Rarity, rare plant species and the New South Wales *Threatened Species Conservation Act* — conservation opportunities and challenges

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Rare species have long exerted a particular fascination for many botanists. The reasons for this are discussed, as are the justifications for the scientific study of rare and threatened species. A high proportion of the threatened species currently on the Schedules of threatened species in New South Wales were first collected by the earliest botanical explorers. Possible reasons for their success in finding rare species are speculated upon.

Legislative requirements for the identification of threatened species have arisen under the Biodiversity Convention, and the particular regime established by the New South Wales *Threatened Species Conservation Act 1995* is described. Features of the plants currently included on the New South Wales Schedules are discussed and the question as to whether they are affected by a variety of recording biases is examined. The consequences of listing for the long term conservation of threatened species are explored.

Introduction

Rare species, or at least some of them, have a high profile today. They are at the forefront in many conservation battles, and large amounts of money, both public and private, are expended on their protection and management. In the popular media it would seem that rare species, collectively, are a synonym for biodiversity, and that biodiversity conservation is to be achieved by protecting rare species (or at least those with the good fortune to be charismatic, cuddly or otherwise appealing to humans).

Concern for the welfare of some rare species has been expressed by an eccentric minority for many years, but has become a popular movement only in the last fifty years or so, stimulated perhaps by increased awareness of the scale of human impacts on the environment and the educative role of the media, particularly television. However, interest in rare species, as objects to be collected because they are rare, has a very long history, predating scientific exploration or cataloguing of the environment.

The occasion of the Robert Brown 200 symposium provided an opportunity to reflect on a number of issues related to the conservation of rare plant species. For many of these issues there are still more questions than answers, and in relation to conservation there is a need for greater debate about objectives and resource allocation.

Scientists will need to be participants in, or even initiators of, debate. In this paper many questions are posed, but few answered. I hope that these unanswered questions will promote further research, and contribute to the agenda for a debate on conservation strategy.

Robert Brown and his contemporaries

The Schedules (the lists of threatened species) of the New South Wales *Threatened Species Conservation Act 1995* contain a surprising number of taxa originally described and collected by Robert Brown during his time in Australia (1801–1805). Collections show that Brown and his contemporaries made many findings of rare species. Even more Mueller taxa (Ferdinand von Mueller 1825–1896) are on the Schedules — many of which were also first found in the primary exploration phase.

Given the richness and diversity of the Australian flora, and its novelty to northern European eyes, how were these pioneers so successful in finding rarities when everything about them was new?

At the beginning of the nineteenth century the British flora was still being explored. While many of the rarities in lowland habitats had long been known (Marren 1999), the upland flora was still being discovered (Raven & Walters 1956). Brown's mentor, George Don ('the acute Mr. G. Don', according to Hooker 1821), was one of the most successful finders of new species in Scotland. Don and his contemporaries had a keen eye for plants and an ability to discover new localities, and it is not unreasonable to think that Brown would have showed similar enthusiasm and skills. Although their search strategies were never documented it seems likely that they had clear ideas of what would constitute 'good ground'. In the context of Scotland, with predominantly base-poor acid soils, many of the famed botanical locations were on 'better' soils or rocks. This was before the development of geological science, so guidance from geological maps was not available. The concept of geological mapping was still several decades away (Winchester 2001), but most of the suitable sites are 'greener' than the surroundings. Such visible evidence can still be useful to identify sites for searching (Ratcliffe 2000). Cliff ledges were also likely to be free from grazing pressure.

In the Australian context such a search image would not have been so immediately profitable, although cliffs and boulder fields would provide refugia for fire sensitive species. The fire prone nature of the Australian landscape and the diversity of plant responses to fire would have been extremely foreign to British experience, so the importance of refugia would not have been recognised. Their early success in finding what are now threatened species could reflect declines in species abundance since European settlement. This may be the case for some of the Cumberland Plain taxa now rare and threatened, but in other cases there is little evidence for either previous greater abundance or more extensive distribution. Some of the plants Brown recorded (such as *Thesium australe*, see Benson & Howell in accompanying paper page 631) are reasonably cryptic and would rarely be noticed today unless specifically sought out. The feats of the early botanical collectors are even more remarkable when it is remembered that there were no floras; information on what had been previously seen (and hence, what had not, and was thus 'new') had to be carried in the head. Collectors had to be sparing in what was collected because of limitations on transport and scarcity of resources such as paper for drying specimens.

Early collectors had upbringings that exposed them to nature on a regular basis; collecting a whole range of natural history objects in childhood was encouraged. Most skilled field naturalists will have assembled diverse collections (Ratcliffe 2000) — today collecting is politically incorrect and in many cases clearly undesirable (egg collecting etc.). However, we no longer encourage careful observation, and despite the need to provide education on conservation, we have perhaps cut off one of the main avenues by which appreciation for nature and science is gained.

However they were acquired, Brown possessed finely honed skills of observation, interpretation and memory which few develop today.

The importance of rarity

Why are we attracted to rare species?

By modern standards Brown and his colleagues were not conservationists (although I suspect were they alive today, they would be), but they certainly were interested in rarity. Dictionaries provide a range of meanings for 'rare'. Some, such as 'undercooked', are not relevant to this discussion; the majority relate to the spatial (and/or temporal) distribution of abundance of things (in the present context, individuals of a species). These explain what rarity is, but do not indicate why humans might be so interested in rare species. Another definition perhaps provides the clue, 'Unusual in respect of some good quality: remarkably good or fine' (Oxford English Dictionary). Species which, because of their distribution, are regarded as rare tend automatically to be assumed 'remarkably good or fine', and it is this characteristic that is a major part of the attraction which rare species have long exerted. For some it is the thrill, or even the glory, of finding rare species (on occasion, possibly, even to the extent of inducing scientific fraud, Sabbagh 1999), for others the interest is more commercial, collecting rare species for trade (although such activity has long been illegal in many jurisdictions).

Interest in rare species because they 'are remarkably good or fine' might serve to attract criticism in the form of recital of Lord Rutherford's aphorism, 'All science is either physics or stamp collecting'. Rare plant hunting could be seen as the botanical equivalent of stamp collecting or train spotting, activities appropriate as hobbies, but not a proper focus for professional research. Can research on rare species be justified?

Why conserve rare species?

The biodiversity paradigm has been accepted as the basis for conservation by both the public and politicians. A number of justifications for biodiversity conservation have been developed, but the scientific underpinning of these arguments is still being built. If investment in biodiversity conservation is to be sustained then research will be required to test current assumptions and counter skeptics. Rare species are a component of biodiversity, so research on rare species will necessarily be part of the research needed to understand and manage biodiversity as a whole.

There is a global interest in species as genetic resources, potential sources of new products which may be valuable pharmaceuticals or of other industrial use (see, for example, Tooth 2001). Any species, including rare ones, may prove to be useful. In the popular media this finds expression in statements suggesting that species need to be conserved because they may contain the cure for cancer or HIV/AIDS. There is no doubt that many drugs and other chemicals have been discovered in organisms, and that many more will be discovered in the future. Some indeed may be found in rare species. Nevertheless, the success rate in screening programs is low, either because many species do not contain useful compounds, or because we cannot as yet see uses for the compound they do contain.

Other species may be valued not for what they contain but for what they are. Some rare species may produce flowers of exceptional beauty, or possess other features of horticultural interest. Production of plants for gardens is a major international business, and rare species in the wild play a significant role in the trade. Research on propagation and other aspects of their biology will be required to take advantage of the horticultural potential of these species.

Most of the reasons given above, both for conserving and studying rare species, are based on perceived utilitarian values. However, there are many who believe that species should be conserved for reasons other than being useful to humans (Ehrenfeld 1978, Mann & Plummer 1995). Such beliefs underlie much conservation legislation and public expectations for the management of biodiversity. Scientific exploration of the biology of rare species will be needed to manage these species so that society's aspirations can be met.

How many species need to be lost before changes occur to ecosystems?

An important argument in favour of conserving biodiversity is the dependence of human existence on ecosystem services (Daily 1997). Our survival depends on the maintenance of healthy, functioning ecosystems. The question is, how many species are required for ecosystem functioning?

This is unknown for any ecosystem but two hypotheses have been proposed. The rivet hypothesis (an analogy between species and the rivets in an aircraft wing, Ehrlich & Ehrlich 1981) suggests that, while a small number of species could be lost without effect, once a certain (but unknown) number had gone structural integrity would be lost. The particular identity of the species is not relevant, it is simply the number lost which is responsible for collapse.

The alternative view is that there is considerable redundancy amongst the species in a community, but that certain species are crucial to maintaining ecosystem integrity. Unfortunately we are not necessarily able to predict which these species are. Top carnivores are possible candidates, and for energetic reasons, these are also likely to be rare (Colinvaux 1980). We can envisage that plant species such as figs in rainforest may also provide ecosystem support. For many rare plants, individually small and with limited populations, the possibility that they may be essential components of ecosystems depends on the scale of ecosystem considered. As each plant species may support its own unique assemblage of fauna (insects, nematodes etc.) every plant species may therefore be considered as the basis of an ecosystem — the loss of any plant species results in the loss of an ecosystem. However, at the larger spatial scale of what is conventionally recognised as a plant community, it is difficult to envisage that loss of a single rare species would have a significant impact on community function. The relationship between species richness of communities and functional attributes such as productivity or resilience has been debated for a long time, but there are still too few data to reach generalised conclusions (Tilman 1997).

Extinction is not a new process — species have been going extinct almost since the origin of life. Species which are rare today may have been more abundant in the past. The fossil record in northern Europe, for example, shows that during the Pleistocene there has been a series of glacial–interglacial cycles; although there are differences in the behaviour of individual taxa between cycles, there is a repeating pattern by which species which were common and widespread under late glacial/early post glacial environmental conditions become rare and local in late interglacials (West 1970, Goodwin 1975). In Australia the glacial/interglacial cycle was reflected in changes between greater aridity during glacial times and times with greater extent of mesic communities in interglacial. Rainforest was restricted to limited refugia during the glacials (Webb & Tracey 1981, Adam 1992, Bowman 2000), although the possible extent of rainforest on what is now continental shelf remains to be explored.

Present environments are ephemeral, environmental change a certainty. Some species rare today may be the common species of tomorrow. From a conservation perspective protecting rare species is about maintaining options for the future. For science the tasks are to understand environmental change and species' responses and to improve predictions.

Rarity in time and space

It is general observation that when a census of an area is made there are a few abundant species and many more which at that locality and at that time would be regarded as rare (Preston 1948, Colinvaux 1980). This finding appears to hold across a range of ecosystems (even though total species richness varies between ecosystems) and for the total biota as well as particular taxonomic subsets.

Are species which are rare in particular localities rare throughout their geographic range, or are they rare only at some localities and abundant elsewhere (Schoener 1987)? Species in the first category, exhibiting 'suffusive rarity' in Schoener's (1987) terminology could be called rare without qualification, and are those which are the focus of conservation concern. Although reliable data are hard to come by for most taxonomic groups it would appear that suffusive rarities are a rare type of rarity, many more species are what Schoener (1987) has called 'diffusive rarities', only rare in parts of their range. Murray et al. (1999), term the categories 'everywhere sparse' and 'somewhere abundant'.

There have been a number of proposals to recognise categories of rare species on the basis of their geographical and/or ecological (habitat) distribution (see Ayensu 1981, Given 1981, Rabinowitz 1981). The most widely adopted scheme, that of Rabinowitz (1981), is a typology of results (the existing verifiable distribution) and not one of causes. Species which are today narrowly restricted endemics may be relics of once wider distributions, newly evolved species, or stable species with highly specialised habitat requirements.

At any one site the relative abundance of species may change over time for a variety of reasons. While there is rightly concern over the numerous and rapid changes (both decreases and increases) which can be attributed to human activities we must remember that there are other causes of change over time. In some cases the fluctuations over time may be more apparent than real, if the presence of a propagule bank is acknowledged. However, from a practical perspective examination of the soil seed banks is unlikely to be part of routine ecological survey.

Some temporal change may be easily predictable (for example seasonal changes) but other cases are far less so. There are many plant species (and associated fauna) which are restricted to particular stages of succession or to ephemeral or post-disturbance habitats. Such species pose interesting management problems. At any one time they may be abundant at a few localities, but are generally rare; at any one place they may be abundant at one time but otherwise apparently absent. Over a region, and over a long period, the population may be relatively stable, although its distribution may move in a kaleidoscopic way across the landscape.

However, as natural bushland becomes increasingly fragmented the probability that a species will be represented in a particular fragment declines. If a species requires a particular form of disturbance then it may be necessary to mimic natural disturbance of the species if it is to be retained in a reserve. This is the practice in a number of European reserves (see for example Frost 1981), but would such practices be supported by the conservation movement in Australia? Recently management regimes involving manipulation of grazing to maintain grasslands have been introduced in a number of Australian reserves (Low 2002), indicating an evolution of policy by agencies, if not yet by the public. A NSW example of a species with infrequent appearance following disturbance is *Olearia flocktonii*. An American example of an endangered butterfly dependent on a single host plant species in turn dependent on a particular post fire vegetation successional stage is *Lycaeides melissa samuelis* dependent on *Lupinus perennis (*Mann & Plummer 1995).

The NSW *Threatened Species Conservation Act 1995* (*TSC Act*)

One of the consequences of countries becoming parties to the Biodiversity Convention has been extensive revision of existing legislation and the introduction of new laws; Australia is no exception to this activity (compare Prineas 1989 with NEDON 2000).

In New South Wales the relevant new legislation is the *Threatened Species Conservation Act 1995* (*TSC Act*) which commenced on 1 January 1996. The first objective of the *TSC Act* (s3 (a) is, 'to conserve biological diversity and promote ecologically sustainable development' — the other objectives (s 3(b) – 3(f) deal with threatened species, populations and ecological communities. Concentrating attention on threatened species reflects public concern but tends to obscure the importance of taking a holistic view of biodiversity. The *TSC Act* substantially increases the protection available to plants across the State, whereas, outside of national parks and nature reserves, previous legislation concentrated on a subset of the vertebrate fauna (Prineas 1989). Threatened components of marine vegetation (algae, sea grasses and mangroves) are listed under provisions of the *Fisheries Management Act 1994* —

compared with legislative models elsewhere, that in New South Wales is unusual in that it divides the identification of threatened biota between two Acts.

If threatened species are to be protected by legislation it is necessary for mechanisms to be established for their identification and listing. For taxa covered by the NSW *Threatened Species Conservation Act* the process of listing on the Schedules is carried out by an independent Scientific Committee. This is unusual in that, in most other jurisdictions, the listing process is the responsibility of a Minister, often acting on the advice of a committee of relevant experts. There has been substantial criticism of the independence of the Scientific Committee, it being argued that decisions should be made by a Minister answerable to Parliament (and hence the people of NSW). (See, for example Hansard record of debates, *Threatened Species Conservation Amendment Bill* 2002.)

The need for accountability is seen as important because of perceptions of the impacts of listing on property rights. However, it is important to recognise that the executive role of the Scientific Committee is restricted to determining whether or not a particular species (or population, ecological community or threatening process) satisfies the criteria for listing established (by Parliament) in the Act. Assessing the case for listing may require professional judgment, but essentially is one of reaching a decision about an objective fact — a species is either threatened or it is not, and that status should not depend on whether or not particular interests may be upset by listing. Listing may have consequences for land use and development, and these may have considerable economic and social impacts. However, under current legislation, presence of a threatened species is not a bar to development; it is merely one factor to be considered when possible approval is being contemplated. New South Wales legislation contains numerous provisions for other social and economic issues to be raised in relation to development and resource management.

Any person may nominate to add to or remove from or amend the Schedules of the *TSC Act*. This permits the very detailed knowledge in the community to be utilised in their development. A variety of criteria have been proposed for the assessment of the status of threatened species, but the Scientific Committee must be satisfied that the criteria specified in the *TSC Act* have been met. Application of the IUCN scheme (Keith 1998, Keith et al. 1997, Keith et al. 2000) may provide very useful guidance, but is not determinative.

What is the appropriate spatial context for listing?

It could be argued that species should be assessed for listing on the basis of their entire geographic range, regardless of whether this encompasses more than one jurisdiction. In most cases, however, legislation requires that species be assessed on the basis of their occurrence within the area subject to a particular jurisdiction. This creates a category of threatened species referred to by Rabinowitz (1981) and Cropper (1993) as 'pseudorare' — species given formal threatened status in part of the range although not regarded as rare or threatened elsewhere. Thus a number of species, not endemic to the State, are listed as threatened on the schedules of the *TSC Act* but are not listed nationally under the *Environment Protection and Biodiversity Conservation Act 1999*. This has attracted criticism, particularly in the case when the only NSW occurrences are very close to the State border.

Recognition of 'pseudorare' species can be justified on several grounds. One of the levels of biodiversity is genetic: disjunct populations, or those at the limit of a species' range may be genetically distinct and thus worthy of recognition (the same argument is also applicable to the recognition of endangered populations under the TSCA within NSW). Populations at the limit of a species' range may be more susceptible to a range of threats than those at the centre of its distribution.

Pseudorare species can act as flagship species for conservation. Local communities can take pride in what is special in their neighbourhood, and through promoting the conservation of individual species can advance the protection of the environment more generally. Few of the rare or threatened species in Britain are endemic and most are more abundant elsewhere in Europe (Marren 1999), but are nevertheless afforded legislative protection and are the subject of considerable conservation efforts. The long history of detailed recording represented in the tradition of county floras (Marren 1999, for examples see Graham 1988, Halliday 1997) means that within Britain locally rare species attract considerable attention.

The identification of locally rare species as objects of community pride may through protection of habitat, serve to advance the cause of conservation. Each local council in NSW is now obliged to report regularly on the State of the Environment within its area of jurisdiction. The resources available to councils vary considerably, and large urban councils may have more specialist officers devoted to State of the Environment reporting than rural councils with tiny populations and rating bases. This disparity of effort is a cause of concern, especially as local government has a key role to play in off-reserve conservation and may be required (*Threatened Species Conservation Act* s70(2)) to report on actions taken to implement recovery plans for threatened species. However, while there is considerable variation between councils in the adequacy of State of the Environment reports, the reporting requirements do mean that all councils are (if but slowly) becoming better informed as to the nature and importance of natural resources within their area. It may be appropriate for councils to consider developing lists of local species of conservation concern as part of the State of the Environment requirements, as a means of heightening local community awareness of conservation issues. (The parallel development of both state and local lists is not without precedence, and already occurs in the listing of heritage items and in relation to noxious weeds where some weeds are listed only in particular local government areas.)

We've got a little list… The Schedules of the NSW *Threatened Species Conservation Act*

The *Threatened Species Conservation Act* has in its Schedules, a large, and growing, list of threatened plant species (Endangered species, populations and ecological communities on Schedule 1, Vulnerable species on Schedule 2).

Are the Schedules comprehensive? The answer is clearly, no. The *TSC Act* permits any taxa to be considered for listing and takes a broad view of 'plant'. Nevertheless the Schedules are overwhelmingly dominated by the higher or vascular plants.

Currently the only non-vascular plants are a small number of basidiomycete fungi. There are no listed bryophytes, lichens (although an endangered ecological community defined by lichens has been listed) or freshwater algae (marine algae are listed under the *Fisheries Management Act*). It is highly likely that there are species in these groups which would satisfy the criteria for listing, but it is highly unlikely that in the foreseeable future, there will be more than a handful accorded threatened status.

The small number of listed non-vascular plants arises for two reasons. Firstly, the basic taxonomic research to enable catalogues of these taxa lags behind that of the higher plants, and, largely as a consequence we lack the basic data on which to make assessments. Secondly, if species have not previously been recognised it is unlikely that there will be evidence of declines in distribution or abundance. Similar lack of data is likely to constrain the growth of lists of threatened invertebrate species. The acceptance of the biodiversity paradigm has raised awareness of the importance of non-vascular plants and invertebrates, but has not yet led to substantial investment in improving our knowledge of these groups. Listing of individual non-vascular species as threatened will be important symbolically, giving formal recognition to the broad concept of biodiversity, but is not in itself likely to substantially improve the conservation status of other cryptogam or invertebrates. Measures to improve protection of habitat, or recognition of endangered communities of which cryptogams and invertebrates are essential components, even if not identified as such in the community diagnosis, are urgently required, as well as increased understanding by habitat managers of the conservation needs of the 'less obvious' components of the biota.

If the lists are very far from being comprehensive for non-vascular plants, can at least we make claim for them being comprehensive for the vascular flora? Any list could only be comprehensive at any one point in time — changing threats will mean that taxa not currently threatened could decline to threatened status in the future, and the process of assessment must be a continuing one. Likewise, some currently threatened species may, either through deliberate management or otherwise, increase so as to be no longer threatened; in the near future it seems probable that more species will be added to schedules than removed. Even taken as today's snapshot the vascular plant schedules may not be comprehensive but be influenced by both taxonomic and geographic biases (see Burgman 2002, and discussion below).

Are the species on the Schedules threatened? The process of nomination and assessment of potential listings guarantees that, in the opinion of the Scientific Committee, the species on the Schedules satisfy the criteria for being threatened. The nomination procedure also provides an 'appeal' mechanism in that as well as nominations for addition, cases can also be made for amendment (for example to move a species from endangered to vulnerable or vice-versa) or removal.

There is a tendency in compiling lists of threatened species for there to be a bias in favour of species with restricted distributions, rather than species which while rare are geographically widespread (Burgman 2002). This tendency is also evident in the NSW list.

Geographically restricted species certainly satisfy definitions of 'rare' but are they necessarily 'threatened'? As an extreme example the Wollemi Pine *Wollemia nobilis* is listed as Endangered on Schedule 1 of the *Threatened Species Conservation Act*. The area of occupancy is very limited; the number of individuals is small (and the number of genetic individuals even smaller) — by any criteria it is an extremely rare species. However all known, wild occurrences are within a National Park.

Given that conservation is the prime objective of management of national parks why is *Wollemia nobilis* regarded as 'Endangered', a category which implies serious risk of extinction? *Wollemia nobilis* is clearly a great survivor. Its very discovery has, paradoxically, exposed it to greater risk. Although the location of the wild population has not been disclosed, and legal access is strictly controlled there is a risk of illegal visitation which would result in introduction of pathogens, illegal collecting and malicious damage. The nature of the location is such that constant surveillance, as has been applied to sites of some conservation icons overseas, is not an economically viable management option. Additionally, beyond deliberate harm, any small and geographically restricted population is at risk from environmental and demographic stochasticity. A single event could result in extinction. While management may be able to do little to alter the level of risk (and arguably should not even attempt to) species with very small populations in limited areas undoubtedly satisfy the criteria for listing as endangered under both the *TSC Act* and IUCN criteria.

More problematic is our ability to use existing criteria to list common and abundant species when a new threat emerges. For example it could have been argued that the American Chestnut *Castanea dentata* was doomed when its pathogen *Endothia parasitica* first reached America, even though at that time it was a major forest canopy tree over a wide area. The current criteria could not easily be used to list equivalent species, but by the time the decline was such as to trigger assessment the opportunity for effective control and recovery may have been lost.

Some interesting features of the current NSW *Threatened Species Conservation Act* Schedules

At present more than 9% of the State's vascular flora has been listed as either Endangered or Vulnerable in the Schedules of the *TSC Act*. These threatened species are not a random 9% sample of the flora. Mokany and Adam (2000) analysed threatened flora, and showed significant patterns in the geographic, community and taxonomic distribution of threatened species.

Are some geographic regions over-represented?

Geographically the highest numbers (and significantly more than expected) of threatened plant species were found in the North Coast and Central Coast Botanical Divisions (using the Anderson 1947 regionalisation of the flora). The North Coast encompasses some of the greatest topographic and ecological diversity in the State, and has experienced severe habitat disturbance (coastal sandmining, coastal development, clearance of the Big Scrub for agricultural development) and includes, on the continental scale, an important biogeographic boundary zone, the MacPherson-Macleay overlap (Burbidge 1960). The presence of large number of threatened species, many of them restricted endemics, is not surprising. The Central Coast has a very rich and diverse flora, and for the past 200 years has been the site of the growth of the most extensive conurbation in the country. Again the high concentration of threatened species is not surprising. What is surprising is the low proportion of threatened species on the South West Slopes, a region where a great deal of the original woodland vegetation has been cleared for agriculture. Is the small number of threatened species 'real', or does it reflect inadequacy of exploration and recording, so that losses and declines have been underestimated?

Since the commencement of the *TSC Act* in 1996 a large number of nominations to list plant species as threatened have been made. Nominations arise from a diversity of sources, but many are from individual members of the public. The majority of additions to the Schedules arising from nominations have been for the North and Central Coasts, the regions which already had the largest number of threatened species. These regions are those where, as a result of continuing urban development, threats to biodiversity are high and very obvious at the individual site level. They are also regions with a large, concerned and informed population, so that the large number of nominations is not surprising. The low number of nominations from west of the Divide, where threats may be more diffuse, and population density lower, may not however, reflect the real status of the flora. The nomination process cannot be relied upon as the only source of information about likely threatened species, and must be complemented by directed surveys.

The Mokany and Adam (2000) analysis of the distribution of threatened species by vegetation community was constrained by the broad nature of the communities for which data were available. Large numbers of threatened species were found in rainforest, sclerophyll forest and sclerophyll woodlands, with higher than expected numbers in woodland. This result is not surprising given that woodland has borne the brunt of agricultural development, but until recently woodlands have not been a focus for conservation action and opportunities for conserving what little of the habitat remains are limited.

Are some taxa over-represented?

Taxonomically some taxa, notably Myrtaceae, Proteaceae, *Grevillea* and *Zieria*, contain more threatened species than would be expected, while other families such as Asteraceae, Poaceae and Cyperaceae are under-represented in the schedules. Are these differences real or artefacts?

There is variation geographically in reports of the taxonomic distribution of threatened species (Edwards & Westoby 2000). In the United States, for example, Asteraceae comprise a high proportion of recognised threatened species (Morse 1996). However, Poaceae and Cyperaceae would appear to be generally under-represented (Edwards & Westoby 2000). Grasses and sedges are likely to be under-recorded in many surveys (or recorded at a higher taxonomic level so that determination of the presence of threatened species is not possible); the small number of threatened species may be more apparent than real. In the Australian context Asteraceae are probably under-recorded, 'daisies' being regarded as 'difficult' by many ecologists. Additionally, Asteraceae are well represented in semi-arid regions, where there is considerable, climatically driven, temporal variation in abundance and identifiability, so that recording requires good seasons. Much more field work will be required to determine whether or not more Asteraceae are threatened in NSW.

Edwards and Westoby (2000) analysed the taxonomic distribution of rarity in the Australian flora. The analysis dealt with rare rather than threatened flora so is not strictly comparable with the NSW analysis of Mokany and Adam (2000). The Edwards and Westoby (2000) analysis is strongly influenced, in the case of temperate taxa, by the very large number of rare species in south west Western Australia. Nevertheless, there are interesting similarities and differences between the threatened flora profile in NSW and that of the rare flora of the whole continent. Families with significantly more species than expected in both State and continent list are Myrtaceae, Proteaceae and Rutaceae, significantly under represented in both lists are Cyperaceae and Poaceae. Over-represented nationally, but not in NSW, are Brassicaceae, Epacridaceae, Orchidaceae and Rhamnaceae; over-represented in NSW, but not nationally are Casuarinaceae and Lamiaceae.

Are some lifeforms under-represented?

Statistically fewer threatened species than expected are herbs; does this reflect biased recording (and the difficulty of identifying many trees in dry times) or is this a special feature of the Australian flora?

Do rare plants share attributes?

There have been many studies which have sought relationships between plant attributes and species rarity and abundance (see Murray et al. 2002). Given the importance of fire in the Australian environment it would be particularly interesting to relate threat status to fire response. Much of the relevant data probably exists, but has yet to be appropriately synthesised.

Unfortunately, most traits have only been investigated in one study and many studies have examined only a few species. Consequently demonstration of generalised relationships is difficult (Murray et al. 2002). Most traits displayed different relationships with rarity in different studies. This suggests that generalised management prescriptions may not be attainable, and also that predicting the characteristics of rare species will be difficult. There is unlikely to be a model rare plant — rather every species will be different.

Are habitats evenly represented?

It would be fascinating to explore correlates of threat status in much greater detail, but appropriate ecological data are not yet available. A relationship between substrate (soils and geology) and rarity has frequently been identified (Marren 1999). Many rare and geographically restricted species are extreme habitat specialists, often being restricted to particular geological outcrops (Keith & Sanders 1990). It is highly likely that this is the case in New South Wales, but the data recorded in the Flora or on herbarium labels is frequently inadequate to address the question. Globally, serpentine outcrops support highly distinctive vegetation and many locally endemic species (Brooks 1987); NSW serpentine outcrops are known to be botanically interesting, but are still not sufficiently recorded to be identifiable as threatened species hot spots.

There are hotspots with concentrations of rare or threatened species. These may be distinctive habitats occupied by extreme habitat specialists, for example, serpentine outcrops (Brooks 1987), or sites which for reasons of geological history have provided refugia (Pigott and Walters 1954). Such places become sites of botanical pilgrimage — but while the concentration of interest leads to further increases in the number of known rare species (often extending to other groups such as bryophytes and lichens) there is a danger that this will discourage exploration of what are perceived as unprofitable sites, so that the distinctiveness of the hotspots may be exaggerated.

Unfortunately there are few data on the occurrence of threatened species in listed endangered ecological communities, but endangered communities will not necessarily have large numbers of, or even any, endangered species. An ecological community is an assemblage that is endangered, although most species characteristic of a particular community will not themselves be threatened. In the Mokany and Adam (2000) analysis this was well shown by wetlands which had significantly under-representation of threatened species. Wetland plant communities are often relatively species poor and many wetland plant species have very wide geographic distributions. Wetland species are habitat specialists but few satisfy the criteria to be listed as threatened. This does not in any way reduce the importance of wetlands in the landscape or provide justification for lessening the range of measures in place to protect and conserve wetlands.

Not all rare species occur in concentrations. Some species are found at single, otherwise undistinguished sites, others (the sparse everywhere group of Murray et al. 1999) may be scattered widely. As Birks (1972) pointed out, understanding the distribution of these rare species presents, 'an inscrutable problem, for one has to explain not so much why a plant grows where it does, as why it is missing from so many other places that are apparently equally suitable. When all the obvious possibilities have been considered, the distribution of many species remains inadequately explained in terms of gross environmental factors.' Predictive modelling of the distribution of these species on the basis of current ecological knowledge is unlikely to be profitable.

What are the consequences of listing?

Preparing lists of threatened species is an interesting exercise, as is exploring correlates of rarity, but does it have practical consequences for biodiversity conservation? The *Threatened Species Conservation Act* provides for both reactive and proactive responses to listing.

The presence of threatened species is a matter for consideration when development applications are before councils or other consent authorities (Conway 2002). However, it is only one of many issues which may be taken into account, and the legislation provides no indication that threatened species will be given greater weight than any other matter. In the six years of the *TSC Act's* operation very few developments have been totally rejected because of the potential impacts on threatened species (Debus 2002) although many more have been modified.

Listing, and the associated publicity, serves to attract criticism from those fearful of consequences, but listing also serves to increase general community awareness of biodiversity and conservation issues. One of the more controversial endangered ecological community listings has been that of the Cumberland Plain Woodland (also listed as endangered by the Commonwealth). This is a community which would have been familiar to Robert Brown and his contemporaries, and which has been extensively cleared. Unlike communities on sandstone around Sydney, which changed directly from bush to housing, the Cumberland Plain was the early agricultural base of the developing colony, so that many of the fragments have been isolated for over 150 years. Today, with the continued population growth of Sydney, both agricultural land and bush remnants are under threat of development. The listing of much of the native vegetation as endangered ecological communities has forced planning authorities to give greater consideration to protection and management of surviving bush, but it is to be regretted that it required the *TSC Act* to bring about a change in approach and perspective. Appropriate planning in earlier decades could have resulted in the retention of ecologically functional landscapes and possibly prevented the need to list communities as endangered.

A major potential danger of a regime in which biodiversity considerations in the planning process are driven by threatened species legislation is that it will fail to take an holistic approach. As Little (2001) has argued, 'biodiversity is more encompassing than just threatened species. What is needed is a wider biodiversity framework aimed at conserving and managing ecosystem processes across the landscape, and within which threatened species issues fit'. Such a paradigm shift has yet to overtake most land management authorities and agencies who continue to take a narrowly reductionist approach to their responsibilities.

Recovery Planning

Pro-active approaches under the *TSC Act* are mandated by the requirements for production of Recovery Plans and Threat Abatement Plans. In my view the terminology 'Recovery Plan' has the potential to create unrealistic expectations amongst both bureaucrats and the general public as to the content of the plans: a more neutral 'Conservation Plan' would have been preferable.

The *TSC Act* states that the object of a recovery plan is, 'to promote the recovery of the threatened species, population or ecological community to which it relates to a position of viability in nature'. *Ex situ* conservation, but loss in the wild, would not be considered a successful outcome. Under the United States *Endangered Species Act* 1973 recovery is defined as the point, 'at which the measures provided pursuant to this Act are no longer necessary'; the objective of recovery planning in the USA is, therefore, delisting. The range of activities which might be considered as promoting recovery is not discussed in the NSW *TSC Act*, nor is 'viable' defined, so it is unclear that delisting is seen as the necessary indication of success of the recovery planning process.

To make rare plants common?

In 1981 John Harper suggested that there was sufficient ecological knowledge available for natural resource managers to make rare plants common, and asked which rare species should be candidates for being made common. At the time there was little enthusiasm amongst his audience for such a prospect, reflecting that rarity *per se* is viewed as a positive attribute — a common species somehow does not have the same appeal as a rare one.

However, if Harper were to ask the same question of an Australian audience today, would the response be the same? I suspect not — rather there would be a significant minority, and perhaps even a majority, who would be advocates of intervention to increase population numbers of threatened species. In part this would be because the term 'recovery plan' implies a return to a previous state, and thus an increase in either abundance or extent of distribution.

Harper's (1981) optimism was perhaps premature. While some species could be made common we know so little about the biology of many rare species that we do not know why they are rare, let alone how they could be increased. But why is the concept of actively promoting an increase in abundance contestable?

If the idea is to 'recover' the population to some previous level of abundance or distribution, how do we determine what the appropriate level would be? For locally endemic habitat specialists there may not be suitable unoccupied habitat so that the option for increasing wild populations may not exist. Would it be appropriate to attempt to establish populations of such species outside their natural range? What might be the consequences of transplanting on genetic diversity?

Every case needs to be examined on its merits. There may be some cases where heroic attempts at 'recovery' and translocation are justified, but equally there will be others where it is inappropriate. In the case of *Wollemia* should we aim for a return to Mesozoic levels of abundance? If so, what species would need to be displaced to make this possible? Given that the existing population is 'viable in nature' at present and, provided the habitat is not degraded, there is no compelling case for field translocation. This argument would require us to recognize that a population may be viable but still at risk from environmental or demographic stochasticity, and therefore still warrant listing.

Recovery plans are yet to be produced for the majority of species listed on the schedules of the *TSC Act*. Plan production is expensive and time consuming, and there is a danger that the process could divert resources away from management. I share Marren's (2001) concern that concentration on the details of individual species may lead us to take our eye off the bigger picture and fail to address the factors impacting not just on selected threatened species but biodiversity on the whole. Habitat protection and reduction in key threatening processes would lead to better conservation outcomes, and be more economical. The recovery planning process has the potential to obscure the necessity for holistic approaches. The lists of threatened species are, as argued previously, merely the tip of the iceberg. There are many more taxa which could be listed if only data were available. Conservation management should, as far as is possible, attempt to improve the status of all threatened species, not just currently listed ones.

Given limited resources is it possible or desirable to prepare recovery plans for all species?

This is a controversial topic, but some argue that triage is essential (see for example Possingham in Carlisle 2002). Inevitably there will be prioritisation of the order of plan production. Under the *TSC Act* (s 58 (2)) highest priority is given to species which are listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act*. However, a strong case could be made that at least some vulnerable species should be given high priority so that steps can be taken to prevent their status worsening to endangered.

The effect of resource limitation will be to make meeting the timetable for recovery planning specified in the legislation difficult and the prioritisation process will result in anomalies. However, to determine that some listed species are beyond redemption, and thus never produce a recovery plan, would be a bold decision. Particularly for perennial long lived plants, long term survival, despite very low population size, may be possible provided the habitat is not destroyed. Such species require, at least, conservation plans which protect habitat. Some endangered species will be close to the end of their geological lifespan and extinction will be inevitable, other species with currently small populations might undergo resurgence under future environmental conditions. Currently we could not with confidence predict which species fall into which category.

Concluding discussion

Given the nature of threats to biodiversity it is likely that more species will continue to be added to the Schedules of the NSW *Threatened Species Conservation Act* and similar legislation elsewhere. Implementation of recovery plans may halt declines but is unlikely to result in improved status for most threatened species.

On the other hand experience teaches us that many rare plants have remarkable survival abilities. This is demonstrated in New South Wales by many species including *Eidothea hardeniana, Gentiana wingecarribiensis*, *Kippistia suaedifolia* and *Wollemia nobilis* and in Britain by the many examples of species which have been known from the same localities for hundreds of years (Raven & Walters 1956, Marren 1999). The most important task is to prevent the loss of habitat of rare species. Some habitat protection can be achieved through general measures (controls on vegetation clearing, for example) but in many cases protection of rare species habitat will require site specific measures.

The first step is to know where species are. This will require much greater attention to recording localities and maintaining data-bases than has been the case to date. Unfortunately, there is no equivalent in Australia to the Biological Records Centre in the United Kingdom, nor atlases with the level of detail of Preston et al. (2002). Achieving such an end will demand that we harness the skills of the many amateur botanists and plant enthusiasts in the population. I recognise the problems in such exercises identified by Underwood and Chapman (2002), and that observers (professional and amateur) will have biases in what they record. Nevertheless with appropriate review and quality control procedures, valuable data can be collected, as is demonstrated by the range of atlases available in Britain and Europe.

We will never have complete catalogues; even in the well studied British Isles new, non-adventive species are still being found (and not just segregates of *Rubus* or *Hieracium*) (Marren 1999). One of the most recent, *Gagea bohemica* is instructive. This occurs at a well known rare plants locality, but eluded detection for so long because its flowering season was well before that of any of the other notable species at the site (Preston et al. 2002). After all, why would anyone visit the site when there was nothing to see? If we are to better understand our biota, we must challenge such accepted wisdom.

In two hundred years knowledge of the New South Wales and Australian floras has developed enormously. We know a great deal about the distribution and ecology of many species. We are increasingly aware of the need for conservation. While not losing sight of the big picture, much more intensive local study will be required if the diversity of flora observed by Robert Brown is to be retained.

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