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Conservation of biota and maintenance of ecological processes in the southwest forests of Western Australia: The roles of legislation, policy, strategic planning, operations management, science and monitoring

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SUMMARY

A critique by Calver *et al.* (1998) of our thesis that the jarrah and karri forests of Western Australia are managed compatibly with sound ecological principles is analysed. We demonstrate that this critique shows little understanding of the extent of strategic risk assessment inherent in current forest policies, management plans, codes of practice and prescriptions. The thinking behind this risk assessment is consistent with the ecological principles proposed by us in 1994. Calver *et al.*'s arguments are weakened by failure to confront a considerable body of existing research, to use crucial factual evidence, and to cite information that does not support their argument, as well as by a belief that personal values have an integral role throughout the scientific process.

Introduction

In their latest contribution to a debate about forest management Calver *et al.* (1998: 258) state that they agree in principle with our view that ...'forests can be logged sustainably, that is, while still retaining the species and processes of the forest ecosystem essentially intact' (Abbott and Christensen 1996: 206) and that 'there are fundamental ecological principles that apply to forest management'.

On the face of it Calver and his six co-authors are in agreement with us because this was the key issue of our two previous articles (Abbott and Christensen 1994 and 1996). However, having said they agreed with what is essentially our main thesis, they then express disagreement on: the perceived utility of the principles which we propose; the extent to which the relevant research is value-free; the adequacy of the current ecological basis for management decisions; and the appropriate precautionary policy for management to follow while these issues are resolved. They further propose that full publication of relevant data, re-evaluation of existing data, research programs embracing field experiments, population viability analysis, ecosystem health methodology and the development of a quantitative definition of precaution applicable to Western Australian forests, are all needed in order to resolve the debate and to reach agreement on a set of quantitative, testable principles to guide management.

Firstly with respect to the utility of the principles it would seem that despite their stated general agreement with the ecological principles which we have proposed, Calver *et al.* (1998) do not demonstrate an appreciation of the concept presented.

We set out to demonstrate the following:

1 From all of the accumulated knowledge in the biological sciences, coupled with the search for order, it is possible to recognize and distil certain fundamental truths or principles of a general nature (Allee and Park 1939). These are principles to which a wide range of organisms across regional and even continental barriers conform in a predictable manner.

2 Forest management in Western Australia, in particular, very largely conforms to these basic biological and ecological principles. This we do not believe in any way to be a radical new idea.

3. Forest management in Western Australia has had little demonstrable adverse effect on the forest as a whole, the plants, animals and processes which comprise the ecosystem. We believe that this indicates that it is not necessary to know and understand every last detail of

the biology of every species and the intimate mechanism of every natural process in order to manage the forest for a continued supply of wood products as well as communities of species and biological processes.

That is not to say that we believe that all is known, or that we do not need to know more about the forest ecosystems, as indicated by our listing of priority topics for ongoing and further research (Abbott and Christensen 1994: 119).

Essentially we propose that forests may be managed for continuing use of reusable wood resources while maintaining the integrity of the forest ecosystem intact so long as management is based upon certain fundamental biological and ecological principles. These principles, which have been formulated and distilled from decades of scientific study, have perhaps not been enunciated before in their present form but are nevertheless embodied in all aspects of forest management. We further propose that the use of such fundamental principles obviates the need for more detailed information on each and every aspect of the forest ecosystem as a prerequisite for sound management. That there may be further valid principles other than the ones we have listed we do not deny and more are likely to be formulated as a result of further monitoring and research in the future. This does not however invalidate the general theses which we are proposing.

Adaptive management has been employed, mostly successfully, in areas such as forestry and fisheries for a very long time. Continued research and monitoring are an integral part of this type of management and new data are continually added in order to refine and improve management.

Management of natural systems is likely always to be based upon general principles, except in cases where management is for one species, because natural ecosystems are complex and will never be understood fully. Consider the following scenario.
Some time in the distant future a utopian situation is achieved, every last detail of species biology for each of the millions of organisms in the forest as well as all of the processes is finally achieved. What will we do with it? How will managers of the forest use it? We suggest that the only possible way in which to handle such a situation is to distil the vast amount of knowledge into a series of general principles which will cater for as wide a range of organisms and processes as possible, with genuine exceptions listed and catered for separately. Management is already incredibly complex despite the fact that only a fraction of all possible knowledge is yet known.

Our own analysis of forest management practices in Western Australia (Abbott and Christensen 1994 and 1996) suggests to us that conformity with the basic principles which we listed has preserved the forest ecosystems in a condition which differs little from their pre-European state, apart from the younger age of most contemporary forest.

Developing a set of sustainability indicators as proposed by Calver *et al.* (1998) and using these to test the condition of the forest is a separate issue. Likewise we do not see their proposals resolving what they refer to as the polarized debate as relevant to our original theme referred to above. We view their introduction of these topics as an attempt to switch their debate with us to the wider debate on forest management. This conclusion we think is further evidenced by their emphasis on ideology in their latest paper (Calver *et al.* 1998).

The wider forest debate, currently charged with high emotion and media attention, we regard as very largely a social issue involving primarily social values with science playing only a minor role. We recognize that in this wider debate there is undoubtedly a polarization of views, but we do not accept that this is the case in our exchange with Calver *et al.* (1998) as suggested by them. We see our differences regarding relevant issues raised by Calver et al (1998) as matters of interpretation or misunderstandings rather than a polarization of views. This is apart from their stated ideological stance which we regard as fundamentally flawed.

In respect of the interpretation of data we find their arguments concerning the lack of data unconvincing, consisting largely of negatives, i.e. not nearly enough is known of this or that etc (p. 262). It would have been more useful if they had supported their arguments with strong reasons why exactly some of the matters for which they insist there is insufficient information are essential knowledge.

We find it somewhat extreme to argue for a reduction in the 'intensity of logging' as a precautionary measure until the evidence currently being gathered is assessed fully. This information, important though it might be, will form only an infinitesimal portion of the whole suite of relevant data on forest silviculture and ecology which have been assembled over decades of study in Western Australia, the eastern states, as well as overseas over many years. It seems unlikely that data from current investigations will make a big enough difference to justify a reduction in the intensity of logging with all the attendant social upheavals.

One might also ask what difference a reduction in the intensity of logging for a period of a few years would make even in the event that some significant new fact were to be uncovered. Available evidence suggests that changes to logging intensity have largely minor and reversible effects in the forest ecosystem. We submit that it is an unrealistic expectation, likely to result in little or no benefit to conservation. No one makes these sorts of demands of other disciplines. Do physicians for example suspend treatment to a proportion of their patients to await a full assessment of current medical research as a precaution against prescribing what might turn out to be a slightly inferior treatment? Do university lecturers stop lecturing as a precaution just because everything is not yet known and they might otherwise teach students something which later changes? We think not. Textbooks are replete with examples of changed ideas as more information becomes available on all aspects of biology.

It could be said that the whole field of human endeavour is based upon the adaptive management approach; indeed this approach is at the very core of human development and progression from caves to computers. Thus a positive aspect of the criticism of Calver *et al.* and many others is that the number of research studies on forest ecology is escalating, thus accelerating acquisition of knowledge in forest ecology and contributing to adaptive management.

We cannot accept the suggestion of Calver *et al.* (1998) that ideology and social factors should be considered in science. Like everyone else, we have social opinions and attitudes but as scientists we firmly believe that it is inappropriate to mix these with biology. The time for social and ideological input is prior to scientific investigation and after, at the implementation of results stage, not during scientific debate or investigation.

In conclusion, we are not going to be drawn into the 'wider forest debate', involving personal values, in this forum. We have however further tried to clarify our position and demonstrate in more detail how the fundamental principles relate to actual forest management. We also address misconceptions and mischaracterizations as well as the issue of personal values in science in more detail.

Ecological and evolutionary principles are not prescriptions for management

Calver *et al.* (1998) believe that ecological and evolutionary principles are unhelpful for forest management because 'no standard is given whereby one would know if a principle has been violated in practice'. This claim demonstrates that they have confused ecological principles with other, more specific, devices intended to manage forests for timber, biodiversity, water, recreation etc.

CALM, the agency charged with managing Western Australia's forests, seeks to provide measurable standards through policy setting, planning (forest management plan, codes of practice, silvicultural guidelines), scientific research and monitoring (Table 1). Ecological principles represent a high-level, overarching integration of scientific knowledge relevant to the jarrah, karri and wandoo forests of southwest Western Australia. We addressed this as:

> *'After setting forth a set of fundamental concepts (principles) based on our interpretation of current knowledge in the biological sciences, we show that the management of the native eucalypt forest of south-west Western Australia is consistent with these principles'* (Abbott and Christensen 1994: 109)

> *'...ecological principles which by their generality subsume the need for detailed information on every population of every species in every stand of forest'* (Abbott and Christensen 1994: 109).

'The essence of science is to seek an understanding of phenomena. One of the methods of doing this is by reducing the complex to the simple, and recognizing universal or common patterns which may then be embodied in a set of general principles...' (Abbott and Christensen 1994: 110).

'Although European technologies have been increasingly applied in forest operations such as prescribed burning and logging, they have been in the context of the ecological principles set out in this paper' (Abbott and Christensen 1994: 115).

'Not only is it possible and practical to use ecological principles in forest management many are already in use and have been for a very long time' (Abbott and Christensen 1994: 117).

'...forest managers in Western Australia have for decades based their management on several of these principles' (Abbott and Christensen 1994: 119).

'Any major changes in how jarrah and karri forest is managed in the future will need to be assessed against the principles set out in this paper. For example, if prescribed burning were to cease, or to take place less frequently, it is inevitable that much of the forest would be swept by high intensity wildfires - this policy would then transgress the bounds of Principles 3 and 19' (Abbott and Christensen 1994: 119).

The key notions expressed in the above excerpts are that forest management is consistent with the ecological principles and does not violate them. The details are, however, contained in publicly available documents which unequivocally state what is permitted and what is prohibited (policy documents, management plans) and which set quantitative and qualitative limits on forest operations (codes of practice, silvicultural guidelines). In addition, settings currently being developed, particularly those concerning monitoring, are alluded to in such documents. Our principles also signal themes which need to be considered in a precautionary manner when formulating policies and plans for forest management. Calver *et al.* (1998: 258) question 'whether current practices are optimal', unaware of the detailed procedures (sometimes known as coarse and fine filters) already in place to safeguard the forests of southwest Western Australia.

We now provide examples of how the principles can fulfil this role, how they synergize, and how they cross-link to key commitments in policy and planning documents that applied when we wrote our paper (Abbott and Christensen 1994). Our principle 1 - *Species vary in their tolerance of climatic, edaphic and other environmental variation and are not distributed haphazardly over the landscape* - is advising forest managers to ensure that representative examples of climatic gradients and soil types are reserved from logging and that appropriate fire regimes are applied.

Examples of application of this principle:

'[I]dentify, locate and seek to conserve threatened or endangered flora and fauna in the forest' (CALM 1992d: 120).

'Fire regimes will be developed which favour threatened or endangered species' (CALM 1992d: 125).

'No harvesting will occur in river and stream zones' (CALM 1992d: 166).

'...preserve and enhance biological diversity in the forests by: ... maintaining a balanced forest structure, including a significant component of the mature and senescent stages of forest development, in perpetuity; ... increasing the area and representativeness of the reserve system ...; ... providing for increased diversity of habitat within the forest reserved for increased multiple purposes by providing riparian zones, reducing cutting-coupe size, coupe dispersal and retaining individual large trees, patches of old trees and corridors of undisturbed vegetation; ... identifying special habitats, such as upland seepage sites, rock outcrops, heathlands, wetlands, ecotones and their protection from soil disturbance...the maintenance of a diverse fire regime' (CALM 1992d: 191).

'Prior to any operation that will not cause the permanent destruction of vegetation (eg: burning or selective logging), information sources are to be consulted to check for the presence of DRF [declared rare flora] or priority flora...If no DRF or priority flora are recorded, then operation may proceed...If DRF or priority flora are present, make every attempt to modify the plan to exclude these plants from impact by the operation...If the DRF or priority flora cannot be excluded from impact by the operation...ensure that the population has been monitored recently so that current status is known...if approval is given [by the Minister for the Environment] for the taking of DRF...take actions to minimise damage, such as, mark the population on the ground, issue specific instructions to contractors, mark logging plans or job prescription sheets...after the operation, momitor the impact on, and regeneration of, the DRF or priority flora' (CALM 1993a: 105).

'Sensitive boundaries including stream zone, road zone....boundaries must be identified prior to cutting.....' (CALM 1993a: 61).

'Where an area to be logged contains habitat suited to a species of fauna which is the subject of a Rare Fauna Species Management Plan; the requirements of that plan will be integrated into silvicultural specifications for that area' (CALM 1993a: 108).

'Ensure that harvesting in the salt sensitive areas of the intermediate and low rainfall zones does not lead to the excessive reduction of forest cover which may then result in a reduction in water quality' (CALM 1991e: 3).

Our Principle 2 - *Most terrestrial organisms, and a large number of their species, occur in the soil* - warns forest managers to take special care in protecting the physical, chemical and biological attributes of soil.

Examples of application of this principle:

'The planning and operational guidelines to minimise impacts on national estate values include...Care to avoid soil compaction, soil erosion...' (CALM 1992d: 165).

'The maximum gap size [in jarrah forest] will be 10 hectares' (CALM 1992d: 166).

'In karri forests the maximum gap size is...80 hectares...Average gap size in karri will be approximately 30 hectares'. (CALM 1992d: 167).

'If a contractor wishes to construct temporary extraction tracks within the forest areas, the location of such tracks shall be approved by the FOIC before construction...' (CALM 1993a: 7).

'At the completion of extraction or during temporary cessation of extraction, erosion control work must be completed. All extraction tracks and temporary roads subject to erosion will have cross drains installed as prescribed by the FOIC' (CALM 1993a: 7).

'In selectively cut forest (ie, jarrah forest, karri thinnings) soil damage must not exceed 10% in area of any single feller's block or sub-coupe, including the landing' (CALM 1993a: 95).

'In clearfelling situations (ie karri forest) the acceptable limits of soil damage are 5% with respect to landings and 20% overall' (CALM 1993a: 95).

'If skidding is stopped in a feller's block because of excessive soil damage then it cannot recommence in that block until the Forest Officer in Charge decides that the soil is dry enough. This decision cannot be made until the local Soil Dryness Index exceeds 500 in the Northern Jarrah Forest and 250 in the Southern Jarrah and Karri Forest' (CALM 1993a: 95).

'Maintain the productive potential of the site by minimising soil damage and delaying prescribed burning for three years after thinning to give sufficient time for the breakdown of leaves in the thinning tops' (CALM 1992c: 1).

'Frequent and repeated logging operations present a risk of accumulated soil damage. It is therefore imperative that the impact of each operation be kept to a minimum. All relevant techniques should be applied, i.e. maximising summer logging, careful selection of sites, the use of tops and scrub to reduce ground pressures and the selection and repeated use of major snig tracks' (CALM 1992c: 3).

Our principle 3 - *Environmental heterogeneity increases the number of species living in the same locality through expanding the supply of resources, providing more ecotones, and creating refuges which enable predators and prey to persist together* - enjoins forest managers to avoid homogenous management of the forest and seek balance between the various types, degrees and scales of disturbance.

Examples of application of this principle:

'The minimum proportion of karri forest representative of the mature and senescent stages of development [is to] be 40 percent' (CALM 1992d: 133).

'The structural goal for the jarrah forest [is to] be the maintenance of existing distribution of size classes. This will ensure that all of the values associated with different stages of tree development will be represented in perpetuity and that the proportion of each will be similar to that exhibited in virgin stands' (CALM 1992d: 134).

'Transitional vegetation (ecotones) [is to] be kept undisturbed for a distance of up to 50 m from the edge of the feature' (CALM 1992d: 160).

'Gaps created by timber harvesting in the karri forest will be dispersed to the maximum level possible within the cutting cycle....' (CALM 1992d: 167).

'An additional 3 200 hectares of mature karri has been excluded from the timber harvesting for retention as patches of native forest amongst clearfelled and regenerated karri stands' (CALM 1992d: 167).

'...ensuring that the forest is subject to a diverse forest regime' (CALM 1992d: 190).

'By orienting temporarily retained strips of forest to link zones containing native forest. These may act as wildlife corridors and allow greater use of regrowth areas' (CALM 1991e: 3).

'Up to 10% of the retained trees [in thinning of jarrah forest] may be 'non crop tree' marri to maintain diversity. Mark to protect native pear, river banksia and examples of snottygobble, peppermint, large blackboys etc.' (CALM 1991e: 9).

'Mature secondary storey species (e.g. sheoak) shall also be marked and retained undisturbed [in gap creation], preferably in clumps, to enhance stand diversity' (CALM 1991e: 10).

'A zone of 5 metres is to be retained undisturbed around all habitat trees and groups' (CALM 1991e: 11).

Our Principle 4 - *Insects and fungi are the most speciose groups in terrestrial ecosystems* - draws forest managers' attention to the fact that the highly visible species (vascular flora, vertebrates) are a small minority of biodiversity. As indicated by Principles 2 and 5, most of the cryptic species occur in the soil, and most of the animal species feed on foliage, alive or dead. Examples of application of this principle can be found under those two principles.

Our Principle 5 - *Most animal species are herbivores* - counsels forest managers against neglecting to provide an ongoing supply of litter and green foliage.

Examples of application of this principle include:

'Within each cutting area (coupe), a minimum of three age or size classes, representing the development stages of the [jarrah] forest, will always be present' (CALM 1992d: 166).

'Strips of uncut forest will be retained between gaps' (CALM 1992d: 166).

'Logging contractors must make every effort during all phases of logging to protect marked crop trees from physical damage...[including]...falling, breaking, or uprooting of a crop tree, or...the removal of more than 30% of the crown of a crop tree' (CALM 1993a: 101).

'...logging contractors must ensure that all logging debris created by a logging operation is removed from the base of crop trees. [This]...is designed to protect crop trees from fire damage...This material must removed at least 1 m away from the bole of a crop tree' (CALM 1993a: 101).

'Retain any healthy jarrah which have survived for a long period in high impact [dieback] sites' (CALM 1989a: 1).

'Stands which contain <5 m^2/ha of retained trees but with adequate sapling regeneration (>500 spha) are to be protected from potential damaging agencies. Prescribed burning and logging may only be undertaken if regeneration will not be damaged' (CALM 1989a: 2).

'Once advanced growth is established and dynamically growing it needs to be protected from all forms of disturbance, including fire. Prescribed burning can be considered once regrowth reaches 6 metres in height' (CALM 1989c: 3).

'Crop tree selection is based on the following species priority: - 1. Jarrah, 2. Marri, 3. Sheoak' (CALM 1986a: 1).

'[Release burning] is carried out [in jarrah forest] to enhance the development of regeneration' (CALM 1991d: 3).

'Small areas of even-aged [karri] regrowth are difficult to protect during regeneration burning if surrounded by clearfelled areas. However because of their value every effort should be made to protect them' (CALM 1989b: 2).

Our Principle 6 - *A small number of species dominate the rest numerically - most species in ecosystems are naturally rare because the size of their populations is limited by shortage of resources (food, breeding sites and shelter), disease, predation and other factors* - cautions forest managers to recognize that rarity is the norm.

Examples of application of this principle, particularly those relating to spatial and temporal dispersion of operations, have been already given under the previous principles.

Our Principle 7 - *Dissipation of energy in its transfer between trophic levels leads to plant biomass exceeding that of herbivores, and herbivore biomass exceeding the biomass of carnivores* - points to the importance of regenerating cut over forests as soon as possible so that leaf area indices (a measure of producer biomass) can increase to levels prior to logging.

Examples of application of this principle have been given already under Principle 5.

Our Principle 8 - *The chemical constituents of organisms used again and again through recycling* - reminds forest managers why maintaining the integrity of soil and mobilizing the availability of nutrients through judicious use of fire are important in ecosystem management.

Examples of application of this principle include:

'...ensure that the ecological processes are maintained by: ... ensuring that there is no loss of soil by disturbance or no net loss of nutrients from forest ecosystems' (CALM 1992d: 190).

For further examples, see citations under Principles 2 and 3.

Our Principle 9 - *Most nutrients in terrestrial temperate ecosystems occur in the soil, and most transformations take place there and are mediated by micro-organisms* - reinforces the need for forest managers to conserve soil values. Examples of application of this principle have already been cited under Principle 2.

Our Principle 10 - *Organismal and population growth is limited by finite supplies of one or more resources* - alerts forest managers to why management must seek a balance between the scale, frequency, intensity, duration and season of imposed change. These aspects of disturbance are what determines the quantities of resources available at a particular time in a particular locality. Key resources include the ongoing supply of hollows of diverse sizes in standing trees and in debris on the ground, and maintaining a diverse mosaic of fire-managed vegetation.

Examples of application of this principle include:

> *'Output from Regional Planning is the Regional Master Burn Plan which is coordinated with other activities. The Master Burn Plan shows the location, year and season for each burn planned with the planning horizon (nominally 10 years)...When an area becomes due for a burn then objective(s) shall be set. These shall be management objectives stating the desired outcome of the burn...'* (CALM 1993b: Fire Protection Instruction 1: 2).

> *'It is essential to know the quantity of fuels present in the forest for reserve areas when prescribed burning is planned...The assessment techniques described here are designed to enable two men to cover an average size aerial burning block (about 3000 ha) in two days depending on the forest or vegetation types of the area...The location of sampling lines must be carefully planned as it is important to assess the full range of major forest or vegetation associations and fuel types in order to reduce costs and damage from the prescribed burning operations'* (CALM 1993b: Fire Protection Instruction 23: 1).

Our Principle 11 - *Climatic and geological changes result in extinction of many species. Extinction of species over geological time is commonplace, with 99% of all species that have ever existed being extinct* - is not an injunction for forest managers to allow forest operations to imperil the persistence of species. It instead notifies that extinctions will occur over long periods of time, as a result of natural causes (see also Abbott and Christensen 1996: 209). As rarity precedes extinction, the species considered to be most at risk are those with relict populations. As previously discussed, prescriptions

and policies in place already protect the habitats such as granitic outcrops where most relict populations are likely to occur.

Our Principle 12 - *The occupation of a pristine environment by humans causes significant ecological change* - is intended to inform forest managers that the jarrah, karri and wandoo forests in 1829 are unlikely to have been identical to the forests that existed *c.*50 millennia BP when humans (aborigines) reached them (see Abbott and Christensen 1994: 114).

Our Principle 13 - *The introduction of European technology into an environment results in a new direction and accelerated rate of change* - has long been recognized by professional forest management. It is why comprehensive plans and prescriptions have existed in Western Australia since 1927, when the first Foresters' Manual was issued (Forests Department 1927). Such documents have been continually revised as new and improved knowledge has become available.

Our Principle 14 - *Species introduced to Australia have profound ecological impacts on elements of the native biota because natural controls present in their place of origin are absent from Australia* - recommends that forest managers be aware of the effects of predators, pathogens and weeds.

Examples of application of this principle include:

> *'Seek to control feral animals where their presence has a significant impact on nature conservation or resource production objectives'* (CALM 1992d: 121).
>
> *'The priorities for control of feral animals on forested lands managed by CALM are: Priority 1: Protection of rare and vulnerable animals, especially where the risk of native species extinction exists...'* (CALM 1992d: 127).
>
> *'It is recommended that: 1. There be a major expansion of the fox eradication program in forests'* (CALM 1992d: 127).
>
> *'...preserve and enhance biological diversity in the forests by: ...eradicating European fox populations over at least 20 percent of the forest in specifically targeted areas during the next 10 years'* (CALM 1992d: 191).
>
> *'Evaluate all forest operations before they commence for their potential to introduce, spread or intensify* Phytophthora *dieback disease and accept, reject or modify the operation following that evaluation'* (CALM 1992d: 121).
>
> *'Populations of native* Banksia grandis *[a favoured host of* Phytophthora*] trees be reduced in areas subject to timber harvesting...to a maximum of four mature cone-producing trees per*

hectare; fire regimes be implemented, where practical, to minimise the development of seed-producing trees' (CALM 1992d: 126).

'Research findings on the use of the fungicide phosphorous acid [are to] be developed into operational prescriptions, for the protection of vulnerable species' (CALM 1992d: 126).

'Action to prevent the introduction of dieback disease to [diverse ecotype zones] will be taken' (CALM 1992d: 165).

'Adequate mapping is a prerequisite for implementing detailed dieback disease control procedures' (CALM 1992b: 3).

'Develop a network of known dieback free basic raw material sources which can be used for unexpected road repair works' (CALM 1992b: 7).

'Sterilise water used in operations...with an appropriate fungicide or utilise water sources free of dieback disease' (CALM 1992b: 7).

'Any contractor involved in road construction and/or maintenance shall observe any instruction and comply with any procedures laid down to restrict the spread of jarrah dieback' (CALM 1993a: 8).

'In jarrah forest not known to be infected with dieback disease, extraction of logs must conform to the techniques of "split-phase logging". This separates the snigging phase of logging from the loading and hauling phase. This is done to minimise the risk of introducing dieback fungus into a sub coupe from material that may be dropped at a landing by log trucks or other vehicles' (CALM 1993a: 66).

'Bush stockpiling is the practice of stockpiling unprepared logs in the forest to supplement mill stockpiles...[and is] to enable the logging contractor to continue log haulage during periods of the year when extraction is not permitted (CALM 1993a: 78).

'Take adequate measures to prevent the accidental introduction of weeds on CALM lands, and where funds are available and priorities dictate, attempt the control of declared and non-declared weeds' (CALM 1992d: 121).

'The priorities for forest weed control are: Priority 1: - Areas of highest value from a conservation, recreation, production or protection aspect...'. (CALM 1992d: 126).

Our Principle 15 - *Natural selection is an ongoing process - even in the absence of humans, populations of organisms are continually evolving or are becoming extinct* - indicates to forest managers that genetic capital should not be impaired. Examples of application of this principle are given under Principles 1, 2, 3, 6 and 19.

Our Principle 16 - *Following disturbance, communities change progressively in species composition (succession), eventually resembling closely the pre-disturbance state unless another disturbance takes place* - is closely allied with Principles 2, 3, 10 and 19, under which examples of application of this principle are given. Further examples include:

> *'Because of the dissected nature of the riparian zone system, some prescribed burning may be required at the time of regeneration burning in adjoining timber harvest areas. Prescribed burning within riparian zones will be of low intensity'* (CALM 1992d: 164).
>
> *'Twenty-five percent of pre-1940 [karri] regrowth will be excluded from felling and "grown on" to develop mature/senescent characteristics - 1400 hectares is allocated. The remainder will be managed in a rotation length of at least 100 years.*
>
> *...All regrowth stands regenerated between 1940 and 1975 and occurring in patches less than 200 hectares in size will be excluded from felling - 200 hectares allocated. The remainder will be managed on a rotation length of at least 100 years.*
>
> *...For all stands regenerated between 1975 and 1990 (26 500 hectares), in any year approximately:*
>
> *10 percent will be felled and regenerated at 60 years**
> *10 percent will be felled and regenerated at 80 years*
> *70 percent will be felled and regenerated at 100 years*
> *10 percent will be "grown on" to the senescent stage*
> ** understocked or fire damaged areas*
>
> *...50 percent of all stands regenerated after 1990 will be grown on to the senescent stage'* (CALM 1992d: 167).

Our Principle 17 - *Most organisms die young, through being eaten by another organism or weakened through starvation, disease or stress* - apprises forest managers of the interdependence of many forest species via the ecological web, and why certain introduced species need to be controlled. Examples of application of this principle are provided under Principles 2, 3, 4, 5 and 14.

Our Principle 18 - *There is a doomed surplus of individuals at the end of the breeding season, with not enough suitable habitat available* - recognizes the adaptation of individual organisms to ensure that their reproductive rate is maximized as much as possible. Disturbance in the forest ensures ongoing heterogeneity and thus creates opportunities for this otherwise doomed surplus. Examples of application are provided under Principles 3 and 16.

Our Principle 19 - *Dispersal is a continual and obligatory process for most mobile species, making good any losses of local populations (other factors being unchanged). Sessile organisms tend to disperse their progeny on site, mostly onto the soil surface* - enjoins forest managers to diversify disturbance events spatially and temporally and thus facilitate dispersal from undisturbed buffers.

Examples of application of this principle include:

> *'1. Movement corridors or linkage zones [are to] be allocated between riparian zones, aesthetic zones and diverse ecotype zones.*
> 2. *Links [are to] be chosen to optimise the mosaic pattern of undisturbed forest and to add to the diversity of habitat types retained.*
> 3. *Upland sites with high moisture status and high nutrient status [are to] be favoured in the selection of links.*
> 4. *The minimum width of linkage zones [is to] be approximately 600 metres, and the maximum distance between patches of retained forest [is to] be approximately 400 metres...'* (CALM 1992d: 160).
>
> *'...three large trees per hectare will be retained to provide habitat for hollow nesting species on every hectare cut-over'* (CALM 1992d: 166).
>
> *'Within each cutting area (coupe), a minimum of three age or size classes, representing the development stages of the [jarrah] forest, will always be present'* (CALM 1992d: 166).
>
> *'Stream zones also provide a wide variety of fauna habitat and act as corridors for fauna movement and recolonisation of disturbed areas'* [a tabulation of width of stream zones according to stream order is presented] (CALM 1993a: 61).
>
> *'For wildlife, TEAS [Temporary Exclusion Area Strips] act as corridors for movement and dispersal into adjacent regenerating forests and contain habitat elements absent from the regenerating area. They also allow for the development of patches of varying age within the coupe, through the staggering of regeneration over 10 to 20 years'* (CALM 1991e: 7).

Our Principle 20 - *Fluctuations in population density of mobile organisms are the rule, not the exception. Populations of long-lived sessile organisms tend to diminish in density over time* - is

intended to draw the attention of forest managers to natural change in abundance of species and hence the need to diversify operations and to monitor abundance (and its correlate, distribution) of a range of species.

An example of the application of this principle has been provided under Principle 10. CALM (1992d: 182-5) notes that rare mammal species and rare flora management programs are being developed and implemented, and that monitoring of ecosystem change through periodic measurement of an extensive system of permanent plots and selected vertebrate and invertebrate species is yet to be initiated.

Are ecological principles cited by Calver *et al.* (1998) relevant to Western Australia's forests?

Calver *et al.* (1998: 260) put forward a list of seven ecological principles, 'not intended to be comprehensive or prescriptive'. These principles, however, are either not applicable to WA forests or are already covered by the principles set forth by us (Abbott and Christensen 1994). We now consider these seven principles to illustrate this conclusion.

The first principle *(Habitat loss, modification and fragmentation are likely to be the most important causes of extinction during the coming century)* emphasizes habitat change and removal as likely important causes of extinction. We agree. However, the loss of jarrah forest occurred mostly before 1920 and the degree of fragmentation within the forest through agricultural clearing is very limited with most in the vicinity of the major towns of Collie, Donnybrook, Nannup, Manjimup, Bridgetown and Pemberton (Fig. 1). Most of the clearing has occurred close to the edge of the original forest, particularly the eastern sector. In contrast, nearly 95% of the original vegetation east of the original jarrah and wandoo forests has been cleared for cereal and sheep farming (Fig. 2). Most nature reserves there are <50 ha in area. The remaining forest resembles a continent in area and cohesiveness, whereas the nature reserves in the wheatbelt have the configuration of islands in an ocean of wheat.

Logging and prescribed burning temporarily modify forest stands but do not cause loss of forest in the way that agriculture and urbanization do. Calver *et al.'s* (1998) point about habitat modification is well recognized by forest managers and the precautions in place to limit habitat modification in space and time have been addressed earlier in this paper. Calver *et al.* (1998) also overlook the role of habitat variegation in the conservation of forest biota.

Their second principle *(Isolated populations beneath a critical minimum size have a low probability of long-term survival in the face of plausible chance effects in their demography or population genetics, in environmental fluctuations, or in natural or human-mediated catastrophes)* is not applicable to WA

forests, as populations are not isolated from one another (see our Principle 19) and recently disturbed forest is always surrounded by less recently disturbed forest (see our Principles 2, 3).

Their third principle *(Maintenance of healthy populations of wild living resources in perpetuity is inconsistent with unlimited growth of human consumption of and demand for these resources)* is a philosophical proposition, not a scientific principle. Our position is that it is possible to maintain populations of harvested and unharvested species - this is the concept of Sustainable Conservation (Armstrong and Abbott 1995, Shea *et al.* 1997).

Their fourth principle *(Extinction is commonly a multicausal process)* and fifth principle *(Loss of one species or group of species can result in major changes in [an ecosystem], including the loss of additional species)* are potentially well supported in certain circumstances. The widespread contraction of the woylie in the jarrah forests (and elsewhere in the southwest) was due to the arrival of an introduced species, the fox, so their example fits well under our Principle 14. The woylie has not declined because of logging or burning.

Their sixth principle *(Populations may grow exponentially yet still not persist because of catastrophes)* is accommodated by our Principles 15 and 20.

Their final principle *(A period of decline often precedes an extinction...)* is a truism; our Table 2 provides illustration for southwest Western Australia. The two extinct mammal species (Bilby and Boodie) were last recorded in the southwest in 1935 and 1942 soon after the fox established. Six of the seven species that have contracted in geographical range in the forest (Chuditch, Numbat, Ringtail Possum, Woylie, Tammar and Quokka) did so following the arrival of the fox in the 1930s. By targeting such species for research and by the development of recovery plans, the subsequent decline in distribution and abundance is now being successfully reversed by widespread fox control in the forest and elsewhere. The remaining species (dingo) was persecuted by settlers because it attacked sheep. It is noteworthy that none of these changes was caused by logging or prescribed burning. Similarly, none of the extinctions or declines of bird species in the forest can be linked to forest management (Abbott in press).

Several of the principles suggested by Calver *et al.* (1998) are weakened by words such as 'likely', 'plausible', 'commonly', 'can', 'may' and 'often'. These adjectives and adverbs allow for exceptions and thus make their principles not susceptible to disproof.

Most other publications cited by Calver *et al.* (1998) as providing exemplars of ecological principles instead offer extended definitions of ecological terms with examples of their use (e.g. Chiras 1991), statements of management implications of a single investigation (e.g. Franklin and Forman 1987), descriptive digests of ecological factors likely to be important (e.g. RAC 1992), or action statements containing value-laden words such as 'should' or 'must' (e.g. Mangel *et al.* 1996). Most similar in

scope, derivation and presentation to Abbott and Christensen (1994) are Watt (1973), Stafford Smith and Morton (1990) and Ludwig *et al.* (1997), none of which specifically treat forests. After having perused many papers and books with the word 'principle' in the title, it seems that the term is a device to attract attention.

Ideology

Ideology refers to the use of personal or other non-objective values in advocacy of a position, over-riding factual data. Calver *et al.* (1998) assess our position incorrectly e.g. we do not deny the existence or importance of personal values. Since Galileo, explicit use of value systems has been superseded by objective collection of data (through the use of telescopes, microscopes, quadrats, experiments etc.), objective analyses of the data collected (using statistics or other mathematical procedures), and objective reporting of results or conclusions. Science has replaced philosophy as a superior method of understanding phenomena because philosophy is a subjective activity and although a logical and coherent system of explanation can be devised, it is not usually empirically testable. The past two millennia of philosophical development have resulted in innumerable systems of answering why questions, and though each is usually internally consistent, the premises of the various systems lead to different conclusions as to how the universe is structured. For these reasons, science has triumphed as a method of rigorously understanding how the world is put together and works, so far better than any other method.

In our view, personal values and subjective experience in science are only appropriate at certain stages removed from the experimental design, data gathering, analysis and interpretation stages of the scientific process. Values can often contribute to the creative phase involving formulation and development of hypotheses to be tested. Thus, if a scientist finds clearfelling an abhorrent practice, then it is quite in order to think through why it is offensive and frame hypotheses and predictions that can be tested empirically. After this, the scientist has to set aside personal beliefs in choosing a research design, factors to measure, methods of analysis, mastering the scientific literature relevant to the topic, and writing up and interpreting the research results. After science has taken its course and at the stage where results are incorporated into practical use – in the case of forests, the preparation of management plans – a scientist may attempt to favour a shelterwood system even though the clearfelling method may have been shown to be superior based on experimental research. At this stage, it becomes a social issue.

The social aspect of science is a different matter all together (Chalmers 1990, Wolpert 1992). Scientists as humans interact in all phases of the scientific enterprise, through submitting a research plan to seek funding of the proposed research, giving presentations to peers at conferences, providing progress reports to funding bodies, and dealing with editors and referees involved in the publishing phase (see Slack 1999 for an entertaining account). Calver *et al.* (1998) have not presented a

compelling case as to why these clear and long held distinctions between the objective and subjective components of the scientific process, described above, should now be abolished. What they offer is an eclectic syncretism of elements of science and environmentalism permeated with advocacy and activism. Such an approach is not intellectually robust (e.g. critiques in Gross and Levitt 1994, Bookchin 1995, and Beckerman 1995).

The consequences for scientists of accepting Calver *et al's.* (1998) marginalization of objectivity is surely loss of scientific credibility and reputation. For the institutions in which such scientists work, there is also the opprobrium of loss of standing, eventually resulting in non-competitiveness with other institutes which continue to recognize and accept the need for rigorous and objective science. Furthermore, funding from many sources will cease to be made available and undergraduate and postgraduate students will choose better institutions. Advice offered by CSIRO scientists will be ignored by governments. This is what we meant by our claim 'the ecological and environmental components of universities will then have no point to their existence' (Abbott and Christensen 1996: 210). The book by Charlesworth *et al.* (1989) provides an enlightening case study of the contrived nature of an attempt to fit the scientific research process at the Walter and Eliza Hall Institute into a postmodern perspective; none of the scientists at this world famous medical institute could accept the relevance or validity of this viewpoint.

Finally, editors of reputable scientific journals will cease asking postmodernist scientists to referee papers submitted because these editors will not be confident that personal values have not been disguised under a veneer of objectivity, thereby subverting and perverting the peer review process.

Calver *et al.* (1998: 261) spent three paragraphs attacking a position that we do not hold. They selectively quoted from Abbott and Christensen (1996: 209), omitting 'much of this recent work is' from their quotation 'not of equal evidential value to empirical studies', thereby implying that we wrote 'all recent work is'. We regard observation, concepts, and experimentation as key elements in the scientific process. Well-executed experiments and careful observations never go out of fashion, whereas mental constructs such as concepts and theories frequently do, as attested by the history of science. Calver *et al.* (1998) caricature us as ultra-conservatives not open to new ideas. However, most of the new ideas put up by conservation biologists are either inappropriate to forests, not well founded, or impractical. Examples of valuable new concepts applicable to forests include habitat variegation (McIntyre and Barrett 1992), intermediate disturbance (Connell 1978), dynamic equilibrium (Huston 1994), and landscape or regional structural characteristics (Franklin and Forman 1987). Concepts such as 'old growth forest', 'forest interior species' and 'minimum viable population size' are of limited application to Western Australia's eucalypt forests (Christensen 1992: 34, Abbott and Christensen 1996, Abbott in press), and other concepts such as 'source/sink and metapopulation structures' are simply a refinement of a concept proposed nearly 50 years ago by Andrewartha and Birch (1954) but not accepted then.

Relevant here is another instance of a sophism. Calver *et al.* (1998: 264) suggested that we advocated that 'all models' should be disregarded. We instead simply offered a brief critique of the applicability and weaknesses of population viability analysis (PVA), not a dismissal of models. If the assumptions of PVA can be justified and tests of significance can be devised, then clearly some of the reasons for our reservations will have been overcome. Problems remain with the concept because available computer programs produce inconsistent predictions (Mills *et al.* 1996), statistical difficulties are formidable (Ludwig 1999), and short-term data incorrectly assess extinction risk (Brook and Kikkawa 1998). It would therefore be foolhardy and irresponsible if forest managers were to rely on outputs from PVA models at this rudimentary stage of their development.

Adequacy of current impact data

Calver *et al.* (1998: 261) selectively use our evidence concerning knowledge of effects of logging and burning of jarrah and karri forests. They pick one line of our evidence and attempt to discredit the whole argument on the grounds that they 'do not believe that counting the number of impact studies is a suitable measure...'. We instead made the argument that the number of impact studies relative to the size of the forest estate in Western Australia was the best in Australia. They then criticized the scope of the 51 studies used by RAC (1993) because of the focus on wood production and mining and the alleged few studies on conservation management. This is an incorrect representation of RAC (1993), as many of the 51 studies (embracing 64 papers) examine crucial and fundamental ecosystem attributes such as soil and water and the ecology of the dominant tree species (now fashionably termed 'ecological engineers') on which all species ultimately depend. In the six years since, knowledge has continued to accumulate and there have been several major reviews of various aspects. These additional impact papers are classified in Table 3.

Calver *et al.* (1998: 262) correctly note that there may be doubts about the quality of some of the studies. However their emphasis of the negative aspects of these research publications reinforces our point (Abbott and Christensen 1994: 109) about unrealistic expectations of the completeness, perfection and sufficiency of knowledge. Such an idealistic position can of course only be satisfied by the 'do nothing until we know it all' viewpoint. It is more appropriate to recognize that knowledge advances conceptually by saltation and factually by increment. Only ongoing acquisition of knowledge reveals the extent of one's ignorance.

Calver *et al.* (1998) advocated the need for more before, after/ control, impact (BACI) or longitudinal experiments and criticized the supposed local nature or short duration of many of the 51 studies cited in RAC (1993). However, they have misunderstood the difference between the space-for-time (retrospective or chronosequence) approach and the manipulative experimental approach. The first is usually more appropriate in forest studies as it provides the essential long term perspective. By its nature, this approach frequently entails only one post-disturbance observation. In contrast, BACI

studies provide important information immediately after disturbance. Do Calver *et al.* (1998) seriously suggest that forest managers should wait 100 years for BACI experiments to run their course, when the space-for-time approach can produce long-term impact information in one year? (Table 4). Are Calver *et al.* (1998) implying that astronomy is not an advanced science on the grounds that BACI experiments are not performed?

The claim that 'there were significant gaps' in knowledge and that our 'assertion of thorough knowledge...was premature' (Calver *et al.* 1998: 262) is an exaggeration. While we acknowledge that there are gaps, they are not significant. To imply that the lack or paucity of studies on fire impacts on reptiles, on amphibians, or of logging impacts on mammals is a problem is a misconception of the reasons behind the strategic direction of forest ecology research in Western Australia in the period 1968-92. Early emphasis was on impacts of prescribed burning, particularly in the management of rare (vertebrate) fauna and key flora in the Perup forest. At the time it was known through historical evidence and studies at the Perup that the contraction in range of many mammal species was due to fox predation, not logging or prescribed burning. Indeed, one of us was responsible for two of the earliest translocations (in 1977, 1983) of mammal species into fox-baited forest (Leftwich 1983). Invertebrate studies commenced in the mid 1970s and continue to the present with great advances in methodology. The recently completed Batalling study (Van Heurck *et al.* 1998) on invertebrates has confirmed the ecological soundness of the strategy of mosaic prescribed burning, as has a more preliminary study of macrofungi (Syme *et al.* 1997).

Apart from the above research at the Perup, most of these studies took place at many locations in the forest. In 1993, it was considered timely to commence an integrated study in which impacts of new logging prescriptions and associated burning were to be examined on a common set of sites. The mammal results have confirmed the early conclusions that the fox, not logging or burning, has the major impact. An experimental study of the impact of clearfelling of the karri avifauna was commenced in 1982. We understand that one of the authors of Calver *et al.* (1998) is publishing the conclusions of the data collection from 1982-89. CALM in 1996 revived this study and the results after 15 years were presented at an international conference in Melbourne in 1998. Clearly, Calver *et al.* (1998) are unfamiliar with the reasons for past research directions and the considerable work done since 1993.

With reference to reptiles, Kitchener *et al.* (1980) in a comprehensive survey of the wheatbelt of Western Australia showed that reptiles were well conserved even in a highly fragmented landscape and no extinctions had occurred. In addition, monitoring in and around bauxite mined jarrah forest has not revealed any ecological surprises and has even discovered that a species with a restricted distribution, *Ctenotus delli*, is locally common within its geographical range. This species was removed from the official list of threatened species in 1990.

Similarly, we knew in 1993 that studies of fire impact on the geographically restricted frog species *Geocrinea lutea* were underway as part of a PhD study. If Calver *et al.* (1998) have concern about these gaps, it is possible for them or their students to commence research studies aimed at filling the so-called 'significant gaps' in knowledge.

The literature survey by RAC (1993) overlooked many impact studies that met their criteria for acceptance as detailed on pages 3-4, ignored fire impact studies on the dubious pretext of 'difficulties in distinguishing between the effect of a fire burnt under prescription and a wildfire (not a human use)', and counted impact studies instead of the papers published from these studies. Prescribed burning is a widespread forest management tool in Western Australia and this State probably does more burning that any other State in Australia. These studies can legitimately be included in the RAC survey. We have updated RAC (1993) for Western Australian forests, utilizing papers published before 1992, as well as papers published from impact studies completed since 1992 (Table 3).

Precautionary approach

Calver *et al.* (1998: 263) selectively quote from page 118 of Abbott and Christensen (1994) and criticize our use of numbers of extinctions as a measure of the precautionary approach and low impact of forest management, as though it was the only indicator tabulated. They also incorrectly claim that pre-logging biological surveys are not performed in Western Australia's forests. It is however a legal requirement (Wildlife Protection Act 1950) for declared rare flora. Vertebrate surveys are performed in a more strategic way, using habitats present in forest blocks as a surrogate (see Christensen 1997). They also took issue with our claim that impacts are reasonably well understood and are minimal. More than a century of activity in the forest has led to a shifting mosaic of disturbances. Most parts of the jarrah forest have been logged 1-3 times and have been prescribed burnt 5-6 times. There is thus a well documented set of spatial information about frequency of the two major disturbances; the extremes of these combinations e.g. virgin karri vs clearfelled karri; jarrah forest unburnt for 60 years vs burnt 5-6 times; virgin jarrah vs jarrah forest cleared for bauxite mining and rehabilitated) have frequently been used to assess long-term change in flora and fauna (Table 3).

The recent development of GIS technology is allowing the key disturbances to be mapped so that in the next few years it will be possible to identify even small patches of forest possessing a certain disturbance history and then proceed to undertake extensive, replicated space-for-time comparisons across the forest.

Development of a monitoring system for detecting significant ecosystem change has been actively considered since 1988 (CALM 1988b). Although long regarded as complicated and virtually intractable, two recent developments are now allowing this perspective to be overcome. The first is the increasing sophistication of GIS, the routine acquisition of digital data relating to planned forest

disturbances, and the wealth of essential environmental background data generated by the Regional Forest Assessment since 1996 (Commonwealth and Western Australian RFA Steering Committee 1998). The second is the acceptance of the utility of the indicator approach, resulting from the Montreal Process. The states and Commonwealth of Australia have agreed to the types of indicators to be used and a strategy for their progressive implementation (Commonwealth of Australia 1998).

Calver *et al.* (1998: 263) incorrectly attribute to us a viewpoint that precaution needs to be defined quantitatively, using statistical power analysis. Our view is instead that precaution involves an ethical approach or position (Abbott and Christensen 1996: 206), thus entailing judgement. An engineer responsible for bridges, roads or railways sets in place a program of preventive maintenance, not to anticipate the possibility of a catastrophe, but to protect the users of the infrastructure from real risks. A physician caring for a patient follows a precept of 'First do no harm', based on applying principles and other knowledge of medical science. A further medical example illustrates that precaution does not involve acting on imagined fears, but instead involves careful evaluation of available evidence and theory. The 'expectation that a symptomless person might comply with a very restricted, lifelong diet in the hope of avoiding a distant complication defies logic' (Duggan 1996).

Publication of data in refereed science journals

Calver *et al.* (1998) place, in our opinion, far too much faith in the peer review process. Most active scientists have experienced the hit and miss nature of getting papers published (e.g. Ernst *et al.* 1993), the cussedness of some referees, and the stark contradictions in reports by referees on the same paper. We agree that publication of data in refereed science journals is the desirable outcome of all sound scientific research but we believe that Calver *et al.* (1998) misrepresent the need to quote unpublished research results. The first and obvious point is that academic and CSIRO scientists work in institutions with no direct responsibilities for land management or conservation of biota. In State Government agencies involved in management of resources such as fisheries, agriculture, forestry, nature conservation, recreation, and mining, there is an additional outcome - to translate research results into improved management practice. We alluded to this (Abbott and Christensen 1994: 119) where we cited our near certainty that the decline of *Macropus irma* Western brush wallaby since 1970 was caused by fox predation. We then asked 'Should we undertake a detailed study over the next few years by which time it may well be too late or should we initiate fox control immediately?'. CALM's Operation Foxglove (later incorporated into Western Shield) began in 1994 and by 1998 monitoring has shown that this species is once again common, with road kills now regularly reported throughout the forests. Similarly, CALM scientists, using information gained early in the Kingston study, met in October 1995 with forest managers and provided evidence why the criteria for selection and retention of habitat trees for hollow-using fauna should be changed. Prescriptions were amended two months later and endorsed by CALM's Corporate Executive. If CALM had waited until the research had been published, all jarrah forest cut to gaps since 1995 would have been less than optimally managed.

The important lesson of these examples is that if we had followed Calver *et al.'s* (1998) injunction to delay doing anything until academics had refereed a research paper written after a three year or longer (in the case of Kingston) study, the species may have become locally extinct throughout much of the forest. (If we had followed such a course of action, we would surely have violated a precautionary approach). It is the ultimate academic conceit that knowledge application and technology transfer should be held in abeyance until research outcomes have been approved by university scientists.

A related matter overlooked by Calver *et al.* (1998) is that delays occur in publishing a scientific paper because the process integrates a complex sequence of decisions that have to be taken. The steps involved are as follows: 1. Data collection ceases; 2. Data analysis begins and is completed; 3. Results of the analysis are integrated with current thinking as indicated in the scientific literature; 4. The research is written up; 5. The first draft is then circulated to colleagues for friendly critique; 6. These critiques are considered by the author and the paper is revised; 7. The revised paper is scrutinized by senior scientists in the CALM**Science** Division for policy implications and scientific merit; 8. If approved, the paper is then submitted to the editor of an appropriate science journal; 9. The editor sends the paper to at least two referees (anonymous) for critique; 10. The editor returns the critiques to the author. At this stage the paper may be rejected; if so the author revises the paper and submits it to another journal (step 8 above); 11. Usually the paper is accepted but some improvements are specified by the editor. The author then revises the paper and returns it to the editor; 12. The paper is then edited and takes its place in the queue; 13. The paper is published.

The time involved in these steps is quite variable depending on complexity; the following are typical: Step 2 1 month-1 year; Step 3 1 month–1 year; Step 4 1 month–1 year; Step 5 & 6 1-3 months; Step 7 1 month; Step 9 6 months–1 year; Step 11 1-3 months; Step 12 6-18 months. Thus the total time involved can vary from 18 months to 6 years. For example, with Atkinson (1994), step 5 (abstract) occurred in 1994 but stage 13 has not yet been achieved.

We agree that unpublished data are an unsatisfactory basis for rebutting refereed papers. However, are Calver *et al.* (1998: 263) suggesting that the alternative is to pretend that as yet unpublished information doesn't exist? We think it would be in Calver *et al.'s* (1998) interests to be much more precautionary before presuming that logging and burning have impacts on flora and fauna in Western Australia's forests, which point they partially concede on p. 263 para 5, and to wait for the results of these ongoing studies to be published in science journals.

Calver *et al.* (1998: 263) criticize our citation of Abbott (1998a) on the grounds that it provides 'scant superficial data with inadequate methodology'. However, they do not acknowledge that one of us in November 1996 presented a public seminar, to which CSIRO staff and academics were invited, where the full methods were explained. The results have since been published (Abbott 1998b). Calver *et al.*

(1998) pretend that data relating to recovery of mammal species after fox control lack status because they are unpublished. However, methods and data have been presented to peers at conferences (Morris 1997 in Taupo, New Zealand, de Tores 1998 in Bunbury, Western Australia) and copies of the papers presented are either available upon request or are in the course of publication.

In recent years we have noticed, with increasing concern, the personal values of editors and referees of science journals intruding into the peer review process. We know of incidences of research papers by CALM scientists that have been submitted to external journals and sent to referees, who have rejected the papers on little more than off-hand comments like 'an attempt to justify CALM's burning and logging practices'. To our surprise, some editors treat these value-laden comments seriously.

Reform is needed in increasing the transparency of the vetting process, particularly in journals publishing conservation biology papers relating to forests. The most significant improvement would entail only a minor change - insisting that referees sign their reports. Other useful advice for referees is provided by Parkes (1998). Editors who select non-experts to referee papers, referees who write non-objective appraisals, and editors who apply their personal values in rejecting papers can expect to be brought to account to the broader scientific community.

Improved communications

Calver *et al.'s* (1998: 264) call for an 'open and frank debate' is only one component of information exchange. However, issues of politics are most appropriately dealt with directly with political decision makers, not public sector scientists. A constructive approach might include the following components:

- When postgraduate students are planning forest ecology studies, they and their supervisors should confer with the agency research director which manages forests. Scientists in these agencies have a wealth of experience and knowledge about forest and relevant literature and therefore can offer advice about how academic investigations can provide useful information to improve management practice. Agency scientists can also facilitate access to district staff and persuade other directors to divert resources to set up special experimental treatments. Agency scientists can also advise whether proposed treatments actually represent current practice.
- The most appropriate agency scientists should be invited to have a genuine role in co-supervising postgraduate students. It is surely in the student's interests to ensure that the thesis produced at the end of the study is credible and defensible by showing evidence that the student is knowledgeable about past and present forest management practices relevant to the research done.
- As the work is written up for publication in science journals, agency scientists most knowledgeable about the subject matter can, if given the opportunity, offer constructive comment. The kinds of errors published by Mawson and Long (1994) and Rhind (1996) can then be averted, without the

subsequent need to rebut them in public (Armstrong and Abbott 1996, Stoneman et al. 1997, Abbott in press).

- Academic scientists similarly should avail themselves of the opportunities to consult with agency scientists in the planning and manuscript preparation stages. Agency scientists are then likely to champion the application of the knowledge generated by the academic study. Unless effective technology transfer occurs (e.g. revised prescriptions), the study is merely an academic curiosity.
- Recognize that forest managers will not alter prescriptions based on unsound science or conjecture. Forest managers would not be impressed if revised prescriptions had to be later withdrawn because of errors in the study. Other things being equal, minor technical blemishes in a piece of scientific research will not be used to discount conclusions (lack of a control treatment in an experiment would, however, be regarded as a major flaw whereas use of an inappropriate statistical test would be considered minor and easily remedied).
- Refrain from sending copies of papers critical of forest management to the media, politicians and lobby groups before the agency has had formal opportunity to assess the soundness of the conclusions and decide if changes in prescriptions are warranted. Of course, if the academic is dissatisfied that the work has not been carefully considered, then it is legitimate to complain publicly.

Government agencies generally have a strong commitment to working with the scientific community. The Department of Conservation and Land Management in Western Australia is no exception (CALM 1995: 4), simply because of the continual need for sound science-based knowledge to underpin forest management. Because the general public is opposed to paying more taxes, and most revenues are expended against health, education and law and order, resources provided by government to forest management and conservation will never be sufficient and so it is essential to tap what the best minds in universities have to offer.

Conclusion

We are pleased to note that Calver *et al.* (1998) state their agreement with the main theses of our two previous papers. They profess not to understand how scientific principles are included into actual forest management processes and continue to pursue the theme of social values and forestry as well as putting up proposals for resolving 'the dispute'. We do not believe that there is a dispute as such with respect to our proposals. Any dispute, we believe, relates to the wider forest debate, not to this interchange on fundamental scientific principles. Their suggestions for resolving the dispute therefore contribute little to this debate.

We would have preferred to see some discussion on the merits or otherwise of management based on fundamental scientific principles. The only sections of the paper in which this occurred was in the

discussion on application of biological principles to forest management and the adequacy of current data.

With respect to management based on fundamental scientific principles, we have shown that there appears to be lack of appreciation of the mechanism of application of science in forest management, possibly because of a lack of awareness of the details of the management process. Concerning the adequacy of current data we feel that the discussion so far has achieved little. Discussion of why extra data, which Calver *et al.* (1998) seem to regard as essential, might be helpful. We find the endless listing of what is not known to be of limited value. We need to question why certain data are considered essential, what would they contribute, and will they make a difference?

Finally we believe that the introduction of personal or social values into a scientific debate to be unprofessional, serving only to distract from the scientific process.

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Fig. 1. The extant jarrah, karri and wandoo forests under public ownership. The forest has been cleared extensively around its original boundary and along major rivers.

Fig. 2. Portion of the Western Australian wheatbelt. The original vegetation of the wheatbelt has been cleared extensively throughout, leaving only small parcels of degraded original vegetation.

Table 1. The planning and scientific processes used in forest management in Western Australia (using examples up to 1994). Note that these processes may also link across levels.

Planning		Science	
Level	Examples	Level	Examples
Local planning	Details of particular burning or logging area or dieback assessment (Forests Dept. 1982, map 7)	Curiosity about observed patterns, intuition, available information	Christensen (1972)
↑		↓	
Prescription & guideline	CALM (1986a, 1989a,b,c, 1991d,e, 1992c)	Ideas, observations	Christensen *et al.* (1985)
↑		↓	
Manual	CALM (1992b, 1993a)	Conceptual scheme	Christensen (1981)
↑		↓	
Code of Practice	CALM (1993a)	Hypothesis with prediction(s)	Abbott & Van Heurck (1985a)
		↓	
↑		Testing	Christensen & Kimber (1975)
		↓	
Management Plan	CALM (1987b,c,d,e,f, 1992d)	Theory development	Abbott & Van Heurck (1985b)
↑		↓	
Policy statement	CALM (1986b,c, 1987a, 1988b, 1990, 1991a,b,c, 1992a)	Understanding of cause and effect, knowledge (review paper or book)	Christensen & Abbott (1989), Christensen (1992)
↑		↓	
Strategic Plan	CALM (1988a)	Principles	Abbott & Christensen (1994)
↑			
Act of Parliament	CALM Act 1984, Wildlife Conservation Act 1950, Bush Fires Act 1954		

Table 2. Bird and mammal species present in the South West Land Division of Western Australia and which have become extinct or have changed in geographical range since European settlement.

Characteristic	Swan Coastal Plain	Original Forest	Wheatbelt	South Coast
No. species extinct				
Birds	16	2	7	2
Mammals	13 (8)	2	23 (21)	8 (4)
No. species with contracted distribution				
Birds	17	4	36	7
Mammals	5	7	9 (8)	5

Source: Birds (Abbott in press); Mammals (unpublished maps of the distribution of individual species in Australia by Baynes, Burbidge and McKenzie and unpublished maps of individual species in the South West Land Division by Abbott). Figures in parentheses apply if evidence from surface fossils is discounted.

Table 3. Number of scientific papers measuring impacts of logging, *Phytophthora* infestation, introduced fox, mining, and fire on environmental variables in the forests of southwest Western Australia.

Factor(s) studied	Number of impact papers							
	Published to 1991			Published 1992-98		In press or MS seen		Total
	References in RAC (1993)	Additional to those listed in RAC (1993) by		CALM officers	Others	CALM officers	Others	
		CALM officers	Others					
Logging, dieback, fox, mining	64	36	14	34	3	5	2	145
Fire	0	23	15	9	3	1	0	51
All	64	59	29	43	6	6	2	196

Source: Papers listed in RAC (1993, Appendix 3, under original studies measuring impacts), Lyons and Gibson (1994) and Wright and Farrell (1998).

Table 4. Attributes of studies of ecological impacts of forest use (data from RAC 1993)

Attribute	Type of study			
	Space-for-time (N=42)		Manipulative experiment (N=8)	
	Median	Range	Median	Range
Maximum time since disturbance (years)	10	0-110	3.5	1-10
Length of study (years)	1	1-5	8	3-9

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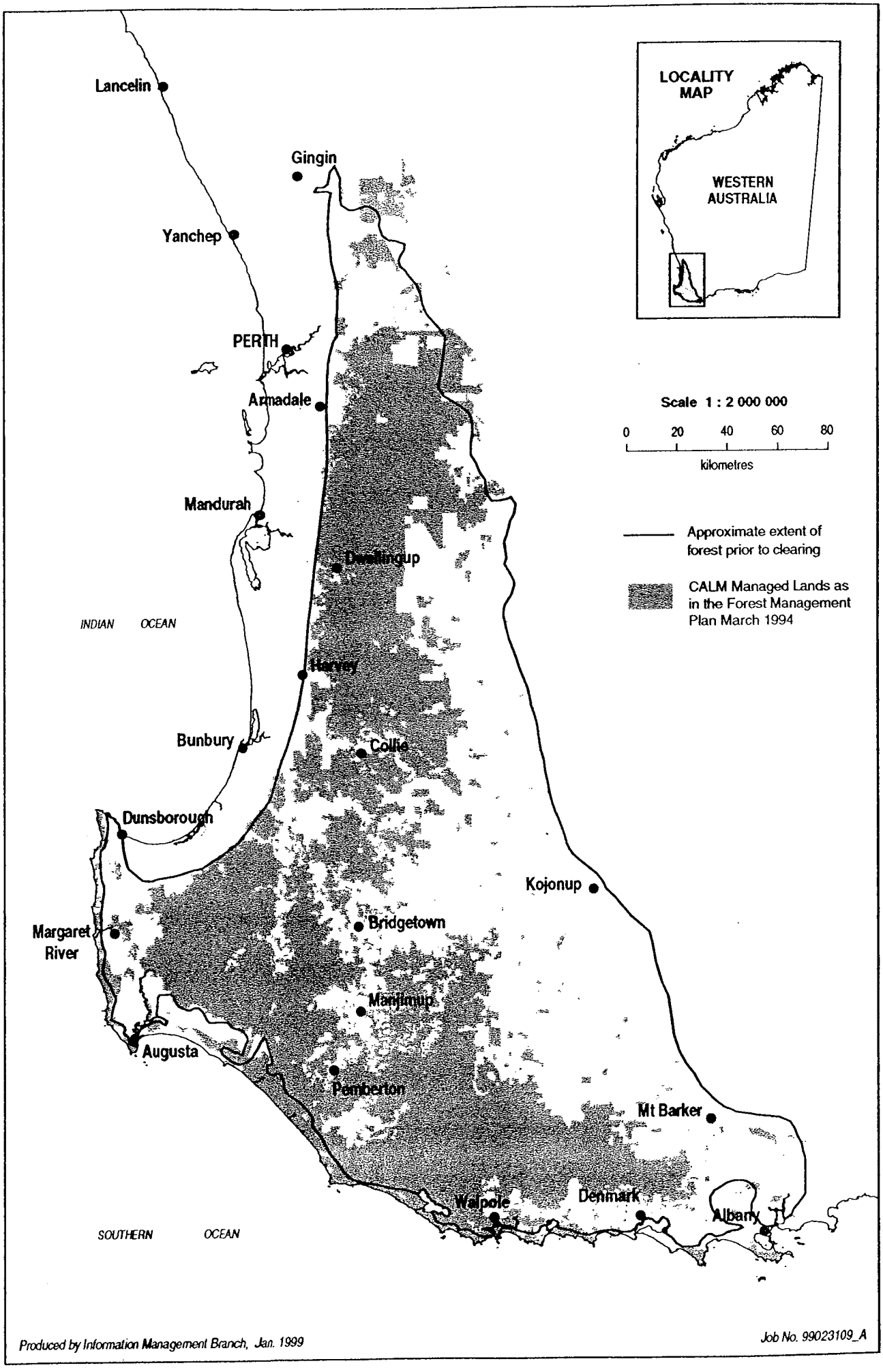
LOCALITY MAP
WESTERN AUSTRALIA
Scale 1 : 2 000 000
0 20 40 60 80
kilometres
Approximate extent of forest prior to clearing
CALM Managed Lands as in the Forest Management Plan March 1994
Lancelin
Gingin
Yanchep
PERTH
Armadale
Mandurah
Dwellingup
INDIAN OCEAN
Harvey
Bunbury
Collie
Dunsborough
Kojonup
Margaret River
Bridgetown
Manjimup
Augusta
Pemberton
Mt Barker
Walpole
Denmark
Albany
SOUTHERN OCEAN
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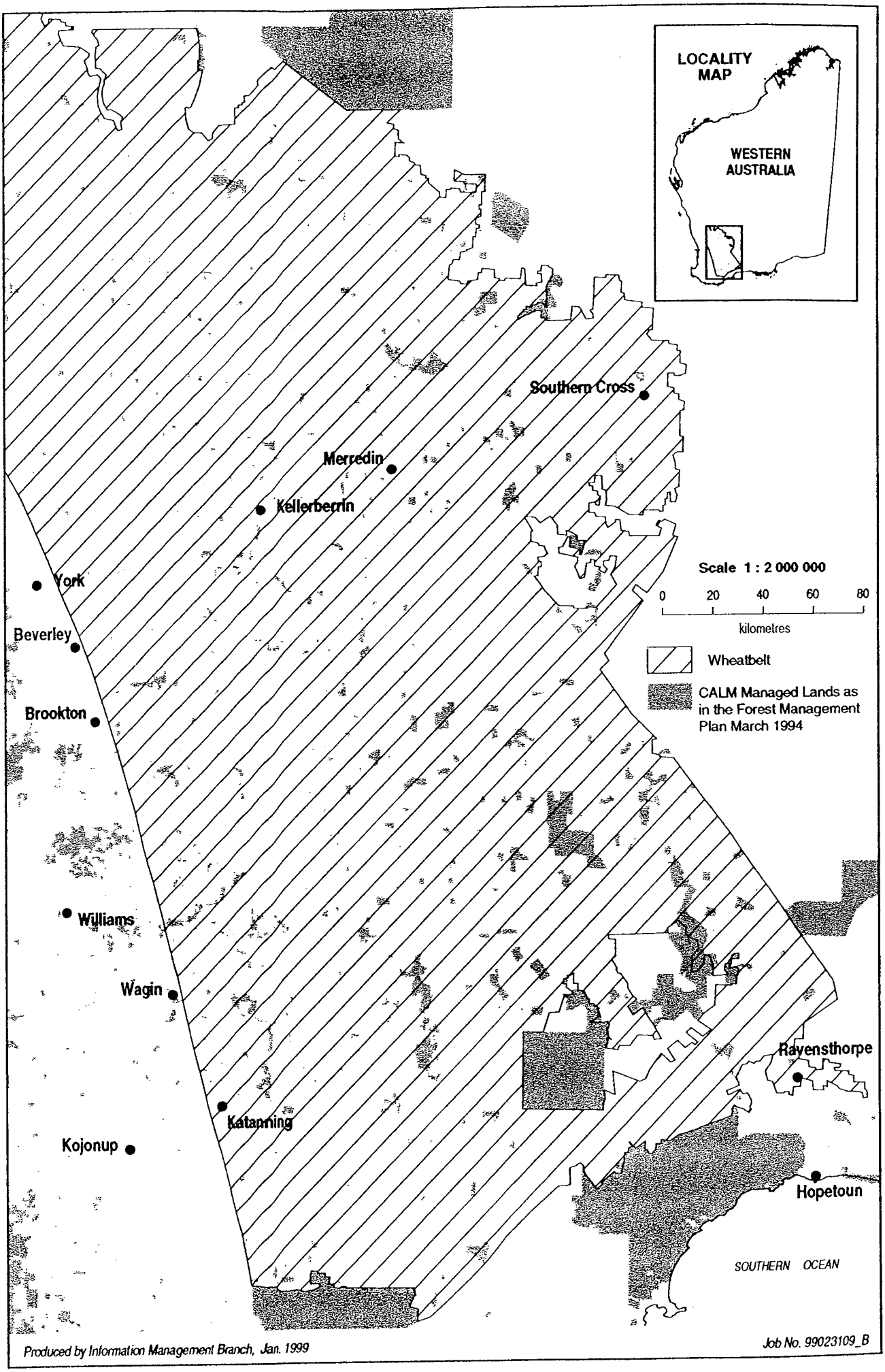
LOCALITY MAP
WESTERN AUSTRALIA
Southern Cross
Merredin
Kellerberrin
York
Beverley
Brookton
Williams
Wagin
Katanning
Kojonup
Ravensthorpe
Hopetoun
SOUTHERN OCEAN
Scale 1 : 2 000 000
0 20 40 60 80
kilometres
Wheatbelt
CALM Managed Lands as in the Forest Management Plan March 1994
Produced by Information Management Branch, Jan. 1999
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