Anc Report 1AQ50 (79)

TREE-RING STUDIES IN THE SOMERSET LEVELS: THE SWEET TRACK 1979-1982

Ruth A. Morgan

INTRODUCTION

Tree-ring studies in the Somerset Levels were initiated on the Sweet track in 1973, and at that stage the sampling was limited and the aims exploratory. Since then, a great deal has been learnt, not only about the track itself, but about the procedure and value in analysing the wood of many different species and sizes. Some of the initial aims are still the same, such as the construction of an oak tree-ring chronology, and some new aspects have been explored as the excavations and analyses proceeded.

Two reports have already dealt with the initial construction of a floating tree-ring chronology based on oak planks from the Railway site (Morgan 1976), and its extension from planks of the Drove site (Morgan 1979). These revealed a difference in the maturity of the oak trees used along the track, an aspect which needed further study. The possibility of a difference in time between the closely associated Sweet and Post tracks could only be resolved with certainty by tree-ring analysis, so samples which might give this evidence were being sought. Also a certain number of samples from roundwood pegs and rails had been examined, but the quantities were small for any thorough analysis of woodland management practices, and further sampling of hazel, ash and the other roundwood species was a priority.

Excavations along the track between 1979 and 1982 provided the opportunity to pursue these aims and also to extend the information already available. The preliminary results are reprted here. There is still much comparative work to do on material from the entire track, from which some 1800 wood samples have now been examined. Tree-ring analysis has by its very nature to compare new results with what has gone before, so there is some reference here to earlier sites, but final discussions will be more appropriate when a definitive report on the archaeology and environment of the track appears.

The concept of tree-ring analysis

The Sweet track was constructed of a great variety of material which falls largely into two categories:

1. Planks split from trees, mainly of oak, with some ash and lime.
2. Roundwood, complete trunks or stems, of hazel, ash, willow, elm, poplar, holly, alder, birch and a few other species.

The same procedure is used in analysing both groups of material, but they give different types of information.

1. Planks

Oak (Quercus sp.) is the wood species used for dendrochronological dating in the British Isles, owing to its widespread use and very suitable growth characteristics. The patterns found in the widths of the annual growth rings can be matched with patterns of known date to give exact calendar dating; dated chronologies extend back to c 200 BC so the dating of Iron Age sites in Britain is now becoming a possibility (Hillam and Morgan 1981). Prior to this date, chronologies established from timbers on a prehistoric site are floating in time, but can still be quite accurately fixed by radiocarbon dating and calibration, and also offer the perhaps more valuable possibilities of relative dating between structures.

The Sweet chronology was first established on the Railway site by cross-matching the growth patterns of 139 planks over a period of 314 years (Morgan 1976). This was then extended at the end to 349 years by the addition of 19 planks from the Drove site at the south end of the track (Morgan 1979), which was dug in 1977. The subsequent excavations reported here have extended the chronology to 408 years and it now involves over 260 planks; the relationships of the site chronologies are illustrated in fig. 3.

The ultimate aim of the oak chronology-building process is to assign absolute dates to the rings and provide a date in which the trees were felled and the trackway built. It may also be useful to determine any planks the rings of which do not conform to the same time scale, and which may thus be earlier or later than the majority. Oak is however not as useful for this purpose as ash (*Fraxinus* sp.), since much of its outer wood (and hence dating information) has been trimmed off. Some of the ash planks extend out to the bark surface, and offer some relative dating information. The ash and lime (*Tilia* sp.) planks have also proved useful in chronology-building, though they will never be linked to a dated chronology of their own species and rely entirely on cross-matching with the oak.

The planks used for chronology-building usually have in excess of 50 measurable growth rings, necessary to provide a pattern sufficiently long for overlap and certainty in matching. However, since many of the Sweet planks were split from the same trees, it has proved possible to match some shorter series of about 30 rings into the long chronology. If they do not match, it is not known whether contemporary but different growth patterns are the cause, or whether the wood dates from an earlier or later period. This is a very different concept from the cross-matching of short series of rings in the roundwood.

2. Roundwood

The pegs and rails of the Sweet track were made from sharpened lengths of roundwood or poles, without any further working.

Because the tree trunk or stem (as some of them are slight) has not been split or trimmed, the growth rings are present from the pith to the outside of the trunk, to the bark or bark surface where the bark has been lost. So the outermost ring represents the year of cutting. The rings can be counted and the diameter measured to study the age and size of the trees being cut down. If there are more than 25-30 rings of variable width, they can be measured and plotted in the same way as the long series from the planks. However, their patterns are compared with the initial assumption that all the roundwood was cut down in the same year to build the track. They are positioned so that their outermost rings correspond, and then examined for similarities to see if this assumption is true. The short curves cannot be used for absolute dating or for overlapping with material from other periods or other trackways - they are viable only for internal relative dating. They are also separated into species, which generally do not show many similarities between each other.

Wood species

Many wood species are involved in the tree-ring studies, and some have proved more valuable than others. The ring-porous group of oak (Quercus), ash (Fraxinus) and elm (Ulmus) usually present no problems in ring-width measurement, with their differing zones of large spring vessels and dense summer wood. Evidence for the age and cutting season is very exact and reliable - if the poles were cut in summer, only the spring vessels are visible around the bark surface, if in winter the entire ring has been formed.

On the other hand, TABLES 4-9 giving age, diameter and other details must be used with more caution for the diffuse-porous species. Certain physiological difficulties have presented themselves; it is now known that hazel (Corylus) can cease growth while still living (Morgan 1983), and lime (Tilia) tends to produce locally present rings,

rings which are discontinuous around the circumference, but both species have proved suitable for measurement and cross-matching.

The rings of willow (*Salix*) and poplar (*Populus*) are generally clear if too uniform and wide for measurement. The remaining species are particularly unsuited to ageing or determining the cutting season. The rings of birch (*Betula*) are difficult to distinguish, and holly (*Ilex*) has a very fine structure with very narrow rings. The values for these species in the TABLES tend to be vague. The season of felling in all the diffuse-porous woods is less certain, since a narrow outer ring could also have a climatic cause.

Sampling and tree-ring analysis

Previous experience in the Levels had indicated that almost total sampling (a section of each suitably preserved piece of wood) was the only means of deducing exactly what materials had been required to build the trackway and how these were related in time and space. Very large sample numbers are also required to make any deductions about woodland management practices in the past, especially as so many species are involved. Thus in the excavations reported here, almost all well preserved pieces were sampled, sometimes several times along their length (the ring pattern may be extended by examining both ends of a plank, or the direction and rate of height growth can be determined in roundwood). Sometimes planks which are to be conserved are sampled, examined and then put back together to go into the conservation tanks (Morgan, Hillam, Coles and McGrail 1981).

It should be noted here that no account has been taken of exactly where the cross-section was removed from in the pegs or stems (except in the case of some rails). Any references to working in the TABLES - split halves and quarters - may be to a section near the facetted base of a peg which is roundwood higher up. The only exceptions were a group of split oak and willow pieces from site TG. The TABLES must not be taken to represent the entire track in terms of the proportions of species and the functions they served, since sampling was not total. There is also a certain amount of selection during the lifting operation in favour of suitable species, especially oak planks. However the TABLES give a general guide. The figures for average age and diameter are intended merely to show the age variations between the different species and their varying growth rates; there is such wide variation that averages do not tell us much otherwise. The TABLES should be considered in conjunction with the histograms (figs. 7, 9, 10) and scatter diagrams (figs. 6, 11).

Details of the actual sampling process are given in the archaeology report (Coles and Orme, these Papers). The cross-sections of wood of up to about 100mm in length, labelled and marked with a red pin, were transported to the DoE dendrochronology laboratory in the Prehistory Department of Sheffield University. The process of analysis has been described in detail elsewhere(Morgan 1979, 1982; Morgan, Hillam, Coles and McGrail 1981; Morgan, Coles and Orme 1978; Baillie 1982). Briefly the sections were deep-frozen and the surface planed to show up the growth rings. Under a low magnification (x10) the rings could be counted and measured, using a travelling stage; the distance travelled across a ring is measured electronically and displayed on a digital display unit. The ring-widths are then plotted as a graph, which can be compared both visually and by computer, by moving one graph or curve along against another and testing their similarity at each year of overlap. The computer program used for comparing the long oak, ash and lime curves calculates Student's _t_ values for each point of overlap (Baillie and Pilcher 1973); values in excess of 3.5 may suggest a match between two curves, but a visual examination of each possible position is most vital. In order to give some support to the proposed matches between the short roundwood series, too short for the computer program, a simple percentage agreement figure was calculated. It allocates 1 for each year in which both curves agree in rising or falling in ring-width, 0 when both curves disagree, and $\frac{1}{2}$ when one curve remains unchanged while the other rises or falls. The total is then converted to a percentage of the number of years of overlap.

Dating

Tree-ring analysis is valued both for relative and absolute dating. One interesting aspect of the Sweet track has been the recognition of another structure, often lying amongst the Sweet wood or running alongside, called the Post track. One of the aims of this study has been to ascertain with certainty whether the Post track is earlier than (and if so, by how much) the Sweet track or whether the two are contemporary. The archaeological information is ambiguous, and tree-ring analysis has not yet been able to prove one way or the other what is the temporal relationship between the two tracks. There is however some relative dating emerging from the roundwood and the ash planks, and perhaps when the thorough collaboration of all related disciplines which will precede the final report has been completed, some details may appear which will help to answer the dating question.

The possibilities of absolute dating are improving all the time, particularly owing to the work of the Swiss (e.g. Ruoff 1981) and the Germans (e.g. Schmidt 1981; Becker and Schmidt 1982), who have extended their chronologies back to before 2000 BC, with long earlier sections closely dated by radiocarbon. In addition there is a chronology based on bog oaks from Ireland which extends back to before 6000 BC (Baillie 1982). Until the Sweet track chronology can be cross-matched, perhaps with one of these, it is dependent on radiocarbon dating, and a series of dates run in 1976 have been calibrated. The six samples were taken from 40 year intervals of the chronology and split at Harwell to give 12 dates(Morgan 1979a). When calibrated (Clark pers. comm.) they show the chronology to span the approximate period 4095-3825 to 3695-3425 BC at 95% confidence limits. It may be worthwhile, now that high precision radiocarbon dating is becoming available (Stuiver 1982) and the Sweet chronology has been extended, to run a further series of dates in order to reduce the time span imposed by the standard deviations. The calibration of a series of radiocarbon dates based on a floating chronology is the most accurate means we have as yet of dating early prehistoric sites.

RESULTS ACCORDING TO WOOD SPECIES

This report deals with the results from each wood species in turn, with a general discussion followed by detailed accounts of each individual site. The sites are ordered in the same way as in the archaeology report, from south to north - Cover site (SWC 1982), Nature Reserve sites (SWGB, SWGZ, SWKD, SWQD, SWQV, SWQZ 1981-2), South Drain site (SWSA 1979), Turbary site (SWTG 1981) and the Wallway site (SWWA 1981). It is clear from the summary TABLE 1 that the majority of samples consisted of oak and hazel; ash and willow were quite plentiful, poplar is examined for the first time and lime is found only on the Nature Reserve sites.

Preservation varies greatly from site to site according to conditions; the least well preserved wood came from sites C and SA, while the wood from sites TG and WA was in good condition. Unfortunately the in situ oak planks usually suffered badly from decay on all sites, presumably due to pressure and varying water levels, yet their role in the tree-ring chronology is vital since their context is known. Some of the planks were extremely thin and did not survive lifting; others reached the laboratory, but cracked so badly on freezing that the wood structure could not be examined. On most sites the losses were minimal. But at site C for example, only 2 oak samples out of 6 wide planks and a total of 21 oak pieces could be measured; the remainder were either too decayed or had too few rings due to their method of conversion.

For details of the samples from each individual site, TABLES 4-9 should be referred to.

OAK (*Quercus* sp.)

The existing oak chronology of 349 years, based on 158 planks from the Railway and Drove sites (Morgan 1976; 1979) has already been mentioned in the introduction. Almost all the curves, 109 out of 112, from planks measured from the sites discussed here have been matched against the chronology in the hope of consolidating and extending it. A list of the planks, with the number of rings, years spanned in the chronology and the Student's <u>t</u> value indicating their similarity, is given in the Appendix. The majority of planks have less than 100 rings (TABLE 3) extending up to a maximum of about 344 rings (SWTG 379).

Curves from the site SA planks extended the existing chronology at the beginning by 34 years, and several curves from sites TG and C extended it at the end by a further 26 years. Its present length (and it is unlikely to be extended much further) is 408 years, the time scale used in this report.

The form of the bar diagram (fig. 1) has been puzzling since it first appeared at the Railway site, and these sites show an identical pattern. Usually many timbers from a site were cut at around the same time and their ring patterns all finish within a few decades of each other (as in the lime curves, see fig. 14). Here however the curves end anywhere between arbitrary years 70 and 408. Many are quite short. The only interpretation which seems possible is that trees around 400 years old were being felled and split into many radial planks. Since these are a maximum of 350mm wide and often much narrower (TABLE 2), and since trees of this age and growth rate probably exceeded 1m in diameter, many planks could be split out of the same tree. Some would come from the inner part of the trunk, and thus would have an earlier ring-width pattern than those which came from the outer part of the trunk. (One possible example of this can be seen in the Nature Reserve planks (fig. 1) where a group terminate around arbitrary year 240 and another group start around this date.) A few wide planks, such as SWTG 379, extend across almost the whole radius of the tree.

When outer wood has been trimmed off a plank, it is impossible to say whether it was from a tree cut down at the same time as another, or earlier or later, only that they have a series of contemporary growth rings. So relative dating is not possible on thoroughly trimmed oak planks. All the Sweet oak is so homogeneous, similar growth rates and patterns, that it evidently all came from a group of trees in the same woodland (though see below, for differences along the track). It is impossible to prove that all the trees were cut down together, though if any were earlier they would have to originate in the same woodland.

The same form of bar diagram appeared for the two other Somerset trackways incorporating oak planks, of the late bronze age - the Meare Heath track (Morgan 1982a fig.37) and Tinney's Ground tracks A and D (Morgan 1980 fig. 64).

The only situation in which the exact temporal relationship of oak timbers can be determined is when sapwood is present. Sapwood is the outer zone of the tree trunk, extending over some 30-50mm of the circumference, as distinct from the inner heartwood. Sapwood consists of living cells, active in carrying sap to the leaves. In many trees, it is indistinguishable from the heartwood, but in oak it is paler in colour and the large earlywood vessels are unblocked by growths. Its value in tree-ring dating lies in its quite regular and predictable width, so that even if only one sapwood ring can be traced on a timber, it is possible to estimate when the tree was cut down by adding an appropriate figure. The debate continues as to what this figure should be (see Hughes, Milsom and Leggett 1981; Baillie 1982, 53-60) and data is continually being collected to try and find some regional patterns, since the figures seem to vary from around 20 years in Germany (Hollstein 1965) to around 32 years in Northern Ireland (Baillie 1982). Variability is allowed for in ± values of 5-10 years.

Evidence of wide sapwood zones appeared from an unusual group of oak roundwood pieces from site TG; the stems were aged 40-70 years and had an average of about 30 rings of sapwood (fig. 2). One stem of 46 years of age was entirely sapwood. These are higher values than would be expected in trees of this age, and are paralleled by evidence from many posts of the Iron Age structure at Fiskerton, Lincs. (Hillam pers. comm.). It is not known whether the rate of transition from sapwood to heartwood varies during the life of a tree, but it is usual for the number of sapwood rings to increase with age.

No planks with traces of sapwood were found among the large assemblage from the Railway site in 1973, and it was thought either to have decayed or to have been trimmed off entirely, or even to have become unrecognisable after long depostion in the peat. Sapwood was then found on some Meare Heath track planks of the late bronze age (Morgan 1982a), and it was known to survive and be distinguishahle. Two small planks from the Sweet Drove site were found to have sapwood but neither was matched into the long chronology(Morgan 1979). Chips of sapwood among the track timbers suggested on-site trimming of the planks. It became apparent that the poor durability of sapwood was well known to the track builders.

Among the recent sites, two planks with sapwood appeared from site TG (379 and 1064), and finally a plank with its entire complement of 25 rings of sapwood was found at site C (120). The bark surface could be recognised along the edge of the plank. Its ring-width sequence matched the long chronology at arbitrary years 269-408, showing that this tree at least was cut in year 408/409. (A span of two years must be given, since the tree could have been felled any time after the completion of the ring for year 408 in about September until the start of growth for year 409 in about May.)

This felling date is supported by the two site TG planks, in which the transition year from heartwood to sapwood lies in year 365 for SWTG 379 (a very aged and narrow-ringed tree which could easily have had over 40 sapwood rings) and in year 375 for SWTG 1064. The addition of 30-40 sapwood rings takes them to a similar felling year. In addition a short chronology for the oak stems from site TG extends out to the bark surface and matches well with SWC 120 and with the long chronology (t = 4.49 and 2.62 respectively). The cutting year of these stems was also arbitrary year 408/409 (fig. 3).

This vital piece of information has been sought for 10 years and the examination of some 550 oak pieces from the track. The discovery of only 3 planks with sapwood out of over 270 measured is certain evidence that it was being thoroughly removed, though it would only be present on a proportion of the planks in any case. If the interpretation of the bar diagram is correct, only some of the planks came from the outside of the tree where the sapwood lies.

The definition of a felling date for the Sweet track oak wood, even if the chronology is as yet floating in time, has two major implications. The first is the possibility of absolute dating. If in the future it is possible to cross-match the 408 year chronology with one of the dated reference chronologies now being established in Germany, Switzerland and Ireland, the exact calendar year in which the trees were cut down to build the track can be specified. Seasoning would be unnecessary and unlikely, so construction would have followed soon after. This precision of dating is now possible for many of the Swiss prehistoric lakeshore settlements (Ruoff 1981). It would give invaluable fixed points in time to the peat deposits and pollen evidence from around the Sweet track and to the artefacts found amongst its timbers.

The second advantage in determining the felling date is the resulting link between wood species. Hitherto it has not been possible to demonstrate any link between the roundwood samples, mostly under 50 years of age and with a definite cutting year, and the oak planks from which an unknown amount had been lost from the outside. No overlap would have existed in any case. Now that the most recent few decades of the oak chronology have been recorded, it is possible to compare the results from all species and assess the potential for cross-matching between them. This has already enabled the ash chronology to be matched with the oak (see below).

A working chronology from some of the component curves has been calculated and is available on request from the author. The formation of a final representative chronology based on 267 curves is under consideration, but presents certain practical difficulties.

Most of the planks were straightforward radial splits, but there was a significant group of true tangential or 'plain-sawn' planks, especially from the southern end of the track (3 from site C out of only 6 wide planks). The most notable northern example was SWTG 378, still <u>in situ</u> in the track on top of SWTG 379. The reason for using this more difficult method of conversion from the tree is not clear, but may be an adaptation necessitated by the use of smaller trees. Such planks are more likely to split lengthwise down the rays. For tree-ring analysis, they rarely provide sufficient growth rings, limited to the thickness of the plank, so they remain largely unmatched into the long chronology and hence of unknown relationship.

A feature of the northern sites was the use of chunky radial oak boards as pegs, board pegs, to hold down the rail, and the ring-widths of a number of these were measured and matched into the overall chronology. So it is clear that they also originated in the same trees and form part of the oak plank assemblage; they probably represent surplus requirements which were put to good use.

It was already known from previous excavations that more mature trees had been split into planks for the central area of track (Railway site) than for the southern end (Drove site). The trees used on site R were estimated at over 400 years old and over 1m in diameter, while at site D trees less than 150 years old and 500mm in diameter were used. The discovery of more tangential planks in the southern track is probably a result of the use of smaller trees, since it is one method of obtaining a wider plank. It is possible that two different woodland sources were being exploited, the northern track builders turning to the Westhay and Meare 'island', while the southern builders may have cut oaks on the Poldens. This aspect of the oak material has been explored with interest in the recent excavations to see if any abrupt or gradual change in the use of mature or young trees could be located.

It was found that all planks from sites north of and including field G (i.e. SWG-K-Q, SWSA, SWTG and SWWA) came from the northern type of mature trees, while all planks from the sites south of field G (i.e. SWF, SWD and SWC) were from immature trees. Many of these planks produce curves which end at roughly the same time, showing that the plank originally occupied most of the radius of the tree (Morgan 1979). This also explains the discovery of the site C plank with complete sapwood.

It is thus evident that somewhere in the area of field G lies the transition between the two types of trees; insufficient oak material was obtained from the small trench at SWGB to prove its origin one way or the other. It is possible to speculate that two or more groups of track builders were responsible for these variations, perhaps working from both ends to meet somewhere in field G. The very mature slow-grown oak suggests a source in primary woodland, while the young vigorous trees may be the result of previous clearances.

In view of the large quantities of oak planking now studied from sites R, SA and TG, a diagram was plotted to see if there were any concentrations of planks from certain parts of the tree lying together in the track, or whether all had been mixed randomly during construction (fig. 4). The latter situation would probably result if the trees were split at the felling site and carried down as planks, but groups from the same part of the tree might be concentrated in one part of the track. No concentrations appear among the site TG planks, but it is interesting to note the cluster of inner tree planks on site SA contrasting with the group of outer tree planks at the northern end of site R (area W) just across the South Drain. The central area of site R is also characterised by the absence of outer tree planks. So while most of the planks have become mixed during processing, transport and use, some groups from the same part of the tree can be noted. It is not possible to divide the planks into groups from the same trees, as was done to some extent on the bronze age tracks (Morgan 1976a; 1980), since all the growth patterns are very similar.

Site C

The 19m long Cover site provided only 21 oak samples, of which 13 were thin slats less than 80mm wide, many in a group at the south end of the site. The remaining 8 were 100-290mm wide, the widest being SWC 46. Five of the wide planks were tangential splits (SWC 9, 23, 46, 134, 158) and only SWC 120 was split radially; thus owing to too few rings and to decay, ring-width measurement was only possible on two planks. SWC 23 is part of the same plank as SWD 66 at the south end of the Drove site(see plan Coles & Orme 1979, 62) and their ring-width patterns have been merged; this plank is 5.3m in total length. SWC 120, a most important piece with its entire sapwood zone preserved, is an insignificant fragment of plank lying at right angles to the track line at about 2m.

The Nature Reserve Sites

Site GB - 5 oak fragments were all wide-ringed radial chips up to 130mm wide. Only one piece (SWGB 31 a broken stray plank with 43 rings) was measured, but the short series could not be matched with certainty. The best fit was at years 120-162 of the oak chronology and an early position would be likely with such wide rings. There is no correspondence with the typical growth pattern from the Drove and Factory sites.

Site GZ - 10 oak pieces consisted of 4 chips and 6 planks up to 200mm wide (SWGZ 21, a thick tangential plank). SWGZ 11 and 26 were not radially split but thick secondary cuts. Again the wood was fast-grown; only two planks (SWGZ 4 and 30, adjacent fragments lying next to the track) were measured, and their growth patterns matched well with the existing oak chronology. They are so far the most southerly examples of planks from the very aged oaks used on the northern length of track.

Site KD - 5 samples consisted of 2 chips and 3 planks up to 170mm wide. SWKD 4 and 11 were more or less in situ; 11 had wide rings as did SWKD 3 lying just to the east, and they were possibly once the same piece. All three were measured. The long ring series from SWKD 4 and 32 extend quite late in the chronology, and thus came from near the outside of the tree; by contrast the very wide rings (2-4mm) of SWKD 11 suggest an origin in a less mature tree. The pattern was matched at years 249-302 of the existing chronology.

Site QD - 5 small oak fragments, 3 chips and 2 small planks, all lay together at the north end of the site and could have originated in two planks - two were wide-ringed and two narrow. Only SWQD 36, an in situ single-pronged plank 130mm wide, was measured and matched early in the chronology.

Site QV - the only oak piece was a plank 250mm wide (SWQV 42) protruding from the section; it was partially measured and the pattern fitted the early part of the chronology.

Site QZ - of 13 oak samples, 3 were chips and the remaining slats and planks extended up to 330mm wide (SWQZ 22, an in situ plank, probably tangential but now very decayed). Ring-widths could be measured on 8 planks; the longest series came from SWQZ 61, a wide plank lying just east of the rail at 5-7.5m. SWQZ 23, 30 and 31 are small fragments in a group at 2.5-3m, while SWQZ 135 was a narrow plank in situ at 10-11m.

Of especial interest were SWQZ 145 and 146, wide planks lying on or beside lime plank 144, and about 1m west of the line of the Sweet track. This is the line of the Post track, which began to run west of the Sweet at the southern end of the Railway site (Coles and Orme 1976). Oak is rarely associated with the Post track;usually the planks are of ash and lime. The ring-width curves of these two oak planks lie in the early part of the long chronology, and there is no reason to suggest any difference in cutting date or origin. They could represent debris washed off the Sweet track during flooding, or if they are in situ they could suggest contemporaneity of the two tracks. In the absence of sapwood or bark surface, it is impossible to determine the relative dating.

Site SA

This 7.5m excavation produced 28 oak samples for examination, consisting of 7 planks, 11 stray fragments, 2 possible rails and 6 rail or board pegs, a wider range of functions than is usual in oak. Widths ranged from 70 to 240mm, as well as a very thin plank 320mm wide at the north end of the site (SWSA 1) which had completely decayed. A further 8 samples were too decayed and distorted for examination, but the ring-widths of 9 planks were measured (with duplicates from SWSA 9 and 12).

All 9 curves were matched with the long chronology, lying mainly in the first half and extending it at the start by 34 years (fig. 1) thus altering the time scale originally used (Morgan 1976). The timbers include 4 board pegs (SWSA 9, 18, 21, 69), chunky radially split pieces found also on sites TG and WA to the north; they are 60-90 x 30-40mm in cross-section. Their correspondence with the plank chronology shows that they were split out of the same trees, and they probably represent surplus and waste. They also indicate that roundwood was not vital for pegs.

Site TG

The 59m long Turbary site produced prolific quantities of well preserved oak, the only losses being some of the in situ planks. 82 samples under 80mm wide were classed as chips, largely radial but with a few tangential; many were wide-ringed. They may represent trimmings from the planks, perhaps to remove the inner 'feather-edge' which would suggest some on-site woodworking. This is further confirmed by a chip of sapwood (SWTG 721); several were also found on the Drove site (Morgan 1979, 66).

There were 79 samples from slats and planks, largely in the range 80-150mm wide (fig. 5 , TABLE 2) up to a maximum of 335mm (SWTG 395). There was far more oak planking than would be needed for the track itself, and the reasons for this excess have already been considered (see Coles and Orme, these Papers). Most of the planks were radial splits, but 3 were tangential; SWTG 545, a stray fragment at 10m, was 90mm wide, SWTG 1061 was the same width and lay transversely beneath the rail at 43.5m, and SWTG 378 was 180mm wide and lay in situ on top of the rail, parallel to and slightly on top of SWTG 379 at 38-43m. It may represent a repair or strengthening of the walking surface. Unfortunately its chronological relationship to all the other timber may never be known - it had only 38 growth rings and such a short series may not have a sufficiently unique pattern to match to the long chronology.

8 planks were too decayed for ring-width measurement, leaving 57 planks and 12 of the larger chips to be measured. There is a higher proportion than usual of ring series of 100-200 years (TABLE 3), up to a maximum of over 340 years (SWTG 379 - the uncertainty is due to the severe difficulties this important plank presented in measurement). 63 out of the 69 curves were readily cross-matched with the existing chronology between years 12 and 384 (fig. 1), the remainder being very short series. A working master chronology from 20 of the curves matched with the existing chronology with a t value of 17.03.

The two planks with sapwood from the TG site (SWTG 379 and 1064) have already been discussed.

In addition to the planks and chips, this site provided a new category of material, oak roundwood, which has never been examined from the Sweet track before except for the odd peg. There were 29 samples, of which 8 were complete roundwood, 12 split in half and 9 split into a little less than a quarter (as was much of the willow from this site); they averaged 94mm in diameter and 49 years in age, so are more substantial than the general peg wood. 9 of the stems were used as transverses, 2 as pegs, one as a rail and the rest were stray. There is no evidence to suggest they were the branchwood from the trees split for planks; they are straight-grained and slow-grown.

The wide sapwood zones, averaging around 30 years, have already been discussed (fig.2). The maturity of the stems enabled the ring-widths of 22 to be measured over a maximum of 71 years; 2o were readily cross-matched and all 16 with undamaged bark surface were cut in the same year (sample numbers SWTG 39, 74, 122, 165, 169, 419, 422, 516, 582, 737, 808, 847, 973/1029, 1024, 1032, 1043, 1117, 1124 and one of unknown context). The 20 matched curves were averaged into a 71 year master chronology, which was found to match the long chronology ending in year 408, the same felling year as the plank with bark surface (SWC 120). This was confirmed by t values of 2.62 with the long chronology, 4.08 with SWTG 1064 and 4.49 with SWC 120. It also matches well with the ash chronology (see below) with a t value of 6.19 (fig. 13). Thus all these trees were cut down at the same time.

One roundwood stem (SWTG 260) does not match the others in the same position, but shows a match 14 years earlier (t = 4.35) and it may be a reused piece..

Site WA

Much of the oak from this site consisted of chips and narrow slats, perhaps the remnants of broken planks. Of the 39 samples, 16 were less than 80mm wide, the remainder extending up to a maximum of 340mm (SWWA 4), one of the widest planks so far discovered in the track. Five small pieces were split tangentially, of which 3 were board pegs (SWWA 39, 40, 41, 73, 80).

The ring-widths of 19 planks were measured and cross-matched (fig. 1); many of the curves were quite short and lie in the first half of the chronology, from the inner parts of the trees,

A number of split pieces had been used as board pegs and two of these were among the cross-matched group, thus originating from the same trees as the planks. Planks SWWA 4 and 95 were notched.

HAZEL (Corylus avellana)

Some 684 hazel stems have now been examined from the entire Sweet track, and their growth characteristics are becoming more familiar and better understood, especially since a study of modern hazel commenced (Morgan 1983). The current sites produced 536 hazel samples, largely from site TG and the Nature Reserve, and ages and diameters are given for this new material as well as being combined with previous results.

The scatter diagrams relating age to diameter (fig. 6) show a typical growth trend for hazel, represented by material up to 60 years old and 110mm in diameter. Ages generally average about 20 years (TABLE 6 for example), though the histogram (fig. 7) shows the range to be wide. Especially after analysing the site TG samples, it became clear that a greater number of stems aged 11 years were present (fig. 9) and other peaks in the diagram are apparent. In order to test their significance, the data is currently being analysed statistically; preliminary results (Fieller pers. comm.) show siginificant peaks at clear 7 year intervals from 4/5 years on, that is at 4/5, 11, 18, and 25 years of age. Further study will now be needed to see if these concentrations are related to human intervention in the woodland, or whether they could represent a natural distribution. Traditionally hazel is cut on a 7 year cycle, and this practice may extend back to the Neolithic.

In stems with sufficiently long and clear growth ring series, the widths were measured and the patterns compared, assuming at first that all the wood had been cut in the same year, Several groups already existed from sites R and D, and they also were compared. Since computer analysis cannot be used to substantiate the matching of these short roundwood curves, percentage agreements were calculated for some of the pairs to show the very high degree of similarity which can occur. Mean curves had been made for groups of stems from sites TG and C, and it did seem that individual curves compared to these mean curves either matched one or the other but not both. The curves which match better with the TG mean largely originate in stems from the north end of the track down to SWQD (fig. 8), while those which match better with the C mean are largely southerly in origin (with the one exception from SWSA). This is a preliminary deduction and there is scope for further study in the hazel curves, but this evidence does support that from the oak - that the wood used in the north of the track may have come from a different source to that used in the south.

Most of the curves end in the same year so the hazel poles were cut at the same time. There are however a number which end before or after the arbitrary hazel cutting year 42; some of the differences can be explained in terms of very narrow outer growth rings which could not be clearly distinguished (and must be treated with caution - see Morgan 1983) or damaged and discoloured outer wood. There is yet no evidence for the rings of hazel to be other than annual, so the curves which extend beyond year 42 are more difficult to explain. They may represent later repairs and additions to the track; that wood was added later is almost certainly proved for some ash planks from site TG (see below), so the track must have been in use for a few years at least.

There is not much evidence for the narrow rings and poor growth found in modern hazel (Morgan 1983) and the often wide-ringed stems especially in the southern track show that hazel was thriving in the Neolithic; it was obviously available in very large quantities in the vicinity of the Sweet track, probably growing as an understorey shrub to oak, ash and lime woodland on the surrounding hills. There seems to have been little selection for size of stem; generally anything larger than about 35mm in diameter would suffice for pegs (fig. 10). The accumulated evidence suggests that some form of coppicing was or had been taking place, perhaps on a rather casual basis and perhaps by draw-felling rather than clear-felling. The poles were probably being cut in winter - 357 out of 536 examined have a wide outermost ring showing completion of the year's growth.

Site C

The 48 stems from this site had been used mainly for pegs, but some large posts thought to be associated with the Post track were also hazel (SWC 3 at 4m, SWC 8 at 15m and SWC 12). The stems averaged

20.2 years in age and 62mm in diameter (TABLE 4). 28 samples were wide-ringed, and contrasted to the slower growth found in hazel farther north in the track; this tendency towards faster growth has been noted in wood of all species at the south end of the track, and supports the idea of a different woodland source.

The ring-widths of 6 pieces 30-39 years old were measured and all were cross-matched; 4 were cut in the same year (fig. 8), including two of the posts, so if they are part of the Post track the hazel evidence would suggest contemporaneity. However SWC 12 and 44 appear to have been cut 2 or 3 years previously; with the knowledge that hazel can cease to form annual rings while still alive (Morgan 1983), it is possible that they too are contemporary. Four of the curves were averaged to enable comparisons to be made with hazel growth patterms from other parts of the track.

The Nature Reserve sites

Details of the hazel from all these sites is summarised in a separate TABLE (TABLE 6).

Site GB - 16 largely stray hazel stems averaged 19.9 years old and 57.9mm in diameter. Several had very narrow outer rings and illustrate the growth decline found in modern hazel (Morgan 1983).

Site GZ - 16 stems averaged 17.5 years in age and 55.1mm in diameter. One had been split to a rectangular cross-section across the pith (cf SWQD). They had been used as pegs and one was a rail.

Site KD - 19 stems averaged 19.1 years and 57.6mm in diameter; two had been used as rails (SWKD 8 and 12) and 9 as pegs.

Site QD - this site produced 24 hazel samples from rails, pegs and stray pieces, aged on average 25.9 years (higher than usual) and 62.2mm in diameter. Two had a rectangular cross-section, split right across the centre of the trunk, similar to examples from SWGZ and SWQZ.

Ring-widths of 6 stems were measured: SWQD 1 and 5 more closely associated with the Post track to the west, SWQD 52, 59 and 60 which were pegs on the Sweet line, and SWQD 56, 1m west of the Sweet. The pair of pegs 59 and 60 have very similar growth patterns and probably came from the same stool or stem; 52 and 56 are very similar too, but do not resemble the 59/60 pattern. They match better with the SWTG and the SWC mean curves respectively (fig. 8).

Site QV - 39 hazel samples from this site included 17 with zones of very narrow outer rings which, judging by modern examples, may suggest they were declining or even had stopped growing before they were cut down. This rather suggests the natural cycle of hazel, with some stems on the stool failing under competition, to be replaced by new shoots.

The average age of these stems was 22.8 years and the diameter 51.5mm. The ring-widths of 6 were measured, all associated with the Sweet track (SWQV 36, 44, 56, 63, 65, 79); all but SWQV 65 matched well with the SWTG mean curve (fig.8). All were cut in the same year except for SWQV 44 which has 6 more narrow rings; unless these are inter-annual bands of growth, this stem was cut down later than the rest. With SWQV 36, it lay over lime plank SWQV 29. Two stems from adjacent SWQZ also postdate the main hazel cutting date by several years.

Site QZ - 43 hazel stems averaged 21.9 years in age and 53.8mm in diameter. 11 had very wide uniform rings, a feature which is unusual in the Sweet track hazel except at the southern end (see site C). Most samples were from pegs and stray pieces, with one rail SWQZ 4. Another example of a rectangular cross-section came from this group.

The ring-widths of 5 stems were measured and cross-matched. SWQZ 48, 133 (stray peg) and 153 (plank peg in hole of plank SWQZ 22) matched the SWTG mean curve with the same cutting year, while

SWQZ 19 (rail peg) and 44 (stray) match 8 and 9 years later with high percentage agreements (fig. 8). With another stem from SWQV, they may represent a later phase of repair and additions to the structure.

Site SA

The site yielded a total of 18 stems used as rail pegs (12 samples), plank pegs (4 samples) and strays (2 samples). They averaged 21.1 years in age and 45.2mm in diameter, this being a much lower figure than usual though the age is consistent with all other sites. The slower growth is apparent in the scatter diagrams (fig. 6), but the sample size is too small to reach any definite conclusions.

The ring-widths of 5 stems were measured; 4 were opposing peg pairs at 1m (SWSA 26 and 27) and 6m (SWSA 5 and 6), and in each case the growth patterns were almost identical, suggesting an origin in the same stem. The other sample SWSA 59, a stray piece, matched well with the 5/6 pair and the SWC mean curve, while the 26/27 pair matched better with the SWTG mean curve (fig. 8). Three of the stems could have been cut one year before the main hazel cutting date, though it is possible a ring could not be distinguished around the stained and often damaged outer surface.

Site TG

The very large sample size from site TG - 291 stems - gave the opportunity to obtain some detailed data on age, size and relationships from one long stretch of the track. The average age of the stems is 21.4 years and the diameter 50.1mm. The histogram (fig. 9) shows a peak in stems aged 11 years, too significant a peak to occur by chance and indicative of some intervention; perhaps an area of hazel had been cleared 11 years previously for some other purpose.

The ring-widths of 24 stems used as pegs and rails were measured, and 18 cross-matched (SWTG 11, 20, 85, 91, 96, 126, 174, 282, 286, 293, 331, 341, 357, 406, 409, 420, 837, and 1003) all ending in the same year, arbitrary cutting year 42. They have been averaged into a mean curve, used in comparisons with hazel from elsewhere along the track (fig. 8). Two other pegs (SWTG 56/817 at 18m and 168 at 30m) were more mature and their growth patterns matched well together over 58 years, but they do not match the large group. This is not evidence that they were cut at a different time.

Site WA

22 hazel pegs averaged 20.9 years in age and 41mm in diameter, another group comparable to the SWSA hazel for its slow growth. The ring-widths of 3 stems were measured and cross-matched well with the SWTG mean curve, though none were *in situ* but lay just to the east of the track. SWWA 104 and 148 ended in the same cutting year but SWWA 133 had two more growth rings and may be a later addition (fig.8).

ASH (Fraxinus sp.)

Ash is the only wood to be used to any extent both as roundwood for pegs and rails, and as split timber for planks; the latter are however more often associated with the Post track and do not seem to have formed part of the Sweet walkway which was probably exclusively of oak planks. Ash trees would have grown in mixed woodland on the surrounding higher ground, with lime and oak; they were smaller and probably easier to fell and split than oak, so would be a suitable choice for a temporary structure like the Post track.

The ash roundwood is regularly 50-60mm in diameter and 20-25 years old, although stems from site C were noticeably younger. Growth tended to be slow and the scatter (fig. 11) is very similar to that for hazel (fig. 6). Only 13 roundwood pieces were measured from site TG and the Nature Reserve, and they show considerable internal consistency but not much similarity in growth pattern between sites. The large group of ash pegs from the Railway site with almost identical growth patterns (Morgan 1976) does not extend to other sites along the track. The lack of correspondence between ash curves from different parts of the track does not suggest they are not contemporary, but it is more likely that they originated in different woods, and from different parts of a tree of which this may be a feature. Ash is less sensitive to external conditions than oak, resulting in a lack of variation in ring-width, and this in turn reduces the quality of cross-matching.

Four of the more mature roundwood samples (more than 50 rings) were compared to the ring records from ash planks, which had up to about 120 rings. Nine planks from the sites under discussion were added to 7 already examined from the Railway and Drove sites. Ages and diameters suggest the felling of a few trees 100-150 years old and around 500mm in diameter, and a few trees 50-70 years old and around 200mm in diameter, as well as the younger roundwood. The trees were not split radially; most planks resemble half a tangential and are narrow and thick.

All 20 curves from these timbers were cross-matched into a 162 year floating chronology (fig. 12). Ash has no recognisable sapwood, so the cutting date is only determined when the bark surface can be recognised. Five of the samples had a definite bark surface and 3 possibly extended to the outside; they show at least 3 cutting phases for the ash. Two or three pieces were cut in arbitrary year 124, three or four in year 155 and one in year 162 or later. The others may fall into any of these groups or they may have alternative cutting years.

The 162 year chronology was then compared to the oak chronology in the hope of relating the cutting years of each; the two curves were found to match with the ash cutting year 155 equivalent to the oak cutting year 408, thought to be the construction date of the track or thereabouts. The closest link is with the 71 year oak roundwood mean curve from site TG (t=6.19; fig. 13). Thus the ash cutting years show that some wood was cut 31 years before the track was built, and more was cut a few years after construction (fig. 3). A closer study of the tree-ring and archaeological associations of these planks and their relationship to other Post and Sweet wood may help to understand this information.

The good correspondence found between the growth patterns of oak and ash has important dendrochronological implications. Ash is occasionally found in archaeological contexts, but never in sufficient quantity to create a reference chronology for absolute dating, so it relies entirely on possible cross-matching with oak. This was first demonstrated on long chronologies from the Urnfield settlement of Zug-Sumpf (Huber and Merz 1962). Calton and Fletcher (1978) found poor agreement between the two species in modern examples, but their study was based on only a few quite young trees. Eleventh century AD ash used in pits, houses and corduroy pathways of Dublin is being analysed and compared to the dated oak chronology from the site (Baillie 1982, 234). The Sweet evidence that the growth patterns of oak and ash can under certain circumstances be correlated is the first proof in Britain, and holds out hope for the future that there is some value in examining preserved ash wood. It also seems to be true that ash was not as thoroughly trimmed as oak, and that recognition of the bark surface on a proportion of samples is of invaluable importance for relative dating, whereas oak rarely provides this information.

Site C

This site produced 22 ash pieces, of which 7 were planks up to 160mm wide, and 15 were roundwood. The latter averaged 13.3 years in age and 56mm in diameter; all were wide-ringed and cut in winter.

At least 9 roundwood samples had been used as pegs; SWC 159 and 160 are an opposing pair of rail pegs at 8.5m, probably from the same stem.

Two split pieces had been used as rails - SWC 64 (=176/461) extended from 16 to 19m and was 115 x 50mm in section, while SWC 422 was 160 x 70mm in section. The ring-widths of SWC 422 and 25 (a stray piece to the west of the track) were measured and matched; SWC 25 has an uncertain bark surface and may have been cut in arbitrary ash year 125 (=oak year 378) while SWC 422 ends in year 139 (=oak year 392) and thus postdates this year though by how much is unknown. It could belong to the group cut in year 155 when the track was built (fig. 12).

<u>The Nature Reserve Sites</u>

<u>Site GB</u> - 6 roundwood samples were aged 10-23 years and were 35-65mm in diameter. Four were winter-cut and 2 wide-ringed.

<u>Site GZ</u> - 4 ash samples came from a rail (SWGZ 1) and 3 pegs. SWGZ 16 and 46 were opposing pegs from the same stem. They were 23-36 years old and 55-80mm in diameter. The growth pattern of SWGZ 1 matched well with two pegs from further north (SWQV 28 and SWQZ 16) with the same cutting year, though little correspondence occurred with ash roundwood from elsewhere along the track. As mentioned before, this does not suggest a different cutting date, but merely that proof of contemporaneity is lacking.

<u>Site QD</u> - this site produced only 2 ash pieces, aged 14-17 years and 40-50mm in diameter, both winter cut. One was a rail (SWQD 37).

<u>Site QV</u> - 5 ash samples included one plank among the roundwood, which was 50-90mm in diameter. An <u>in situ</u> peg SWQV 28, among many hazel pegs, was cross-matched with peg SWQZ 16 and rail SWGZ 1. Two other pegs lying between the two groups of planks on the site, SWQV 32 and 37, were measured and their patterns matched the plank chronology; they extend to the bark surface and were cut in ash

year 155, the track construction year (fig. 12).

The plank SWQV 2 lay at right angles among the pile of lime planks; its growth pattern ended in arbitrary year 103 of the ash chronology and its cutting year is unknown.

Site QZ - 6 ash samples consisted of 5 roundwood and one plank 120mm wide (SWQZ 105). Its growth pattern extends to the bark surface and it was cut in arbitrary year 124 of the ash chronology, 31 years before the track's construction. It was a stray piece, as was the other ash plank cut in year 124 from the Railway site (area W), so neither may be connected to the track itself.

The roundwood included 2 wide-ringed and 3 narrow-ringed pieces. The pattern of SWQZ 16 matched with SWQV 28 some 4.5m to the south and with rail SWGZ 1.

Site SA

Two ash stems both used as rails were 24-26 years old and about 60mm in diameter. They were winter cut.

Site TG

This site produced the largest assemblage of ash, 33 samples of roundwood and 8 planks. The roundwood averaged 26.5 years in age and 57.5mm in diameter (TABLE 8) though the range is wide (fig. 9 and 11). The ring-widths of 3 stems were measured: SWTG 118 and 723 were a peg and a transverse almost opposite each other at 21m, and their patterns of growth are almost identical. They also resemble over their 39 years the mean curve for 5 ash posts from the Drove site (Morgan 1979, 71) with the same felling year; the agreement reached 73%. SWTG 320 had only a short and dissimilar pattern of growth.

A concentration of ash planks lay on the track surface at 32-41m. They were roughly radially split and up to 290mm wide. The growth patterns of 6 were measured (SWTG 383, 389, 398, 433, 439, 449/146; 147 was too decayed) as well as two rails 443 and 1030; they all cross-matched into a 112 year chronology and were so similar as to suggest an origin in the same or adjacent trees. This in turn matched the Railway site chronology and led to the creation of the 162 year mean curve representing the entire track (fig. 12).

SWTG 383 has possible bark surface and along with 433 ends later than the general cutting year 155, so it appears that these ash planks were later additions and repairs to the track. The other planks could also end later than year 155; it is likely that they were all cut at the same time since they are positioned overlapping each other and have such similar growth patterns.

Site WA

Three small ash pegs were 10-13 years old, 40-45mm in diameter and winter cut.

LIME (Tilia sp.)

The use of lime in the trackway is confined to the area of the Nature Reserve, especially field Q. It has been examined before - planks from the Drove site enabled an 81 year mean curve to be produced (Morgan 1979); and in Germany the wood was used for the panels of paintings which have been used for dendrochronological dating (Klein 1979). Modern lime is renowned for the contortions of its growth rings and for locally present rings (which disappear around part of the circumference); these difficulties were not noted in the Drove lime, nor here with the exception of the SWQD group which had some very narrow and locally present rings.

Lime does not occur as roundwood and presumably was considered unsuitable for pegs. Most of the planks were radial, though 4 were cut right across the pith and 3 were tangential. The widest radial plank was 180mm (SWQV 27) and the widest cut across the pith (hence almost diameter) was 220mm (SWR SX 30 - planks from previous excavations are also included). Thus lime trees up to about 350mm in diameter were being felled and split, but the majority were probably about 200mm in diameter. The maximum number of rings recorded is 75, and the majority span 40-60 years; even allowing for the loss of some outer wood, the limes were probably around 70-80 years old when felled. They would have grown on the surrounding hills with oak and ash.

The ring-widths of many lime planks from the track have been measured though a few were too decayed, and the wood is now very soft compared to oak and ash. Cross-matching revealed two tree groups, planks or fragments which probably came from the same tree, from the Drove site and site QD (fig. 14). Otherwise pairs or small groups of planks tended to match each other well within each individual site and not so well with the assemblage as a whole. This suggests the use of single trees in each area. Computer-calculated t values between correlated curves lie between 2.8 and 4.8.

The bark surface was never recognised, being very soft and eroded, so no felling dates can be determined for the lime. The curves do however end quite uniformly around arbitrary years 80-90 that the year(s) of cutting cannot be very far distant.

A mean curve of 97 years was calculated from 16 individuals and compared to the ash and oak mean curves, in the hope of linking together their time scales and cutting years, but no correspondence could be found. This is unfortunate in view of the frequent association of lime with ash in the Post track.

The Nature Reserve sites

Site GB - two lime planks 70-100mm wide were found, one used as a rail (SWGB 1) and the other lying to the west (SWGB 47); the short ring sequence of the latter was matched into the lime chronology (fig. 14).

Site GZ - two lime planks SWGZ 2 and 3 were 140mm wide and both lay adjacent on the Sweet track - this combined with their very similar growth patterns suggest an origin in the same plank or tree. They cross-match with the overall chronology ending in arbitrary year 81.

Site KD - two planks consisted of one stray radial piece (SWKD 20) and a tangential plank 100mm wide (SWKD 30) lying among the Sweet timbers below the rail and an oak plank SWKD 4. Their ring-width patterns were very similar over a combined span of 36 years, which is provisionally matched into the chronology ending in year 89 (fig. 14).

Site QD - the largest group of 14 samples all came from the line of the Post track. A glance at the plan suggests that many of the pieces were once part of the same plank, and this is supported by the very similar growth patterns. All the samples were radial, up to 150mm wide. The ring-widths of 7 were measured, and show a much greater year to year variation in ring-width than had previously been noted for the Sweet lime, with some very narrow locally present rings which make an accurate ring pattern difficult to record. The patterns were almost identical and could be averaged for comparison with the other lime curves; the latest ring lies in year 97 of the lime chronology, probably close to the cutting year. This group end a little later than the others (fig. 14) and were either cut later or reach nearer to the felling year.

Site QV - 9 samples came from planks and chips up to 180mm wide. SWQV 27 and 29 had been used as a Sweet track rail, held down by pegs. Several samples were in a very decayed state, but SWQV 19 and 27 were measured and had almost identical growth patterns, suggesting a common origin. Also identical is the pattern from a plank sampled from a 1980 tracing site just to the south (SWQS; Coles and Orme 1981). This group of three was cross-matched into the lime chronology ending in year 79 (fig. 14).

Site QZ - one plank 170mm wide was cut across the centre of the tree (SWQZ 144); it lay to the west of the Sweet with two oak planks SWQZ 145 and 146 and some pegs, and is probably linked with lime planks found at the southern end of the Railway site (Coles and Orme 1976). These were not sampled in the early stages of tree-ring analysis. The ring-width pattern of SWQZ 144 matched the lime chronology ending in year 76.

WILLOW (Salix sp.)

The 103 samples of willow examined were confined to the northern sites, especially site TG. It would have grown in and around the Levels; perhaps it was more plentiful in the north. The growth rings are invariably wide and uniform, showing its constant access to plentiful water supplies. The stems were simply aged and measured; ring-width measurements were not taken on any samples.

One interesting aspect of the willow was its regular splitting to a little less than one quarter of the stem, but extending beyound the pith, to leave an oblique-angled triangle in cross-section. This method was very common on site TG, not only in willow but also in oak roundwood, The explanation may be straightforward, such as the availability only of stems which were too large, or there could be some functional reason (see also Coles and Orme, these Papers).

Willow was also examined at the Neolithic Baker site (Morgan 1980a, 24).

Site SA

Only 2 worked willow pieces were found, which were of indeterminate diameter; one was 19 years old.

Site TG

The very large sample size, 88 stems, enabled some useful size and age figures to be collected. The average age was 16 years and the average diameter a very high 104 mm. The growth rate was very rapid compared to ash and hazel (fig. 11). Two thirds of the stems had a wide outer ring and were probably cut in winter.

The majority of the willow stems had been worked in some way, many to the quartered shape already described; some (like some of the lime and hazel) resembled small planks of rectangular cross-section, split right across the pith.

Site WA

13 willow samples also came from wide-ringed young trees, averaging 9.2 years old and 48mm in diameter. All except two were roundwood and probably winter cut.

POPLAR (Populus sp.)

The poplar has a very similar structure and growth rate to willow (fig. 11). It is a light-demanding tree which often invades open ground with birch; it cannot be coppiced but spreads by suckers (Rackham 1976). It too only occurs in the northern track and has never been examined on previous sites.

Site SA

The 6 samples probably include 5 from the same rail about 4m long which had broken into pieces. It is around 25 years old and 70mm in diameter along most of its length. The ring-width patterns from each sample are almost identical; there is more year to year variation than in the willow.

Site TG

32 samples average 70mm in diameter and 15.6 years in age. Several sections were cut from a rail (SWTG 143/219) at the southern end which was probably about 12m long; the tree was about 20 years old. Most of the poplar stems had been used for pegs.

Site WA

Three stems averaged 21.6 years and 89mm in diameter. Two were rails (SWWA 2 and 28) which were sampled at both ends and found to be laid in opposite directions. Their total lengths are unknown as both extend into the section, but SWWA 28 was at least 5.5m long. This rail was laid down with its base to the north, while SWWA 2 was laid with its base to the south. Details such as this are being gathered for the entire trackway, and should help to reconstruct the actual building methods used.

ELM (Ulmus sp.)

The stems of elm were found largely at sites QZ and TG. Two samples from site QD (40/41) were from the same stem 14 years old. Six from site QV averaged 17.8 years and 57.8mm in diameter. They were largely rail pegs, SWQV 97 passing through a stray piece of hazel SWQV 30. Four were winter cut, one possibly in summer (the exact felling season being easier to determine in this ring-porous species).

The 13 stems from site QZ were all pegs except one used as a rail (SWQZ 50); 11 were winter cut and most were wide-ringed. The average age was 18 years and diameter 61.7mm. The ring-widths of the rail were measured, but bear little resemblance to other elm patterns from the track. The two samples from site SA (13 and 40) were probably from the same peg, around 22 years old and 55mm in diameter. Site TG produced 14 stems, averaging 17 years old and 57mm in diameter; most were wide-ringed and winter cut. They had largely been used as pegs, with one rail (SWTG 346) running from 40.5 to 48m. This had been sampled at either end, the south end being about 25 years old and 145mm in diameter, while the north end was 13 years old and 85mm in diameter. The figures give some idea of the growth rate of this tree. One stray piece from site WA was 12 years old and 50mm in diameter.

ALDER (Alnus glutinosa)

Alder occurs only occasionally in the track; since any available wood species seems to have been suitable for pegs and rails, it may not have been growing in the vicinity, or was not favoured for some reason. A large wide-ringed split stem was found at site C, around 160mm in diameter and more than 14 years old, probably cut in winter. A small split piece occurred at site KD, from a trunk 40 years old and over 100m in diameter.

Site TG produced 5 stems with indeterminate wide rings, around 8-21 years old and 45-160mm in diameter. The largest group of 7 stems came from site WA; they averaged 10.3 years and 38mm in diameter. Four had been used as pegs and 3 were stray.

HOLLY (Ilex aquifolia)

The hard and fine textured wood of holly was found largely at the southern end of the track. The rings are extremely difficult to distinguish and often narrow, so the ages are not accurate to the year. The 9 stems from site C were about 25-60 years old and 82mm on average in diameter. A group of 5 pegs was found at the northern end of the site. A transverse piece SWC 47 is directly in line with SWC 149, but proof of their origin in the same stem cannot be gained from the growth rings. Eight stems from site GB included two used as rails (SWGB 2 and 3); they were all 20-25 years old and 40-70mm in diameter. Site GZ produced 7 stems 50-65mm in diameter and 20-30 years old; at least 3 had probably been cut in winter. Three pieces from site QD were 22-23 years old and 55-60mm in diameter, while one from site QV about 30 years old and 50mm in diameter was a peg inserted through lime plank SWQV 14 on the Post track line. The only northern sample was one stem from site WA, 6 years old and 20mm in diameter. It was probably winter cut.

BIRCH (*Betula* sp.)

The growth rings of birch are occasionally clear, but usually include groups of narrow uncertain rings, and it is not a very reliable or useful species for tree-ring analysis. Only 14 stems were examined; 4 of these came from site QD, used as pegs, and they were 18-40 years old and 55-80mm in diameter. One birch peg was found on site QV, 10 years old, 50mm in diameter and winter cut. The largest group consisted of 9 stems from site TG, which proved to be the slightest stems in use here, 7-15 years old and 19-57mm in diameter.

DOGWOOD (*Cornus sanguinea*)

Only 6 stems of dogwood were found on these sections of track, possibly a reflection of its scarcity in the local woodland, or of the qualities of the wood which is very hard. It is a shrub which prefers calcareous conditions and quickly colonises abandoned pasture; it often occurs in ash-hazel woodland (Rackham 1980).

One stem 13 years old, 55mm in diameter and probably winter cut, was used as a peg on site QZ. Five stems came from site TG, 13-30 years old and 35-117mm in diameter. They lay close together at around 48m; 3 were pegs and one (SWTG 333) a slightly branching rail 5.5m long.

CONCLUSIONS

The basic tree-ring data for each excavation along the track since its discovery has now been presented, and research is currently in progress on assessing and collating all the evidence from the track. It must be viewed as a single structure, despite the tendency in a long-term study to divide it into arbitrary units. Some comparative work has been done - tree-ring analysis could not proceed otherwise - and the oak, ash and lime bar diagrams are based on and include some previous results. They will probably change little. But few studies have yet been made on the total evidence for each wood species or for the functions performed by the different woods. For example, rails are particularly important components of the track since they were presumably laid first and cannot readily be replaced or altered. A study of their species, age, diameter, ring growth pattern, direction of laying, associations and so on, based on all the rails examined, promises to be valuable in trying to interpret the sources of wood, the reasons for selection of certain species and size, and the way in which the wood was then used.

As well as the summary work, it is also particularly important now to assess the archaeological associations of the various timbers linked by the cross-matching of their ring patterns. When all the information from tree-ring analysis and archaeology is combined, it may be possible to find evidence for the temporal relationship between the Sweet and Post tracks, as well as to look more closely at the many differences along the 1800m long Sweet track. The results of all this research will be published in a final report on the trackway.

The sites discussed here, especially site TG, have been invaluable in providing samples required to pursue some of questions raised by previous analyses on the track. The most important result is undoubtedly the extension of the oak chronology to its most recent point, only possible by the discovery of one plank from site C with its entire sapwood complement. This ring is equivalent to the year of cutting of the trees and very close to the construction year of the track. The 267 planks contributing to the floating tree-ring chronology make it an extremely reliable time scale over about 400 years of the early

References:

BAILLIE, M.G.L. 1982. Tree-Ring Dating and Archaeology. Croom Helm, London.

BAILLIE, M.G.L. and PILCHER, J.R. 1973. A simple cross-dating program for tree-ring research. Tree-Ring Bulletin 33, 7-14.

BECKER, B. and SCHMIDT, B. 1982. Verlängerung der Mitteleuropäischen Eichenjahrringchronologie in das Zweite Vorchristliche Jahrtausend (bis 1462 BC). Archäologisches Korrespondenzblatt 12, 101-106.

CALTON, N. and FLETCHER, J. 1978. A comparison of the ring-widths of oak and ash. In J. Fletcher (ed) Dendrochronology in Europe B.A.R. S51, 185-186.

COLES, J.M. and ORME, B.J. 1976. The Sweet track, Railway site. Somerset Levels Papers 2, 34-65.

COLES, J.M. and ORME, B.J. 1979. The Sweet track: Drove site. Somerset Levels Papers 5, 43-64.

COLES, J.M. and ORME, B.J. 1981. The Sweet track 1980. Somerset Levels Papers 7, 6-12.

HILLAM, J. and MORGAN, R.A. 1981. Dendro dates from Sheffield. Current Archaeology 7, 286-287.

HOLLSTEIN, E. 1965. Jahrringchronologische Datierung von Eichenhölzern ohne Waldkante. Bonner Jahrbuch 165, 12-27.

HUBER, B. and MERZ, W. 1962. Jahrringchronologische Untersuchungen zur Baugeschichte der urnenfelderzeitlichen Siedlung Zug-Sumpf. Germania 40, 44-56.

HUGHES, M.K., MILSOM, S.J. and LEGGETT, P.A. 1981. Sapwood estimates in the interpretation of tree-ring dates. Journal of Archaeological Science 8, 381-390.

KLEIN, P. 1979. Alter Gemälde auf Holzgemalt. Jahrringanalytische Untersuchungen an Gemaldetafeln. Holz-Zentralblatt 105, 2287-2288.

MORGAN, R.A. 1976. Tree-ring studies in the Somerset Levels: the Sweet track. Somerset Levels Papers 2, 66-77.

MORGAN, R.A. 1976a. Dendrochronological analysis. In J.M. Coles and B.J. Orme. The Meare Heath trackway - excavation of a Bronze Age structure in the Somerset Levels. Proc. Prehistoric Society 42, 312-316.

MORGAN, R.A., COLES, J.M. and ORME, B.J. 1978. Tree-ring studies in the Somerset Levels. In J. Fletcher (ed) Dendrochronology in Europe. B.A.R. S51, 211-222.

MORGAN, R.A. 1979. Tree-ring studies in the Somerset Levels: the Drove site of the Sweet trackway. Somerset Levels Papers 5, 65-75.

MORGAN, R.A. 1979a. Tree-ring studies in the Somerset Levels: floating oak tree-ring chronologies and their C14 dating. Somerset Levels Papers 5, 98-100.

MORGAN, R.A. 1980. Tree-ring studies in the Somerset Levels: Tinney's Ground. Somerset Levels Papers 6, 69-72.

MORGAN, R.A. 1980a. Tree-ring studies in the Somerset Levels: the Baker site. Somerset Levels Papers 6, 24-28.

MORGAN, R.A. 1982. Current tree-ring research in the Somerset Levels. In M.Bell and S. Limbrey (eds) Archaeological Aspects of Woodland Ecology B.A.R. S146, 261-277.

MORGAN, R.A. 1982a. Tree-ring studies in the Somerset Levels: the Meare Heath track 1974-1980. Somerset Levels Papers 8, 39-45.

MORGAN, R.A. 1983. Tree-ring studies in the Somerset Levels: the examination of modern hazel growth in Bradfield Woods, Suffolk, and its implications for the prehistoric data. Somerset Levels Papers 9, 44-48.

MORGAN, R.A., HILLAM, J., COLES, J.M. and MCGRAIL, S. 1981. Reconciling tree-ring sampling with conservation. Antiquity 55, 90-95.

RACKHAM, O. 1976. Trees and Woodland in the British Landscape. Dent, London.

RACKHAM, O. 1980 Ancient Woodland. Arnold, London.

RUOFF, U. 1981 Altersbestimmung mit Hilfe der Dendrochronologie. Helvetia Archaeologica 12, 89-97.

SCHMIDT, B. 1981. Beitrag zum Aufbau der Holozanen Eichenchronologie in Mitteleuropa. Archäologisches Korrespondenzblatt 11, 361-363.

STUIVER, M. 1982. A high-precision calibration of the AD radiocarbon time scale. Radiocarbon 24, 1-26.

TABLE 1. Summary of tree-ring samples of each species from the Sweet track, 1979-82.

SITE	WOOD SPECIES OAK	HAZEL	ASH	LIME	WILLOW	POPLAR	ELM	ALDER	HOLLY	BIRCH	DOGWOOD	TOTAL
SWC	21	48	22					1	9			101
SWGB	5	16	6	2					8			37
SWGZ	10	16	4	2					7			39
SWKD	5	19		2				1				27
SWQD	5	24	2	14			2		3	4		54
SWQV	1	39	5	9			6		1	1		62
SWQZ	13	43	6	1			13				1	77
Nature Reserve Total	39	157	23	30			21	1	19	5	1	296
SWSA	28	18	2		2	6	2	1				59
SWTG	190	291	41		88	32	14	5		9	5	675
SWWA	39	22	3		13	3	1	7	1			89
TOTAL	317	536	91	30	103	41	38	15	29	14	6	1220

TABLE 2. **Summary of plank widths from the Sweet track.**

OAK PLANK WIDTH mm	SWEET WA	TG	SA	Nature Reserve	C	Total
up to 80(chips)	16	82	15	15	13	141
80-150	19	54	10	14	2	99
150-200	1	13	-	5	3	22
200-250	2	4	2	3	2	13
250-300	-	6	-	1	1	8
300+	1	2	1	1	-	5
Total	39	161	28	39	21	288

TABLE 3. **Summary of the number of growth rings which could be measured in the oak planks.**

NO. OF GROWTH RINGS(WHERE MEASURED)

	WA	TG	SA	Nature Reserve	C	Total
30-60	8	11	5	-	-	24
61-100	6	28	3	7	1	45
101-150	1	16	-	5	1	23
151-200	2	10	1	-	-	13
200+	2	4	1	-	-	7
Total	19	69	10	12	2	112

TABLE 4. Summary of tree-ring samples from Site C.

SWC SPECIES	NO. OF SAMPLES	CROSS-SECTION ROUNDWOOD 1	 ½	 ¼	 CHIPS	 PLANKS/ SLATS	AGE AVERAGE	 RANGE	DIAMETER (MM) AVERAGE	 RANGE	WINTER CUT	NO. MEASURED
OAK	21				13	8	(up to 140)					2
HAZEL	48	47		1			20.2	3-37	62.2	13-105	34	6
ASH	22	14	1		3	4	13.3	6-33	56.1	32-110	15	2
ALDER	1			1					(160)		1	
HOLLY	9	8			1?			c.25-60	82	50-135		

TABLE 5. Summary of tree-ring samples from the Nature Reserve sites (SWQ/K/G).

SWQ/K/G

SPECIES	NO. OF SAMPLES	CROSS-SECTION ROUNDWOOD 1	½	¼	CHIPS	PLANKS/SLATS	AGE AVERAGE	RANGE	DIAMETER (MM) AVERAGE	RANGE	WINTER CUT	NO. MEASURED
OAK	39				15	24	(up to 176)					14
HAZEL	157	127	11	17		2	see Table				86	17
ASH	23	15	6			2	30.2	8-58	64.3	24+-200	12	5
LIME	30				13	17	(up to 62)					16
ELM	21	17	3	1			17.5	9-31	60.1	38-90	17	1
ALDER	1			1			(c40)		(50)			
HOLLY	19	15	1	3			c25	c15-40	54.5	38-70	3	
BIRCH	5	5						10-40		50-80	1	
DOGWOOD	1	1					(13)		(35)			

TABLE 6. Summary of hazel tree-ring samples from the Nature Reserve sites.

SWQ/K/G HAZEL

SITE	NO. OF SAMPLES	AGE AVERAGE	AGE RANGE	DIAMETER (MM) AVERAGE	DIAMETER (MM) RANGE	WINTER CUT
SWQZ	43	21.9	7-37	53.8	30-85	29
SWQV	39	22.8	5-43	51.5	16-90	19
SWQD	24	25.9	11-41	62.2	32-90	15
SWKD	19	19.1	6-32	57.6	23-90	8
SWGZ	16	17.5	7-32	55.1	27-92	9
SWGB	16	19.9	4-30	57.9	17-120	6

TABLE 7. Summary of tree-ring samples from Site SA.

SWSA

SPECIES	NO. OF SAMPLES	CROSS-SECTION ROUNDWOOD 1	½	¼	CHIPS	PLANKS/ SLATS	AGE AVERAGE	AGE RANGE	DIAMETER (MM) AVERAGE	DIAMETER (MM) RANGE	WINTER CUT	NO. MEASURED
OAK	28				15	13	(up to 214)					10
HAZEL	18	18					21.1	11-39	45.2	28-69	12	8
ASH	2	2						24-26		60-65	2	2
WILLOW	2			2			(19)			70+-120+		1
POPLAR	6	5		1			24.8	24-27		60-230+		4
ELM	2	2						21-22		54-61	2	2
ALDER	1	1					(18)		(80)			1

TABLE 8. Summary of tree-ring samples from Site TG.

SWTG

SPECIES	NO. OF SAMPLES	CROSS-SECTION ROUNDWOOD 1	ROUNDWOOD ½	ROUNDWOOD ¼	CHIPS	PLANKS/ SLATS	AGE AVERAGE	AGE RANGE	DIAMETER (MM) AVERAGE	DIAMETER (MM) RANGE	WINTER CUT	NO. MEASURED
OAK	190	8	12	9	79	82	52 (based on 29 stems)	36-71	100	58-160	11	90
HAZEL	291	249	18	15		11	21.4	2-58	50.1	11-110	208	25
ASH	41	26	4	3	8		26.5	3-80	57.5	16-105	25	11
WILLOW	88	20	5	46	17		16.2	4-25	104	18-180	55	
POPLAR	32	18	2	10	2		15.6	3-36	70	24-112	25	
ELM	14	11	3				17	2-47	57	17-145	11	
ALDER	5	3	2				14.4	8-21	93	45-160	4	
BIRCH	9	9					8	c7-15	37	19-57	3	
DOGWOOD	5	5					22	13-30	62	35-117	2?	

TABLE 9. Summary of tree-ring samples from Site WA.

SWWA

SPECIES	NO. OF SAMPLES	CROSS-SECTION ROUNDWOOD 1	½	¼	CHIPS	PLANKS/ SLATS	AGE AVERAGE	RANGE	DIAMETER (MM) AVERAGE	RANGE	WINTER CUT	NO. MEASURED
OAK	39				16	23	(up to 221)					19
HAZEL	22	20		2			20.9	4-45	41	17-90	17	3
ASH	3	3						10-13		40-45	3	
WILLOW	13	11		2			9.2	5-13	47.8	37-60	12	
POPLAR	3	3					21.6	13-27	89	47-130	3	
ELM	1	1					(12)		(50)		1	
ALDER	7	7					10.3	7-13	38	30-52	4	
HOLLY	1	1					(6)		(20)		1	

LEGENDS TO FIGURES:

Fig. 1 Bar diagram showing the span of years covered by each oak (*Quercus* sp.) plank cross-matched from the sites discussed in the text. The scale in arbitrary years is derived from floating chronologies already established from oak planks on the Railway and Drove sites, with which the new curves were matched. Dotted lines and + indicate rings too narrow or unclear for measurement but which could be counted or noted. Vertical bars represent outer sapwood, partially present on two SWTG planks but complete on the SWC plank, so that its final ring in year 408 is equivalent to the felling year of the tree. Details of each curve are given in the Appendix.

Fig. 2 The width of the sapwood compared to tree age, based on 23 oak roundwood samples from site TG. The sapwood averages around 30 years for trees ages 40-70 years.

Fig. 3 A summary bar diagram showing the relative positions of all the oak site shronologies established for the Sweet track. The time scale is floating somewhere around 4000-3500 BC. The site code is on the left of each bar; on the right is a number, indicating the total number of cross-matched planks from that site. Hatching represents sapwood (the double-ended arrow on the SWTG bar shows the variation in transition year from heartwood to sapwood). The solid vertical line represents the bark surface in one SWC plank and all the SWTG roundwood, equivalent to the trees' cutting year 408. Also shown at the base is the ash chronology, based on 20 planks with three different cutting years (see fig. 12), which could be cross-matched with the oak chronology.

Fig. 4 Distribution of the final rings of each oak plank in the floating chronology compared to the position of the planks in the track at sites R, SA and TG. The horizontal scale is as in figs. 1 and 3; the end point of each bar in fig. 1 is equivalent to the circles here. The vertical scale is in metres, from south to north. The diagram was plotted to see if any clustering appeared, of planks coming from the same part of the tree lying together in the track. The distribution is random, apart from a group of inner tree planks from SWSA and outer tree planks from SWR area W just across the South Drain. There is also a lack of outer tree planks in the centre of SWR. The pattern seems largely to confirm the idea that planks were split at the felling site, and became thoroughly mixed up during construction.

Fig. 5 The variation in width of the oak planks and slats from site TG, omitting the large number of chips under 80mm wide.

Fig. 6 Scatter diagrams showing the age/size relationship of all hazel stems from site TG (239 samples), R (37 samples), D (106 samples) and SA (18 samples). They illustrate the typical growth trend for hazel, although the small SA group are noticeably slower-grown.

Fig. 7 Age distribution of all the roundwood stems from the whole track (hatched; 860 samples) and of the hazel stems only (540 samples). The majority of stems lie between 10 and 26 years old, and there are significant peaks at 7 year intervals which may be related to some system of woodland management.

Fig. 8 The relationship of hazel growth curves to each other and to curves already established from other sites. The thick vertical line on the right is the bark surface, and generally the cutting year is consistent at arbitrary year 42. There are however a few stems cut before or after this date apparently; sometimes this is owing to very narrow outer rings which are often locally present and may not have all been recorded, or some may be inter-annual bands. Stems may stop growing before they are cut (Morgan 1983). Percentage agreements between some individual curves and the mean curves from sites TG and C are given on the right; the matches suggest two pattern groups, one based in the northern half of the track and the other in the south.

Fig. 9 Histograms showing the age range of stems from site TG of hazel, ash, poplar and willow. The range is generally wide, but note the 11 year peak of hazel stems.

Fig. 10 Histogram showing the range in size of all the roundwood from site TG. A sharp increase in stems of 35mm diameter is evident, followed by a gradual fall-off in size.

Fig. 11 Scatter diagrams showing the age/size relationship of stems of poplar (25 samples), willow (62 samples) and ash (26 samples) from site TG. The ash distribution is similar to hazel (fig. 6) with quite slow growth, contrasting with the rapid growth of poplar and especia willow to very large diameters.

Fig. 12 Summary bar diagram of the ash tree-ring curves from all sites along the track. The scale covers the 162 years of the chronology, and the corresponding oak scale is also given. A number of samples extend to the bark surface (thick vertical line) and show three phases of cutting at least. Cutting year 155 is equivalent to the oak cutting year 408, so some of the site TG ash planks are later additions to the trackway. SWR JX6 had some 30-40 very narrow rings on the outside which could not be measured.

Fig. 13 Ring-width curves illustrating the good agreement between oak and ash from the Sweet track. Each circle represents the ring-width, on a vertical scale in mm which is logarithmic. The horizontal (arithmetic) scale is in years, according to the oak floating chronology of 408 years. The upper curve is the mean of 19 oak roundwood samples from site TG; the lower curve is the mean of 9 ash planks from sites TG and R. The two curves match with a t value of 6.19.

Fig. 14 Summary bar diagram of the lime tree-ring curves from all planks examined in the track; they are confined to the southern half. No examples of bark surface were recognised so the felling year is unknown, but since many of the curves end within the same decade or so, it is probably quite close. The lime mean curve of 97 years could not be matched to the oak or ash chronologies.

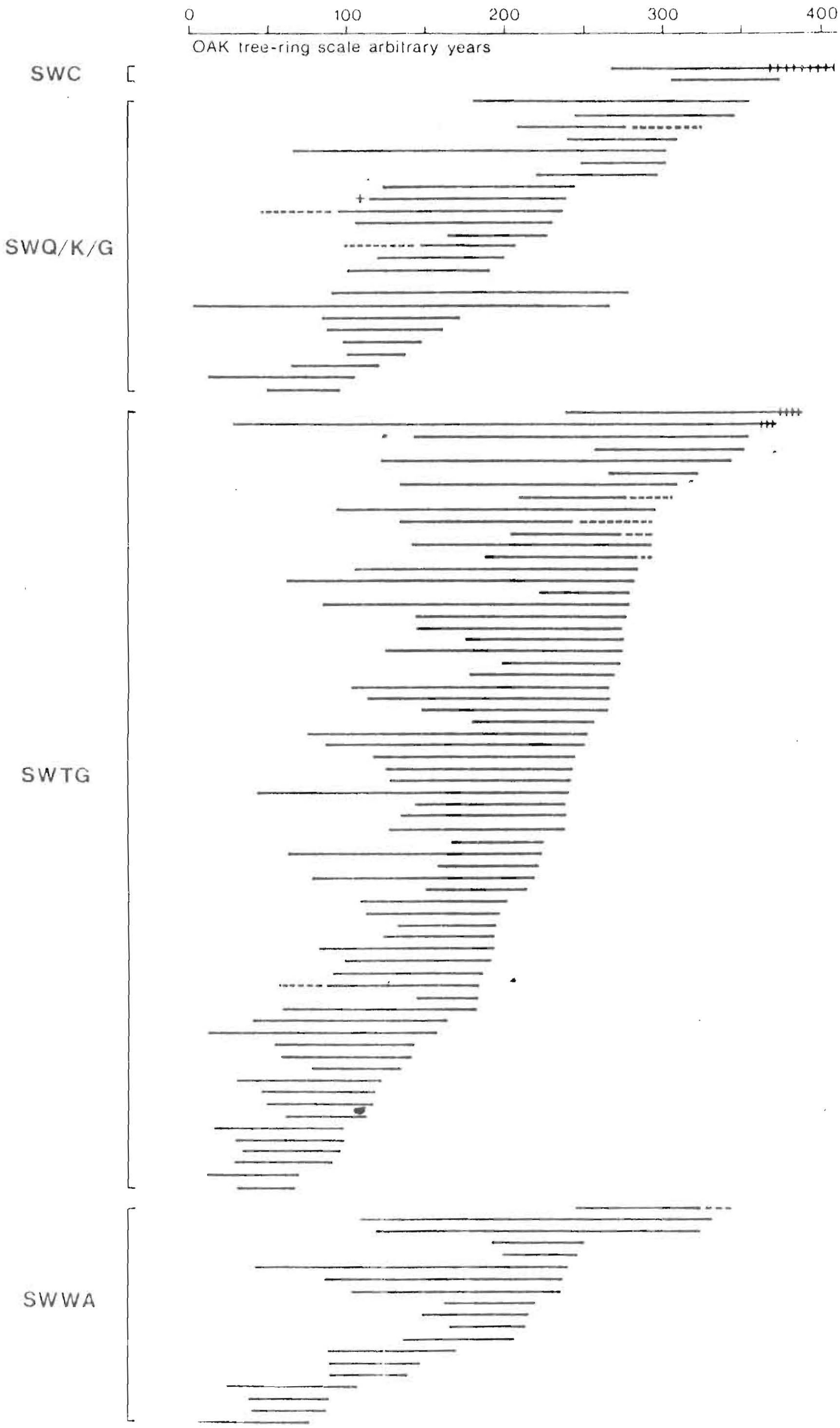

0
100
200
300
400
OAK tree-ring scale arbitrary years
SWC
SWQ/K/G
SWTG
SWWA

FIG. 1

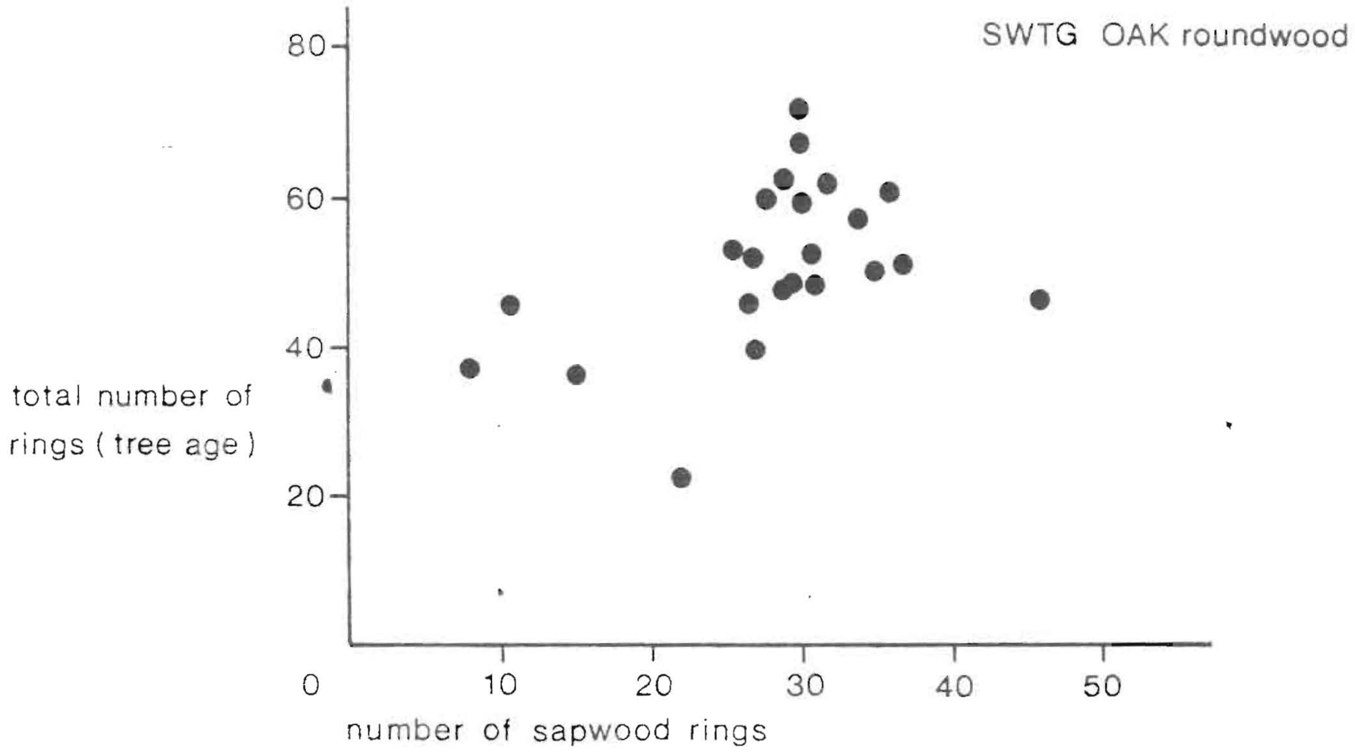

SWTG OAK roundwood
80
60
40
20
total number of rings (tree age)
0
10
20
30
40
50
number of sapwood rings

FIG. 2

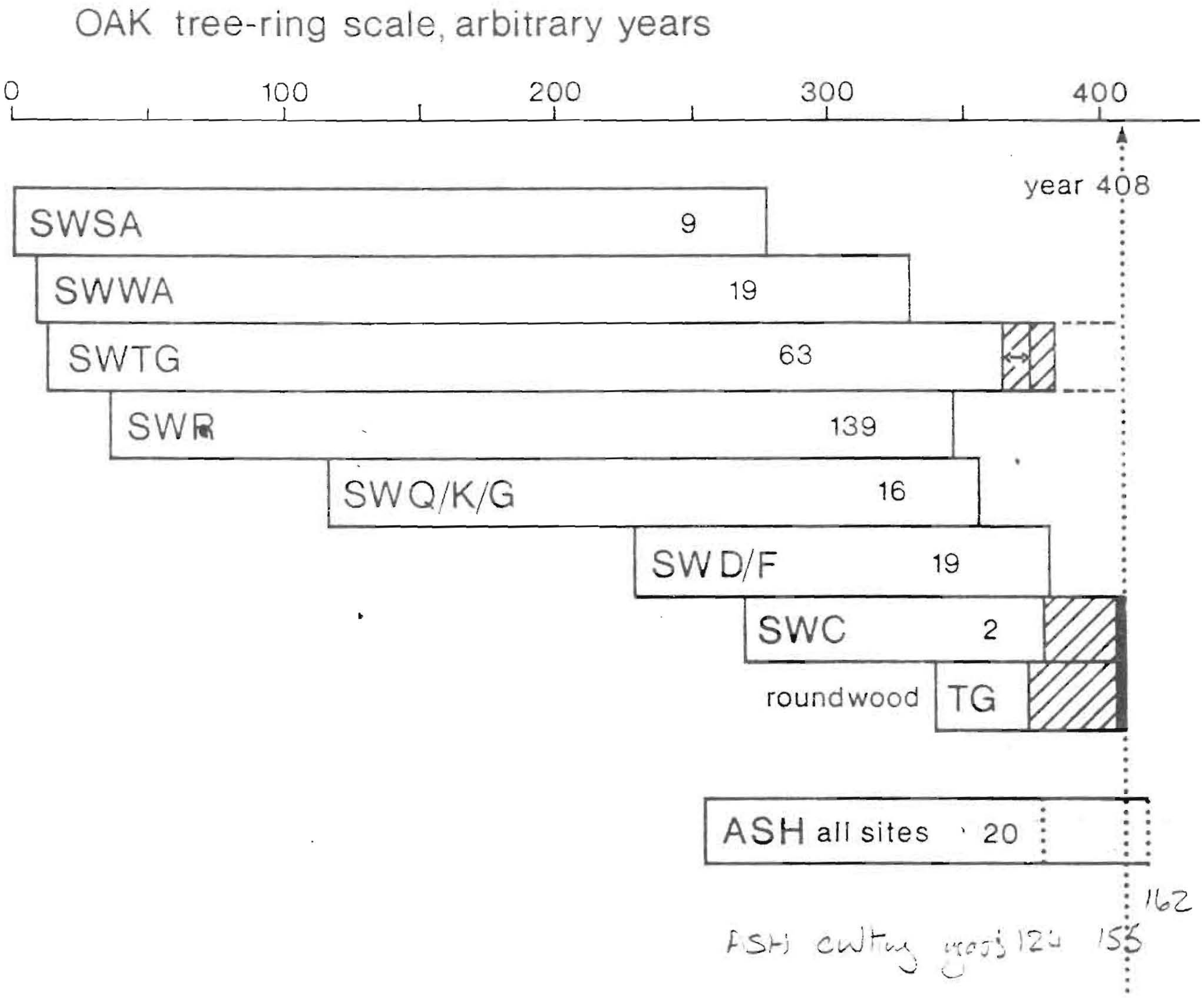

OAK tree-ring scale, arbitrary years
0
100
200
300
400
year 408
SWSA 9
SWWA 19
SWTG 63
SWR 139
SWQ/K/G 16
SWD/F 19
SWC 2
roundwood TG
ASH all sites 20
162
ASH cutting years 124 155

FIG. 3

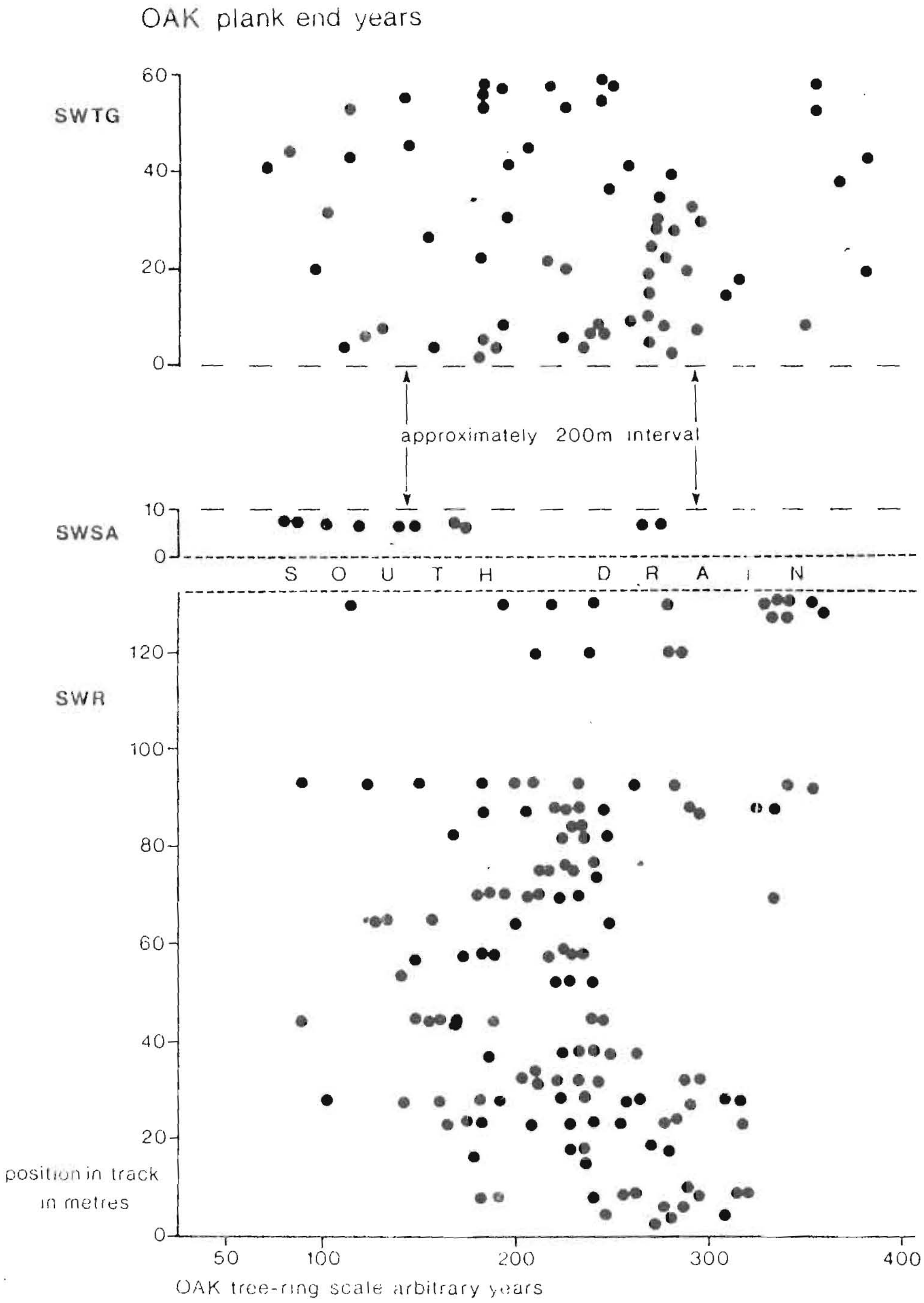

OAK plank end years
SWTG
60
40
20
0
approximately 200m interval
SWSA
10
0
S O U T H D R A I N
SWR
120
100
80
60
40
20
0
position in track in metres
50
100
200
300
400
OAK tree-ring scale arbitrary years

FIG. 4

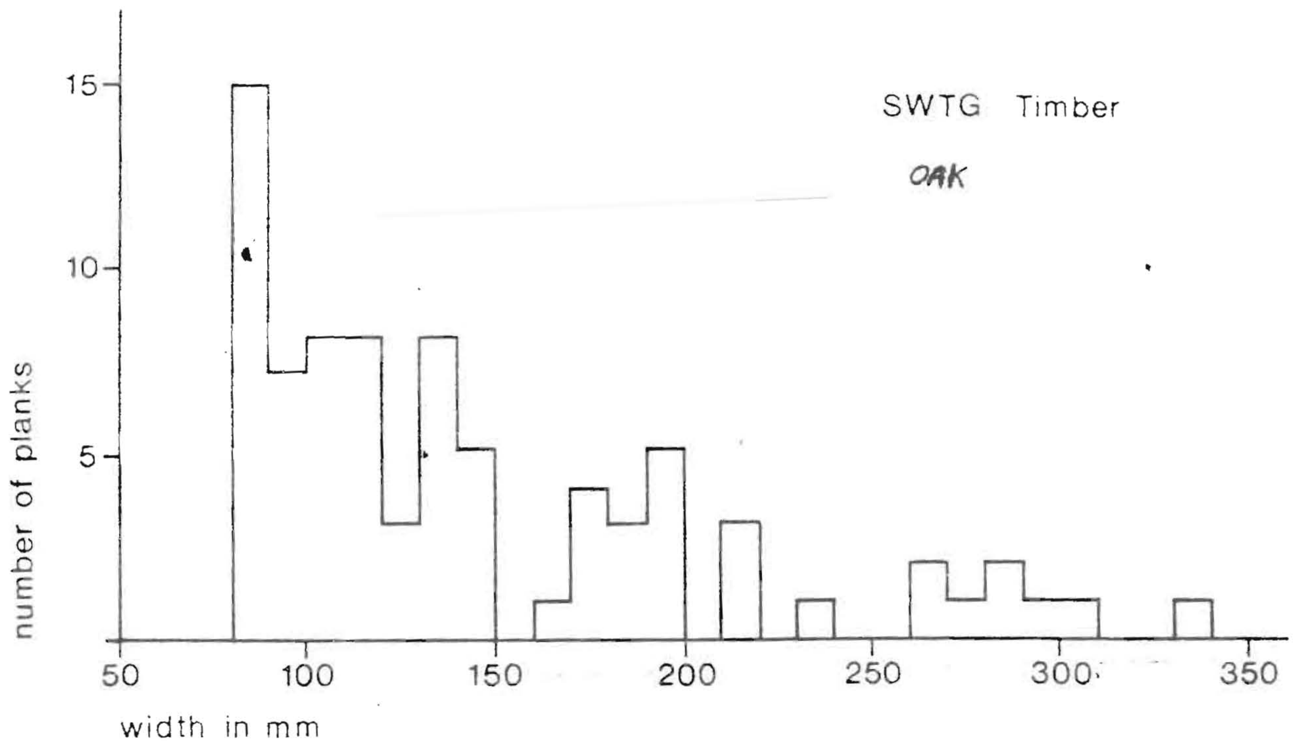

SWTG Timber
OAK
15
10
5
number of planks
50
100
150
200
250
300
350
width in mm

FIG. 5

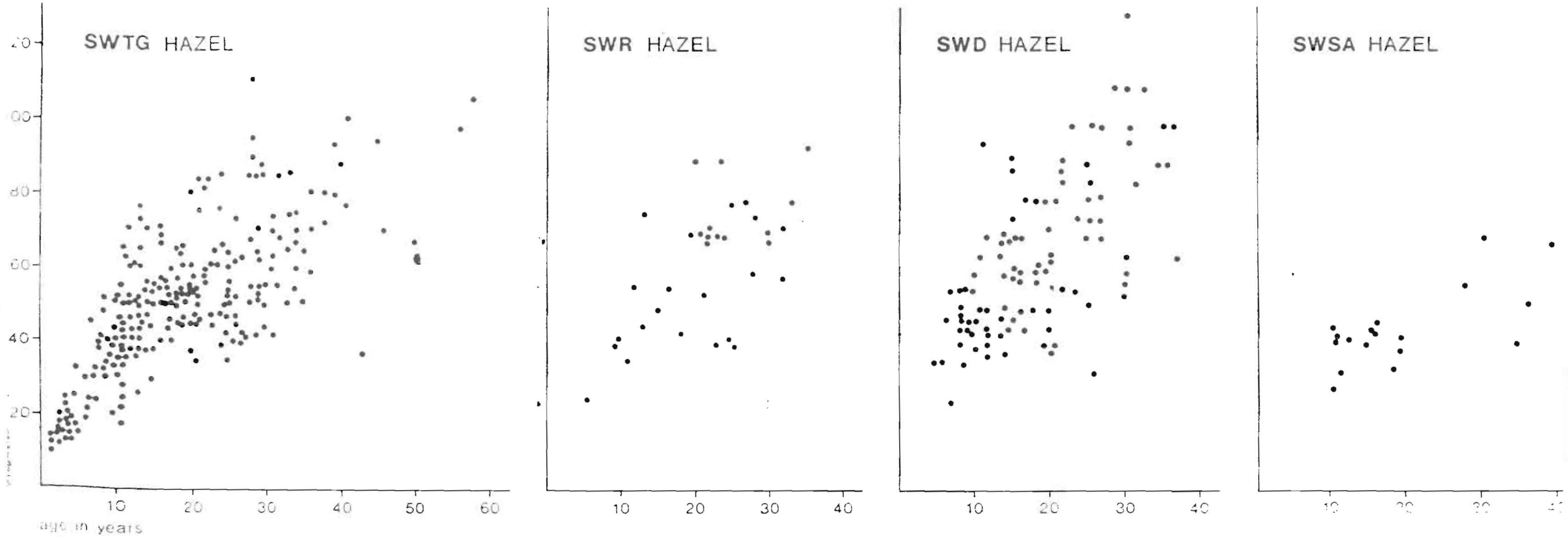
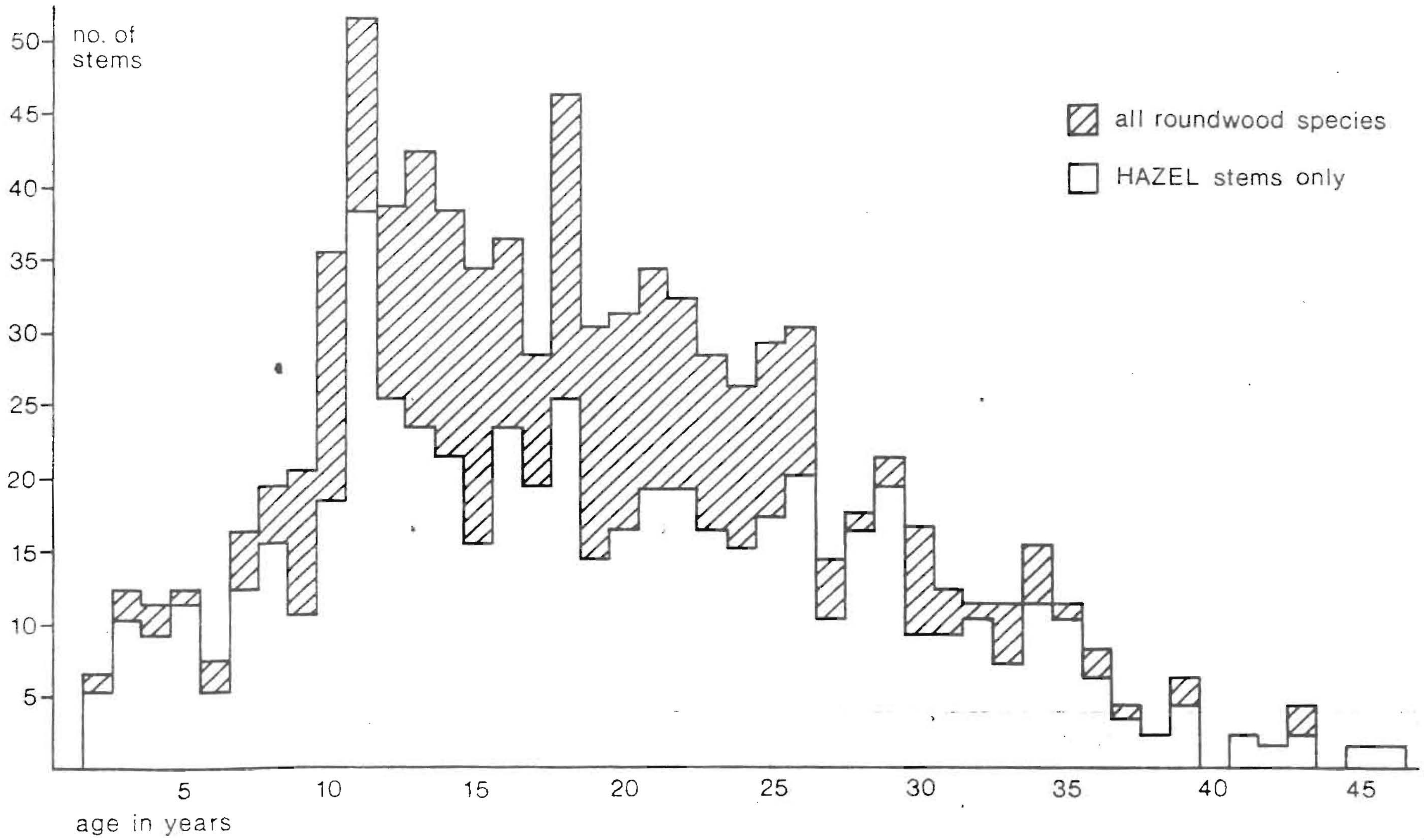

SWTG HAZEL
SWR HAZEL
SWD HAZEL
SWSA HAZEL
40
20
10
20
30
40
50
60
age in years

FIG. 6



no. of stems
50
45
40
35
30
25
20
15
10
5
5
10
15
20
25
30
35
40
45
age in years
all roundwood species
HAZEL stems only

FIG. 7

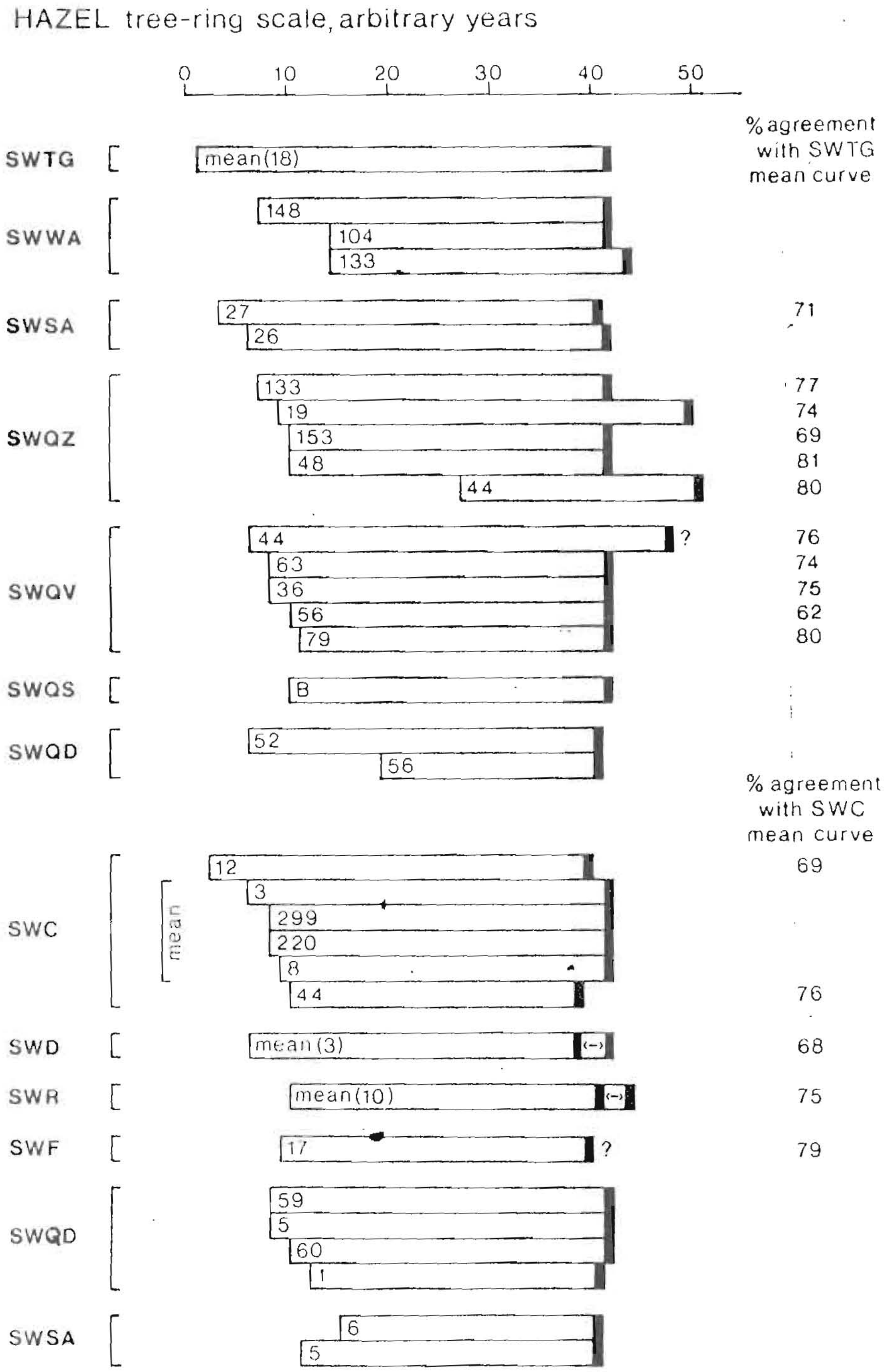
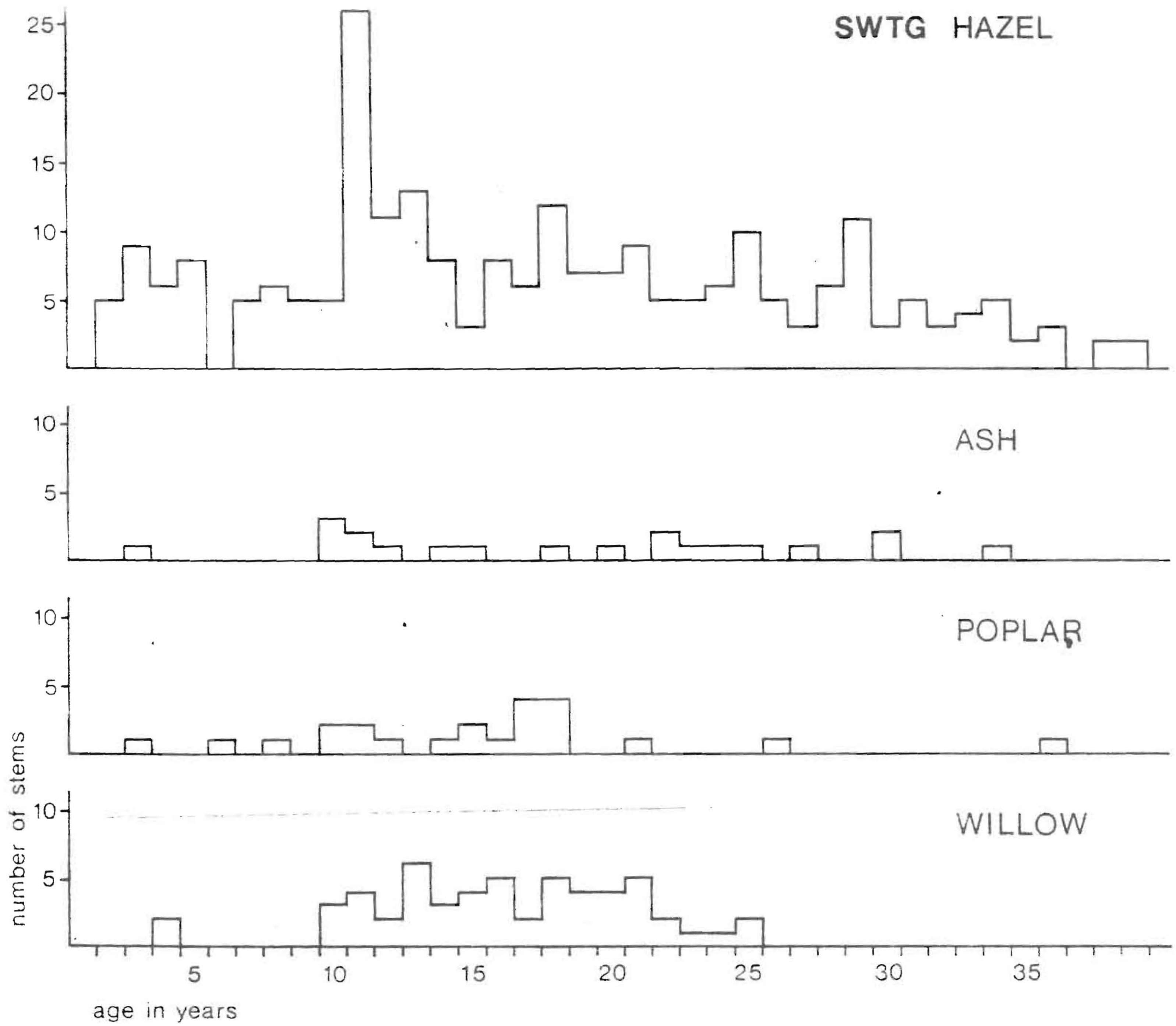

HAZEL tree-ring scale, arbitrary years
0 10 20 30 40 50
% agreement with SWTG mean curve
SWTG
mean(18)
SWWA
148
104
133
SWSA
27
26
71
SWQZ
133
19
153
48
44
77
74
69
81
80
SWQV
44
63
36
56
79
?
76
74
75
62
80
SWQS
B
SWQD
52
56
% agreement with SWC mean curve
SWC
mean
12
3
299
220
8
44
69
76
SWD
mean (3)
68
SWR
mean(10)
75
SWF
17
?
79
SWQD
59
5
60
1
SWSA
6
5

FIG. 8


SWTG HAZEL
ASH
POPLAR
WILLOW
number of stems
age in years
25
20
15
10
5
10
5
10
5
10
5
5
10
15
20
25
30
35

ar a

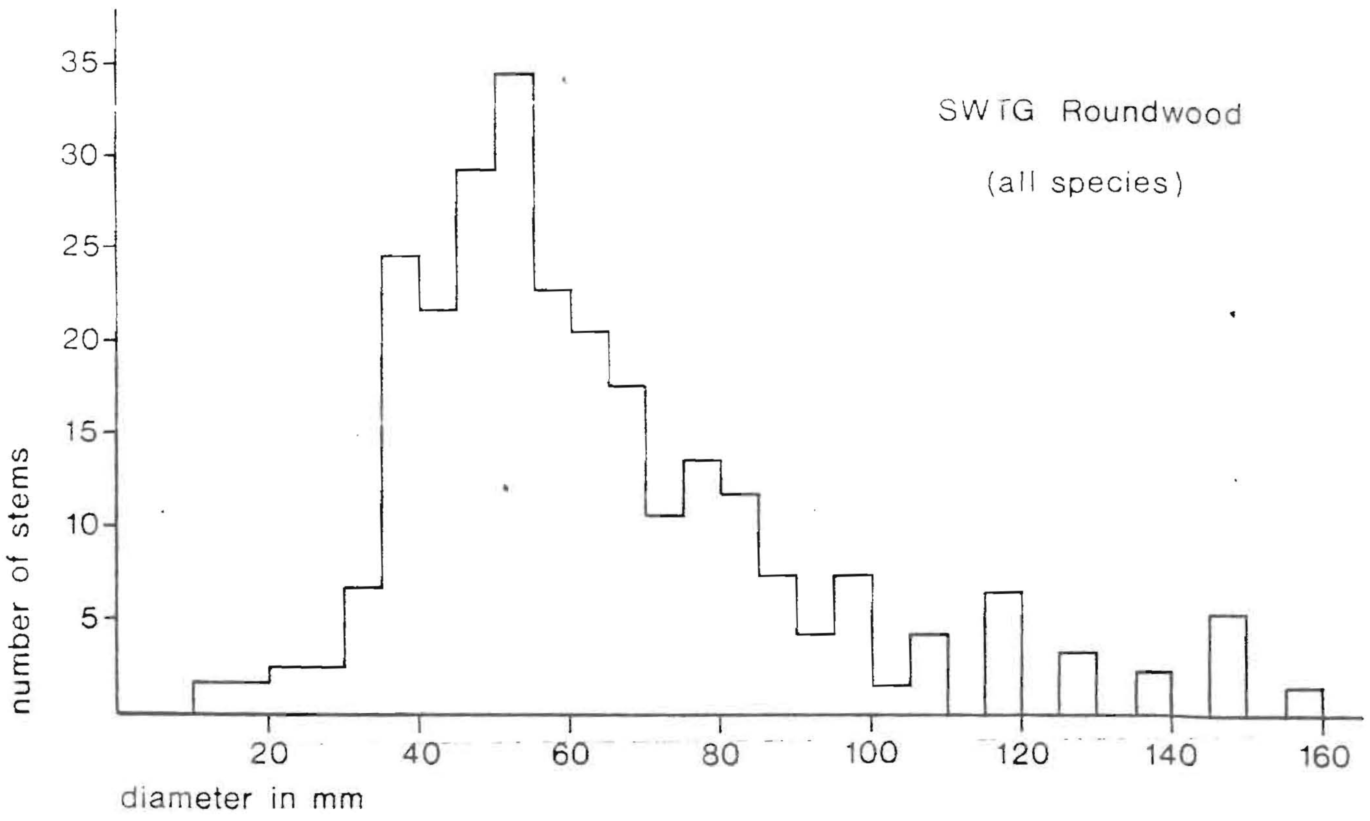
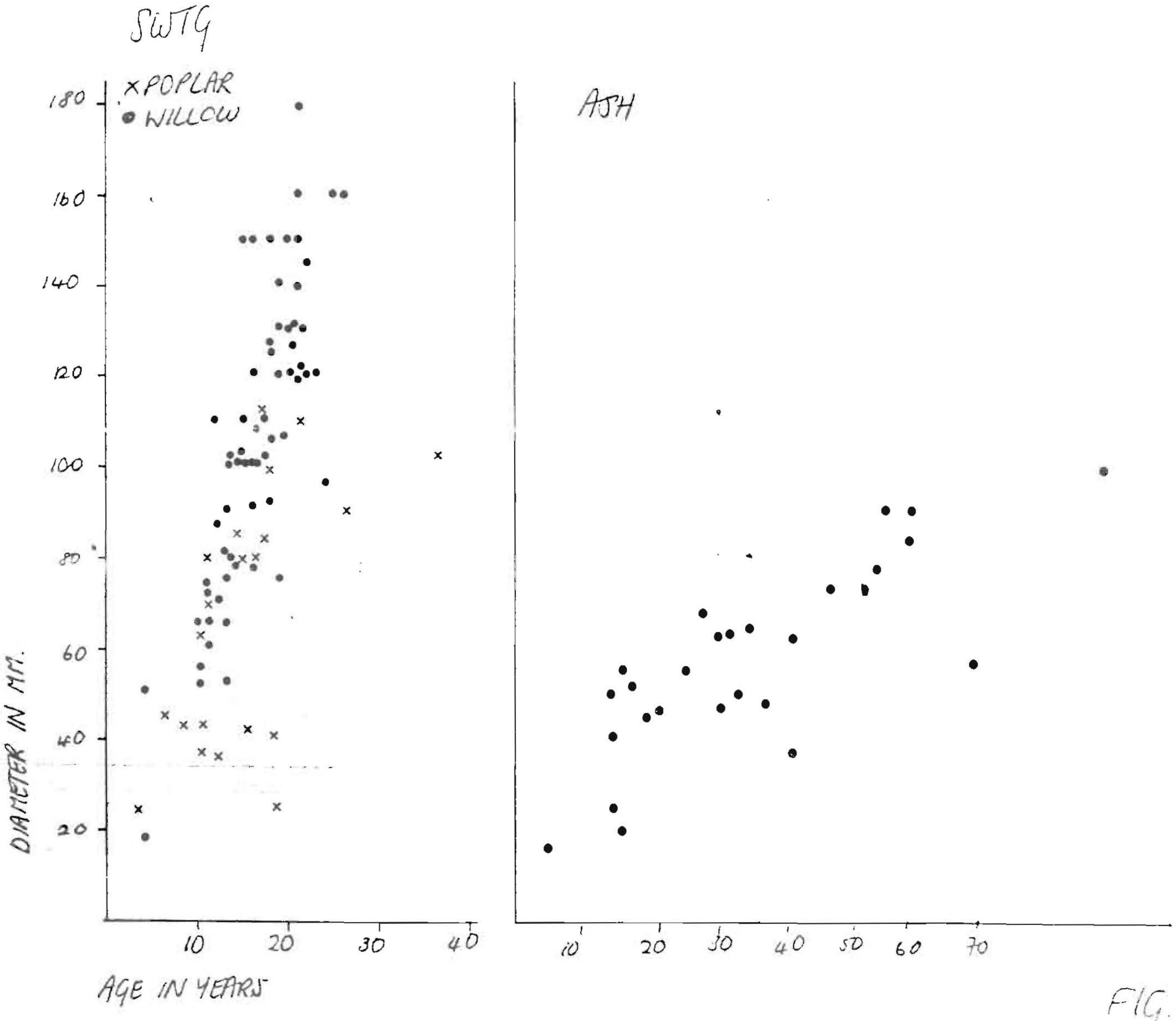
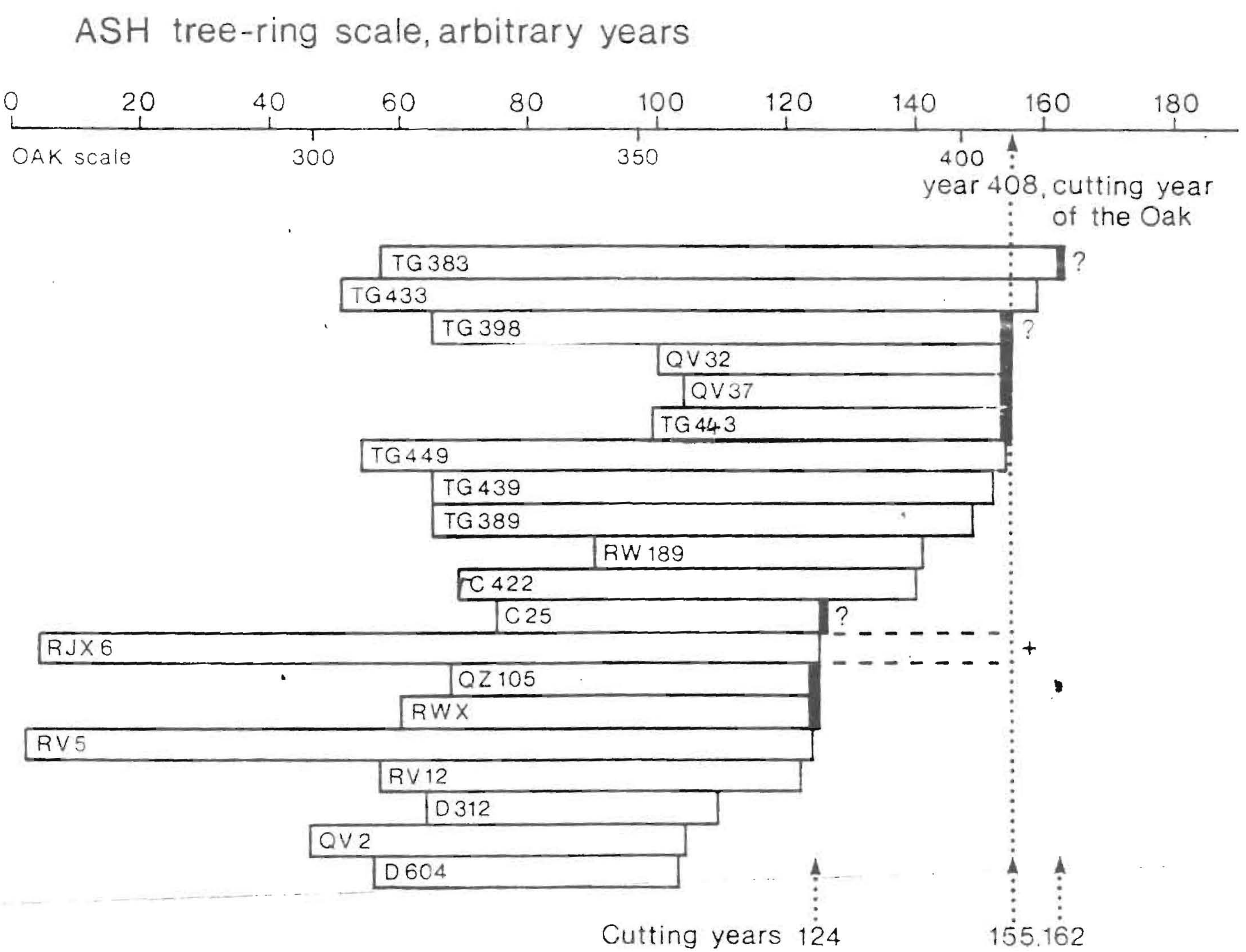

SWTG Roundwood
(all species)
number of stems
35
30
25
20
15
10
5
20
40
60
80
100
120
140
160
diameter in mm

FIG. 10



SWTG
× POPLAR
● WILLOW
ASH
180
160
140
120
100
80
60
40
20
DIAMETER IN MM.
10
20
30
40
50
60
70
AGE IN YEARS

FIG. 11


ASH tree-ring scale, arbitrary years
0
20
40
60
80
100
120
140
160
180
OAK scale
300
350
400
year 408, cutting year of the Oak
TG 383
?
TG 433
TG 398
?
QV 32
QV 37
TG 443
TG 449
TG 439
TG 389
RW 189
C 422
C 25
?
RJX 6
+
QZ 105
RWX
RV 5
RV 12
D 312
QV 2
D 604
Cutting years 124
155,162

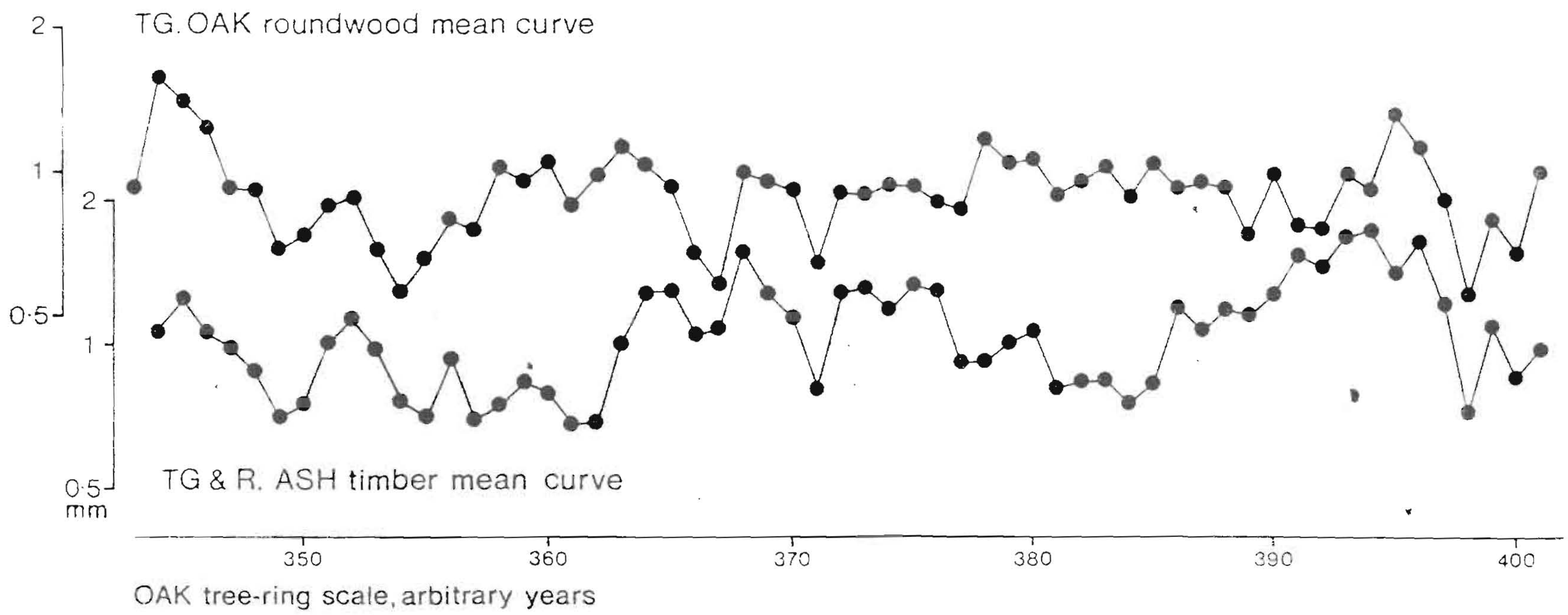
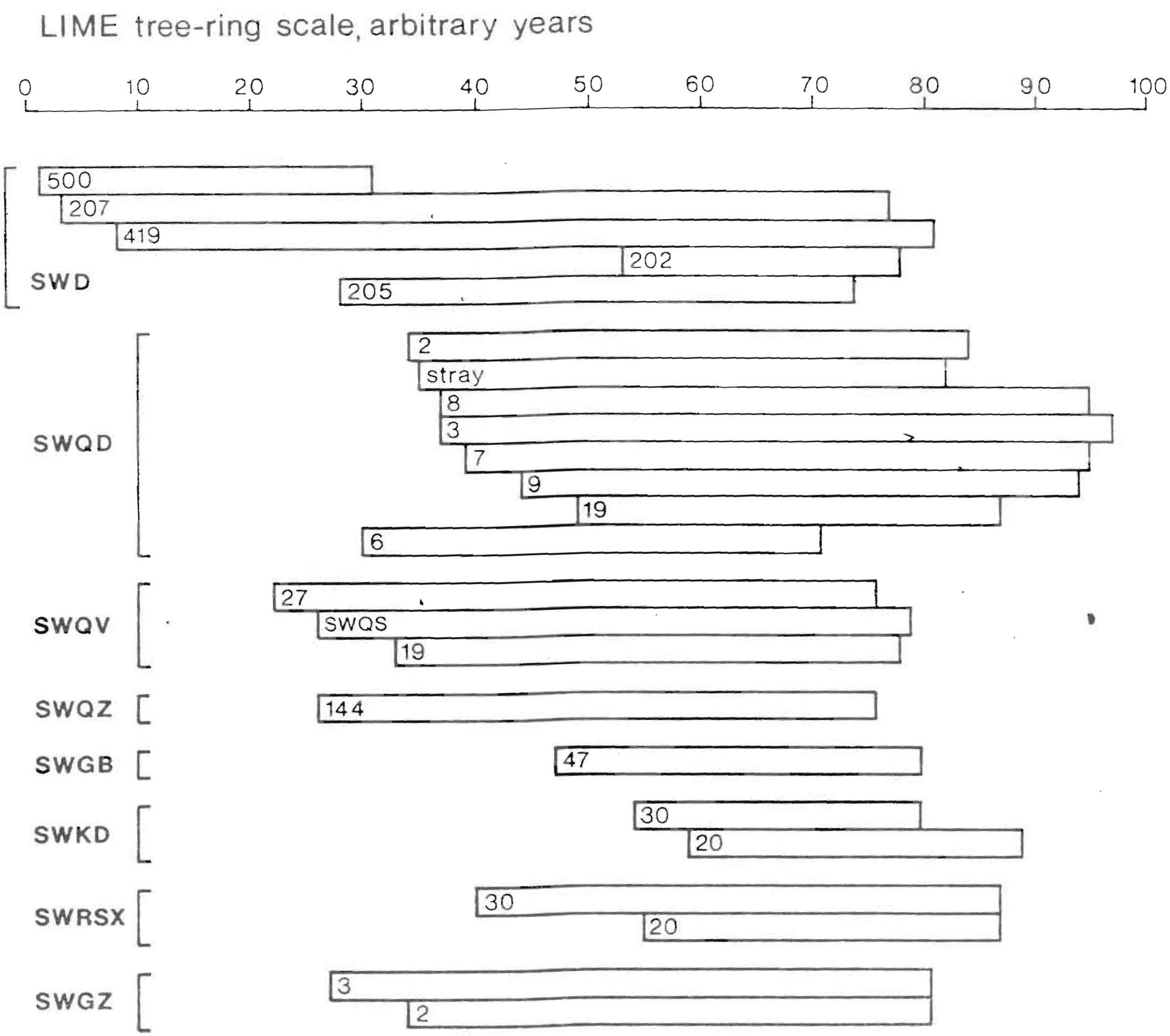

2
TG. OAK roundwood mean curve
1
2
0·5
1
0·5
mm
TG & R. ASH timber mean curve
350
360
370
380
390
400
OAK tree-ring scale, arbitrary years

FIG. 13


LIME tree-ring scale, arbitrary years
0
10
20
30
40
50
60
70
80
90
100
SWD
500
207
419
202
205
SWQD
2
stray
8
3
7
9
19
6
SWQV
27
SWQS
19
SWQZ
144
SWGB
47
SWKD
30
20
SWRSX
30
20
SWGZ
3
2

APPENDIX

Details of cross-matched oak planks from the Sweet track, 1979-1982

Sample no.	No. of growth rings (sapwood)	Span in 408 year chronology	t value with existing oak chronology
SWC 23	71	305-375	6.89
120	140 (25)	269-408	4.15
SWGB 31	43	?120-162	3.38
SWGZ 4	78	221-298	1.98
30	72	240-311	5.4
SWKD 4	176	181-356	5.43
11	54	249-302	5.37
32	103	244-346	7.27
SWQD 36	122	122-243	4.45
SWQV 42	+124	+116-239	5.24
SWQZ 23	65+c 60	211-275(-c375)	7.93
30	c45+63	(c100-)146-208	4.89
31	87	101-187	5.83
61	235	68-302	9.88
116	76	122-197	5.24
135	61	167-227	6.00
145	c40+143	(c50-)96-238	6.25
146	125	107-231	6.26
SWSA 9	77	89-165	6.19
12	267	1-267	7.61
18	36	101-136	4.62
21	87	85-171	4.18
32	95	12-106	7.84
34	189	89-277	10.9
61	54	67-120	3.86
69	50	98-147	4.09
74	47	50-96	6.67
SWTG 7	202	95-296	10.92
29	c30+99	(c58-)88-186	4.51
36	180	77-256	6.65

cont.

SWTG	54	178	134-311	10.25
	55	164	104-267	12.34
	60	142	17-158	5.6
	76	178	107-284	11.95
	78	198	83-280	10.51
	89	91	178-268	9.2
	101	134	143-276	6.58
	193	61	134-194	4.58
	217	68	49-116	4.9
	221	95	92-186	6.35
	227	112	128-239	4.28
	228	154	114-267	6.95
	238	90	101-190	8.05
	239	121	42-162	4.69
	259	221	125-345	3.8
	287	68+c30	210-277 (-c307)	7.09
	307	120	61-180	6.45
	321	212	145-356	7.78
	328	+52+	+62-113+	4.14
	359	94	109-202	6.88
	369	77	181-257	4.13
	370	71	47-117	4.35
	371	85	113-197	5.51
	379	c344(c14)	c29-372	
	385	215	68-282	9.41
	395	164	88-251	9.93
	400	118	150-267	9.67
	436	82	19-100	9.2
	438	154	141-294	7.66
	464	198	46-243	4.36
	468	139	79-217	6.97

cont.

SWTG	479	70	124-193	4.61
	500	75	200-274	4.33
	508	97	179-275	3.87
	656	65	158-222	7.89
	658	63	151-213	13.21
	679	58	169-226	7.0
	690	60	222-281	4.06
	731	56	78-133	3.93
	749	60	36-95	4.35
	778	107	135-241	6.48
	793	111+c50	135-245(-c295)	11.75
	828	150	126-275	9.55
	829	41	144-184	5.5
	846	134	145-278	6.7
	869	115	129-243	7.03
	914	98	144-241	6.15
	924	89	34-122	3.86
	952	59	12-70	5.13
	1012	71+c20	205-275(-c295)	6.19
	1053	96+c7	188-283(-c290)	8.91
	1063	82	61-142	4.02
	1064	146 (9)	239-384	5.22
	1073	109	83-191	0.8
	1076	88	56-143	3.04
	1077	157	67-223	6.3
	1080	130	117-246	6.9
	1082	119	127-245	7.18
	1092	96	259-354	3.63
	1121	52	30-81	3.89
SWWA	4	197	43-239	7.75
	20	221	111-331	9.47

cont.

SWWA	23	152	86-237	9.53
	32	205	118-322	7.56
	33	51	164-214	5.42
	45	56	91-146	4.53
	47	60	161-220	8.55
	48	84	26-109	7.77
	58	69	8-76	5.56
	59	64	151-214	7.27
	78	133	102-234	10.16
	95	80+c20	246-325(-c345)	5.81
	100	50	90-139	4.68
	111	73	136-208	3.89
	115	59	193-251	5.4
	118	50	199-248	3.63
	122	49	41-89	5.69
	124	53	38-90	5.7
	155	80	90-169	2.99