04	4.50	4.62	5.00	5.00

Table 3: Phenology Correlation coefficients between flushing values in 1992, 1994 en 1997.

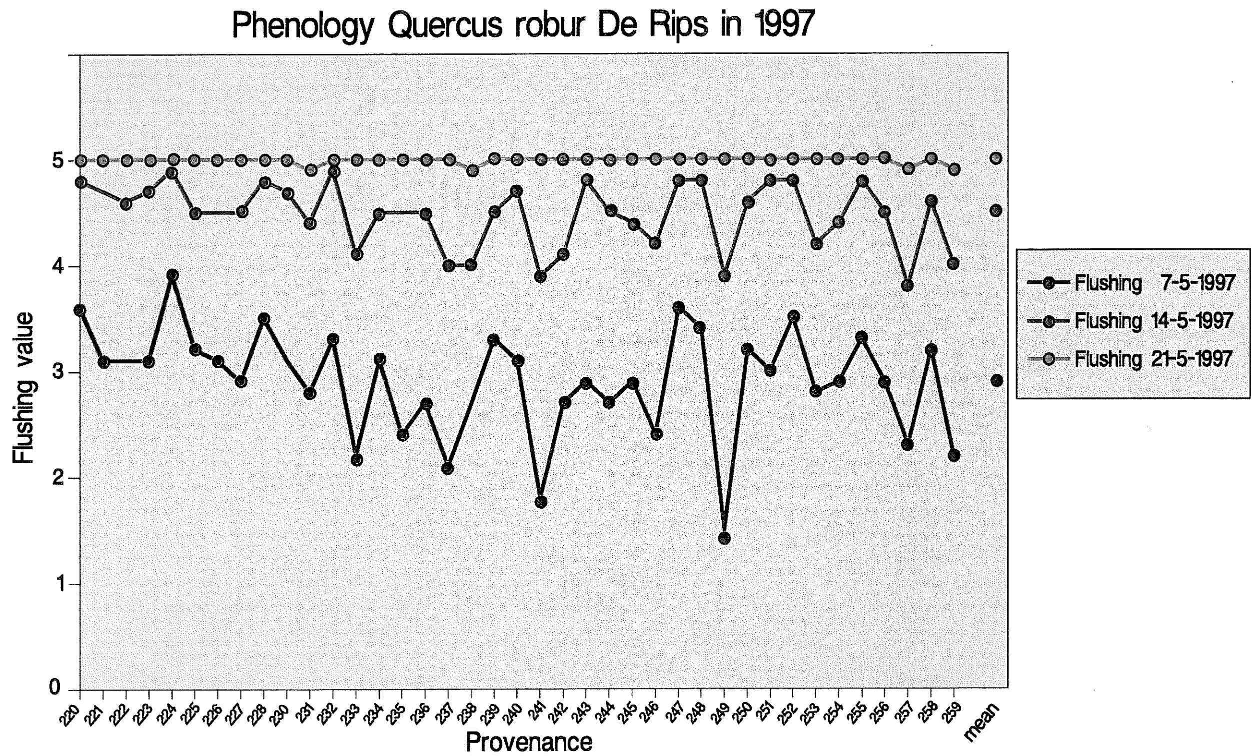
Flushing values:	*7-5-92 Bl. 1/6 All t.*	*3-5-94 Bl. 1/6 All t.*	*7-5-97 Bl. 1 All t.*	*7-5-97 Bl. 1 5 t.*	*14-5-97 Bl. 1 All t.*	*14-5-97 Bl. 1 5 t.*
7-5-92 Bl. 1/6 All t.	*	*0.8967*	*0.6815*	*0.5734*	*0.6599*	*0.4705*
3-5-94 Bl. 1/6 All t.	*0.8967*	*	*0.7487*	*0.6193*	*0.7024*	*0.4823*
7-5-97 Bl. 1 All t.	*0.6815*	*0.7487*	*	*0.8288*	*0.8758*	*0.6132*
7-5-97 Bl. 1 5 t.	*0.5734*	*0.6193*	*0.8288*	*	*0.7205*	*0.7702*
14-5-97 Bl. 1 All t.	*0.6599*	*0.7024*	*0.8758*	*0.7205*	*	*0.7074*
14-5-97 Bl. 1 5 t.	*0.4705*	*0.4823*	*0.6132*	*0.7702*	*0.7074*	*

Figure 4.



Phenology Quercus robur De Rips in 1992, 1994 and 1997.
Flushing value
Provenance
Flushing 7-5-92
Flushing 3-5-94
Flushing 7-5-97
0
1
2
3
4
220 221 222 223 224 225 226 227 228 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 mean

Figure 5.



Phenology Quercus robur De Rips in 1997
Flushing value
0
1
2
3
4
5
Provenance
220
221
222
223
224
225
226
227
228
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
mean
Flushing 7-5-1997
Flushing 14-5-1997
Flushing 21-5-1997

Table 4. **Growth cessation in autumn 1997 at the age of 10 years after establishment.Percentage of trees having the majority of leaves of the terminal leader, not being Lammas shoots, with yellow tints.**

Sel. Nr.	30-09-97	14-10-97	28-10-97
220	20	40	100
221	0	50	90
222	10	60	90
223	10	80	100
224	20	70	100
225	10	60	100
226	0	70	90
227	0	60	90
228	10	40	100
230	30	50	70
231	0	40	80
232	10	50	90
233	10	50	90
234	10	60	100
235	10	60	90
236	0	100	100
237	0	40	90
238	0	60	90
239	50	50	90
240	10	40	90
241	0	30	90
242	0	30	80
243	0	40	80
244	0	50	90
245	0	40	80
246	10	70	90
247	0	40	80
248	0	50	70
249	60	80	100
250	20	40	90
251	10	30	90
252	0	70	80
253	10	10	90
254	10	50	90
255	20	50	80
256	10	60	100
257	10	70	80
258	0	30	90
259	10	50	70
Mean:	9.7	51.8	88.7

Figure 6

Form according to NFV-Bonitur.

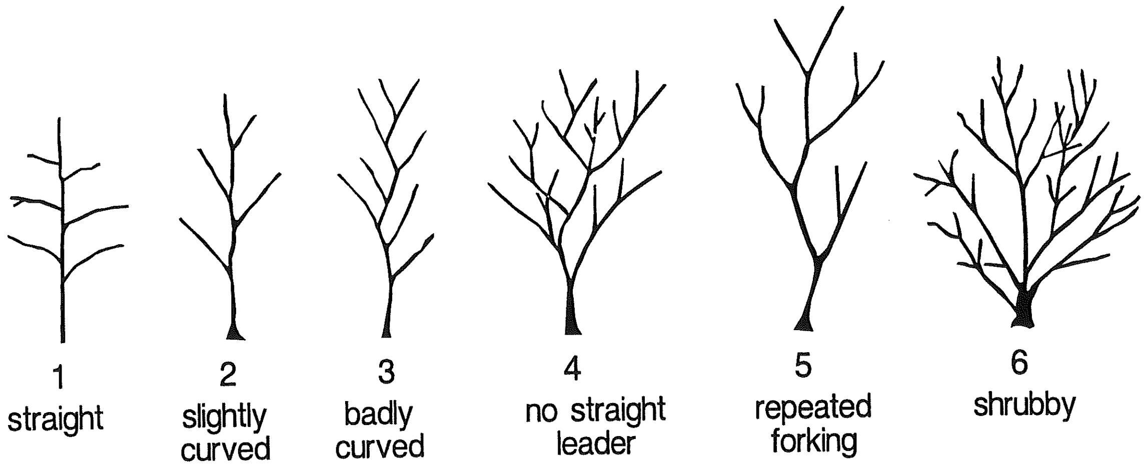


Table 5: Tree form in autumn of 1997 at the age of 10 years after establishment.

Sel. Nr.	Mean	Class: 1 in %	2 in %	3 in %	4 in %	5 in %	6 in %
220	3.6	10	20	20	-	50	-
221	4.1	-	30	-	-	70	-
222	3.6	-	20	40	10	20	10
223	3.6	-	40	10	-	50	-
224	3.6	10	20	20	-	50	-
225	3.8	-	30	10	10	50	-
226	3.8	10	30	-	-	50	10
227	3.6	-	40	10	-	50	-
228	4.2	-	20	10	-	70	-
230	5.0	-	-	-	-	100	-
231	4.8	-	-	10	-	90	-
232	3.4	-	40	20	-	40	-
233	3.1	10	30	40	-	-	20
234	3.3	-	50	10	-	40	-
235	3.7	10	-	40	20	20	10
236	2.8	-	70	-	10	20	-
237	2.5	10	40	40	10	-	-
238	3.1	10	30	30	-	30	-
239	3.8	10	20	10	-	60	-
240	3.0	10	40	20	-	30	-
241	2.8	10	60	-	-	30	-
242	2.9	30	20	10	10	30	-
243	4.4	-	10	10	10	70	-
244	3.4	10	40	-	-	50	-
245	3.2	-	40	30	-	30	-
246	2.7	30	30	20	-	-	20
247	3.9	-	20	20	10	50	-
248	2.4	20	60	-	-	20	-
249	2.7	10	50	10	20	10	-
250	2.8	20	40	10	-	30	-
251	3.5	-	40	20	-	30	10
252	3.5	10	10	40	-	40	-
253	4.6	-	10	10	-	70	10
254	2.9	-	50	30	-	20	-
255	2.8	10	60	-	-	30	-
256	3.8	-	40	-	-	60	-
257	3.5	10	10	40	10	20	10
258	4.4	-	20	-	-	80	-
259	3.1	10	20	40	10	20	-
Mean:	3.5	6.7	30.8	16.2	3.3	40.5	2.6

Table 6: Survival at the end of 1997 at the age of 10 years after establishment.

Sel. Nr.	Survival number of plants per plot	Percentage
220	19	95
221	18	90
222	16	80
223	17	85
224	19	95
225	14	70
226	18	90
227	19	95
228	19	95
230	20	100
231	19	95
232	15	75
233	18	90
234	20	100
235	17	85
236	18	90
237	17	85
238	19	95
239	18	90
240	15	75
241	20	100
242	19	95
243	17	85
244	19	95
245	17	85
246	17	85
247	16	80
248	17	85
249	18	90
250	19	95
251	19	95
252	19	95
253	20	100
254	16	80
255	19	95
256	15	75
257	19	95
258	19	95
259	17	85
Mean:	17.9	89.5

Table 7: Ranking from 1 to 4 for height, flushing value, form and survival.Bold and underlined provenances combine the preferred features: fast growth, late flushing and straight stem form.The 'Total' is the sum of the four ranking numbers, while the final 'Ranking' indicates the position of this 'Total'.

Sel. Nr.	*Height*	*Flushing*	*Form*	*Survival*	*Total*	*Ranking*
220	2	4	3	1	10	5
221	2	3	4	2	11	6
222	2	3	3	4	12	7
223	1	4	3	3	11	6
224	2	4	3	1	10	5
225	2	3	3	4	12	7
226	**1**	**2**	**3**	**2**	**8**	**3**
227	**2**	**1**	**3**	**1**	**7**	**2**
228	2	3	4	1	10	5
230	1	3	4	1	9	4
231	3	1	4	1	9	4
232	1	3	2	4	10	5
233	3	2	2	2	9	4
234	3	3	2	1	9	4
235	2	3	3	3	11	6
236	**1**	**3**	**1**	**2**	**7**	**2**
237	**2**	**2**	**1**	**3**	**8**	**3**
238	3	2	2	1	8	3
239	3	3	3	2	11	6
240	1	3	2	4	10	5
241	4	1	1	1	7	2
242	3	2	1	1	7	2
243	3	2	4	3	12	7
244	**2**	**2**	**2**	**1**	**7**	**2**
245	4	2	2	3	11	6
246	4	1	1	3	9	4
247	1	4	3	4	12	7
248	4	4	1	3	12	7
249	**1**	**1**	**1**	**2**	**5**	**1**
250	4	3	1	1	9	4
251	4	2	3	1	10	5
252	2	3	3	1	9	4
253	3	2	4	1	10	5
254	**2**	**2**	**1**	**4**	**9**	**4**
255	4	3	1	1	9	4
256	2	3	3	4	12	7
257	3	2	3	1	9	4
258	2	3	4	1	9	4
259	4	1	2	3	10	5

To order IBN Research Reports advance payment should be made by giro transfer of the price indicated in Dutch guilders to postal account 948540 of the *DLO Institute for Forestry and Nature Research, P.O. Box 23, 6700 AA Wageningen, The Netherlands.* Please note that your payment is considered as an order form and should mention only the report number(s) desired. Reports are sent free of charge.

93/1 G.J. Nabuurs & G.M.J. Mohren 1993. Carbon stocks and fluxes in Dutch forest ecosystems. 85 p. (NLG 25)
93/2 A.G. Brinkman & J.P.C. Smit 1993. Porewater profiles in the EcoWasp ecosystem model. 63 p. (NLG 20)
93/3 A. Bobiec & G.F.P. Martakis 1993. Biodiversity: theory and practical meaning in forest monitoring. 36 p. (NLG 10)
93/4 G.J. Nabuurs & G.M.J. Mohren 1993. Carbon fixation through forestation activities; a study of the carbon sequestering potential of selected forest types, commissioned by the Foundation FACE. 205 p. (NLG 60)
93/5 A.G. Brinkman 1993. Estimation of length and weight growth parameters in populations with a discrete reproduction characteristic. 43 p. (NLG 15)
93/6 A.G. Brinkman 1993. Biological processes in the EcoWasp ecosystem model. 111 p. (NLG 35)
93/7 L.G. Moraal 1993. Prevention of vole damage on trees. A review of literature. 11 p. (NLG 10)
94/1 W.W.P. Jans, G.M. van Roekel, W.H. van Orden & E.G. Steingröver 1994. Aboveground biomass of adult Douglas fir. A data set collected in Garderen and Kootwijk from 1986 onwards. 58 p. (NLG 15)
94/2 M. Posma, W.W.P. Jans & E.G. Steingröver 1994. Net CO2 uptake and carbon sequestration in a 32-year old Douglas-fir stand in The Netherlands. 41 p. (NLG 20)
94/3 not issued
94/4 A. Oosterbaan 1994. Different establishment methods of ash (Fraxinus excelsior), a trial project. 25 p. (NLG 20)
94/5 A.J. Beintema & W.H. Diemont 1994. Wetlands and migratory waterbirds in West Africa. 47 p. (NLG 20)
94/6 C.J. Camphuysen & M.F. Leopold 1994. Atlas of seabirds in the southern North Sea. 126 p. (NLG 25)
94/7 K.G. Kranenborg 1994. Abies grandis provenance research in The Netherlands. 30 p. (NLG 30)
94/8 K.G. Kranenborg 1994. Abies alba provenance research in The Netherlands. 22 p. (NLG 30).
94/9 A.L. Spaans, M. Bukacinska, D. Bukacinski & N.D. van Swelm 1994. The relationship between food supply, reproductive parameters and population dynamics in Dutch Lesser Black-backed Gulls Larus fuscus: a pilot study. 65 p. (NLG 40)
94/10 A. Brenninkmeijer & E.W.M. Stienen 1994. Pilot study on the influence of feeding conditions at the North Sea on the breeding results of the Sandwich Tern Sterna sandvicensis. 49 p. (NLG 30)

94/11 K. Kramer & G.M.J. Mohren 1994. Final Report of the N.O.P.-project: phenological reactions of Dutch tree species to climate change described by a simulation model of the annual cycle. 121 p. (NLG 50)

95/1 K.G. Kranenborg & S.M.G. de Vries 1995. Douglas fir provenance research in The Netherlands; 1966/67 IUFRO series. 26 p. (NLG 30)

95/2 W.H. Diemont 1995. Land-use options for the Singkil swamp, Aceh, Indonesia. 11 p. (NLG 20)

95/3 W.H. Diemont & D.L. Schuiling 1995. Potential for sago palm in buffer zones in Aceh Selatan, Indonesia. 18 p. (NLG 20)

95/4 G.J. Nabuurs 1995. Quantification of forage supply to ungulates in forests; part 1: dynamic simulation of the herb layer. 90 p. (NLG 40)

95/5 T.M. 't Hart & J.W.M. Langeveld 1995. The environmental situation in Bamenda, Cameroon; results of a workshop on 30 September 1994. 22 p. (NLG 30)

95/6 P.W. Evers, L. Haanstra, A. Prat & E. Vermeer 1995. Rejuvenation and micropropagation of Quercus suber<D>. 27 p. (NLG 34)

95/7 P.W. Evers, L. Haanstra, J. van Laar, E. Vermeer & S.J. van Eeden 1995. Automated micropropagation of rejuvenated elite genotypes of Quercus robur L. 50 p. (NLG 38)

95/8 P.W. Evers, L. Haanstra, A. Prat & S.J. van Eeden 1995. Propagation and regeneration of Salix alba in vitro. 57 p. (NLG 38)

96/1 B.J. Ens, J.D. Goss-Custard & T.P. Weber 1996. Effects of climate change on bird migration strategies along the East Atlantic Flyway.158 p. (NLG 60)

96/2 P.J.W. Hinssen & Rukmantara 1996. The cost comparison model: a tool for financial budgetting of reforestation projects. Part A: General description. 57 p. (NLG 40)

96/3 P.J.W. Hinssen & Rukmantara 1996. The cost comparison model. Part B: CCM Prototype user's guide. 83 p. (NLG 40)

96/4 P.J.W. Hinssen & Rukmantara 1996. The cost comparison model. Part C: CCM Prototype reference manual. 112 p. (NLG 50)

96/5 P.J.W. Hinssen & Rukmantara 1996. The cost comparison model. Part D: Information analysis and functional design. 58 p. (NLG 40)

96/6 H. van Dam, H. Houweling, F.G. Wortelboer, J.W. Erisman & S.M. Smeulders 1996. Long-term changes of chemistry and biota in moorland pools in relation to changes in atmospheric deposition. 147 p. (NLG 50)

96/7 H.F. van Dobben & C.J.F. ter Braak 1996. Monitoring of epiphytic lichens in The Netherlands (1977-1990). 60 p. (NLG 40)

96/8 M. de Kam, H.J.P.A. Verkaar, P.W. Evers, B.C. van Dam & F.J. Breteler 1996. Biologie de l'Okoume; rapport final de l'appui technique. 185 p. (NLG 66)

96/9 M. de Kam & A. Nikièma 1996. Projet assistance néerlandaise au Centre National de Semences Forestières; rapport final. 98 p. (NLG 72)

96/10 J. van den Burg & A.F.M. Olsthoorn 1996. National research project on forest fertilisation; 1985/86-1991/92. 43 p. (NLG 30)

97/2 K.G. Kranenborg & S.M.G. de Vries 1997. Genetic differences in Wild cherry (Prunus avium) and Ash (Fraxinus excelsior) in relation to the afforestation of former agricultural sites. 32 p. (NLG 31,50)

97/3 A.J. Beintema, C. Amerasekare & R. Galappatti 1997. Wetland Conservation Project Sri Lanka. Evaluation Mission 7 - 20 September 1997. 62 p. (NLG 40)

98/1 P.J.M. Bergers & W. Nieuwenhuizen 1998. Guidelines for forest landscape networks for sustainable small mammal populations. 49 p. (NLG 30)

98/2 P.W. Goedhart & C.J.F. ten Braak 1998. The analysis of wildlife monitoring data using Genstat. 57 p. (NLG 41,50)

98/3 G.J. Nabuurs & R. Sikkema 1998. The Role of Harvested Wood Products in NationaleCarbon Balances; An evaluation of alternatives for IPCC guidelines. 53 p. (NLG 50)

98/4 R.P.B. Foppen & J.P. Chardon 1998. LARCH-EUROPE a model to assess the biodiversity potential in fragmented European ecosystems; An expert system under the MIRABEL umbrella. 48 p. (NLG 42)

99/2 D.M. Otchagov, R. Reijnen, R.O. Butovsky, G.M. Aleshenko & G.S. Eremkin 1999. Ecological networks and biodiversity in central Russia; a case study for peat bogs in Petushinski subregion. 64 p. (NLG 45)

99/4 K.G. Kranenborg & S.M.G. de Vries 1999. Provenance research Quercus robur in De Rips. 36 p. (NLG 35)