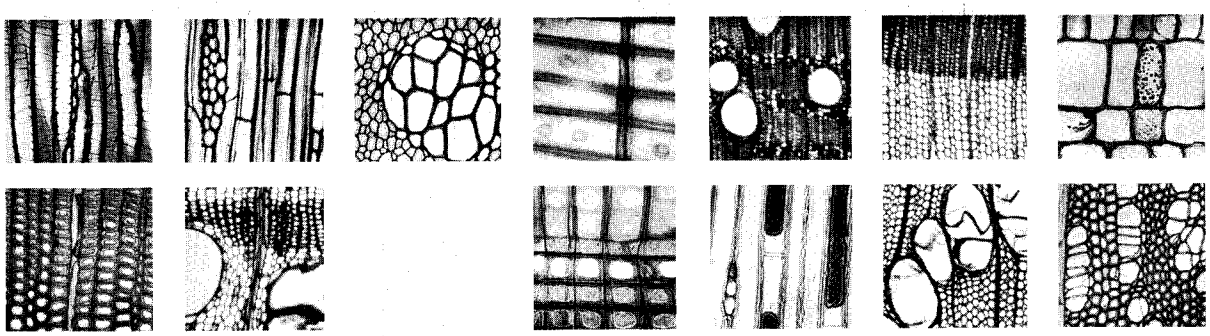

Computer-Aided Wood Identification

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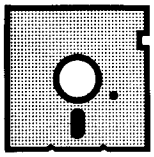

Reference Manual

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Part I
Introduction to Computer-Aided Wood Identification

Given the vast number of species of woods, identification of an unknown wood sample can be a difficult task, especially if you do not know the geographic source of the wood. Many species are described in the literature, but it is impractical to survey it all, so dichotomous or multiple entry identification keys are used.

Multiple entry keys for wood identification were first developed with marginally perforated cards (Clarke, 1938). Such keys consist of a series of cards with each card representing one taxon. The cards are perforated along the margin with each perforation denoting one feature or characteristic (see sample).

To identify an unknown wood sample, a needle is passed through the stack of cards at a perforation representing a character observed in the unknown. The cards of those species with the feature notched as present will fall out during the sorting process. Cards of species with the feature absent stay on the needle. The sorting process is repeated for each feature selected until a single card or a few cards remain.

Multiple entry keys allow you to chose the combination of characters used for identification and the sequence in which the characters are used. New species can be added to multiple entry keys by inserting cards or by adding entries to a computerized database. The data from perforated cards can be easily computerized and this has been done in the U.S.A. for the OXFORD/PRL database (Pearson and Wheeler, 1981) and in Australia (Ilic and Hillis, 1984).

Computer Sorting

Computer sorting has many advantages over mechanical card sorting. Speed is an obvious advantage, but the most important advantage is flexibility. A specified number of mismatches in feature descriptors between an unknown sample and taxa in the database can be allowed. Even when mismatches are allowed, the presence or absence of certain features can be "required" of any proposed match. When cards are manually sorted, all features used have to match.

Some Cautions

1. The computer allowance for mismatches overcomes some of the limitations of any database for variable materials such as woods. However, the total range of variability of many genera and species is probably not adequately described. Consequently, it is best to allow for one or more mismatches, especially for tropical hardwoods.

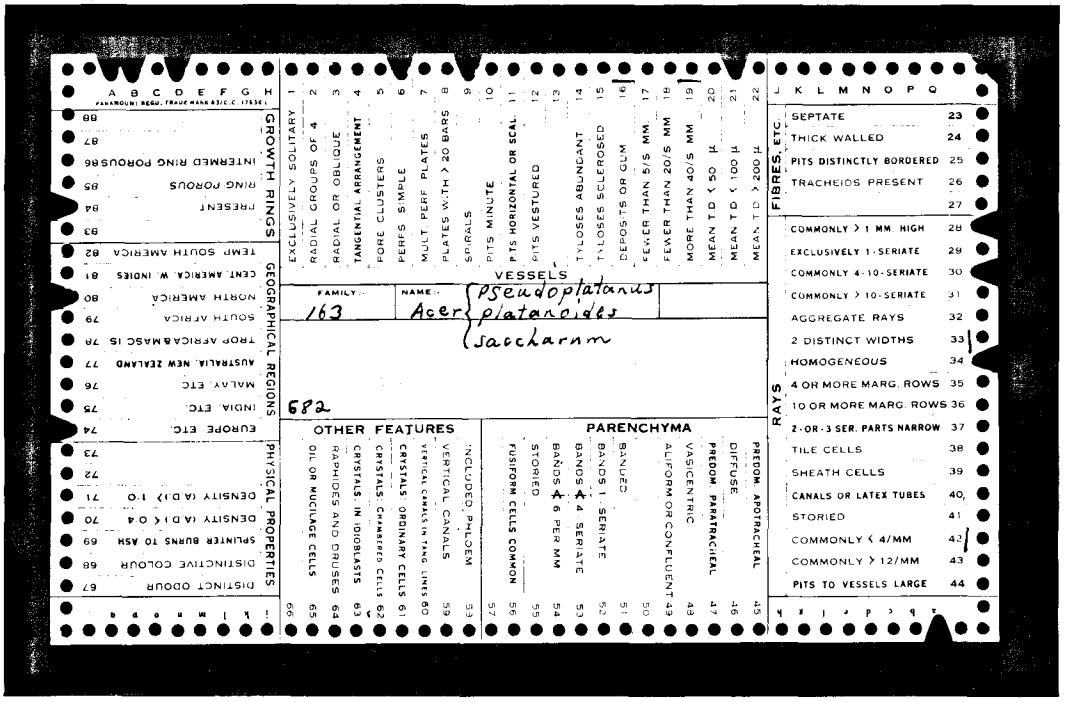
2. Many of the entries in the OXFORD/PRL database for hardwoods are based on only one or a few samples of a particular species. As the *IAWA Bulletin* pointed out, there are relatively few authenticated samples of many tropical species, and only a few species of many tropical genera have been studied.

3. A search can result in a correct identification only if the species to which the unknown sample belongs is in the key. Since no key has all woods in it, there is always the possibility that the unknown belongs to a species not included in the key. The expanded OXFORD/PRL hardwood database contains enough species (over 4000 entries representing more than 2500 genera and 200 families) so that a search will probably result in the name/s of closely related genera and species, if not the actual genus or species.

4. Use of computerized multiple entry keys is just a first step in the identification process. The purpose of the multiple entry key, particularly for the hardwoods, is to generate a small list of possible matches for an unknown sample. Although there are instances where the key distinguishes between species of a genus, this is not always possible with the key alone. For example, *Ulmus americana*, *Ulmus rubra* and the hard elm species of the United States can be distinguished on the basis of earlywood pore arrangement and size, but these particular earlywood characteristics are not among the numbered features of the key.

5. An "answer" from a computer is no more reliable than an answer derived in a more traditional manner. The unknown sample and the suggested match/es should be carefully compared, using vouchered wood samples, photographs, published descriptions, and the whole computerized record for each taxon.

For several reasons, a single match, particularly for a tropical hardwood, should be considered suspect and in need of verification because: (a) many species descriptions in the database are based on but one or a small number of samples; (b) not all characters useful in distinguishing between species are features coded in the database; and (c) not all woody species are included in the database. The objective of a hardwood database search is a small list of taxa.



Sample card used at Commonwealth Forestry Institute, Oxford, for recording wood anatomical data. Chalk and co-workers gathered information for over 4000 species. The information from these cards forms the core of the Oxford/PRL/NCSU computerized hardwood database.

Part II
Hardwood Identification

Section 1. The Hardwood Database

The majority of the hardwood database entries are based on perforated card data from the Commonwealth Forestry Institute, Oxford. They represent data accumulated by Chalk and co-workers during the preparation of the first edition of *Anatomy of the Dicotyledons* (Metcalfe and Chalk, 1950) and recorded on the cards Clarke developed. The features chosen for the card were those experience had shown to be useful for wood identification. Indicating the presence or absence of these features was not intended to be considered a complete description of a wood.

The original cards unquestionably contained some doubtful entries and errors, some of which may have been introduced when the cards were punched. There are also inconsistencies in the interpretation of some features, particularly the parenchyma. Some of the original cards may represent samples incorrectly identified. The Oxford data cards were prepared before 1950, so some taxon names are no longer valid. We have brought all the generic names into agreement with Willis (1973). Although no systematic effort was made to update the species names, changes were made when indicated by the literature consulted during checking and revision of many entries.

Other entries represent data from the Princes Risborough Laboratory (PRL) (Brazier and Franklin, 1961). The PRL list of characters did not include pore density (Oxford features 17, 18, 19), ray density (Oxford features 42, 43) or the number of parenchyma bands per mm (Oxford feature 54). For the PRL entries, these features have been coded as indicated by other literature or an Oxford card, or coded as unknowns if no information was found.

For some species there are two or more entries. Replicate entries are used when there is information from more than one source and there are differences between the descriptions. For instance, there are separate entries for the PRL and Oxford card data for the same taxa.

The database is not finished. Not all species names have been updated. Incorrect codings will need to be corrected as they are discovered. More information is needed for some entries, and additional species will be added as new literature is surveyed.

Sources (other than the Oxford card data) used in constructing the database are indicated as follows:

Feature 73—Princes Risborough Laboratory (PRL)

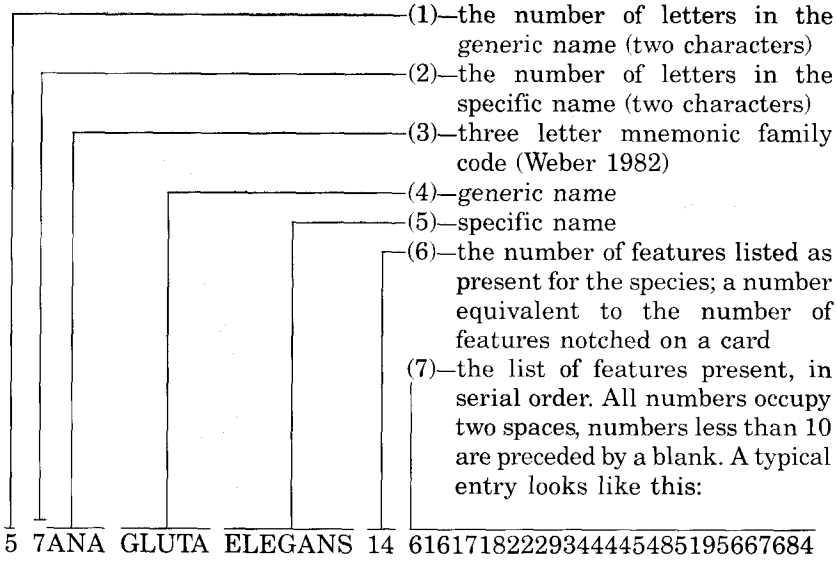
(−, +)—Some entries have been created or modified by consulting post-1950 literature, mostly the family monographs listed by Gregory (1980). A species name followed by a hyphen (e.g. BETULA ALBAE—JH) represents an entry derived solely from the reference indicated by the initials which follow. A species name followed by a plus (+) indicates that information from a reference was used in addition to that on the Oxford card. The letters are initials of the author(s) of the publication on that taxon. The Appendix contains a listing of these initials sorted by the three letter family code with the complete reference given. Use of this Appendix provides a means of finding additional information on suggested species matches.

The Centre Technique Forestier Tropical (CTFT) of France has published descriptions and illustrations of wood from Africa and South America. These valuable publications have data for multiple entry keys and we have added data from two of these publications to the database. There are many similarities in the anatomical descriptors used in the CTFT keys and the OXFORD/PRL keys, but the numbers assigned to the descriptors are different. We used the computer to convert the CTFT feature numbers into the equivalent OXFORD/PRL feature numbers. The CTFT keys have more detailed parenchyma descriptors, but do not use equivalents of OXFORD/PRL feature numbers 11, 12, 15, 25, 27, 37, 38, 39, 63, and 64. The text and/or accompanying photographs generally enabled us to determine if these features were present or absent, otherwise they were coded as unknowns.

K after a species name indicates Kribs (1968). Like the PRL entries, Kribs entries have commercial importance.

Database Entry Format

The fixed format of each record in the OXFORD/PRL database should be readable by most common computer languages. Information for each entry is in this order:



Changes in the Oxford/PRL Hardwood Database

Feature numbers are shown on the datasheet reproduced on page 5. The following changes from the original card entries should be noted.

New Features

Feature 27—spiral thickenings in the fibers.
Feature 57—marginal parenchyma.
Feature 66—presence of silica bodies.
Feature 83—shrub

Feature Qualifiers

Variability (V). Qualifier 95 before a feature number in the database indicates a variable feature (i.e. a feature present in some samples, absent in others, or not well-defined) and results in the letter V appearing after that feature number in the output. Variable features are considered a match for both the presence and absence of a feature.
ANA MANGIFERA INDICA 6 14 17 18 22 44 47 49 57V 61 73 75 84

Knowing that a feature is variable can be helpful. For instance, if all fibers in the unknown have distinct septations, that unknown is unlikely to be a species with feature 23 (septate fibers) coded as a variable feature (23V in the output). Some samples of species coded 23V would not have septate fibers, the other samples with septate fibers would generally have few of them.

Unknown Features (?). Qualifier 99 entered before a feature number in the database indicates that no information was available on that feature and results in ? after the feature number in the output.
CSL CASSIA SP 6 12 16 17 18 22 24 34 47 48 57? 62 68 75

Additional Qualifiers. (A, F, O, R, S, T). Several features have qualifiers (91-94, 96, 97) which provide additional information on that feature, such as whether inclusions are located in the rays (R) or axial parenchyma (A). These qualifiers are listed on page 12 and discussed in Section 3.

HARDWOOD DATASHEET

Sample No. _____

	VESSELS	Present	Absent
1	Exclusively solitary		
2	Radial groups of 4		
3	Radial or oblique		
4	Tangential arrangement		
5	Pore clusters		
6	Perf. simple		
7	Mult. perf. plates		
8	Plates with ► 20 bars		
9	Spirals		
10	Pits minute		
11	Pits opposite or scal.		
12	Pits vestured		
13	Vessels absent		
14	Tyloses abundant		■
15	Tyloses sclerosed		■
16	Deposits or gum		■
17	Fewer than 5/sq. mm		
18	Fewer than 20/sq. mm		
19	More than 40/sq. mm		
20	Mean T.D. ◄ 50 microns		
21	Mean T.D. ◄ 100 microns		
22	Mean T.D. ► 200 microns		
	FIBERS, ETC.	**Present**	**Absent**
23	Septate		
24	Thick walled		
25	Pits distinctly bordered		
26	Tracheids		
27	Spiral thickenings		
	RAYS	**Present**	**Absent**
28	Commonly ► 1mm high		
29	Exclusively 1-seriate		
30	Commonly 4-10-seriate		
31	Commonly ► 10-seriate		
32	Aggregate rays		
33	Two distinct widths		
34	Homocellular		
35	4 or more marg. rows		
36	10 or more marg. rows		
37	Bi- or tri-ser. parts narrow		
38	Tile cells		
39	Sheath cells		
40	Canals or latex tubes		
41	Storied		
42	Commonly ◄ 4/mm		
43	Commonly ► 12/mm		
44	Pits to vessels large		
	PARENCHYMA	**Present**	**Absent**
45	Predom. apotracheal		
46	Diffuse		
47	Predom. paratracheal		
48	Vasicentric		
49	Aliform or confluent		
50	Rare or absent		
51	Banded		
52	Bands 1-seriate		
53	Bands ► 4-seriate		
54	Bands ► 6/mm		
55	Storied		
56	Fusiform cells common		
57	Marginal/zonate		
	OTHER FEATURES	**Present**	**Absent**
58	Included phloem		
59	Vertical canals		
60	Vert. canals in tang. lines		
61	Crystals: ordinary cells		
62	Crystals: chambered cells		
63	Crystals: in idioblasts		
64	Raphides or druses		
65	Oil or mucilage cells		
66	Silica bodies ★		
	PHYSICAL PROPERTIES	**Present**	**Absent**
67	Distinct odour ★		■
68	Distinctive colour		■
69	Splinter burns to ash ★		
70	Density (A.D.) ◄ 0.4 ★		
71	Density (A.D.) ► 1.0 ★		
	GEOGRAPHIC REGIONS	**Present**	**Absent**
74	Europe, Asia		
75	India, etc.		
76	SE Asia, Malaysia		
77	Australia, New Zealand		
78	Trop. Africa & Masc. Is.		
79	South Africa		
80	North America		
81	Cent. and Trop. S. America		
82	Temp. South America		
83	Shrub ★		
	GROWTH RINGS	**Present**	**Absent**
84	Distinct		
85	Ring porous		
86	Semi-ring porous		

■ Feature to be used positively (Present) only

★ Incomplete information on this feature

Section 2. Identification Procedure

Computer Programs

SEARCH is the main program used for searching the database. The SEARCH program is available in PL/1 for batch use with a mainframe computer or in PASCAL for interactive use with a microcomputer. PASCAL versions are available for the Apple IIe (developed by T. Zack), IBM-PC (developed by C.A. LaPasha), and compatible microcomputers. Instructions on the use of the IBM-PC and Apple II search programs are available.

The basic procedures for entering the description of an unknown are similar for both versions, as features are described in terms of their presence or absence, mismatches are allowable, and the presence or absence of certain features can be required.

Two features of the microcomputer versions make them more user-friendly than the mainframe version. Descriptions of unknowns can be entered by coded feature numbers or by "menu." There are menus for hardwoods, softwoods and fibers. With the microcomputer versions it is not necessary to enter feature numbers in serial order (e.g. feature 11 can be entered before feature 2).

With the menu option, the feature numbers and brief definitions appear on the screen. The IBM-PC version has an optional "verbose" output with the brief descriptors appearing with the feature numbers of suggested matches.

Datasheets

Use the datasheet to code features as present or absent. The absence of some features may be as important as the presence of others. For example, the absence of feature 11 indicates that intervessel pitting is alternate, not opposite, transitional, or scalariform.

Some features are best to use positively only. These are indicated as such on the datasheet.

If you are not sure how to code a particular feature, do not use it.

It is not necessary to fill in the entire datasheet. However, the more features you code, the more likely your search routine is to yield a small number of potential matches. Coding 20 or fewer descriptors is generally enough. For any unknown, you may try more than one series of descriptors because different combinations of characters generally result in somewhat different output lists.

The more positive features the wood has, the smaller the number you will need to enter to generate a small list of potential matches. Many of the features Clarke chose are relatively uncommon. Therefore, if an unknown has present ten or so of the features on the datasheet, that will probably be sufficient for generating a small number of matches. Also, many features are mutually exclusive. For instance, if a wood has feature 29 (rays exclusively uniseriate), then it cannot have feature 30 (rays commonly 4-10 seriate), feature 31 (rays 10 or more cells wide), or feature 33 (rays of two distinct widths); if feature 29 is present, you do not need to code features 30, 31, or 33 absent.

Data Entry

Step 1. The first number indicates the number of mismatches allowed (see page 7).

Step 2. The entry of features for unknown samples varies slightly between the mainframe and microcomputer versions. For the PL/1 mainframe program, enter feature numbers from the datasheet in serial order and follow each feature number with a code to indicate presence (1) or absence (0). Follow prompts in the PASCAL versions, coding presence (P) or absence (A).

In the PL/1 version, feature numbers and codes must be separated by one blank or by a comma.

Step 3. At the end of a description in the PL/1 version, enter a negative number (e.g. -9) to indicate that the description is complete.

Mismatches

Data entry with no mismatches. No mismatches means that only taxa with all the descriptors you use will be considered to match. All features of the unknown designated "present" must be present in the match and all features designated "absent" must be absent. For a search with no mismatch, enter 0 as the first number.

Example—no mismatch:

0 4 1 5 1 6 1 7 0 9 1 11 0 23 0 26 1 28 0 30 1 34 1 41 0 47 1 57 1 80 1 85 1 -9

This describes a wood with:

tangential arrangement of the pores (4 1),
pore clusters (5 1),
exclusively simple perforation plates (6 1, 7 0),
spiral thickenings in the vessels (9 1),
alternate pitting (11 0),
nonseptate fibers (23 0),
tracheids (26 1),
rays more than 4 cells wide (30 1),
rays homocellular (34 1),
rays nonstoried (41 0),
predominantly paratracheal parenchyma (47 1),
marginal parenchyma (57 1),
which grows in North America (80 1),
and is ring porous (85 1).

The results of this search, given below, show that only four entries in the data base have these characteristics with no mismatches. It is now relatively easy to determine the most likely species match from other features not used for the search routine.

Data entry with one mismatch. If you want to allow one mismatch, enter 1 as the first number. As the next example shows, using the same unknown as before, permitting one mismatch increases the number of suggested matches from 4 to 8. Note that the output (page 8) identifies the feature mismatched between your description and the suggested match(es).

```
**********************************************************
     RESULTS OF SEARCH FOR IDENTITY OF UNKNOWN SPECIES
**********************************************************

UNKNOWN SPECIES NO. 1 : DATA CARD GIVES FOLLOWING INFORMATION -

NO. OF MISMATCHES PERMISSIBLE = 0
NO. OF FEATURES ENTERED = 16
FEATURES AND THEIR CONDITION CODES ARE:
 4 1  5 1  6 1  7 0  9 1 11 0 23 0 26 1 28 0 30 1 34 1 41 0
 47 1 57 1 80 1 85 1

LIST OF SPECIES POSSIBLY MATCHING THE UNKNOWN SPECIES: -

ULM ULMUS AMERICANA (1ROW.LRG.EW.PORES): SERIAL#=3974, MISSES=0
FEATURES: 4 5 6 9 14 22 26V 30 34 44V 47 48 57V 62 73 80 84 85

ULM ULMUS DAVIDIANA,LACINIATA; SERIAL#=3975, MISSES=0
FEATURES: 4 5 6 9 14 22 26V 30 34 44V 47 48 57V 62 73 74 80 84 85

ULM ULMUS RUBRA (2.OR.MORE.ROWS.EW.PORES): SERIAL#=3979, MISSES=0
FEATURES: 4 5 6 9 14 22 26 30 34 44V 47 48 57V 62 80 84 85

ULM ULMUS THOMASII (HARD.ELM,1ROW.EW.PORES): SERIAL#=3981, MISSES=0
FEATURES: 4 5 6 9 14 24 26 30 34 44V 47 48 57 62V 73 80 84 85

          COMPLETION OF SEARCH FOR UNKNOWN SPECIES NO. 1

                NO. OF SPECIES SEARCHED = 4084

                NO. OF MATCHING SPECIES = 4
*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*
```

If you allowed one mismatch and received a very long list of possible species, then change to no mismatches and/or use more features. If you allowed one mismatch and found no possible species in the database, then change to two mismatches allowed.

Note: Generally, allowing one mismatch the first time you try to identify an unknown is a good idea.

Required presence or absence. If you are certain of the presence or absence of some features, you can require that these features be characteristics of any possible matches. For the PL/1 program, code 2 after the feature number to require its presence and 3 after the feature number to require its absence. For the PASCAL programs, code R to require presence and E to require absence.

Requiring absence of a feature is particularly helpful in specifying that the pitting is alternate (11 3 or E), or that the parenchyma distribution is not aliform or confluent (49 3 or E). In the example, the presence of five features is required: 6 (simple perforation plates), 26 (tracheids), 34 (homocellular rays), 80 (North America location), and 85 (ring porous wood).

Example—1 mismatch, five required features:

1 4 1 5 1 6 2 7 0 9 1 11 0 23 0 26 2 28 0 1 30 1 34 2 41 0 47 1 57 1 80 2 85 2 -9

```
**********************************************************
      RESULTS OF SEARCH FOR IDENTITY OF UNKNOWN SPECIES
**********************************************************

UNKNOWN SPECIES NO.   1: DATA CARD GIVES THE FOLLOWING INFORMATION -

NO. OF MISMATCHES PERMISSIBLE = 1
NO. OF FEATURES ENTERED = 16
FEATURES AND THEIR CONDITION CODES ARE:
 4 2  5 1  6 1  7 0  9 1 11 0 23 0 26 2 28 0 30 1 34 2 41 0 47 1
 57 1 80 2 85 2

LIST OF SPECIES POSSIBLY MATCHING THE UNKNOWN SPECIES: -

CSL CERCIS CANADENSIS+K: SERIAL #=942, MISSES=1
FEATURES:   2  4  5  6  9  26 30 33V 34 41 47 48 49 55 57 62 80 85
MISMATCHED FEATURES(S): 41

CSL GLEDITSIA TRIACANTHOS: SERIAL#=983, MISSES=1
FEATURES:  4  5  6  9 12 16 24 26 28 30 31 34 42 46 47 48 49 51 57
80 84 85
MISMATCHED FEATURE(S): 28

PPL ROBINIA LUXURIANS: SERIAL#=2991, MISSES=1
FEATURES:   4  5  6  9  12 14 24 26 34 47 48 55 56 57? 80 84 85
MISMATCHED FEATURE(S): 30

ULM PLANERA AQUATICA+ES: SERIAL#=3969, MISSES=1
FEATURES:   4  5  6  9  20V 21 26 30 34 45 46 48 51 57 61 80 84 85V
MISMATCHED FEATURE(S): 47

ULM ULMUS AMERICANA (1ROW.LRG.EW.PORES): SERIAL#=3974, MISSES=0
FEATURES: 4 5 6 9 14 22 26V 30 34 44V 47 48 57V 62 73 80 84 85

ULM ULMUS DAVIDIANA,LACINIATA; SERIAL#=3975, MISSES=0
FEATURES: 4 5 6 9 14 22 26V 30 34 44V 47 48 57V 62 73 74 80 84 85

ULM ULMUS RUBRA (2.OR.MORE.ROWS.EW.PORES): SERIAL#=3979, MISSES=0
FEATURES: 4 5 6 9 14 22 26 30 34 44V 47 48 57V 62 80 84 85

ULM ULMUS THOMASII (HARD.ELM,1ROW.EW.PORES): SERIAL#=3981, MISSES=0
FEATURES: 4 5 6 9 14 24 26 30 34 44V 47 48 57 62V 73 80 84 85

          COMPLETION OF SEARCH FOR UNKNOWN SPECIES NO. 1

              NO. OF SPECIES SEARCHED = 4084
                NO. OF MATCHING SPECIES = 8
            *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*
```

The COMBFEAT Program

When you are working with Paleogene or Cretaceous fossil woods, you do not expect to find a species to match the unknown. For such woods you need a list of families and genera which have a particular combination of features. The database may contain hundreds of entries with that combination of characters, but the SEARCH program stops when 100 matching taxa are found.

The COMBFEAT program for the mainframe is an alternative which allows no mismatches and which will list all entries which have any particular combination of up to 30 features. COMBFEAT also retrieves entries with any single feature, a list of woods with storied rays (feature 41), for example.

```
//COMBFEAT JOB
*** JCL IS IN COMBFEAT.CNTRL                                          00000030
*** PROGRAM SEARCHES SPECIES LISTS FOR TAXA WITH SPECIFIED            00000040
*** COMBINATION OF MISSING OR PRESENT FEATURES                        00000050
***                                                                   00000060
*** FILE OR FILES TO BE SEARCHED ARE TO BE IN DDNAME "G.SPECS"        00000070
*** INPUT DATA FOLLOW '//G.SYSIN DD * " AS UNDER:                    00000080
*** LINES 1 AND 2: MAIN AND SUB-HEADINGS (80 CHARS. MAX.             00000090
*** PER LINE) PUT A BLANK LINE IF A HEADING IS NOT WANTED.           00000100
*** LINE 3: PAIRS OF NUMBERS IN WHICH FIRST NO. OF EACH PAIR         00000110
*** IS THE CODE NO. OF THE FEATURE AND THE SECOND NO. IS 0 OR 1.     00000120
*** A TAG OF 0 INDICATES THE FEATURE MUST BE ABSENT; A TAG           00000130
*** OF 1 INDICATES THAT THE FEATURE MUST BE PRESENT FOR A MATCH.     00000140
*** IF THE SPECIFIED FEATURE IN THE SPECIES BEING SEARCHED IS        00000150
*** VARIABLE, I.E. IT IS NOT ALWAYS SEEN (95), OR IS UNKNOWN (99),   00000160
*** THEN A MISMATCH DOES NOT RESULT, NO MATTER WHETHER THE TAG IS    00000170
*** IS 0 OR 1.                                                       00000180


WOODS WITH LRG DIAM PORES 7 SCAL PP

 MAY 1, 1985 DATABASE

DATA ENTRY GIVES THE FOLLOWING VALUES:
 6  0  7  1 22  1
FEATURES TO BE MATCHED ARE ACCORDINGLY;
 6  7 22
NO. OF FEATURES TO BE ABSENT = 1
NO. OF FEATURES TO BE PRESENT = 2
TOTAL NO. OF FEATURES TO BE MATCHED = 3

1048 DLL DILLENIA RETICULATA
 20  1  7  8  11 17 18 22V 24 25 28 30 33 35 42 44 46 48 63 64R 76

1049 DLL DILLENIA SP
 19  1  7  8 11 17 18 22 25 28 30 33 35 44 46 63 64R 75 76

1958 MAG AROMADENDRON ELEGANS + JC
 13 7  9 11S 18? 22V 25 28? 44 45 57 65R 76 84V

END OF SEARCH FOR SET NO.  1
NO. OF TAXA SEARCHED = 4010
NO. OF MATCHING TAXA FOUND = 3

ALL SEARCHES COMPLETED
```

Section 3. Hardwood Features: Descriptions and Comments on Coding

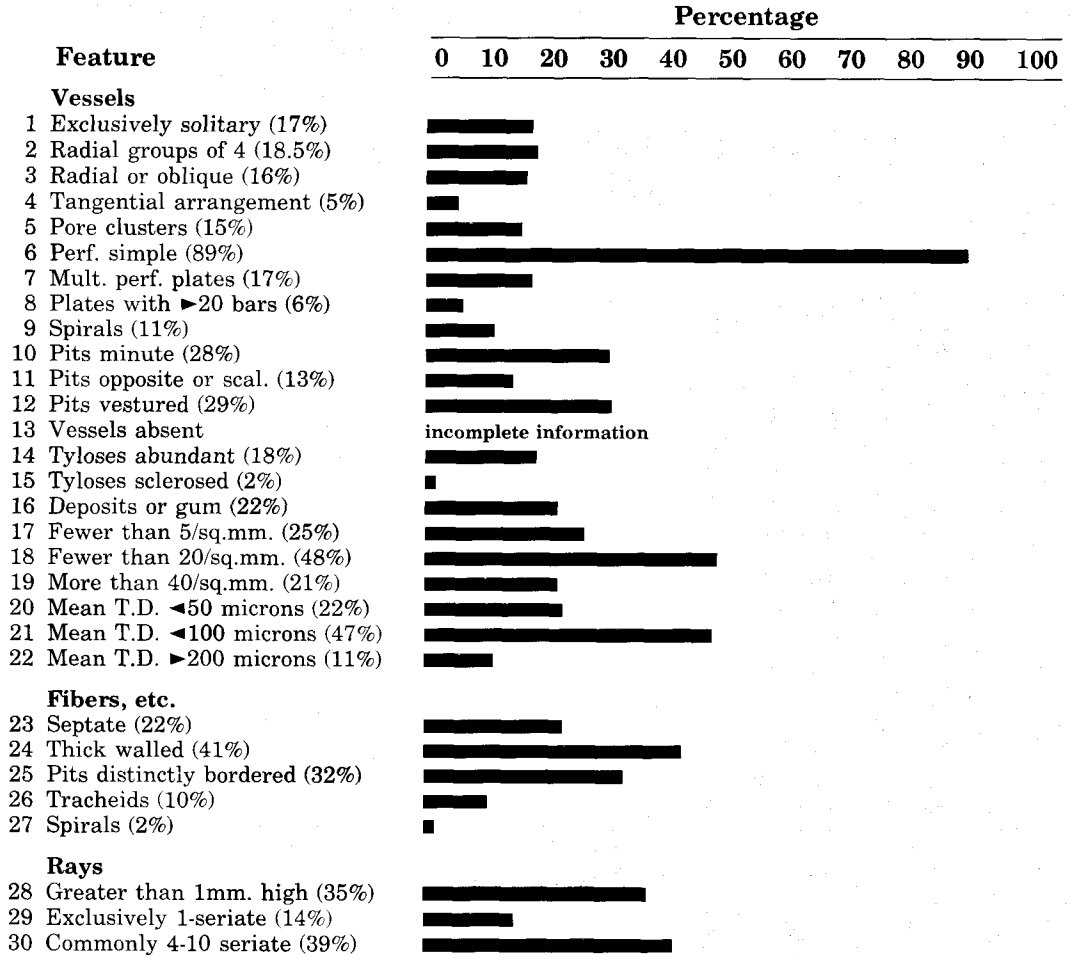
The success of any search depends on understanding the coded features. Before using the search program on the hardwood database, you should read this section carefully!

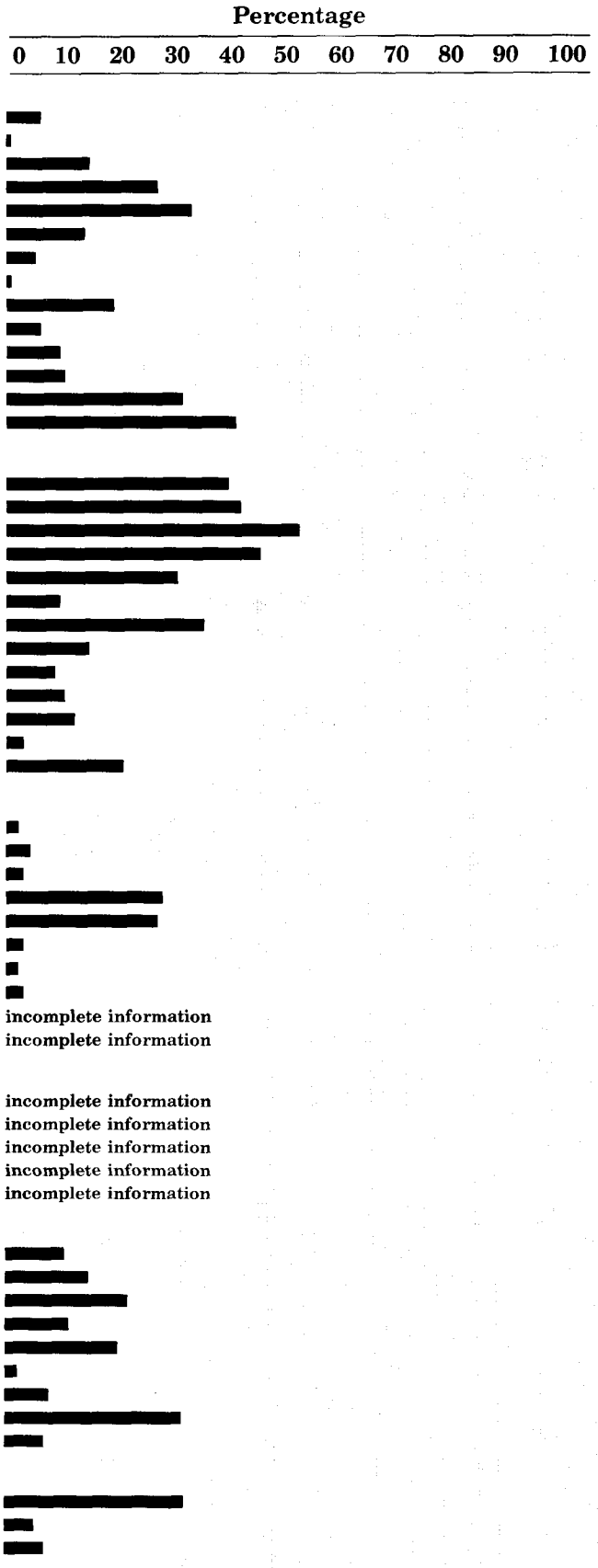
Describing an unknown hardwood generally requires using absence of features, so it is important to interpret the descriptors accurately and appreciate the use of combinations of present and absent features . This section assumes the reader has some basic knowledge of wood (secondary xylem) structure. The following texts are helpful resources: *Textbook of Wood Technology*, Panshin and deZeeuw, 1980; *Wood. Structure and Identification*, Core, Côté, and Day, 1979; *The Structure of Wood*, Jane, 1970; *Anatomy of Seed Plants*, Esau, 1977; *Explanation of Coding Procedure*, Miller, 1981.

Unless otherwise noted, the quotations in the definitions are from the *IAWA Multilingual Glossary* (IAWA Committee on Nomenclature, 1964)

Some features are more useful than others for generating a small list of matches because they occur in relatively few taxa. The following table shows the percentage of the database in which each feature occurs.

The percentages were computed for the October 1985 database—4080 entries. Because some entries represent more than one species and some species have more than one entry, this is not equal to 4080 species. The percentages for the features range from .8 percent (Feature 32—Aggregate rays) to 89 percent (Feature 6—Simple perforation plates).




Percentage
0 10 20 30 40 50 60 70 80 90 100
Feature
Rays (continued)
31 Greater than 10-seriate (6%)
32 Aggregate rays (1%)
33 Two distinct widths (14%)
34 Homocellular (26%)
35 4+ marginal rows (32%)
36 10+ marginal rows (13%)
37 2- or 3- ser. pts. nar. (5%)
38 Tile cells (1%)
39 Sheath cells (13%)
40 Canals or latex tubes (6%)
41 Storied (9%)
42 Fewer than 4/mm. (10%)
43 More than 12/mm (30%)
44 Pits: vessels large (39%)
Parenchyma
45 Predom. apotracheal (37%)
46 Diffuse (40%)
47 Predom. paratracheal (50%)
48 Vasicentric (43%)
49 Aliform or confluent (29%)
50 Parenchyma rare or absent (9%)
51 Banded (34%)
52 Bands 1-seriate (14%)
53 Bands more than 4-seriate (8%)
54 Bands more than 6/mm (10%)
55 Storied (12%)
56 Fusiform cells common (3%)
57 Marginal/zonate (20%)
Other Features
58 Included phloem (2%)
59 Vertical canals (4%)
60 Vert. canals tang. lines (3%)
61 Crystals: ord. cells (27%)
62 Crystals: cham. cells (26%)
63 Crystals: in idioblasts (3%)
64 Raphides or druses (2%)
65 Oil or mucilage cells (3%)
66 Silica
incomplete information
83 Shrub
incomplete information
Physical Properties
67 Distinct odor
incomplete information
68 Distinctive color
incomplete information
69 Splinters burns to ash
incomplete information
70 Density (A.D.) ◄ 0.4
incomplete information
71 Density (A.D.) ►1.0
incomplete information
Geographical regions
74 Europe, N. Asia (10%)
75 India, Pakistan, etc. (14%)
76 SE Asia, Malaysia (21%)
77 Australia, New Zealand (11%)
78 Trop. Africa & Madagascar (18%)
79 South Africa (2%)
80 North America (8%)
81 Cent. & Trop. S. Amer. (30%)
82 Temp. South America (7%)
Growth Rings
84 Distinct (31%)
85 Ring porous (5%)
86 Semi-ring porous (7%)

Summary of Feature Qualifiers

In the printed output certain letters appear **after** certain feature numbers. In the database, qualifiers (91,97-99) appear **before** certain feature numbers.

V(95) — variable feature, present in some samples of a species/genus and absent from other samples.

?(99) — indicates there is no information on whether the feature is present or absent. Features so coded will never be mismatches.

S(91) — 11S: intervascular pits primarily scalariform.
— 23S: septate fibers are scanty;
— 34S: rays exclusively square and upright cells;
— 48S: scanty paratracheal to vasicentric parenchyma;
— 51S: parenchyma bands scalariform.

O(92) — 11O: intervascular pits primarily opposite;
— 51O: parenchyma bands oblique.

R(93) — 61R, 62R, 63R, 66R: inclusions or oil cells in the rays;
— 64R: raphides, not druses, present.

A(94) — 61A, 62A, 63A, 65A: inclusions or oil cells in the axial parenchyma;
— 46A: parenchyma diffuse-in-aggregate;
— 47A: parenchyma unilateral (abaxial or adaxial) paratracheal;
— 49A: parenchyma predominantly aliform.

F(96) — 65F: inclusions or oil cells in fibers;
— 58F: foraminate included phloem;
— 80F: species grows in Florida.

T(97) — 9T: spiral thickenings at vessel element tips only;
— 40T: latex or tanniferous tubes;
— 59T, 60T traumatic canals.

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