The Identification of Eucalypts

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PREFATORY REMARKS

Identification of Eucalypts and the Practising Forester

This paper is concerned with the analysis of one major problem — the identification of the eucalypt. The treatment is botanical and detailed, though certain practical aspects have not been neglected.

Many important commercial eucalypts (possibly 100 species) are well-known, easily recognized and cause no problem to an Australian forester interested in their utilization. However he is often incensed and confused by the botanists who periodically announce a change of name for one of these trees.

This same forester, when confronted with the information in this paper, might well be discouraged by «botanical niceties» and wonder if botanists are not completely unpractical in outlook. An overseas forester may come to the conclusion that the eucalypts are so difficult to recognize that any seed with which he is supplied stands a high possibility of being wrongly named. This is far from the truth.

Many problem species or «forms» are of slight practical value, but this does not relieve the forester of his responsibility to know as much about the identity and variability of what he is growing as he knows of its timber and silvicultural characteristics.

Recognition of races of a species and provenance effects has great practical significance, as is known by many a forester who has seen the results of the use of unsuitable varieties of exotic pines in Australia : the use of material neither adapted to the new environment nor genetically capable of producing a good log.

No apology is made for treating the question in a botanical sense for, with an understanding of the nature of eucalypt populations, relationships of species and breeding mechanisms, the forester will be able; in many cases; to immeasurably increase forest productivity.

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I. INTRODUCTION

It is generally accepted that great difficulty is experienced in establishing the identity of many eucalypts. This problem is not confined to extra-Australian countries but is experienced by botanists, foresters and other workers who handle material in Australia. Not only herbarium specimens — but even mature trees in their native habitat may not be identified with certainty (Gardner, 1952 +).

In this paper the causes of the difficulties will be discussed, and reference made to recent work which has a bearing on identification. Suggestions are made for improving the situation in the future.

II. DEMARCATION AND DESCRIPTION OF PLANT SPECIES

Identification rests on observation of the characteristics of an unknown individual and a personal interpretation of previously recorded knowledge which delimits the taxons concerned. An original species-description must be based on an adequate sample of its constituent populations and should clearly delimit the species from closely related ones. This may prove to be difficult to achieve because of genetic diversity and intraspecific morphological variabilty.

The concepts of most species are too narrow at first. They change and embrace a greater range of variance of individual characters as knowledge of more and more populations is gained. Species are difficult to demarcate in a genus containing a large number of forms many of which extend over wide geographic areas. Furthermore, having decided that a particular population or group of populations does constitute a taxon, it may be a matter of personal appraisal as to whether the unit is a species, subspecies, race or variety.

These considerations are responsible for part of the confusion in both the taxonomy and nomenclature of the genus *Eucalyptus*.

III. VARIATION IN THE GENUS EUCALYPTUS IN AUSTRALIA

In considering problems of identification, it is illuminating to determine the degree of diversity displayed by the eucalypts.

The inherent variability within the genus is acknowledged to be very great. Blakely (1955) describes 522 species and 150 varieties (including hybrids) in this genus, sufficient proof of the extraordinary diversification which has been achieved through evolution of the eucalypts. What then is the nature and cause of this variability ? What part does it play in the problem of identification ?

Several kinds of variation can be detected in the eucalypts.

(A) *Limited Variability and Well-defined Species*

There are a good many species which can be recognized with no great difficulty, even though some of them might possess disjunct distribution and demonstrate ecotypic variation, e.g.

E. leucoxylon F. Muell (Pryor 1955a). Their natural variability does not produce individuals likely to be confused with other species. Many

of these biotypes possess especially distinctive features which make them exceptional among their closest relatives, e.g.

E. leucoxylon is a smooth-barked species among «ironbarks»;

E. planchoniana F. Muell. is an «ash» eucalypt with very large fruits;

E. melanophloia F. Muell. is an «ironbark» with leaves which are always opposite and sessile.

(B) *Genetic Variability and Mixed Populations*

(i) *Mutations*

Chance mutation accounts for rare occurrences of variants in otherwise normal populations and is not considered to cause significant complication in identification.

(ii) *Mixtures of «Forms» in Populations*

In the field some species demonstrate more than one form. For instance *E. melliodora* A. Cunn. populations in the Australian Capital Territory have both green-leaved and glaucous-leaved trees in the same stand. Mixed populations of this kind sometimes constitute part of a cline (Barber, 1955). In the Barrier Range area of New South Wales (Cleland, 1956), *E. camaldulensis* Dehn. displays two forms, each with a diferent type of operculum.

(iii) *Hybridization as a Source of Variation*

Many people have reported the occurrence of eucalypt hybrids, both in Australia and elsewhere e.g. Pryor (1950a, 1950b) and Jackson (1958). Curtis (1956 records sixteen combinations from Tasmania where only twenty-five species of eucalypts are now recognized. Pryor (1955) mentions combinations between. *E. viminalis* Labill. as one parent and eighteen different species of the Macrantherae (Normales) in South-eastern Australia, under natural or semi-natural conditions.

Hybridization occurs readily between species in closely related groups, the more closely-related the species concerned, the more likely will be the survival of the hybrids due to increased vigour and, possibly heterosis (Pryor, 1956b, 1957).

Eucalypts from widely separated sstematic groups apparently cannot hybridize, e.g. Renantherae and Macrantherae.

Complex hybrids involving more than two parent species have been recorded e.g. *E. rossii x dives x macrorrhyncha* (Pyor, 1952a), *E. rubida x macarthuri x viminalis* (Pryor, 1952b) and, as knowledge is being accumulated, the hybrid nature of more and more individuals and populations, once given specific rank, is being proved. For instance, Pryor (1953a) lists twelve probable hybrids between members of Terminales and Porantheroideae of Blakely (1955). These have been described as species or varieties.

In nature, hybrid eucalypts can occur as scattered individuals (often F_1 plants), as small groups and segregating hybrid swarms, or as unstable populations which are rather less variable than the swarms.

The common occurrence of this hybrid material has a most important effect on identification and taxonomy — much confusion exists in nomenclature as a result.

a. *F_1 Hybrids*

The characteristics of F_1 hybrids are usually intermediate between those of the parent species. This is so in the case of most diagnostic characters e.g. cotyledons (Pryor, 1956b), juvenile leaf shape and anatomy, adult leaf shape and anatomy, adult leaf shape and venation, as well as bud, anther shape, floral structure and fruit shape (Pryor, 1953a, 1957), features of the wood and internal and external bark characters (Pryor et al., 1956) (Chattaway, 1953).

Variation in the number of flowers in the inflorescence occurs in hybrids (Pryor, 1954). This author states «it seems it may be taken as a rule that the presence of three-flowered clusters in the basal position of a single shoot indicates hybridism» in individuals which usually have seven-flowered inflorescences. That is, the plant is a cross between some three-flowered and a seven-flowered parent species. Carr & Carr (1959b) modify this statement on P. 120.

Lignotubers (Pryor, 1957) and leaf oil composition and yield (Pryor and Bryant, 1958) are strongly inherited in eucalypts and are capable of recombination in hybrid material. This means that hybrid individuals, which have an appearance similar to non-lignotuberous parent species may, in fact, possess lignotubers. Another individual may have an oil of a different type to the parent it morphologically resembles. In view of the value of leaf oils in identification it is clear how confusion can arise from the fact that oil characters are much more variable in segregating hybrids than in either parent species. Pryor (1952b) suggests oil variability could, in some cases, aid survival of hybrid plants over one of the parents by being unpalatable to insects.

b. *Hybrid Swarms*

Segregating hybrid swarms have been studied by barber (1955), Binet and Clifford (1954), Brett (1937), Clifford (1955), Pryor (1953a, 1955a, 1955b), Pryor et al (1956), Pryor and Willis (1954).

The significance of these swarms to identification is clear. Barber (1956) says that the components vary «in all or almost all the diagnostic characteristics used in identification». Pryor (1951) demonstrates the segregation of a number of diagnostic characters in progeny from apparent F_1 hybrids found in the field. Though F_1 hybrids posses characteristics in the main intermediate between the two parents, the later segregates show a great deal of variability, but, in relatively undisturbed natural communities, many of these individuals are unable to exist in the competitive environment, being themselves of low vitality.

Habitat differences sort out the hybrid material and on each type of habitat favour the ones most like the species already present.

Why then are eucalypt hybrids so common in the Australian vegetation ?

Since man has inhabited Australia he has brought about disturbance of the natural communities, frequently producing conditions of reduced ecological pressure under which hybrid seedlings can grow into mature trees.

Mass regeneration from seed on cleared or abandoned country frequently includes hybrid individuals, identified mainly in the young stages, by variation in juvenile leaves. Widespread destruction or modification of natural vegetation by burning (or even by protection from burning) has been responsible for the persistence of hybrid individuals too, and it is not uncommon to find comparatively young segregates alongside fence-lines, roads, and clearings for power-lines, etc.

In natural communities the hybrids occur along junction lines or intermediate zones between different associations which contain species which can hybridize if brought in contact. The species are usually reproductively isolated by ecological factors (Pryor 1953b). Disturbance along the boundaries often produces swarms or segregating populations of allows active spread of previously existing swarms. For instance *E. x rariflora* Bailey in south east Queensland. This population is a hybrid swarm resulting from the crossing of poplar box (*E. populifolia* Hook.) and narrow leaf ironbark (*E. crebra* F. Muell.) and is very common. A great variety in habit, bark type, leaf shape and colour is displayed in these swarms. The two species, *E. pilularis* Sm. and *E. planchoriana* provide a similarly variable hybrid population in a less-disturbed area in northern New South Wales (between Grafton and Coffs Harbour). In this instance the site is extremely poor, the underlying rock a conglomerate, and there is little competition from understorey layers after fire. This may have allowed the hybrids to survive in spite of reduced vigour.

The number of individuals and degree of variability in hybrid swarms of this kind seem to vary considerably.

c. *Other Unstable Populations*

Certain so-called species form unusually variable populations in some areas. They differ from hybrid swarms in that the degree of difference is at a lower level. The situation suggests that a population has been evolving from a mixed origin — but has not yet achieved the relative stability of a species. Such seems the case with *E. vitrea* R. T. Baker in South Australia. This form shows considerable variation in leaf characteristics; size, texture and venation; suggesting that a «peppermint» and a «snow-gum» have been involved in producing the instability. Yet the snow-gum is no longer present in the vicinity. Climatic changes, as mentioned later in this paper, could produce this situation, eliminating the snow-gum from the locality providing a habitat suitable for the survival of hybrid material. A new species has almost evolved. *E. dalrympleana* Maiden is similarly variable in Tasmania (Brett 1937) and in the A.C.T.

Hybridization creates important problems in eucalypt identification and nomenclature in Australia, but this is by no means the only difficulty. Changing environments produce genetic and phenotypic differences in species.

(C) *Genetic Variability and Graded Populations (Clines)*

Clinal variation develops as a result of selection of adaptive characteristics along some ecological gradient. Individuals chosen from distant positions along the cline are so unlike as to be assigned to different species. When intergrading forms are found at a later stage, difficulties in taxonomy and nomenclature develop.

Incorrect delimitation of species results from incomplete field knowledge, from lack of understanding of genetical constitution of the populations and from fragmentary sampling of the minor taxa constituting the species. The importance of selection is stated by Barber and Jackson (1957) thus — «Selection itself will create genetic diversity in the local populations of different habitats or micro-habitats.» If the variation in habitats is gradual, then clinal variation will result.

A number of authors have described clines in eucalypts in relation to changes in altitude, frost activity, aridity and latitudinal effects. Gradation in leaf size, fruit size, bark thickness, tree height and seedling growth-rate were found in altitudinally distinct populations of *E. pauciflora* Sieb. (Pryor, 1956a). This author suggests a number of Blakely's species and varieties should be reclassified as «cline forms» of *E. pauciflora*. Barber (1955, 1956) gives examples of clinal variation of glaucousness which he ties to frost activity. He finds parallel clines associated with the distribution of eight species out of a total of twenty-five Tasmanian eucalypts. Again, Barber 1956) Barber and Jackson (1957) show clines can involve the shape of juvenile and adult leaves, stem surface and phenological characters. Variation bridges the gap between the two species *E. urnigera* Hook. f. and *E. johnstoni* Maiden.

This leaves no doubt of the importance and frequency of this kind of variation in the genus.

(D) *Genetic Variability of Disjunct Species*

(i) *Nature of Discontinuous Variation*

A good many species occur in a disjunct pattern over a considerable range of environmental conditions. Some eucalypts of this kind spead across the northern part of Australia (*E. jensenii* Maiden, *E. aspera* F. Muell, *E. herbertiana* Maiden, see Blake (1953) and others e.g. *E. umbra* R. T. Baker, and *E. resinifera* Sm., extend from Atherton to Sydney, a north-south distance equal to 17° of latitude. The separate populations are fragments of larger parent populations, which were disrupted by environmental changes. Since isolation, the different fragments have developed under widely differing conditions and selection has produced a number of distinct races or ecotypes, e.g. *E. alba* Reinw. (Blake, 1953).

Apart from the action of selective mechanisms, a number of disjunct populations, differing from the parent ecotype in mean and variety of characteristics, could arise by genetic drift in small population fragments.

Somentimes races may overlap or there may be short gradations connecting certain populations. This latter case could be clinal, or the gap might be bridged by intraspecific hybridization as mentioned by

Gardner (1952+) in the case of the highly variable *E. oleosa* F. Muell. Gardner divides *E. oleosa* into six varieties whereas, in previous literature, four specific names, *E. longicornis* F. Muell., *E. transcontinentalis* Maiden, *E. kochii* Maiden and Blakely, *E. grasbyi* Maiden and Blakely, were involved. Referring to difficulties of identification in this species the author says — «There are six more or less distinct forms of *Eucalyptus oleosa* in Western Australia which can, in general, be recognized in the field. With some of them variations exist and we also find connecting forms which are perhaps hybrid in origin and confuse even the experienced botanists». This problem is not uncommon in eucalypts.

Where the ecotypes are morphologically (and genetically) quite distinct, «subspecies» might be appropriate.

(ii) *Climatic History and the Development of Eucalypts*

There is good evidence to suggest that Australian climatic and erosional history has had a significant effect on a great number of eucalypt species, being responsible for much of the variability found in present day forms (Crocker, 1959 and Blake, 1953). Significant fluctuations of temperature and rainfall have been widespread in the past, sometimes allowing active colonization of new habitats, sometimes severely restricting species and all but annihilating others. Remnants were left in scattered refuges, some persisting in this way to this day, e.g. *E. nesophila* Blakely, (Blake, 1953).

Movements of species outwards and inwards from refuge areas have brought together unusual assemblages of species in some areas, species which do not normally grow together. One such region exists in the country west of the Darling Downs in Queensland. Here the coastal species *E. carnea* R. T. Baker, *E. hemiphloia* F. Muell. ex Benth., *E. punctata* DC. and *E. maculata* Hook., intermingle with the inland trees *E. polycarpa* F. Muell., *E. bloxsomei* Maiden, *E. camaldulensis, E. racemosa, E. dealbata* A. Cunn., and *E. exserta* F. Muell. Another unusual species here is *E. melliodora,* which occurs only as outliers this far north. Some of these ecotypes are quite unlike the main occurrences of the species elsewhere.

It can be imagined how much opportunity there has been to introduce variability into the genus from the type of environmental instability involved. The bringing together of closely related species which are normally reproductively isolated from one another occurs under the above conditions. Hybridization is then a potent source of variation as is demonstrated by the representatives of the «redgum group», the series «Exsertae». One such instance is referred to by Cleland (1956), and involves the hybridization of *E. blakelyi* Maiden, *E. tereticornis* and *E. dealbata* each with *E. camaldulensis.*

(E) *Non-genetic Variation*

(i) *Variations on Single Individuals*

Even on single individuals some diagnostically valuable features vary a great deal. For instance, the number of flowers in the inflores-

cence varies on the same tree. Blake (1953) says «in many instances the range of variability between different parts of the same individual may be but little less than the supposed variability of the species». He is here referring to species in the north of Australia, where conditions are complicated by annual burning and crown destruction in the eucalypt dominated communities. Identification difficulty arises when collection of atypical or incomplete material is made from such trees.

(ii) *Variations Between Individuals of a Biotype*

Response to differences in environmental conditions is responsible for considerable variations between individuals of a species. This is particularly so in young plants. Leaf size and leaf retention seem very sensitive to soil moisture and fertility levels. When transplanted, these differences may disappear.

IV. THE PROBLEM IN AUSTRALIA — THE HUMAN ELEMENT

(A) *Confusion in Taxonomy and Nomenclature*

An enormous amount of time has been devoted to the study of eucalypts by many workers in a variety of fields, yet the problem of identification has not been satisfactorily overcome. The large number of people involved has, in itself, helped to create difficulties.

Workers at different times and locations have studied similar material. Their interpretations of taxonomic status have often deviated. More than one specific name has been bestowed on many a species of eucalypt. Consequently name changes are often recommended, further confusing the issue, particularly when well-known and long-applied names are involved.

Some species have been created on fragmentary and unrepresentative material. Their characteristics are still not fully known and others have been described with no real knowledge of their field occurrence, ecology and relationships to other forms. It is inevitable that this should have happened but the thought makes identification no easier.

The gigantic task entailed in finding, studying in the field, collecting, describing, classifying and nterpreting the relationships of some 600 forms of one genus from all over a continent the size of Australia can only be completed by many workers. Much has been accomplished but a great deal of research remains to be done.

Confusion arising from a multiplicity of scientific names is matched by the variety of vernacular names applied to the eucalypts. The species recognize no state or district boundaries, but the local people pin their own labels to the trees. Many names are misleading, they may suggest some scientific relationships with other species, but more often than not such relations do not exist. Beware of interpreting taxonomic position of any species from its vernacular name. For instance, the «narrow leaved grey gum» (*E. seeana* Maiden) is not in the «grey gum group» — the series Pelliculares — but is one of the series Exsertae i.e. the «redgum-group». The red gum *E. tereticornis* Sm. is called «blue gum» in Queensland but the «blue gums» of south eastern Australia may be

either in the Transversae (e.g. *E. saligna* Sm. the «Sydney blue gum») or in the Globulares (e.g. *E. globulus* Labill. the southern blue gum). Nomenclatural problems of this kind have bred uncertainty amongst those who have worked with eucalypts.

(B) *Blakely's «A Key to the Eucalypts»*

A newcomer to the field of eucalypts is faced with the lack of a complete key with clear-cut means of identifying his «unknowns». The title, «A Key to the Eucalypts», of Blakely's (1955) work is quite misleading. Problems posed by this work are mentioned in Penfold and Willis (1961) pp. 82-84. Though the latest edition includes valuable descriptions of all but a few of the species and varieties ever discovered, it is impracticable as a key. The anther characters on which the primary division of the genus is based are too difficult to interpret and have, in certain cases, proved to be quite artificial, cutting across the true phylogenetic units e.g. Bisectae (Pryor, 1956b). At various points in the «Key», species and varieties cannot be conclusively separated because differences in the same characteristic have not been employed.

Blakely's work is of greatest value when used in conjunction with Maiden's (1909-1933) eucalypt drawings.

When studying the descriptions of closely-related species in this book, it is apparent that words themselves are inadequate to make clear the small differences which separate the taxa concerned. This suggests that a number of those eucalypts described as species should be given a lesser rank. Blake (1953), C. A. Gardner (1952+) and others have reached this conclusion and are in favour of reducing the number of species. The creation of an unnecessarily large number of species in this genus can be attributed to incomplete knowledge of field occurrence and variation, inability to recognize hybrid material in the absence of progeny tests and the desire to give everything, that is different, a name. In the eucalypts the «fixity of the species» is far from real. An identification is frequently based on carefully considered evidence of a conflicting nature, due to the inadequacy of the original descriptions to cover the full range of variation in the species and the human «failing» to be particularly attracted by the unusual when sampling a population.

VI THE PROBLEM OVERSEAS — EUCALYPTS EXOTICS

A high proportion of species of eucalypts have been planted overseas both in plantations and as ornamentals. In order to make the best use of the introduction of the genus to new localities it is essential to have planting stock correctly identified. Should a provenance of a species be particularly successful, or another one fail, little use can be made of the results the origins of the materials are known. Considerable responsibility rests on the shoulders of the seed supplier and collector.

Identification of much material from outside Australia has proved to be difficult and, if anything, the problem is greater in this case than when handling specimens from most Australian-grown trees.

Identification is likely to be uncertain because of the following points :

(A) *Eucalypt Response to New Environments*

Eucalypts as exotics are often introduced to new types of environment and changes in phenotypic response occur on a significant scale. The absence of natural enemies, the greater fertility of sites, cultivation, lack of competition and more favourable moisture regimes produce increased growth, larger, thinner leaves and drooping branches. Even bark characteristics are probably affected a good deal. Absence of burning (which is common in many Australian stands) would further modify growth.

(B) *Hybridization*

Species and varieties, closely-related yet normally isolated from one another, are brought into contract. If flowering periods overlap and the forms are compatible, hybridization will result. In view of the common occurrence of natural hybrids and ease with which artificial crossing is produced in the genus, it is not surprising that hybrids have been recognized overseas, e.g. *E. x favieri* (Chevalier, 1951). Also see Giordano, 1960a, 1960b.

(C) *Survival of Weaker Individuals*

Under systems of clean-tending and wide-spacing. all individuals in plantations are given a good chance of survival. Weak, abnormal and hybrid individuals persist in these environments though they would die at an early age in the natural state.

(D) *Physiological Response, an Aid to Identification ?*

Separation of exotic plants into different species, based on distinct physiological behaviour, may be tempting at times, particularly if there are changes in morphology associated with the varying responses. However, when it is seen that great differences in frost sensitivity (for instance) occur in separate populations of the same species (Boden, 1958) it is obviously unwise to use these features without careful consideration being given to other taxonomically significant characters.

(E) *Problems of Origin*

Incomplete, or inaccurate records of seed origin increase the problem. The whole field of eucalypts must be studied before an identification can be made but if the natural geographic origin is authentic, many species can be eliminated from consideration. Incorrectly identified seed, mixed seed and seed of hybrid origin can, and have, added to the general confusion.

Having attempted identification of overseas herbarium material, the author is convinced that the above circumstances all play a part. Incomplete and badly-chosen hand specimens supported by insufficient data on bark, habit and other gross features make correct identification less likely.

VI. CURRENT METHODS OF IDENTIFICATION

(A) *Features Host Useful in Identification*

Eucalypt identification is based on the combination of a considerable number of morphological features, many of which demonstrate a significant range of variability within a species.

A successful naming based on a sigle character is possible in a few species of extraordinary nature (e.g. operculum of *E. erythrocorys,* fruits of *E. lehmanni* Preiss and the fruit of *E. tetraptera* Turcz), but this is all too rare.

Each characteristic may be valuable or otherwise when fixing the identity of a particular eucalypt.

Features of widest use are discussed below and they are not listed in order of greatest value.

Habit — The size and shape of species is of considerable use, particularly when plants of unusual size (giant eucalypts e.g. *E. regnans* F. Muell *E. diversicolor* F. Muell.) or peculiar life-form (mallees, e.g. *E. kybeanensis* Maiden and Cambage) are involved. Size and shape, however, are subject to environmental changes of considerable magnitude, so much so that there are species which may occur as trees or, under different conditions, as mallees e.g. *E. marginata* Sm., *E. oleosa* and *E. dumosa* A. Cunn. Gardner (1952+).

Crown shape, density and colour vary according to the severity of insect attack in Australia. Some mature trees (e.g. *E. rubida* Deane and Maiden) may be entirely clothed in juvenile leaves after recovering from complete defoliation. Exotic-grown specimens should be identified primarily on other features.

Bark — The diversity of bark-type plays an important role in identification. Persistence, structure, colour, sculpturing and mode of decortication are all useful details which are generaly characteristic of a species and sometimes of a group e.g. «stringybarks», «ironbarks», «boxes». Care must nevertheless be exercised since anomalous bark types do exist in nearly all groups. This anomalous bark-type plus one or more features of group significance may really simplify identifications of certain species, e.g. *E. citriodora* Hook. is a smooth-barked «bloodwood» with lemon scented oil, *E. exserta* is a «redgum» with a persistent bark, narrow leaves and typical «redgum» fruits. Sometimes abnormal barks are seen in a species, due perhaps to an unhealthy condition or parasitic attack. *E. melliodora* often has extremely rough and dark coloured bark on the trunk and larger branches. Trees of this type may be grouped together or scattered through an otherwise normal stand.

The degree of persistence of rough bark on the trunk and branches can be most useful in separating some, otherwise rather similar species. For instance *E. gummifera* Gaertn). Hochr. has clean smaller limbs, *E. intermedia* R. T. Baker, is rough barked to the twigs.

It is well to remember that young, fast-grown trees may exhibit very different bark to the mature individuals e.g. *E. sideroxylon.*

Glaucousness — Barber (1955, 1956) says glaucousness «is of great diagnostic importance in the morphological definition of species in numerous groups of eucalypts.» In his papers, however, he shows that, within species, considerable variability exists with respect to this character. Clinal and other kinds of variation are involved, and less glaucous forms are likely to occur in more protected natural environments.

Leaves — Nearly all eucalypts have strongly dimorphic foliage, some are highly heterophyllous. Leaf characteristics (shape, size, colour, insertion, orientation, structure vary as an individual grows from a young seedling to a mature tree. Cotyledons, seedling leaves, juvenile, intermediate and adult leaves commonly differ in the one species. Although there is much environmental control over size and other features of leaves, the juvenile and intermediate types are most significant aids to identification. The juvenile types of leaves are commonly borne on epicormic shoots in the crown or on the trunk of damaged eucalypts, so are frequently available. Cotyledons have proved of value in taxonomic studies. A major fault in Blakely's (1955) arrangement of species is cleared up by grouping together species possessing deeply biseted cotyledons i.e. «Bisectae» (Pryor 1956b).

In adult leaves, and sometimes in more juvenile types, the venation, oil-dot pattern and oil composition (as judged by smell and stickiness) are very valuable. A number of conditions are confined to certain eucalypt groups and it is often possible to separate a species from a number of other possibilities by these features alone. Blake (1953) has stressed the value of the number of pairs of lateral veins and the ratio of length to breadth of leaves in species comparisons. These features are less responsive to environmental changes than its leaf size and work could be done on these characters in the more difficult groups of species.

Seedling leaves, the first few pairs above the cotyledons, are of little use. They do not persist for long and show a limited amount of variation.

Inflorescence — The structure and number of buds in an inflorescence can be useful criteria for identification. Some «groups» usually have corymbose types («Bloodwoods» — Corymbosae), the «boxes» and «ironbarks» commonly have paniculate inflorescences and most other «groups» have umbels. Should a species have solitary flowers or flowers in groups of three, identification is greatly simplified. The «southern bluegums» (Euglobulares) are separated in this way. A good many Renantherous species have a high number of flowers in an umbel i.e. over seven.

Buds — In buds, the nature of the operculum and the ratio of its length too that of the calyx tube are the most important features. Buds of many different species look rather alike, particularly within the larger groups. However, a number of species have very characteristic buds (warty and large in *E. globulus* and *E. bicostata* Maiden, Blakely and Simmonds, scarlet operculum in *E. erythrocorys* F. Muell. and an abruptly narrowed, beaked operculum in *E. camaldulensis*.

Flowers — Subdivision of the genus on the basis of floral morphology has been employed in Blakely's (1955) arrangement of species. The nature of the anther is an important phylogenetic character, but difficulty is experienced in recognizing the above author's anther types. From an identification point of view it is impracticable to use any the simplest division on this basis, and, because of the absence of flowers for extended periods, it is usual to fix the identity of a specimen or tree in the field by means of a combination of other features. A number of species have exceptionally beautiful or large flowers which characterize the species e.g. *E. torquata,* J. G. Luehm. *E. woodwardii* Maiden, *E. macrocarpa* Hook., *E. ficifolia* F. Muell., *E. caesia* Benth. In the «boxes» and «ironbarks» a division into Sections «Porantheroideae» and «Terminales» is made on the fertility of the stamens — the latter section having an outer ring of infertile stamens present. This feature can be useful in separating some ironbarks (*E. paniculata* Sm. and *E. drepanophylla* F. Muell.).

Fruits — Eucalypt capsules are invaluable when determining species and lower categories in the genus. In spite of the relatively small size of a great number of them, there is extraordinary diversity in overall shape, nature of the disc, valves and calyx tube. Many a species is in doubt until fruits are available for study. This arises from the common occurrence of sequences of species or varieties — i.e. in the same «group» (Series or Subseries) — which show an increase in fruit size as their major distinction. For example, the «grey gums» *E. propinqua* Deane and Maiden, *E. major* Blakely, *E. punctata* DC., and *E. canaliculata* Maiden show increasing fruit size in that order. Fruits are little subject to changing environment. Great importance, therefore, is placed on the carpological characters.

Lignotubers — The presence or absence of lignotubers is characteristic of the species. Though they are lacing most often in the «ash group» (Series «Fraxinales»), some species in unrelated groups are also non-lignotuberous, e.g. *E. grandis* (Hill) Maiden of the «Transversae» and *E. camaldulensis* of the «Exsertae».

The «Eucalypt Groups» and Anomalous Characters

Throughout the eucalypts, closely-related species are seen to have a number of characteristics in common. It is therefore possible to form «groups» of species (maybe differing in actual taxonomic status) but of phylogenetic significance nevertheless. The «groups» often correspond to Blakely's «Series» or «subseries».

This type of arrangement of the eucalypts assists a worker to organize the extraordinary complexity of diagnostic characteristics in a useful way, aiding the memory and facilitating identification. When identifying unknown eucalypt material, either in the field or in the herbarium, there is many an enlightening idea which springs from the practice ium, there is many an enlightening idea which springs from the practice of considering eucalypts as components of these «groups» : studying the similarities and differences between groups and between the species within the categories. In all groups certain sharp deviations from the

characteristic features are found. Anomalous bark structure is not uncommon, e.g. *E. exserta* is a rough-barked member of the «red-gum group». Again, urceolate fruits are normally found in the «bloodwood group» (Corymbosae), but both *E. urceolaris* Maiden and Blakely (Renantherae) and *E. urnigera,* a «mountain gum» (of Macrantherae) have this type of fruit shape. This emphasizes the need to *use as many characters as possible when making an identification.*

In the book «Forest Trees of Australia» (F. & T. B. 1957) certain of these groups are mentioned, but, as yet, there is no complete account of the groups and their characteristics available. In australian literature (e.g. Anderson, 1956) reference is often made to the «boxes», «ironbarks», «peppermints», «gums», etc. These names may refer to phylogenetic groups but, more commonly, they allude to convenient collections of species which have a common bark-type and are used for the construction of keys. The author of this paper envisages the use of taxonomic groups based on a combination of characters as a starting point for building up a deep and useful knowledge of the eucalypts.

(B) *Aids Available for Assisting Identification*

Few attempts have been made to produce a coverage of the whole genus for purposes of either taxonomy or recognition. This is not surprising when the size of the task is considered. Most botanists are more than fully employed on work involving the flora of a single region or state, their knowledge of the eucalypt flora of Australia, as a whole, is limited.

Though considered to be out of date in some respects (arrangement, classification and nomenclature of certain species) Blakely's (1955) «Key to the Eucalypt» brings together descriptions of all known species at the time. In this alone the book is invaluable. As pointed out previously, *it is not a key* and separation of species and varieties is very difficult at a number of points in the book. Taken in conjunction with Maiden's (1909-1933) illustrations, where referred to in Blakely's text, identification is simplified in many cases. With this in view the Commonwealth Forestry and Timber Bureau published a leaflet containing illustrations of the buds and fruits of most species. (F. & T. B., 1959).

Hall and Johnston (1954) produced a complete coverage of the genus (638 species and varieties) in their card sorting key which has some distinct advantages over the usual dichotomous botanical keys. In particular, it is neither necessary to understand the taxonomy of the genus, nor is it essential to have complete material of the species requiring identification. Of course, the less complete or uncharacteristic the available material happens to be, the more doubtful may be the name selected by the cards. With reservation in the preceeding paragraph reference to Blakely's standard descriptions should settle most problems at the final stages of sorting. Because of the uncertain state of eucalypt taxonomy and nomenclature, careful checks should be made of any card sorting identification. As it stands this key is too bulky for field use.

On a regional scale, keys to indigenous species are used. In Australia there are the following :

New South Wales (Anderson, 1956), Victoria (Ewart, 1930),
Tasmania (Brett, 1937 Curtis, 1956), South Australia (Black 1952 (*),
Burbidge, 1947) South Western Australia (Blackall, 1954),
Northern Australia (above lat. 20°S.) (Blake, 1953),
Australian Capital Territory (Burbidge, not yet published).

Overseas, several authors have published keys to the eucalypts grown in individual countries :

New Zealand (Hall, 1934-5), Italy (Moggi, 1960)
Portugal (Goes, 1960), South Africa (Marsh, 1939) and
Morocco (Metro, 1954).

Other more recent publications which aid identification deal with selections of eucalypts. A general Australia-wide selection of sixty-seven species of forest trees has been prepared by the Forestry and Timber Bureau (F. & T. B., 1957). (Gardner 1952) and Blake and Roff (1958) cover some trees of Western Australia and south eastern Queensland (38 spp.) respectively and included in Penfold and Willis (1961) monography are descriptions of 150 species. Although no keys are included in these works, the illustrations and descriptions are helpful. Gardner's drawings are a particularly fine collection.

«Os Eucaliptos em Portugal» (Goes, 1960) is an illustrated monograph containing descriptions of ninety species.

Comparison with authentic herbarium specimens is the surest means of establishing the identity of an unknown. In Australia there are State government herbaria and a collection at the Commonwealth Forestry and Timber Bureau, Canberra. Certain other institutions such as the C.S.I.R.O., the Waite Institute (South Australia) and the Universities have their own collections. In some cases, many of these specimens have been identified and signed by W. F. Blakely. Overseas enquiries (regarding the identity of eucalypts) are welcomed by the Forestry and Timber Bureau at Canberra.

VII. RECENT WORK BEARING ON IDENTIFICATION

In the past, extensive field-collecting and work in the herbarium have uncovered a great number of eucalypt forms. A partially incorrect and impracticable arrangement of these taxa has been produced. The development of an awareness of the importance of population genetics has resulted in a much better understanding of the status and relationships existing between eucalypts and the taxonomic situation is rapidly improving. The significant research in this field has been referred to all through this paper.

The Australian work carried out by Pryor, Barber and others such as Jackson 1958), has been supported by data from overseas (Ruggeri, 1959; Giordano, 1960a, 1960b; and Chevalier, 1951) all helping to unravel some of the most confusing aspects of field variation in eucalypts.

In addition, studies of seed structure (Gauba and Pryor, 1958, 1959) and floral morphology (Carr and Carr, 1959a, 1959b) have elucidated a number of problems, indirectly assisting in the recognition of species.

(*) Black, J. M. (1952) Flora of South Australia III, Govt. Printer, Adelaide.

Several workers have studied the morphological characters of seeds (Grose and Zimmer, 1958) and seedlings (Floyd, 1960; Zingier, 1959), each confining their attentions to a limited range of species.

VIII. RECOMMENDATIONS FOR THE FUTURE

The widespread use of eucalypts as exotics makes problems of identification and nomenclature of considerable importance. In order to improve the existing, unsatisfactory position several things can be recommended for immediate consideration.

(A) *An Australian National Eucalypt Herbarium and Research Organization*

The establishment of a national organization specializing in eucalypt identification should be considered. With adequate funds and an expert staff available, work would embrace the fields of taxonomy, morphology, variation and genetics of the genus.

Primarily the establishment would obtain and disseminate general information about the nature and propagation of the eucalypts. Studies of the field occurrence of geographic races, their environmental requirements and adaptability would furnish valuable data of the kind required, and would lead to a better understanding of the taxonomic status of the different populations encountered, the basis of accurate identification.

Extensive field-collecting and study of progenies of known origin could be used to build up a practical means for identifying eucalipts at all stages from the seed to the mature tree.

Co-operation with existing State and Commonwealth organizations could simplify the tasks involved.

(B) *Overseas Herbaria*

As recommended by De Philippis (1960), herbaria should be set up in all major eucalypt-growing regions. The establishment of one herbarium in the Mediterranean Basin is a starting point. One function of the Australian National Herbarium would be to forward authentic specimens of Australian material to these herbaria.

(C) *Material for Identification*

Emphasis is placed on the necessity for despatching complete and representative herbarium material, when identification is required. Careful notes of habit, crown-condition and bark should accompany the specimens, and the value of juvenile and intermediate leaves should not be overlooked. If the origin of the seed is known it should be farwarded as well.

(D) *Seed Certification and Records of Origin*

It is recommended that all people engaged in seed collection, seed distribution, establishment of plantations and field collection, should maintain full and accurate records of the origin of all material handled. Provenance is vital to the best use being made of eucalypts. Certification

of seed as to origin should be demanded by buyers and widespread use of international seed certification, as recommended for forest tree seed (F. A. O.), should be implemented immediately.

(E) *The Blakely Numbers — a Precaution*

Finally, a note of caution is sounded. It is common practice to refer to individual eucalypts by the «Blakely numbers» (Blakely, 1955). Though a useful reference system for locating species descriptions in Blakely's book, this numerical order is misleading when used to place species in any form of list. Current research shows that closely-related species may occur at widely-separated positions in the numerical arrangements and the numbers, in many cases, suggest relationships which do not exist in fact.

A new classification of all species is urgently needed. This will place species into their natural «groups» and aid identification.

L. D. Pryor and L. Johnson are at present engaged in the preparation of a rearrangement of Blakely's species and, when published, this will be a most important advance in our knowledge of the eucalypts.

The establishment of a National Eucalypt organization in Australia, as recommended in this paper, would provide the necessary stimulus and work conditions to remove much of the present confusion surrounding the identification, taxonomy and nomenclature of the genus *Eucalyptus*.

This National Eucalypt Herbarium would thus make it possible to fulfil the recommendation of the First World Eucalypt Conference — namely that :

> «The Conference deemed it expedient that the classification of the genus *Eucalyptus* be revised by a team of Australian botanists and forestrs...»

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L'IDENTIFICATION DES EUCALYPTUS

Résumé

On éprouve une grande difficulté en identifiant plusieurs eucalyptus. Des descriptions originales insuffisantes d'espèces ou la démarcation de diverses taxas out causé des difficultés pour la taxonomie et la nomenclature. Une variabilité inhérente des eucalyptus cause de grandes difficultés dans l'identification.

La variabilité de la population est due à la mutation (un évènement rare) le recouvrement de deux "formes" ou plus, peut être des parties d'une "cline", etc.

Vu la grande importance économique des eucalyptus, il est recommandé que :

1. Le matériel rassemblé pour l'identification soit aussi complet et représentatif que possible — bien appuyé de notes sur les coutumes, écorce, etc.
2. Les herbiers d'outremer soient établis dans les principales régions où l'on cultive l'eucalyptus.
3. Un Herbier National Australien pour les Eucalyptus soit établi. Que cette institution soit un centre de recherches sur l'eucalyptus et s'occupe des demandes de toute sorte venant d'outremer, et de la distribution de semences certifiées.
4. La certification des semences sur des bases internationales, comme suggéré par la F.A.O. pour les "semences forestières", soit instrumentée, et les régistres d'origine des semences soient soigneusement tenus pour toutes les plantations commerciales.

LA IDENTIFICACIÓN DE LOS EUCALIPTOS

Resumen

Haâ grand dificultad en la identificación de muchos eucaliptos. Las descripciones originales de las especies no satisfactorias o la demarcación de muchos taxones han causado problemas en taxonomia y nomenclatura. La variabilidad inherente en el eucalipto causa muchas dificultades en identificación.

La variabilidad de población ocurre por mutación (de ocurrencia rara), superposición de dos o más "formas", talvez partes de una variación climal, etc.

En virtud de la gran importancia del eucalipto, se recomienda :

1. El material cogido para identificación debe ser lo más completo y representativo posible bien apoyado por sus anotaciones sobre sus hábitos, corteza, etc.
2. Deben establecerse herbarios en las regiones principales de ultramar de cultivo del eucalipto.
3. Un Herbario Nacional Australiano para Eucalipto debe ser organizado. Esta institución sería el centro de pesquisas del eucalipto, que atenderia las consultas de ultramar de toda clase y también la distribuición de semillas certificadas.
4. La certificación de semillas sobre base internacional, como fué sugerido por la F.A.O. para "semillas de árboles forestales" debiera ser implementada y los registros de origen de la semilla cuidadosamente guardados para plantaciones comerciales.

A IDENTIFICAÇÃO DOS EUCALIPTOS

Resumo

Experimenta-se grande dificuldade na identificação de muitos eucaliptos. Descrições originais pouco satisfatórias das espécies ou demarcação de vários "taxa" criaram dificuldades na taxonomia e nomenclatura. A variabilidade inerente causa a maioria das dificuldades na identificação.

A variabilidade de população é ocasionada por mutação (ocorrência rara), sobreposição parcial de duas ou mais formas, talvez partes dum grupo ecológico, etc.

Em vista da grande importância econômica dos eucaliptos, recomenda-se :

1. Que o material coletado para identificação seja tão completo e representativo quanto possível — bem complementado por anotações sôbre os hábitos, casca, etc.
2. Que sejam estabelecidos herbários ultramarinos nas principais regiões em que se planta o eucalipto.
3. Que seja fundado um Herbário Nacional Australiano do Eucalipto, e que esta instituição seja um centro de investigação do eucalipto que atenda consultas de todos os tipos e distribua sementes certificadas.
4. Que a certificação de sementes em bases internacionais, tal como é sugerida pela FAO para sementes de árvores florestais, seja terminada, e que os registros de origem das sementes sejam em seguida cuidadosamente mantidos para tôdas as plantações comerciais.