Conservation Science W. Aust. 4 (3) : 1–9 (2002)

The role and relevance of taxonomy in the conservation and utilisation of Australian *Acacias*

BRUCE R. MASLIN[1]

[1]Department of Conservation and Land Management, Locked Bag 104,
Bentley Delivery Centre, Western Australia 6983 Email: brucem@calm.wa.gov.au

SUMMARY

In biology, taxonomy is defined as the science of delimiting organisms, naming them and determining their relationships. It is the foundation upon which all biological sciences rely. ***Acacia*** is the largest genus of flowering plants in Australia (comprising almost 1 000 species) and is an important component of many ecosystems, particularly in arid and semi-arid areas. The species exhibit considerable morphological, ecological and biological variation and as such offer considerable scope for economic, social and commercial utilisation. In order to undertake effective conservation, utilisation and management of this enormous resource it is essential to have meaningfully defined, and named, biological entities (e.g. species and infraspecific taxa)**.** The provision of names through taxonomic research is fundamentally important because names are the 'hooks' by which information about taxa is stored, retrieved and exchanged. Taxonomic keys are the tools that enable us to identify specimens. In a large genus like ***Acacia***, electronic multi-access keys have advantages over conventional paper-based keys. Voucher specimens, which enable names to be verified, provide an important mechanism for protecting the value of information assembled for taxa. The implications for Australia of the proposal to divide ***Acacia*** into five genera are discussed briefly.

INTRODUCTION

It is not coincidental that the first paper in these proceedings of the Dalwallinu ***Acacia*** Symposium deals with taxonomy. As discussed below, taxonomy is the foundation upon which all biological sciences rely because, in the absence of classifying organisms and naming them, biology has nothing to work with. Indeed, none of the papers presented in this volume would have been possible unless ***Acacia*** species had been discriminated and named.

There are almost 1 000 described species of ***Acacia*** in Australia (Maslin 2001b and 2001c) and an estimated 100 or so remain undescribed. This is an enormous resource which offers considerable potential for economic, social and environmental utilisation, but it is important that the species are conserved effectively and managed sustainably. It is the aim of this paper to examine the role of taxonomy in achieving these goals.

Acacia is ubiquitous in Australia. Species of this genus are represented in almost all major terrestrial habitats and they form a conspicuous, dominant element of many ecosystems, particularly in arid and semi-arid areas. The greatest species-richness occurs in the flat, edaphically complex, semi-arid wheatbelt region of south-west Western Australia (Hnatiuk & Maslin 1988). This area is located within the Transitional Rainfall Zone (Hopper 1979), so named because it lies between the arid interior of the continent and the temperate forest region near the south-western coast. The richness here may be illustrated by the fact that within a 100-kilometre radius of Dalwallinu there are about 185 species of ***Acacia***, this being the same number that occurs in North and South America combined, and more than occurs on the entire continent of Africa where 144 species are recorded (Maslin ***et al***. in press). The other principal area of species richness lies south of the Tropic of Capricorn in eastern Australia and is associated with the rocky tablelands of the Great Dividing Range. Although species numbers decline in the Arid Zone, acacias are often a more conspicuous and dominant element of the landscape there than elsewhere. Here for example we find the Mulga lands dominated by species of the ***A. aneura*** complex (Miller ***et al.*** this proceedings).

Besides the high number of species, acacias show great morphological, ecological and biological variation and so offer considerable scope for economic, social and environmental utilisation. Understanding these species, and in particular knowing how they might assist in providing solutions to the very serious problem of land degradation that has occurred in many agricultural regions, was a major theme of the Dalwallinu Symposium. Biological attributes of ***Acacia*** such as their diversity in growth form, longevity, coppicing or suckering ability, and their adaptation to a wide range of soil types and habitats, render them well-suited to a wide range of uses. Furthermore, they have the ability to fix atmospheric nitrogen, are usually easy to germinate and grow, and generally show good survival and rapid growth rates under cultivation.

Australian acacias are widely utilised, especially abroad (for reviews see Midgley and Turnbull in prep.; McDonald ***et al.*** 2001; Turnbull ***et al.*** 1998; Searle 1995, 1996; Thomson ***et al***. 1994). They are used for a range of purposes but in particular as a source of wood products (e.g. construction and high-value timber, pulp and fuelwood), tannin, edible seeds, fodder and for land amelioration. Today, Australian ***Acacia*** species are grown in about 70 countries where they cover about 2 million hectares. As summarised by Midgley and Turnbull (in prep.) the most widely cultivated species are ***A. mearnsii*** for tannin, fuelwood and charcoal (c. 300 000 ha. in South Africa, Brazil, China and Vietnam), ***A. saligna*** for fuelwood, fodder and land amelioration (over 500 000 ha. in North Africa, the Middle East, western Asia and Chile), ***A. mangium*** for paper pulp and timber (over 800 000 ha. in Indonesia and Malaysia), ***A. crassicarpa*** for paper pulp and timber (about 50 000 ha. in Indonesia and Vietnam) and ***A. colei*** as a human food in India and sub-saharan Africa. In developing countries the demand for fuelwood is increasing as populations grow, and ***Acacia*** species are generally considered to be good fuel sources with high calorific values and biomass production (Thomson ***et al.*** 1994). In Australia, ***Acacia*** is largely an under-exploited resource. Although some commercial timber is gained from species such as ***A. melanoxylon*** (Blackwood; see Searle 1996) and ***A. celsa*** (Brown Salwood; see McDonald and Maslin 2000), most species grown in this country are used in amenity and land amelioration programs (McDonald ***et al.*** 2001). There is, however, a growing interest in exploring the potential for a more comprehensive use of ***Acacia*** in Australia, especially as widescale commercial crops in southern agricultural regions for salinity control (Bartle ***et al***. this proceedings).

WHAT IS TAXONOMY?

In biology, taxonomy is essentially the science of delimiting organisms, naming them, and determining their relationships. Taxonomy is the foundation upon which all biological sciences rely, but very few people understand what taxonomists actually do. As noted by Vane-Wright (1996), there is a need to both demystify taxonomy and make taxonomic products more readily accessible, not only to the scientific community but also to non-specialist users. In so doing this science may become better understood and appreciated, which in turn may lead to better resourcing of this crucial discipline.

Taxonomists assemble information about organisms from many sources and employ various methods to analyse and synthesise these data to arrive at a definition and classification of taxa, to apply names to them, and to develop generalised insights into their phylogeny and evolution. In other words, taxonomists:

- analyse natural variation to delimit and name taxa;
- provide a means for identifying taxa; and
- arrange taxa into predictive classification systems.

These points form a convenient framework for discussing the significance of taxonomy in the context of the conservation and utilisation of ***Acacia***. It should be remembered, however, that taxonomists also establish systems for assembling and disseminating knowledge about taxa and, as discussed below, provide scientific verification for their work through a system of vouchering.

Delimitation and naming*: *the determination of boundaries between taxa and the application of names to the biological entities that are recognised

The circumscription and naming of meaningful biological entities is at the core of the scientific discipline of taxonomy. Providing names (whether formal or informal) is of fundamental importance for biology because names enable us to communicate and exchange information about taxa. In fact, in the absence of names, biology has nothing to work with, the taxa for this purpose do not exist. Names are not merely tags or labels, however, rather they are the principal ‘hooks’ by which information about an organism is stored and retrieved. If taxa are poorly defined, or if the names applied to them are incorrect, then the information that is assembled and disseminated is likely to be wrong, or at least its value will be diminished. While it is most desirable that the taxa be formally named in accordance with the ***International Code of Botanical Nomenclature*** (Greuter ***et al***. 2000), there are circumstances where time and / or resources are limiting, and then an interim arrangement of informal ‘phrase names’ is acceptable. Therefore, the first imperative for effective conservation, utilisation and management of any biological organism is the provision of meaningfully circumscribed and accurately named taxa.

These points are well illustrated by the following examples drawn from recent studies in ***Acacia***.

In recent years certain tropical Australian acacias have assumed considerable commercial importance as sources of pulp and high-value timber, principally in south-east Asia. The main species being grown are ***A. mangium***, ***A. auriculiformis***, ***A. crassicarpa*** and the hybrid ***A. auriculiformis*** × ***mangium*** (Turnbull ***et al***. 1998; McDonald ***et al.*** 2001; Midgley and Turnbull in prep.). However, a less well-known tropical species, ***A. aulacocarpa***, which was also commonly grown in forestry field trials in south-east Asia, showed very variable performance, suggesting that more than one taxon was included under the name. A subsequent revision of the ***A. aulacocarpa*** group by McDonald and Maslin (2000) revealed that there are, in fact, six species included within what was formerly called ***A. aulacocarpa***. Of the four new species described in that paper, three–***A. celsa***, ***A. midgleyi*** and ***A. peregrina***–grow to large trees 30(-40) m tall and have potential as forestry plantation species. ***Acacia aulacocarpa*** itself was shown to be a variable taxon, ranging from a spindly small shrub to a small tree 8(-15) m tall, that appears quite unsuitable for major forestry use. Thus, the name ***A. aulacocarpa*** had no reliable biological meaning before the taxonomic work was undertaken because encompassed by this one name were six separate species. It was not until the taxonomists had gathered, recorded and analysed data, then drawn boundaries around and named the natural biological units that a meaningful framework was provided for furthering knowledge of the taxa involved. New data, together with at least some of the previously acquired data (see

Vouchering, below), could now be referred to the appropriate species instead of being 'pooled' under the one name, ***A. aulacocarpa***. Indeed, had the taxonomy of this group not been resolved there is a likelihood that the value of these data would have been greatly diminished, rendered essentially useless or even lost. It is worth noting that, just because a taxon has a name, it does not necessarily mean that the entity has precise biological meaning. The only way to ensure that taxa represent meaningful biological entities is to subject them to careful taxonomic scrutiny.

Similar examples of taxonomic resolution facilitating research and management of ***Acacia*** utilisation include:

- ***Acacia colei***, ***A. cowleana*** and related species as a source of seed for human food (Maslin and Thomson 1992; McDonald and Maslin 1997: see McDonald ***et al***. 1996 for discussion);
- ***Acacia acuminata*** as a host for Sandalwood (***Santalum spicatum***) (Maslin ***et al***. 1999; Brand 2002)
- ***Acacia tumida*** for use as fuelwood and in land rehabilitation (McDonald in prep.).

Effective conservation research and wildlife management also depend on well-defined, named taxa. This point is well illustrated by Burgman ***et al.*** (2000) in their study of almost 200 Western Australian species of ***Acacia*** that were listed on the Priority and Declared Rare Flora lists. They found that nearly a quarter of these species were neither formally described nor even informally recognised prior to 1970. This meant that neither science nor the relevant management agencies were aware of their existence until after this date. The study concluded that conservation research and setting conservation priorities depend on a sound taxonomy for, without it, conservation has nothing to work with; indeed, the first priority for conservation should be straight-forward species circumscription and description.

This point can be illustrated by reference to ***A. bifaria***, a species which in 1995 was given a formal name and which was segregated from its very similar-looking close relative, ***A. glaucoptera*** (Maslin 1995). ***Acacia bifaria*** was shown to be reasonably uncommon and was therefore included on the Priority Flora List. It had a fairly restricted distribution and was known from populations confined largely to degraded road verges around Ravensthorpe. ***Acacia glaucoptera***, on the other hand, was shown to be a common species with a wide geographical distribution. It therefore did not warrant particular conservation attention. Thus, before 1995 when the two taxa were not distinguished, ***A. bifaria*** was not afforded any protection because it was included within a broadly circumscribed species, ***A. glaucoptera***. According to Burgman ***et al.*** (2000), very few of the ***Acacia*** species then included on the Declared Rare Flora list or the Priority Flora list would have been guaranteed protection in Western Australia if the taxonomy of the ***Acacias*** had not progressed beyond that known in 1970. In other words, inadequate (or inaccurate) classifications may lead to the loss of diversity through inadequate protection.

Of course it is incumbent upon the taxonomist to do an effective job when they analyse variation and discriminate and name taxa. Unfortunately it takes time, and therefore resources, to produce good taxonomic work and the amount of resource needed depends on the size and / or complexity of the group being studied. However, it can be very costly if the taxonomy is inadequate or incorrect. In the above example of ***A. aulacocarpa***, imagine the problems that would have occurred in future plantings had the tall tree ***A. celsa*** not been properly distinguished from the spindly ***A. aulacocarpa***. The same applies in conservation work. Consider the potential waste of time, money and effort, and even possible legal ramifications, if species that are referred to the Declared Rare and Priority Flora lists are not 'good' biological entities. More often than not the amount of money spent on taxonomy is trivial compared with the benefits that are derived from the result of this work.

Identification: referring an individual specimen to a previously recognised group

Taxonomic keys are the principal means of identifying organisms. There are two basic types of key–the conventional dichotomous key that is normally produced as printed copy, and the interactive multi-access key that is produced via an electronic medium.

Conventional dichotomous keys comprise a sequence of questions that eventually lead to a name. Because of their linear structure, conventional keys suffer from a serious problem, the 'unanswerable couplet problem'; that is, if any question in the sequence cannot be answered then further progress is blocked (Maslin and Thiele 1998). For example, consider trying to identify a plant for which you have no flowers, in a key where most of the questions relate to flower characters. Despite this problem there is certainly a place for conventional keys but they can be hard to use, especially when the number of species included is large. In these cases the key maker often has to resort to 'cryptic' characters that are difficult to interpret, or to combinations of characters, in order to try and guide the user to the correct answer.

There are a number of contemporary conventional keys for identifying Australian Acacias but, except the one provided in the recently published ***Flora of Australia*** (Maslin 2001), these are regional in scope, or deal with specific species complexes. Regional keys to ***Acacia*** include:

- Western Australia: south-western W.A., Lewington (1998); Hamersley Range, Pilbara region, Maslin (1982); Kimberley region, Wheeler (1992).
- Victoria: Entwistle ***et al***. (1996).
- Queensland: Pedley (1978, 1979).
- New South Wales: Kodela and Harden (2002).
- South Australia: Whibley and Symon (1992).
- Northern Territory: Darwin region, Dunlop ***et al.*** (1995).
- Central Australia: Maslin (1981).

- South-eastern Australia: Costermans (1981); Tame (1992).

A key to some Australian ***Acacia*** species that are commonly utilised abroad is given in Maslin and McDonald (1996).

As discussed by Maslin and Thiele (1998), computer-based, interactive multi-access keys provide a solution to, or at least ameliorate, the problem of unanswerable couplets. Although multi-access keys also require users to answer questions in order to name taxa, the user chooses which questions to answer, and in what order–in other words, the user controls the identification process, rather than the key builder. Taking the example above, the multi-access key questions relating to flowers can be simply ignored and alternative ones used. Furthermore, with an interactive multi-access key the user can choose to use 'easy' characters early in the identification process. Most multi-access keys also allow users to select more than one answer to multiple-choice questions. This is important, because one is not forced to make a decision between qualitative character-states which, by their nature, may differ only by degrees. There are many other attractive features of interactive multi-access keys. For example:

- the computer programs can scrutinise character lists dynamically to find the best ones to use in order to identify a specimen most quickly (this is particularly useful if the user is not familiar with the group of organisms being keyed);
- suspect or wrong answers can be quickly deleted without having to backtrack laboriously through the key;
- context-sensitive help, perhaps in the form of annotated images or notes, can be provided to help with technical jargon or difficult characters;
- once an organism has been named it is simple to deliver a cluster of information about it, such as drawings, photographs, videos, sounds, distribution maps and notes.

Interactive multi-access keys are especially useful when dealing with large groups of organisms. Therefore, in a genus of the enormous size and variability of ***Acacia***, electronic keying is the only way to name specimens reliably and efficiently. The recently-published electronic key ***WATTLE: Acacias of Australia*** (Maslin 2001c) provides interactive identification for the entire Australian ***Acacia*** flora. This key greatly empowers the user and makes the identification process reasonably simple.

Interactive multi-access keys need not be restricted to providing names for taxa. They can also be very effective in selecting taxa that conform with non-morphological criteria such as environmental, biological or utilisation attributes. In this way one can, for example, list all species occurring in a particular geographical region, or those suited to commercial wood production, effective as wind breaks, helpful in salinity control, and so forth. The electronic key to ***Acacia*** species of the Kalannie region (Maslin 1998) was constructed with environmental utilisation in mind.

Classification and phylogeny*: *the placement of organisms within a hierarchical system and the determination of the historical relationships between them

Modern biological classifications are hypotheses of evolutionary relationships that aim to bring related taxa together into groups that are commonly named and that are arranged in a hierarchical fashion. An effective classification will serve as a major summary of knowledge and is also likely to embody at least some predictive power. Predictive in this context means that if a species has some quality or characteristic then other species that have the same attributes are likely to appear close to it in the classification. This has practical (and potentially very significant) implications for conservation and resource management. For example, the grouping of genetically related taxa may facilitate the search for desirable chemical or biological attributes. Or, by providing a framework that reflects the genetic diversity within a taxon (e.g. a genus), a classification can be a useful tool for assessing biodiversity and for setting conservation priorities. Raven (1995) put the crucial role of classification in the following way: '. . . it is ultimately the scientific process of classification–the grouping of organisms into meaningful units–that makes possible everything else in systematic, evolutionary and environmental biology, and which ultimately gives meaning to all of biology.' In Raven's sense the term classification applies to all levels of the taxonomic hierarchy, i.e. species, genera, families etc.; in the discussions below, I restrict my use of the term to the genus and infrageneric levels (e.g. subgenus, series, section) in ***Acacia***.

At the infrageneric level it is most regrettable that there is no meaningful classification for the 'Australian group' of ***Acacia***, namely, subgenus ***Phyllodineae*** which includes some 960 species. To some extent this shortcoming has constrained effective utilisation and conservation work, because people requiring knowledge of species relationships must either search literature for the relevant information or rely on the few taxonomic specialists to nominate presumed close relatives. In both these cases the information obtained can be somewhat limiting. The most generally used classification for subg. ***Phyllodineae*** is that of Pedley (1978) in which seven sections are recognised. This classification represents a good, pragmatic attempt at rationalising earlier schemes by Bentham (1842, 1864, 1875) and Vassal (1972)–the relationship between these various schemes is discussed and illustrated in a number of publications, e.g. Pedley (1987a), Maslin (1989), Chappill and Maslin (1995) and Maslin (2001a). While Pedley's scheme has certainly been a useful framework it is largely artificial, scarcely any of the sections being monophyletic (see Maslin ***et al.*** in press). A consequence of this is that the predictive power of the classification is diminished. Furthermore, 855 species (more than 80% of total within the subgenus) are contained in just three large sections, namely, ***Phyllodineae***, ***Plurinerves*** and ***Juliflorae***. Apart from being non-monophyletic each of these sections is simply too large to show meaningful relationships between species. What is needed is a classification that aggregates related species into smaller groups that are formally named and arranged in a hierarchical framework that reflects their evolutionary relationships.

Undoubtedly, molecular information will prove pivotal to understanding evolutionary relationships between species of subgenus ***Phyllodineae*** and, consequently, to the establishment of a meaningful classification for the group. Recent DNA sequence data from Miller ***et al***. (in press) and Murphy ***et al.*** (2000 and in prep.) are generating new insights into species relationships, but to date these studies have involved only about 15% of the species comprising the subgenus. The challenge for the future is for these (very expensive) studies to be expanded to include more of the taxonomically 'critical' species (Maslin and Stirton 1998), then for taxonomists to correlate the molecular findings with morphological characteristics to produce a functional classification.

Despite the above-mentioned constraints there does exist for ***Acacia*** a body of knowledge of species relationships and this has facilitated a number of recent utilisation and conservation projects. For example, such knowledge was crucial in the assessment and ranking of about 350 ***Acacia*** species from the temperate dry zone of Australia for their potential as a source of seed for human consumption (Maslin ***et al***. 1998). Similarly, an assessment of the 500-odd taxa of ***Acacia*** from the South-West Botanical Province of W.A. was undertaken by the author recently to identify deep-rooted native species that might be suitable for widescale planting in the region for salinity control (Bartle ***et al***. this proceedings). This task was greatly facilitated by having a knowledge of species relationships because, when a species was located that possessed potentially desirable characteristics (e.g. pale heartwood), it immediately focused the search on its close relatives to see if they, too, shared these attributes.

Other examples of knowledge of species relationships aiding work on utilisation of ***Acacia*** is seen in Sandalwood (***Santalum spicatum***) host selection studies involving ***Acacia acuminata*** (Maslin ***et al.*** 1999; Broadhurst and Coates 2002; Byrne ***et al.*** 2002; Byrne this proceedings) and in the domestication research involving multipurpose utilisation of tropical dry-zone ***Acacia*** species (McDonald ***et al***. 1994).

In conservation research the study of Buist ***et al.*** (this proceedings) is a good example of how critical phylogenetic knowledge can be. This study aims to determine how ecological and genetic characters contribute to an understanding of rarity by comparing rare, geographically restricted species with their common, widespread closest relatives. The work is dependent upon taxonomic relationships having been determined for the species-pairs under study, namely ***A. lobulata*** and ***A. verricula*** (Cowan and Maslin 1990), ***A. anfractuosa*** (Maslin 1976) and ***A. sciophanes*** (Maslin 1977).

At the generic level it is now evident that, in the light of recent molecular and morphological evidence, ***Acacia*** is polyphyletic and cannot be maintained as a single genus. This means that the genus, as currently conceived, will be divided into a number of genera, and this will have significant and practical implications worldwide. Although splitting ***Acacia*** will improve the taxonomy of the group there will be unavoidable and unfortunate nomenclatural consequences. As currently defined, ***Acacia*** is a cosmopolitan genus of more than 1350 species placed in three large subgenera, namely, subgenus ***Acacia*** (c. 160 species, pantropical), subgenus ***Aculeiferum*** (203 species, pantropical) and subgenus ***Phyllodineae*** (960 species, largely confined to Australia). Pedley (1986) proposed that these three subgenera should be treated as distinct genera, namely, ***Acacia***, ***Senegalia*** and ***Racosperma*** respectively. Although Pedley's proposal was not taken up (see Maslin 1987, 1989, also see Pedley 1987a & 1989 for defence of his scheme), there has been significant morphological and molecular research over the past 15 years and it is now apparent that the genus will have to be divided into at least five genera (for discussion see Maslin ***et al.*** in press). These genera correspond to Pedley's groups except that the New World component of ***Senegalia*** will be divided into three genera. This new taxonomy is an improvement over the existing classification because it is saying that most of the 'Acacias' that occur, for example, in Australia are significantly different from those in Africa, Asia and the Americas.

This change will improve our ability to communicate meaningful information when we talk about '***Acacia***'. However, because there are internationally accepted rules that govern what names must be applied to each of the five genera, there is a possibility that the generic name of most 'Australian acacias' may be changed, perhaps to ***Racosperma***. The group comprising the 'Australian acacias' is not only by far the largest within the genus (almost 1 000 species), it is also the one that is utilised most extensively for commercial, social and environmental purposes. Therefore, there will be widespread global impact affecting many people if species of the 'Australian group' are given a new generic name. Within Australia such a change would cause many organisations and individuals to incur significant costs by having to modify information storage and retrieval systems. It is for this kind of reason, and in the interest of nomenclatural clarity and stability, that Maslin ***et al.*** (in prep.) are preparing a proposal to have the name ***Acacia*** retained for the 'Australian group'. This proposal will be considered by an international committee which governs botanical nomenclature and, given the urgency of this matter, it is hoped that it will not take long for a decision to be made one way or the other. It is clear from the above discussion that taxonomic classifications may have significant impact, both socially and economically, and taxonomists need to be very mindful of these sorts of issues.

Vouchering: collection and preservation of specimens representing an organism or taxon under study, therefore enabling verification of its identity

Hedberg (1979) noted that a basic requirement of scientific investigation is that the results should be verifiable. It must be possible for other researchers to check the validity of the work by repeating experiments or observations. This implies that any biological material used for whatever purpose must be named reliably. The way to verify that names so used are correct is to examine the (voucher) specimen on which that name is based. If voucher specimens are not cited in research it can seriously diminish the value of information, because there may be no way to relate the data to a particular taxon. Given the obvious benefits of vouchering it is surprising that it is so often not done (see Hopper and Brown 2001 for examples).

Vouchering is especially relevant when a polymorphic species is divided, because verification of names through the examination of voucher specimens usually enables information to be correctly related to the appropriate segregated taxon. An excellent example of this is the study of ***A. aulacocarpa*** discussed above. For many years the Australian Tree Seed Centre (CSIRO Forestry and Forest Products) collected seed of '***A. aulacocarpa***' from Queensland and Papua New Guinea and distributed it, as numbered seedlots, for use in forestry plantation research both within Australia and abroad (principally south-east Asia). Seedlot numbers were linked to herbarium voucher specimens which were collected from the same plants as the seed and subsequently deposited in herbaria for safe keeping and future reference. As discussed above, McDonald and Maslin (2000) showed that the name ***A. aulacocarpa*** had been widely misapplied, and what was thought to be a single species in fact comprised seven distinct taxa. Because of the good vouchering practice by ATSC it was possible to publish a list of seedlot numbers showing the new names that applied to them, thus enabling users worldwide to align their operations with the new nomenclature (McDonald and Maslin 1998). Over the years a substantial body of research on '***A. aulacocarpa***' accumulated, and Thomson (1994) produced a comprehensive annotated bibliography of these publications. Unfortunately, voucher specimens were not cited all in these works. Therefore, while it is possible in some cases to relate the previously published information to one or other of the seven taxa recognised by McDonald and Maslin, there are many cases where it is not possible. In these latter cases the value of the previously published data is greatly reduced, or in some cases even rendered useless, because it is not known to what segregate of ***A. aulacocarpa*** they refer. This situation, which could have been avoided by citation of voucher specimens, is most unfortunate, not only because of the loss of information but also because it is wasteful of resources, given the expense of conducting the research in the first place.

Mulga is likely to be another case where a substantial amount of expensively-acquired data may be lost because of a lack of vouchering. Until relatively recently, typical Mulga was thought to comprise just two species, ***A. aneura*** and ***A. ayersiana***. Randell (1992) segregated the species ***A. paraneura*** and ***A. minyura*** and described two new varieties under ***A. aneura***, and Pedley (2001) increased the number of varieties of ***A. aneura*** to ten. It is possible that still more taxa will be recognised in this group (Miller et al. this proceedings). There is an extensive body of literature on Mulga (much relating to ecology and utilisation, e.g. Turnbull 1986) and it will be a challenge to see how much of this information can be related to the various taxa comprising this large, important arid zone species-complex.

Notwithstanding the importance of vouchers, it must be remembered that it is very expensive to collect and preserve voucher specimens: $41.89 per specimen was cited by Armstrong (1992) as the cost from collection to final placement in a herbarium but the standard measure now used by herbaria has now increased to around $52. Therefore, in some cases at least alternative strategies to retaining a voucher specimen may have to be considered to off-set at least the costs associated with specimen preservation. This applies particularly to studies that involve multiple sampling of the same taxon within a single population. For example, population genetic studies may require 10 or more individuals from numerous populations in order to generate a meaningful set of information. In such cases it may be prohibitively costly and physically impractical to retain all voucher specimens that are collected: photographing or scanning the specimens may be appropriate alternatives in these circumstances (even though there are costs associated with establishing and maintaining photographic and electronic records). There may also be situations where it is not necessary to keep voucher specimens indefinitely. These are important issues that confront and challenge herbarium managers.

CONCLUSION

It is clear that effective conservation and utilisation of ***Acacia*** depend upon having a sound taxonomy. In the first instance it is absolutely essential that meaningful biological entities be delineated and described accurately. These entities, whatever their rank (genus, species, variety etc.), are the basic building blocks upon which both conservation and utilisation rest. Secondly, it is essential that the biological entities be named because there is no other way of communicating about them. In fact, in the absence of a name the entities for this purpose do not exist and are therefore not available for consideration in either conservation or utilisation. While it is most desirable that taxa be formally named in accordance with the ***International Code of Botanical Nomenclature***, in circumstances where time and / or resources are limiting then an acceptable interim arrangement is to use informal 'phrase names'. Thirdly, it is essential that taxonomists provide effective means for identifying taxa, and this usually means constructing workable keys for identification. Once taxa are accurately identified then users can assemble, access and disseminate information about them. Fourthly, it is essential that organisms be classified into meaningful units (e.g. species, genus, family) because this provides the framework that makes investigation of organisms possible. It is therefore clear that neither conservation nor utilisation of ***Acacia*** (or any other biological organism) can proceed in the absence of sound taxonomic practices.

REFERENCES

Armstrong, J.A. (1992). The funding base for Australia's biological collections. ***Australian Biologist 5***, 80-88.

Bentham, G. (1842). Notes on Mimoseae, with a synopsis of species. ***London Journal of Botany 1***, 318-528.

Bentham, G. (1864). ***Acacia***. ***Flora Australiensis***, vol. 2, pp. 301-421. Lovell Reeve, London.

Bentham, G. (1875). Revision of the Suborder Mimoseae. ***Transactions of the Linnean Society of London 30***, 335-664.

Brand, J.E. (2002). Review of the influence of ***Acacia*** species on the establishment of Sandalwood (***Santalum spicatum***) in Western Australia. ***This Proceedings.***

Broadhurst, L. and Coates, D. (2002). Genetic diversity within and divergence between rare and geographically widespread taxa of the ***Acacia acuminata*** (Mimosaceae) complex. ***Heredity 88***, 250-257.

Burgman, M.A., Maslin, B.R., Andrewartha, D., Keatley, M.R., Boek, C. and McCarthy, M. (2000). Inferring threat from scientific collections: power tests and an application to Western Australia ***Acacia*** species. In ***Quantitative Methods for Conservation Biology*** (S.Ferson and M.Burgman, eds), pp. 7-26. Springer, New York.

Byrne, M., Macdonald, B. and Coates, D.J. (2002). Phylogeographic patterns and high cpDNA diversity within the ***Acacia acuminata*** (Leguminosae:Mimosoideae) complex in Western Australia. ***Journal of Evolutionary Biology 15***, 567-587

Chappill, J.A. and Maslin, B.R. (1995). A phylogenetic assessment of tribe Acacieae. In ***Advances in Legume Systematics***, 7, ***Phylogeny*** (M.Crisp and J.J.Doyle, eds), pp. 77-99. Royal Botanic Gardens, Kew.

Costermans, L. (1981). ***Native Trees and Shrubs of South-eastern Australia***. Rigby Publishers Ltd, Adelaide.

Cowan, R.S. and Maslin, B.R. (1990). ***Acacia*** Miscellany, 1, Some oligoneurous species of ***Acacia*** (Leguminosae: Mimosoideae: section Plurinerves) from Western Australia. ***Nuytsia 7***, 183-199.

Dunlop, C.R., Leach, G.J. and Cowie, I.D. (1995). ***Acacia***. In ***Flora of the Darwin Region***, Northern Territory Botanical Bulletin ***20***, 1-21. Conservation Commission of the Northern Territory, Darwin.

Entwistle, T.J., Maslin, B.R., Cowan, R.S. and Court, A.B. (1996). Mimosaceae. In ***Flora of Victoria*** (N.G.Walsh and T.J.Entwistle, eds), vol. 3, 585-656. Inkata Press, Melbourne.

Greuter, W., McNeill, J., Barrie, F.R., Burdet, H.M., Demoulin, V., Filgueiras, T.S., Nicolson, D.H., Silva, P.C., Skog, J.E., Trehane, P., Turland, N.J. and Hawkesworth, D.L. (2000). ***International Code of Botanical Nomenclature (Saint Louis Code)***. Koeltz Scientific Books, Königstein.

Hedberg, O. (1979). Introduction. In ***Systematic Botany, Plant Utilization and Biosphere Conservation*** (I.Hedberg, ed.). Almqvist & Wiksell International, Stockholm.

Hnatiuk, R.J. and Maslin, B.R. (1988). Phytogeography of ***Acacia*** in Australia in relation to climate and species-richness. ***Australian Journal of Botany 36***, 361-383.

Hopper, S.D. (1979). Biogeographical aspects of speciation in the southwest Australian flora. ***Annual Review of Ecology and Systematics 10***, 399-422.

Hopper, S.D. and Brown, A. (2001). Contributions to Western Australian orchidology: 1. History of early collections, taxonomic concepts and key to genera. Nuytsia ***14***, 1-26.

Judd, W.S., Campbell, C.S., Kellogg, E.A. and Stevens, P.F. (1999). ***Plant Systematics: a Phylogenetic Approach***. Sinauer Associates, Massachusetts.

Kodela, P.G. and Harden, G.J. (2002). ***Acacia***. In ***Flora of New South Wales*** (G.J.Harden, ed.), vol. 2, 2nd edn, pp. 381-476. Royal Botanic Gardens & Domain Trust, Sydney.

Lewington, M.A. (1998). Mimosaceae. In B.J.Grieve, ***How to Know Western Australian Wildflowers***, part II, 2nd edn, pp. 140-333. University of Western Australia Press, Nedlands, in association with the Wildflower Society of Western Australia (Inc.), Floreat.

Maslin, B.R. (1976). Studies in the genus ***Acacia*** (Mimosaceae), 5, Miscellaneous new phyllodinous species. ***Nuytsia 2***, 95-102.

Maslin, B.R. (1977). Studies in the genus ***Acacia*** (Mimosaceae), 6, Miscellany. ***Nuytsia 2***, 145-161.

Maslin, B.R. (1981). ***Acacia***. In ***Flora of Central Australia*** (J.Jessop, ed.), pp. 115-142. A.H. & A.W.Reed, Frenchs Forest, Sydney.

Maslin, B.R. (1982). Studies in the genus ***Acacia*** (Leguminosae: Mimosoideae), 11, ***Acacia*** species of the Hamersley Range area, Western Australia. ***Nuytsia 4***, 61-103.

Maslin, B.R. (1987). Report of discussions at I.G.S.M. meeting no. 6 on the proposal to split ***Acacia***. ***Bulletin of the International Group for the Study of Mimosoideae 15***, 108-118.

Maslin, B.R. (1989). Wattle become of ***Acacia***? ***Australian Systematic Botany Society Newsletter 58***, 1-13.

Maslin, B.R. (1995). ***Acacia*** Miscellany, 13, Taxonomy of some Western Australian phyllocladinous and aphyllodinous taxa (Leguminosae: Mimosoideae). ***Nuytsia 10***, 151-179.

Maslin, B.R. (1998). ***Wattle of the Kalannie region: their Identification, Characteristics and Utilisation***. CD-ROM Publication for the Kalannie Land Care District by Department of Conservation and Land Management, Perth.

Maslin, B.R. (2001a). Introductory essay. In ***Flora of Australia***, vol. 11A, ***Mimosaceae, Acacia part 1*** (A.E.Orchard and A.J.G.Wilson, eds) pp. 3-13. Australian Biological Resources Study, Canberra, & CSIRO Publishing, Melbourne.

Maslin, B.R. (2001b). ***Acacia*** species descriptions ***p.p***. In ***Flora of Australia***, vols 11A, 11B, ***Mimosaceae, Acacia parts 1 & 2*** (A.E.Orchard and A.J.G.Wilson, eds). Australian Biological Resources Study, Canberra, & CSIRO Publishing, Melbourne.

Maslin, B.R. (coordinator) (2001c). ***WATTLE Acacias of Australia***. CD ROM Publication. Australian Biological Resources Study, Canberra, & Department of Conservation and Land Management, Perth.

Maslin, B.R., Byrne, M., Coates, D., Broadhurst, L., Coleman, H. and Macdonald, B. (1999). The ***Acacia acuminata*** (Jam) group: an analysis of variation to aid Sandalwood (***Santalum spicatum***) plantation research. Report to the Sandalwood Business Unit, Department of Conservation and Land Management, Perth.

Maslin, B.R. and McDonald, M.W. (1996). ***A key to useful Australian Acacias for the seasonally dry tropics***. CSIRO, Australia.

Maslin, B.R., Miller, J.T. and Seigler, D.S. (in press). Overview of the generic status of ***Acacia*** (Leguminosae: Mimosoideae).

Maslin, B.R., Orchard, A.E. and West, J.W. (in prep.). Nomenclatural and classification history of ***Acacia sens. lat***.

Maslin, B.R. and Stirton, C.H. (1998 [1997 on publication]). Generic and infrageneric classification in ***Acacia*** (Leguminosae: Mimosoideae): a list of critical species on which to build a comparative data set. ***Bulletin of the International Group for the Study of Mimosoideae 20***, 22-44.

Maslin, B.R. and Thiele, K. (1998). Why use an interactive multi-access key. ***ACIAR Forestry Newsletter 24***, 3.

Maslin, B.R. and Thomson, L.A.J. (1992). Re-appraisal of the taxonomy of ***Acacia holosericea***, including the description of a new species, ***A. colei***, and the reinstatement of ***A. neurocarpa***. ***Australian Systematic Botany 5***, 729-743.

Maslin, B.R., Thomson, L.A.J., McDonald, M.W. and Hamilton-Brown, S. (1998). ***Edible Wattle Seeds of Southern Australia: a Review of Species for Use in Semi-arid Regions***. CSIRO Australia, Collingwood.

McDonald, M.W. (in prep.). Revision of ***Acacia tumida*** (Leguminosae: Mimosoideae) and close allies, including the description of three rare taxa.

McDonald, M.W. and Maslin, B.R. (1995). The environmental and social utilization of Australian Acacias. ***The Institute of Foresters of Australia Newsletter 36(2)***, 6-8.

McDonald, M.W. and Maslin, B.R. (1997). A reappraisal of ***Acacia cowleana*** and allied taxa, including the description of a new species, ***A. elachantha***, from the Tropical Dry-zone of Australia. ***Australian Systematic Botany 10***, 303-320.

McDonald, M.W. and Maslin, B.R. (1998). Name changes impending for CSIRO seedlots of ***Acacia*** aulacocarpa. In ***Recent Developments in Acacia Planting*** (J.Turnbull, H.R.Crompton and K.Pinyopursarerk, eds), pp. 376-378. ACIAR Proceedings no. 82, Australian Centre for International Agricultural Research, Canberra.

McDonald, M.W. and Maslin, B.R. (2000). Taxonomic revision of the salwoods: ***Acacia aulacocarpa*** Cunn. ex Benth. and its allies (Leguminosae: Mimosoideae: section Juliflorae). ***Australian Systematic Botany 13***, 21-78.

McDonald, M.W., Maslin, B.R. and Butcher, P.A. (2001). Utilisation of Acacias. In ***Flora of Australia***, vol. 11A, ***Mimosaceae, Acacia part 1*** (A.E.Orchard & A.J.G.Wilson, eds), pp. 30-40. Australian Biological Resources Study, Canberra, and CSIRO Publishing, Melbourne.

McDonald, M.W., Maslin, B.R. and Harwood, C.E. (1996). Taxonomic studies of tropical dry-zone ***Acacia*** species facilitate their domestication. In ***Tree Improvement for Sustainable Tropical Forestry***, Proceedings of QFRI-IUFRO Conference, Caloundra, Queensland, Australia, 27 Oct. - 1 Nov. 1996 (M.F.Dieters, A.C.Matheson, D.G.Nikles, C.E.Harwood and S.M.Walker, eds), pp. 96-98. Queensland Forestry Research Institute, Gympie.

Midgley, S.J. and Turnbull, J.W. (in prep.). Domestication and use of Australian Acacias: an overview. ***Australian Systematic Botany***

Miller, J.T., Andrew, R. and Bayer, R.J. (in press). Molecular phylogenetics of the Australian acacias Fabaceae: Mimosoideae) based on the trnK intron.

Miller, J.T. and Bayer, R.J. (2000). Molecular phylogenetics of ***Acacia*** (Fabaceae: Mimosoideae) based on chloroplast TRNK/MATK and nuclear histone H3-D sequences. In ***Advances in Legume Systematics*** 9 (P.S.Herendeen and A.Bruneau, eds), pp. 180-200. Royal Botanic Gardens, Kew.

Miller, J.T. and Bayer, R.J. (2001). Molecular phylogenetics of ***Acacia*** (Fabaceae: Mimosoideae) based on the chloroplast MATK coding sequence and flanking TRNK intron spacer region. ***American Journal of Botany 88***, 697-705.

Murphy, D.J., Udovicic, F. and Ladiges, P.Y. (2000). Phylogenetic analysis of Australian ***Acacia*** (Leguminosae: Mimosoideae) by using sequence variations of an intron and two intergenic spacers of chloroplast DNA. ***Australian Systematic Botany 13***, 745-754.

Murphy, D.J., Miller, J.T., Bayer, R.J. and Ladiges, P.Y. (in prep.). Molecular phylogeny of ***Acacia*** subgenus Phyllodineae (Mimosoideae: Leguminoseae) based on DNA sequences of the internal transcribed spacer region.

Pedley, L. (1978). A revision of ***Acacia*** Mill. in Queensland. ***Austrobaileya 1***, 75-234.

Pedley, L. (1979). A revision of ***Acacia*** Mill. in Queensland (concluded). ***Austrobaileya 1***, 235-337.

Pedley, L. (1986). Derivation and dispersal of ***Acacia*** (Leguminosae), with particular reference to Australia, and the recognition of ***Senegalia*** and ***Racosperma***. ***Botanical Journal of the Linnean Society 92***, 219-254.

Pedley, L. (1987a). In defence of ***Racosperma***. ***Bulletin of the International Group for the Study of Mimosoideae 15***, 123-129.

Pedley, L. (1987b). Australian acacias - taxonomy and phytogeography. In ***Australian Acacias in Developing Countries***, Proceedings of an International Workshop held at the Forestry Training Centre, Gympie, Qld, Australia, 4-7 Aug. 1986 (J.Turnbull, ed.), pp.11-16. ACIAR Proceedings no. 16, Australian Centre for International Agricultural Research, Canberra.

Pedley, L. (1989). ***Racosperma*** again. ***Australian Systematic Botany Newsletter 59***, 1-2.

Pedley, L. (2001). ***Acacia p.p.*** In ***Flora of Australia***, vol. 11B, ***Mimosaceae, Acacia part 2*** (A.E.Orchard & A.J.G.Wilson, eds), pp. 309-328. Australian Biological Resources Study, Canberra, and CSIRO Publishing, Melbourne.

Randell, B.R. (1992). Mulga, a revision of the major species. ***Journal of the Adelaide Botanic Gardens 14***, 105-132.

Raven, P.H. (1995). The university, the state, and the loss of plant diversity. ***Madrono 42***, 295-306.

Searle, S.D. (1995). Australian Acacias, no longer the forgotten genus. ***The Institute of Foresters of Australia Newsletter 36***, 9-15.

Searle, S.D. (1996). Wood and non-wood uses of temperate Australian Acacias. In ***Farm Forestry and Plantations: Investing in Future Wood Supply***, Proceedings of 1996 Australian Forest Growers Conference, Mount Gambier, South Australia, 9-12 September 1996, pp. 256-266.

Tame, T. (1992). ***Acacias of Southeast Australia***. Kangaroo Press, Kenthurst.

Thomson, L.A.J. (1994). ***Acacia aulacocarpa, A. cincinnata, A. crassicarpa and A. wetarensis: an Annotated Bibliography***. Australian Tree Seed Centre, CSIRO Division of Forestry, Canberra.

Thomson, L.A.J., Turnbull, J.W. and Maslin, B.R. (1994). The utilization of Australian species of ***Acacia***, with particular reference to those of the subtropical dry zone. ***Journal of Arid Environments 27***, 279-295.

Turnbull, J.W. (ed.) (1986). ***Multipurpose Australian Trees and Shrubs: Lesser-known Species for Fuelwood and Agroforestry.*** Australian Centre for International Agricultural Research, Canberra.

Turnbull, J.W., Midgley, S.J. and Cossaltar, C. (1998). Tropical Acacias planted in Asia: an overview. In ***Recent Developments in Acacia Planting***, Proceedings of the Third International ***Acacia*** Workshop, Hanoi, 27-31 Oct. 1997 (J.W.Turnbull, H.R.Crompton and K.Pinyopusarerk, eds), pp. 29-35. ACIAR Proceedings no. 82, Australian Centre for International Agricultural Research, Canberra.

Vane-Wright, R.I. (1996). Systematics and the conservation of biological diversity. ***Annals of the Missouri Botanical Garden 83***, 47-57.

Vassal, J. (1972). Apport des recherches ontogéniques et séminologiques a l'étude morphologique, taxonomique et phylogénique du genre ***Acacia***. ***Bulletin de la Société d'Histoire Naturelle de Toulouse 108***, 105-247.

Wheeler, J.R. (1992). ***Acacia***. In ***Flora of the Kimberley Region*** (J.R.Wheeler, B.L.Rye, B.L.Koch and A.J.G.Wilson, eds), pp. 284-337. Western Australian Herbarium, Department of Conservation and Land Management, Como.

Whibley, D.J.E. and Symon, D.E. (1992). ***Acacias of South Australia***. South Australian Government Printer, Adelaide.