Do current forestry practices threaten forest fauna? A perspective

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ABSTRACT

The question posed is whether current forestry practices threaten forest fauna? No confident direct answer can be given to this question. There are numerous reasons for this uncertainty. The question entails 'proof of the negative' which, in science, is typically a difficult task. Necessary observations of a sufficiently broad and relevant nature and over a sufficient time frame are of an anecdotal kind and few in number. There is a large number of fauna species involved, many of them rare and about which relatively little is known or it is difficult to obtain information concerning them. There are problems of scale in undertaking the appropriate scientific study of the possible impacts of forestry activities on native fauna. Then there is also the long time frame of logging cycles. Given sufficient time highly improbable contingencies have a propensity to become probable.

An indirect answer to the question is offered by way of the provision of comment on over-arching priorities in the future conservation management of our forest fauna. Knowledge and information in two themes are canvassed. The first theme relates to our own species, or rather to our capacity for technological innovation and, as a consequence of that innovation, our impact on the environment. The second theme concerns our knowledge of the ecological resource requirements of the fauna in which we are interested, together with a perspective on the nature and reasons for our losses of this fauna.

The core strategy in the future conservation management of forest fauna I see should be that of Popper's inverse (or negative) utilitarian. Rather than focussing on positive management the aim should be to identify and set priorities to avoid or minimise undesirable impacts of our human uses of the Australian landscape: to identify and ameliorate the undesirable impacts, or better, to desist from doing those things that are harming our fauna. In the context of the above strategy all evidence suggests that government decisions and policies that encourage or condone the permanent clearing of the native vegetation from lands of better quality soils, irrespective of land tenure, if continued, will probably have the most damaging of impacts on Australia's native fauna. In that same context the evidence indicates that whilst such land clearing continues, concern over threats to our native fauna by current forestry practices would be considerably misdirected.

Key words: forest fauna, arboreal marsupials, conservation management, philosophical approach, geology, foliage nutrients, fauna abundance relations, land tenure allocation, land use practice, land clearing.

Introduction

Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise.

John W. Tukey (1962)

The native forests have been, and continue to hold, centre stage in some of the most bitter environmental disputation Australia has seen. Prominent on that stage is our native fauna. The reasons why our fauna has featured thus are many but include particularly public empathy and concern over the conservation and welfare of our fellow species on this planet. The disputation is not over whether this fauna should be conserved *per se*, i.e. in intergenerational equity. It is between different perspectives as to whether or not current forest use practices might pose unacceptable levels of damage or risk. Therein lies a dual problem. On the one hand the question is important to many people – the reason it is so frequently asked. However, for the scientist it is a difficult question to answer definitively for a variety of reasons, many of which I go into later, but the principal one is that it involves 'proof of the negative'. As Pasteur discovered to his dismay in his efforts to prove spontaneous generation of life is a ridiculous idea (Dubos 1960), proving the negative can be a difficult task. In science, the absence of evidence cannot be taken as evidence of absence. On the other hand, the perspectives people hold are highly divergent. How each of us views and decides about the many things we hold as important, or cherish, depends greatly on two things, experience and context.

When Dan Lunney requested a contribution from me for this book and suggested the above topic I thought about this issue, about the importance of experience and context in determining perspective and in influencing decision-making. This contribution presents my perspective on the question posed. That the reader may appreciate my perspective – I am not asking people to necessarily agree with me – I provide here a deal of necessary background information. The perspective is that of a CSIRO scientist who was directed, with relatively little choice on his part, to undertake research to assist that part of Australia's timber industry based on the native forest resource. In undertaking my research, and in eventually arriving at the perspective I present, a not insignificant

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aspect, I consider, is the fact that the initial request for CSIRO's assistance came from the Australian Forestry Council (AFC), a committee of State, Territory and Commonwealth Government Ministers responsible for our timber production forests.

My research vocation with the CSIRO, which I joined as a professional officer in 1962 but since 1955 had previously worked with as a field technician on a temporary basis, primarily and initially concerned waterfowl biology. My vocation change on the 1st July 1977 to research forest fauna was due to various factors. Primarily though, it was the then burgeoning public disquiet and questioning of the possible environmental impacts of the export woodchip industry, including particularly the effects on the native fauna. CSIRO's assistance was formally requested in a letter sent from the AFC to the then CSIRO CEO Jerry (Sir Robert) Price. Mine then is the privilege of being amongst the first government-employed biologists assigned specifically to study fauna conservation management in Australia's native forests.

Debate and discussion of the possible threats of forestry practices to native fauna inevitably trail into discussion of many related questions, problems, issues and concepts of which the reader will no doubt have read or heard much. There is the long-term nature of the things that we need to take into consideration. For instance, the fact that trees take a long time to mature and, accordingly, logging cycles are typically of the order of 100-200 years plus. To address the question posed entails 'crystal-ball gazing'. There are also numerous related topical, essentially philosophical, concepts to consider, such as 'Ecologically Sustainable Development', 'Ecologically Sustainable Use' and 'Biodiversity Conservation Management'. I give my perspective concerning these concepts in varying detail.

In 1977, reading what was then known about the effects, or likely effects, on fauna of forestry management and listening to the advice of those who purported to have some experience, what was obvious was what was then 'known' was often little more than anecdote or speculation. There seemed few facts on which one could rely. The core problem, as I saw it then, and which remains so today, was knowing with reasonable precision what fauna occurred in the forests at any particular time and where it occurred. Without that basic information to discuss impacts, or potential impacts, of forest management on native fauna was, and is, nonsense. My first task was thus obvious. I had no alternative than to 'go in on the ground' and check for myself.

However, there were at least two additional significant problems. The first of these was the large number of fauna species that occur in forests. In the Murwillumbah region of north–east New South Wales, for example, an area of rich volcanic soils and good rainfall, there is of the order of 500 terrestrial vertebrate species. Of these, about 50 species are listed in the New South Wales *Threatened Species Conservation Act 1995*. In this region, no patch of forest occurs that is not, or is unlikely to provide, habitat for several or more of the listed fauna. This fact creates major problems in forest management. Wherever a fauna species occurs or, on expert opinion, is thought possibly to occur, and the species is also listed as threatened, then there is an onus on forest managers to take the likely impacts of forestry operations on the animal and its habitat into consideration in forest management planning. Each species has its own special requirements. Hence disturbance by forestry operations can, or can be expected to, affect the various species and their habitats differently. Some species may be advantaged, others disadvantaged to varying degrees by any given forestry activity as well as by the phase of forest growth following a logging operation, from recent regrowth to mature forest. Then there is the additional problem with rare fauna. Typically, these are species listed in the *Threatened Species Conservation Act 1995*, mainly due to their rarity. For many, little is known about them. A number of them, especially the mammals, are nocturnal in their habits and, in forested environments, are especially difficult to find, to study and to collect information about them. The biologist looking into issues pertaining to rare fauna is thus frequently faced with that maxim already mentioned, that absence of evidence is not evidence of absence. Hence the need to consider 'potential habitat' as well as those areas of forest in which they have been observed. Thus, in determining forestry operations in any given area of forest, how do you deal with the often-competing needs of habitat by the many different species present? And how can you, as required by law, demonstrate that the threatened species, about which little may be known but, by law, you are required to consider, have been given appropriate consideration?

The second problem relates to the question of whether we should be concerned about individual animals or a population of a species. The scientist will say the long-term persistence of populations is the priority concern. The eco-evangelist will say, especially with rare fauna, that every individual animal in existence at any particular point in time, or at least while the species remains rare, is what must be considered. How can we say that any hurt, at any time, to an individual animal of a particularly rare species does not constitute a significant adverse impact on the population of that species? There are, of course, instances where this may be so, or can be reasonably assumed. There are many instances, probably the majority, where it can be reasonably assumed that does not occur. Nature, it is said, is red in tooth and claw. Even in rare species, or in species officially designated as such, there is a high turnover of individuals. The death of one individual does not necessarily mean a net loss from the population. Compensatory factors are often in play, especially in those circumstances where animal habitats can be viewed as having a certain 'carrying capacity' – a given habitat will support, long-term, only a given maximum density of individuals of a species and no more. In science there is no certainty, only reliability. Francis Bacon (1561-1626) went on record to the view that, of course, all swans are white – that the concept of there being a black swan is rubbish. But that was because Australia with its black swans had not yet been discovered. Bacon's opinion was reasonable on the information available to him at the time. Thus the scientist has to concede the eco-evangelist may be right, though the scientist's opinion may also be that, on the information available and on balance, the eco-evangelist is over-playing the case.

These difficulties highlight the impossibility of science and scientist's providing a definitive answer to such a basic general question as whether current forestry practices threaten forest fauna. If we cannot answer this question then what do we do? How do we proceed in managing our forests to take appropriate account of wildlife values? Scientists cannot throw up their hands in horror and say, 'it's all too hard', and walk away from the question. Politicians and forest managers demand some guidance from scientists. Otherwise why bother training and employing people in this profession?

Concepts such as 'Ecologically Sustainable Development' 'Ecologically Sustainable Use' and 'Biodiversity Conservation Management', to my mind, have an unpleasant theological odor to them. They are idealistic. For those interested in science and its applications, Popper's criticisms of such idealism (see below) may be useful. In relation to the management of fauna in forests I have found much difficulty in seeing how concepts such as these may be translated into practice. If you do not have 'on the ground information', and have little likelihood of obtaining it to test such concepts and, if need be, to modify them, then to debate them, or worse, to advocate their implementation, is a waste of time. That is why, frequently, I am irritated by those who advocate the need for application of such concepts to native fauna. If one examines the credentials of such apologists one often finds that the degree of practical field experience is inversely proportional to those person's loquaciousness on such matters. They should be pointed towards a few thousand hectares of timber production forest, handed a pair of binoculars, notebook and pencil and challenged to demonstrate that the measures of fauna abundance and habitat use that they would use to test and demonstrate that what they are advocating is practicable. Without hard data and factual information, discussion of such topics becomes characterised by endless debate and much frustration over what is, or seems to be, needed. Generated in the debate are major incongruities in perceptions about what the problems are and how to resolve them between concept advocates, politicians, government bureaucrats, conservationists and forestry field managers and biologists. As one management specialist of some repute aptly diagnosed:

> *What A sees so vividly, B does not see at all. And, therefore, what A argues has no pertinence to B's concerns, and vice versa.*
>
> Peter Drucker (1993)
> *The Ecological Vision*

Trees are long-lived organisms and take many years to mature - a reason why commenting on what might happen in timber production forests and crystal-ball gazing probably have much in common. We see that R.A. Fisher, the renowned statistician, for example, when musing on Darwin's theory of evolution concluded that when given enough time, highly improbable contingencies become highly probable (Fisher 1954). And it is only a little more than 60 years since a freakish run of weather conditions culminated in the holocaust of the Black Friday, 13 January 1939, bushfires in south-eastern Australia (Pyne 1991). A not too dissimilar event hit Canberra on 18 January 2003. Despite the foregoing reason as to why predicting the future is a notoriously uncertain business, quite a few thinkers have had a crack at it with varying degrees of success. George Orwell's novel *Nineteen Eighty-four*, lambasting utopianism, springs to mind. So too do some of Williams' (1987) comments in his book, *Outpourings*. Williams lists a few of the bloopers made by scenarists of some note, including Ernst Mach, Alfred Nobel, Edward Teller, Thomas Edison, Lord Kelvin, John van Neuman, Robert Milliken and Albert Einstein. Thus, in commenting here on the future, rather than have my name added to Williams' illustrious list, I have taken the 'cop out' of, firstly, declaring that, like Popper (1972), I regard myself as a fallibilist. And secondly, in my philosophical approach to the topic I have borrowed from Popper's (1961, 1966, 1980, 1983) and Heilbroner's (1995) thinking, amongst others.

In a draft manuscript to this contribution I had assumed that most scientists would be familiar with Popper's philosophy and ideas. I had not, therefore, explained what I had 'borrowed' from his, as well as from Heilbroner's writing. Two referees requested me to please enlighten the potential reader, not to mention themselves. Well here are two excerpts from a recent reprinting of Popper's *Realism and the Aim of Science*:

> *I think there is only one way to science- or to philosophy, for that matter: to meet a problem, to see its beauty and fall in love with it; to get married to it, and to live with it happily, till death do ye part – unless you should meet another more fascinating problem, or unless, indeed, you should obtain a solution. But even if you do obtain a solution, you may then discover, to your delight, the existence of a whole family of enchanting though difficult problem children for whose welfare you may work, with a purpose, to the end of your days. (p. 8)*
>
> *Science is not only, like art and literature, an adventure of the human spirit, but it is among the creative arts perhaps the most human: full of human failings and shortsightedness, it shows those flashes of insight which open our eyes to the wonders of the world and of the human spirit. But this is not all. Science is the direct result of that most human of all human endeavours – to liberate ourselves. It is part of our endeavour to see more clearly, to understand the world and ourselves, and to act as adult, responsible, and enlightened beings. (p. 259)*

The Popperian approach to science, as I have interpreted Popper, is an essentially 'bottom-up' approach. One commences with an immediate and obvious problem and then you work your way, solving (hopefully) problem after problem, through layer by layer of understanding. When faced with some immediate problem one does not begin from the top, so-to-speak, by searching around for some 'off-the-shelf' and seemingly relevant theoretical precept or idea and then with reference to or by applying that precept deduce a convenient 'solution' – a solution convenient, that is, according to some perceived context such as an immediate bureaucratic, political or legal requirement or self interest factor, etc. The process of obtaining a 'solution' may have an advantage of speed and thus give an appearance of efficiency. However, the precept, and hence the 'solution', for various reasons neither understood nor examined at the time but usually connected with the realities of the world in which lives may have little or no relevance to the kind of problem for which a solution is sought. The mistakes, failures and embarrassments that have occurred, or been caused by problems of this kind, abound. Charles Darwin, for example, never outlived his embarrassment over a scientific paper he published on geological formations in Wales that he assumed were caused by wave action by the sea. He didn't look hard enough at the landscape and think about glaringly obvious anomalies to his initial assumption. It turned out that the formations were caused by glaciation (Darwin 1892).

One of the best summarizers and explicators of Popper's philosophy that I have come across is Magee (1975, 1997), educator, journalist, broadcaster and one time politician. Magee provides the following example of how, on Popperian principles, children's education might be best managed. It has long seemed to me that the underpinning philosophy in this example provides an ideal guide as to how also best deal with concerns over the welfare and future of Australia's wildlife.

> *The general guiding principle for public policy put forward in [Popper's] The Open Society is: 'Minimize avoidable suffering'. Characteristically, this has the immediate effect of drawing attention to problems. If, say, an Education Authority set itself the aim of maximizing opportunity for the children under its care it might, understandably, not be sure how to go about doing this, or it might start thinking in terms of spending its money on the building of model schools. But if, rather, it sets itself the aim of minimizing disadvantage, this directs its attention immediately to the most underprovided schools - those with the worst staffing problems, the most overcrowded classes, the slummiest buildings, the least or worst educational equipment - and makes doing something about them the first priority. The Popperian approach has this consequence right across the board: instead of encouraging one to think about building Utopia it makes one seek out, and try to remove, the specific social evils under which human beings are suffering. In this way it is above all a practical approach, and yet one devoted to change. It starts from concern with human beings, and involves a permanent, active willingness to re-mould institutions.*
>
> Bryan Magee (1975)
> *Popper*

Popper, ever the realist, is indefatigable in his criticism of idealism. He put it this way, for example, in his *Realism and the Aim of Science* (Popper 1983, pp. 102-103), '. . .realism is the logically stronger of the two metaphysical theories' (i.e. of idealism and realism). 'It [i.e. realism] is preferable for logical reasons: metaphysical idealism turns out to be void of *any* explanatory power.' And, ' . . . idealism does solve all problems – by emptying them.' (Italics emphasis, Popper's.) It is my observation and experience that idealists tend to blindness of the realities of the world in which we live and to see themselves as *possessors* of truth. And, conversely, that the realist is a *seeker* of truth (see also e.g. Popper 1980, p. 281. Italics emphasis here, Popper's).

Heilbroner (1995), in his book *Visions of the Future: The Distant Past, Yesterday, Today, Tomorrow,* points out that 'Today' (which Heilbroner defines as the period since the mid-1950s), dominating the expectations of Western culture are three immense forces that were unknown in the 'Distant Past' (the pre-1700s). The first of these is science with its promise of controlling nature. A second is the advent of capitalism, the means of organizing production. The third is the appearance of the revolutionary idea that people themselves are the master of their destinies. Given these three forces 'Yesterday's' (1700s to mid-1950s) view of the future, Heilbroner contends, was something quite unknown in the Distant Past: the expectation that the future will be better than the present. Our view of the future, of 'Tomorrow', Heilbroner points out, is not so rosy. Our view is still linked to science, capitalism, and democracy. However these powerful forces no longer appear as unambiguous carriers of progress. We look to science with apprehension, as well as with hope; capitalism on a global scale brings economic difficulties along with new horizons; the expression of mass political sentiments conjures up the nightmares of, for example, some of the African nations, as well as possibilities for a widening of democratic government. Humanity's expectations of life on earth in the future, in Heilbroner's view, may well be an extension of the past. His thinking on our human future, it seems to me, is also applicable in assessing the likely future changes in Australia's wildlife, including that of our forest fauna.

> *Looking back, I think it was more difficult to see what the problems were than to solve them.*
>
> Charles Darwin (1859) In:
> *The Autobiography of Charles Darwin and Selected Letters*

Thinking about the problem of how best to conserve the fauna of our native forests a workable philosophical basis, it seems to me, is a combination of Popper's recommended approach to society's management with Darwin's identification of the principal difficulty inherent in appropriately focusing scientific study – the difficulty of identifying the appropriate problem. Popper, incidentally, is a Darwinian. At the age of 12 his father tutored him in Darwin's ideas and his philosophy owes much to Darwin's theory of evolution by natural selection (Popper 1974). An awareness of a problem, plus an understanding of the problem's nature, are obvious pre-conditions to its solution. When I commenced research on the fauna of Australia's forests, and as it remains today, there was no question as to the starting point, the over-arching problem and my lodestar. It was, and is, intergenerational equity. The problem, and objective, is to maximise the wildlife resources we pass on to future generations of humankind. A directing ideology and enduring strategy? The nature of the problem determined these. And of that, when I started work in the forests, I didn't have the foggiest idea - though I pretended otherwise. Enough, to begin with, was my immediate problem of gaining familiarity with and an understanding of the fauna and its habitats that I was dealing with and in working out means of survey sampling animal numbers and their distributions (see Braithwaite et al. 1984a). Whilst thus engaged I concomitantly formulated, and set in some sort of priority order, the research questions that I should maybe address. The optimum strategy I came to see and appreciate is 'Popperian' - the strategy of the inverse utilitarian directed to ameliorating or minimising the efficacy of the cause of the problem rather than to that of ameliorating symptoms. I have often thought that the problem of the human AIDS epidemic is of similar kind to that of wildlife conservation. No matter how ethically desirable, not the most practicable way of dealing with AIDS is to expend scarce resources providing humanitarian relief to sufferers. The logical approach is to apply the maximum of resources to education programs and other support, such as the subsidized provision of contraceptives, needles, etc. to high risk members of the community and directed to minimising the spread of the infection until such time that, hopefully, a vaccine is developed. In terms of conserving Australia's wildlife the strategy should be, as the priority, to avoid or minimise further loss. This means defining, articulating and keeping constantly before public and political view, in priority order, the various threats to the fauna. Of the essence are hard facts to work with and to present to those who influence or make the necessary decisions.

With a philosophical framework established on how best to proceed, the task then is to begin gathering facts. We can examine our present knowledge and understandings of those forces that have determined the faunal resources of our forests as we now find them. The reasonable assumption is those same forces will continue in play. With that information, we can identify and set priorities to avoid or minimise the impacts of at least some of our human uses of the Australian landscape that seem undesirable. Maybe indicated will be things that we are at present doing and, as the priority we would be wise to discontinue. Also there may be some things that we are not doing and that we would be wise to implement.

In this task of fact gathering I see two priority themes. Theme 1 relates to our capacity for technological innovation and, as a consequence, our impact on the environment. I use the term 'technological innovation' in its broadest sense as the practical application of anything new, of new information, knowledge, procedures or, say, using a tool to advantage for purpose(s) other than those for which the tool was initially designed. Experience tells us that technology frequently precedes scientific understanding – that things are invented or certain practices become custom (e.g. the use of animal dung and fallowing in agriculture) and often it is not until later that scientific understanding reveals why these things work. This is not to deny that once this first step of 'invention' or 'discovery' has taken place, knowledge achieved through scientific study then sets in train a positive cycle of further technological innovation. Scientific study may produce even greater efficiencies and benefits or, in some instances, detriments (e.g. weaponry). Theme 2 concerns the biota, the fauna and its habitat, in which we are interested, or rather our knowledge of our biota's ecological resource requirements, together with a perspective on the nature and reasons for the substantial losses of these resources since settlement. By examining knowledge within each theme we see linkages between the themes. And it is in these linkages, it is my contention, that we find valuable insight for assessing the possibilities for the future of the fauna of our native forests.

Theme 1. Technology

Human cultural success over most of the entire past 10 000 years has been intimately related to the development of expertise in agriculture is historical fact (e.g. Morris 1971; Diamond 1998). Until about the last two centuries, only a few societies have managed to escape that stricture with varying degrees of success. Wherever food production has been constrained by environmental or cultural factors the societies so affected have remained primitive, e.g. hunter-gatherers, herders of stock or maintainers of small garden plots. In the absence of reliable supplies of nutritious foods from which 'surpluses' have been available for distribution (or, rather, to be extracted as taxes), support for the prerequisites of more advanced cultures has been impossible, i.e. for the necessary bureaucracy (to collect the taxes, amongst other things), for expertise and labour to build food storage and transportation facilities, irrigation systems, defence works and monuments, including tombs for kings and temples for priests (to encourage obeisance in the proletariat), and so on.

Knowledge about soils, including means of effectively disseminating and applying such knowledge, has been critical in the success of agriculture. What I find remarkable as a biologist whose focus of interest is the conservation management of the Australian fauna is that the development of this self-same knowledge has not hereto been identified as a key factor in one the most serious of global problems in biological conservation; this especially so if we reflect that this factor is coupled with a second serious problem, that of our burgeoning human population. I find, for example, Huston (1993, 1994), in his examination of global problems in biological conservation has singularly failed to focus on the relevance of the connection between our knowledge of soils and of land clearing practices. Just how important it is we can begin to appreciate as we address Theme 1 and look into the question of some of the things that we have learnt about soils, and when we learnt them. In a reconnaissance of this topic, I found these excerpts revealing:

~2000 BC

In relation to agricultural practices of late Stone Age people in Arran, Scotland:

> *. . . even in prehistoric times, soil chemistry, if not a soil chemist, was influencing land use policy decisions.*
>
> M.S. Cresser *et al.* (1993)

~37 BC

> *. . you can judge whether land is fit for cultivation or not, either from the soil itself or from the vegetation growing on it: from the soil according as it is white or black, light and crumbling easily when it is dug, of a consistency not ashy and not excessively heavy; from the wild vegetation growing on it if it is luxuriant and bearing abundantly its natural products.*
>
> M.T. Varro (ca 37 BC).
> *Res Rusticae* (On agriculture)

~60 AD

. . . there are three kinds of terrain – champaign, hilly and mountainous. . . . under each of these classes there fall six species of soil – fat or lean, loose or compact, moist or dry. . . .

No kind is considered worse than that which is at the same time dry, stiff and lean. This type, whether in tillage or fallow, is a source of grief to the husbandman and should be shunned as if it were plague-ridden ground; for the one type brings death, and this brings starvation, that most frightful attendant of death.

L.J.M. Columella (ca 60 AD)
Res Rustica (On agriculture)

1644

In advising on how to best educate students:

After evening repast, till bed-time, their thoughts will be best taken up in the easy grounds of religion and the story of Scripture. The next step would be to the authors of Agriculture, Cato, Varro and Columella, for the matter is most easy, and if the language is difficult, so much the better; it is not a difficulty above their years. And here will be an occasion of inciting and enabling them to improve the tillage of their country, to recover the bad soil and to remedy the waste that is made of good; for this was one of Hercules' praises.

John Milton (1644)
Of Education

1776

Agriculture, though the most necessary, has been perhaps the most neglected of all the arts. Every other art has undergone considerable improvements in this and the last century; but we cannot affirm the same for agriculture. It seems to me little better understood in Europe at present than amongst the ancients and I believe Virgil and Columella may still be reckoned the best authors on that subject.

Francis Homes (1776)
The Principles of Agriculture and Vegetation

Homes' (1776) account well indicates the knowledge landscape on scientific thinking about the role of soils in agriculture around the time of Australia's settlement in 1788. The 1776 publication was the third edition of his book, the first edition having been published in 1757. Homes' book was thus presumably popular at the time. Homes, a physician by profession had, by 1776, recognised six categories of soils: Loam, Clay, Sand, Chalk, Till and Moss (Peat). Loam was recognised as by far the best soil. Clay, Sandy and 'Till' (soils of poor quality and reddish-grey or yellowish in colour) were identified as needing much husbandry effort to keep them productive. Mossy soils, especially, required lime to make them productive. Manures used included those recognised as of 'fossil' origin ('fossil', at that time, meaning anything dug up from the ground, e.g. marl, limestone and chalk), soot and vegetable and animal waste (including dung and urine). The importance of fallowing and of the exposure of soils to the atmosphere (cultivation) was emphasised, as was crop rotation (alternating fibrous rooted crops with those such as turnips and carrots). Homes makes extensive mention, indicating the interest at the time, of the enhanced growth response of vegetables with the addition to soils of 'nitre' in one form or another, including saltpetre (potassium nitrate), a key constituent of gunpowder. There is speculation that 'Nitrous acid' may exist naturally in the air. We see presaged recognition of nitrate as an important factor in soil fertility, and hence the potential value in agriculture of using chemical fertilisers. In that era the term 'geology' had yet to enter the lexicon. Homes makes no mention, suggesting that there was as yet no cognisance of the significance, of parent rock type in determining soil fertility. The state of understanding about the determinants of agricultural production in this era seems eloquently stated by Homes:

It is the common fate, in all disputed points, that each attaches himself to one side, without allowing the other any share of the truth. I have found by experience, that each side has generally some truth in it; that mankind err by extending that particular truth to a general one; and that the real truth is generally made up of somewhat taken from each opinion. The reasoners on agriculture have failed, because they asserted, that plants were fed either by air, water, earth, or salt. I join, in some measure, with all these; and that plants are nourished by these bodies united with two others, oil and fire in a fixed state. These six principles joined together, in my opinion, constitute the vegetable nourishment.

Francis Homes (1776)
The Principles of Agriculture and Vegetation

The colony at Sydney Cove, established in 1788, had as its first governor Arthur Phillip. Phillip's credentials for the appointment included 'experience in agriculture' (Hughes 1982). Given this fact, plus the obvious need and priority in the colony's establishment for self-supporting agricultural production, I found it surprising that Homes' book is not listed amongst the reference works brought to Australia with the First Fleet in 1788 (see Steele and Richards 1988). Nonetheless, what is included are the initial volumes of the journal *Annals of Agriculture and Other Useful Arts*. These volumes show that the information on agriculture available to the first settlers closely followed that in Homes' book. Certainly, the horticultural methods applied by James Ruse, Australia's first farmer, (Clark 1962, Egan 1999) resemble those then advocated by Homes (1776). And again, if further evidence is needed of the social and political interest in and awareness of the potential importance of the development and application of scientific knowledge in agriculture, we see the below statement, this time by a professional from an entirely different discipline, that of economics, whose book had a level of impact on social and political thought then, and since, probably not dissimilar to Charles Darwin's *The Origin of Species*:

The produce of the land . .[is]. . the sole or the principal source of the revenue and wealth of every country.

Adam Smith (1776)
The Wealth of Nations

The impact of Smith's ideas on thinking on national development is nowhere better provided than in William Pitt, the British Prime Minister's 1792 speech on the State of the Nation. In deference to the then late Dr Adam Smith (1723-1790), Pitt notes Smith, whose:

. . .depth of research, power of reasoning and extensive knowledge have long made him the object of veneration and respect.

The profits of one year produced profits on another, and operated as compound interest . . .if peace should continue for any length of time the ultimate increase in the capital of the kingdom could not, he said, be calculated while one Ipot of ground in the country had not reached its highest degree of cultivation.

William Pitt (1792)

Kociumbas' (1992) contribution to *The Oxford History of Australia* indicates the prominence of Smith's economic individualist ideas in underpinning 18th Century thinking on Australia's settlement and the colony's social, political and economic development. In *The Wealth of Nations*, Smith was primarily interested in the processes whereby national wealth is created. He emphasised the importance of the division and the efficacy of various kinds of labour and the importance of governments encouraging the pursuit of self-interest and free trade. Notwithstanding Smith's focus of ideas in the generation of wealth his book shows that he was also well aware of the importance to agriculture of climate and soils.

How effectively did the colonists use this knowledge and understanding? What we see is the taking of notes on the quality of soils, if not the actual collection of soil samples, was a routine procedure on excursions. The overseeing of soil sample collection was assigned to a Marine. The samples were placed in calico bags for later evaluation, evidently by one or another of the ships' surgeons (see Fitzhardinge 1961; Fletcher 1975). We find the following diary entries:

1788

We walked over a vast extent of rich land and through some pleasant valleys, and the soil seemed fit for producing any kind of grain, but from its situation, the quantity of heavy timber growing upon it, to render it fit for cultivation, it would require a vast number of people, and teams of cattle, and a great length of time.

George B. Worgan (1788)
Journal of a First Fleet Surgeon

George Worgan, the surgeon on the Sirius, was on an excursion probably in an area west of what is now Pennant Hills on Sydney's North Shore. In his diary, under the date of Monday 9th June 1788, Worgan's comment on the need for cattle reflects, presumably, his appreciation of the need of these animals to assist in removing the timber, ploughing the ground and providing manure for the cultivated lands. If one gazes today over Sydney's sprawling metropolis, Worgan's note seems eerily prescient. We see prophesized the demise of a substantial portion of Australia's forest biota. Another comment, this time from a colleague and close friend of Worgan's, Watkin Tench, a Captain of the Marines:

1790

On all these excursions we brought away, in small bags, as many specimens of the soil of the country we had passed through, as could be conveniently carried; in order that by analysis its qualities might be ascertained.

Watkin Tench (1790)
A Complete Account of the Settlement at Port Jackson

By 1823 we see that soil parent material type had been recognised as an important factor in soil fertility. A report to the government of Great Britain concerning the state of agriculture in the new colony:

1823

The country that extends on the whole line of the sea coast of the county of Cumberland, from Coal Cliff to Broken Bay, and for six miles into the interior is a succession of ridges of stratified sandstone. . . . The surface of this part of the country is covered with a thin soil of decomposed sandstone. . . . The external appearance of the coast and the country around it is of the most sterile and forbidding kind.

The soils of which the interior of the county of Cumberland is generally composed is thin and light, lying on aluminous, red, yellow, or blue clay, that deepens toward the interior, and upon a substratum of aluminous slate. . . . It is more fertile as the land rises gradually into hill. . . .

The alluvial land in the county of Cumberland is distinguished by its depth and inexhaustible fertility. . . . Nearly in the centre of the county is a tract of land consisting of a deep red loam, covering the summit, sides and base of an elevated hill that is composed of whinstone, and that has long been distinguished for its fertility. It is called Prospect Hill, and is situated five miles to the west of Parramatta.

J.T. Bigge (1823)
Report of the Commissioner of Inquiry on the State of Agriculture and Trade in the Colony of New South Wales

Bigge, in his report, may have capitalized on the knowledge of local wealthy landholders:

1826

Forest lands are variously designated according to the quality of the soil, or the nature and number of trees growing thereon, such as good, poor, open or thick forest.

It is, however, always to be understood, that forest means land more or less furnished with timber trees and invariably covered with grass underneath and destitute of underwood. Under the head of forest lands are included some of the best and most improvable soils in the colony: they are generally either clay or loam of various degrees of tenacity with a layer of vegetable earth on the top, extremely well calculated for the growth of grain.

In the county of Cumberland one immense tract of forest extends, with little interruption from below Windsor to Appin, a distance of 50 miles; large portions of this are cleared and under cultivation, and the remainder that is still in a state of nature, a great part is capable of much improvement. The whole of this tract and indeed of all forest in this county was thick forest land, covered with very heavy timber, chiefly iron and stringy bark, box, blue and other gums and mahogany.

The quality of most forest land, and indeed most others will be found to be governed by the nature of the rocks and stones that form the basis of the soils; thus in this tract of forest, in the county of Cumberland, the rocks *are either common or calcareous sandstone, ironstone and in some few places whinestone*[1]*, these form soils of various degrees of goodness, the whinestone generally the best . . . .*

James Atkinson (1826)
An Account of the State of Agriculture and Grazing in New South Wales

From this point we see rapid advancement in technological and scientific knowledge relating to agriculture. A positive feed-back loop had been established. Advances in knowledge were both driven by, and driving, the colonists' keen interest in developing Australia's natural resources. Strzelecki (1845) in his report of extensive field surveys and researches in New South Wales and in Tasmania, or Van Diemen's Land as it was then known:

1845

Strzelecki in the 'Introduction' to Section VIII (pp. 357-358) of his report:

The subject of Agriculture will appropriately form the present or concluding section of this work, because no branch of science is more dependent and more consequent upon other branches of physical inquiry; appearing, in all its most important facts, as a mere result of previously acquired studies.

From this admirable connection and wholesome concurrence of the positive sciences in the promotion of one which embraces all the most important and vital interests of human industry, it follows necessarily, that the delineation of the agricultural character of New South Wales and Van Diemen's Land, including both the general and specific character of soils, and their adaptation either to indigenous or exotic plants, will involve an unavoidable repetition of facts and observations already contained in the preceding sections.

To this will be added an inquiry into the state of agriculture, as it is actually practised in the two colonies, and also a survey of their pastoral operations.

The practical application of science will come next, not only to point out and correct mistakes and prejudices if such are found to be entertained amongst farmers, but also to suggest the speediest, cheapest and most attainable means by which the actual mode of farming or grazing may be improved, the forces and vitality of agricultural and pastoral lands preserved or exalted, and the crown or other unoccupied lands rendered available to industry.

Extracts from the report (pp. 360-362):

In New South Wales, granite, sandstone and conglomerates preponderate; in Van Diemen's Land porphyry, greenstone, basalt, and trachyte.

In the former, limestone is confined to few localities; in the latter, that species of rock is more diffused.

From this difference in the geological materials of the two colonies, it necessarily follows that their respective soils must be different also. . . . .

The analysis of the prepondering soils of the one and the other colony, shows, at the outset, that the soils of New South Wales contain from a quarter to one third less of matter soluble in hydrochloric acid than those of Van Diemen's Land; and further, in the final determination of the constituents, the analysis shows a larger quantity of alkalies and salts in the soils of greater solubility, and a larger quantity of silica in those of lesser solubility. . . . .

Compared with the virgin soils which the writer has examined in Canada, the United States, Brazil, the Argentine Republic, Guatemala, Mexico and the islands of Bailly and Lumbock, those of New South Wales and Van Diemen's Land are greatly inferior in the amount of salts and alkalies they contain, and therefore in fertility. . . .

Classification of Soils

The varieties of soils which are observed in the two colonies may be traced not only to the kind of rocks characteristic of each colony, but to their respective configuration, and to the greater or lesser denudation and renovation of the surface consequent upon that configuration. . . .(Strzelecki's underline emphasis.)

The sudden condensation of vapours in New South Wales, and their gradual condensation in Van Diemen's Land, have been pointed out, in Section III, as meteorological facts which distinguish the respective climates of these colonies. Their effects, as bearing down upon the question before us, are obvious; and thus, in New South Wales, the denudation may be safely inferred to be the greater, and more injurious to the country than in Van Diemen's Land.

From what has been said, it follows that the soils of the two colonies consist of two distinct classes, within which all the minor varieties may be include: the first, impoverished by denudation; the last enriched by the drift, presenting every inducement for agriculture[2]*. (Strzelecki's underline emphasis.)*

Strzelecki concludes (p. 461):

The highest nobility lead the way to a new national glory – the glory of the perfection of agriculture! The Dukes of Richmond, Rutland, Portland, Buccleugh, and Sutherland, Lords Spencer, Ducie and Aberdeen, Sir

[1]Soils later recognised of basaltic origin and considered moderately fertile (see e.g. Chapman and Murphy 1989).

[2]Strzelecki (p. 374), in noting the contrast in the fertility of the soils of Tasmania, compared to mainland Australia, relates this to the then, i.e. in 1845, substantial difference in the area of land under cultivation. Though Tasmania (Van Diemen's Land) was established in 1804, 16 years after the establishment of the settlement at Sydney Cove, by 1845 there were 160 000 acres under cultivation. In New South Wales, by comparison, there were only 120 000 acres.

The general fertility of Tasmania's soils, relative to those of the mainland, it might be speculated, may partly explain the difference in abundance of ground mammals between the two regions. Wildlife biologists familiar with the fauna of mainland Australia, with its dearth of individuals of many ground mammal species of forest and woodland habitats, are always pleasantly surprised at the numbers of these animals they see in Tasmania. The two quolls, the Spotted-tailed Quoll *Dasyurus maculata* and the Eastern Quoll *D. viverrinus*, which is now extinct on the mainland, are particular examples.

Robert Peel, etc. etc. are at the head of the movement, and identifying themselves with that noble profession "upon which the welfare and development of the whole human species, the richness of states, and all commerce, depends." (Strzelecki's underline emphasis.)

P.E. Strzelecki (1845)
Physical Description of New South Wales and Van Diemen's Land

Strzelecki, apart from his interest in exploring and in geology and soils, was also keenly interested in the pastoral industry in New South Wales. I had read his book *Physical Description of New South Wales and Van Diemen's Land* to the end, including his foregoing observations and comments and was mulling over the question of how that information and knowledge was translated into practice for the benefit of the early settlers. From my general reading it seemed that many of the earliest settlers with their flocks of sheep used pretty much a 'hit or miss' method of choosing suitable grazing land. Given the substantial investment at stake, the settler's economic survival if not his life in displacing and fighting off the native inhabitants, that seemed to me rather odd. Then I recalled the following note (p. 366) in Strzelecki's book. When I re-read this, its implications were instantly obvious.

Those of the sheep-owners who were owners also of large landed property, covered it with their flocks; those again, who invested their capital in sheep alone, fell upon the unoccupied land belonging to the Crown. If the tract which they came across suited them, they remained on it [i.e. squatted], erected, in a day or two, a bark hut, and, in the course of a fortnight completed the sheep establishment, and applied for and obtained a squatting licence. If it did not suit them, they struck camp and proceeded further. In both instances, - that is, whether the sheep run was private or crown property, - the choice of the daily pasture was left to the instinct of the animal; and in nine cases out of ten, it was the flock which guided or determined the direction which the shepherd took. (My underline emphasis.)

P.E. Strzelecki (1845)
Physical Description of New South Wales and Van Diemen's Land

The new settlers (i.e. especially squatters), we learn, were using their sheep as a 'bio-indicator' to select efficiently areas of best graze and hence of better soils. Then, checking the early 1800s standard texts on sheep husbandry I found that, given the following advice, this 'trick' in the selection of grazing land was evidently little other than the expected.

Nothing will conduce so much to the health of the sheep, and to the speedy taking on of fat, as the frequent shifting of the flock. Disease will doubtless still affect the animals, but illness will be rare and mortality diminished, if by the care of their rulers, they are enabled to obtain what instinct tells them is the best medicine.

Ambrose Blacklock (1839)
A Treatise on Sheep

Thus was the scene set for the application, with vengeance, of Adam Smith's thinking and ideas to Australia's national development. The colony of New South Wales was granted responsible government by Great Britain in 1855. This was followed, in 1861, by the colonial government passing the Crown Lands Alienation Act. The Act was designed to 'open up' the colony to settlement. With minimal restrictions all land was opened to application by a new wave of settlers who, it was prophesised, would '. . . .produce more wealth on one acre than the squatters could do on a hundred.' (Clark 1978). Failure of a settler to develop his 'selection' within the approved time and guidelines would result in forfeiture of the land back to the Crown. It goes without saying that the land alienated from the Crown in this way was predominantly the land available of the better soils. The consequences were twofold. There was destruction and waste of timber as otherwise commercial forests were cleared (Carron 1985, Grant 1989, Reed 1991). But there was also suitable land for development not immediately cleared, much of it 'stock-piled' by the more acquisitive or 'entrepreneurial' souls for later (including current) development. Land assigned for sale by the Crown was gridded on maps into one mile by one mile squares, the standard block size thus being one square mile (640 acres), called a section (Clark 1950). If a selector wished to purchase a lesser area than a full section, special application was needed. The selector was obliged on his 20-640 acre (8-260 ha) block to only cultivate one acre in ten, or erect a habitable building, or enclose his selection with a substantial fence. The system of selection was moreover open to much fraud. Squatters often obtained title to more than one selection by the use of 'dummies' – persons paid for the use of their name as a *bona fide* selector. A favourite ploy was the use of the 'flying hut' – a hut which could be quickly taken to pieces and moved from one district to another. Evidence of selection was thereby provided for the benefit of officers of the Lands Department whose task it was to ensure the conditions of selection were met. It was, and remains, the land alienated from the public estate and 'stock-piled' for later development or sale, that has thereby retained its native vegetation cover. It is this same land that has been a principal focus of attention of land developers to the present day.

In the context of furthering Australia's development, Strzelecki's work, through increasing the level of understanding about Australia's soils, unquestionably increased efficiencies in the process of determining the agricultural potential of different areas and in determining the major foci of land clearing. With the exception of the Gippsland region of Eastern Australia his researches may not greatly have affected, at least initially, the rate of land alienation from the Crown. With sheep such a 'ready-and-at-hand' and effective bio-indicator, intending squatters and purchasers of land presumably had little need for Strzelecki's science. That doesn't mean to say that Strzelecki's, and others' (see below) scientific research is not critical to our understanding of the identity and nature of a key problem in wildlife conservation management. Without scientific facts and the associated explanatory understanding the chance of success in achieving our objective of intergenerational equity is diminished.

Marshalling the necessary political support is more difficult. Only in relation to Gippsland does it seem that a pamphlet published by Strzelecki directly encouraged new settlement (Bride 1898). In Western Australia, by 1831, the first agriculturists had discerned the correlation that exists between the type of native vegetation and soil quality and were using this relation to guide their selection of land (Cameron 1979).

Despite official condemnation of land clearing (e.g. Australian Forestry Council 1992; Resource Assessment Commission 1992a) this process has continued from the 1860s to the present day (Wells *et al*. 1984; Kirkpatrick 1987; Woodgate and Black 1988; Nadolny 1991; Graetz *et al*. 1992, 1995; Benson and Doherty 1993; Queensland Comprehensive Regional Assessment Task Force 1994; Environmental Research and Information Consortium 1998; New South Wales Department of Land and Water Conservation 2001a, 2001b). The difficulty of addressing the land clearing issue is, I think, no better indicated than by the fact that in 1997 the CSIRO was 'highly supportive' of a draft proposal prepared by two NSW State Government agencies that, in effect, allowed for further clearing of Mallee in the far west of the state (Freudenberger *et al*. 1997)[3]. Woodford (2000) noted that official approvals for land clearing in New South Wales in the period January 1998 to August 2000 amounted to 208 360 hectares. Australia-wide, in 1999 and 2000, land clearance each year amounted to some 500 000 hectares (Australian State of the Environment Committee 2001). We also see this observation and comment in a scientific journal and from a reputable source:

> *The Sydney Morning Herald of 19 July 2000, printed an article by the New South Wales Government to take action against a landholder in north-west New South Wales who has cleared or is clearing 130 square kilometres of coolibah-belah scrub after it had been aerially sprayed. The article went on to say that there had been no successful prosecutions of 360 breaches of the Native Vegetation Conservation Act and that 95 % of applications are approved of the total of approximately 1300 square kilometres that are cleared per annum. . . . Stories such as the one instanced emphasise the perception by city populations that we are wrecking our future sustainability . . .*
>
> John Kerin (2001)
> Minister for the Environment and the Arts
> Hawke Labor Governments 1987-1988

Today in Australia, readily observable, is the fact that land development has avoided the areas of poorest soils. Even in the highly populous Sydney Basin region native vegetation cover within the sandstone country of very low fertility remains mostly intact (Benson and Howell 1990).

From Strzelecki's time until recent decades, if pressures for land clearing were at times relaxed, governments of all persuasions have retained a positive view of land development. Active and effective government support for land clearing was provided through taxation incentives and the contribution of research information. In Prime Minister Menzies era in particular, in the aftermath of WWII from the mid to late 1940s through the 1960s and beyond, the considerable resources of the Commonwealth's research agency, the CSIRO, were applied to the assessment of land for its agricultural potential (e.g. CSIRO 1946-1977; 1949-1988; 1953-1972)[4]. Some of the conclusions in these research publications make interesting reading, such as:

1964

> *In the heavily timbered country of the Gnangara association clearing costs may be justified . . . .*
>
> W.M. McArthur (1964)

1978

> *. . . . land system surveys are general purpose and at this stage provide an excellent basis for preliminary economic assessments of the infra-structure likely to be justified by future developments. . . .*

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[3]As the clearing of Mallee covered by this approval is, presumably, complete, there seems a good opportunity now available to evaluate the underpinning assumptions and the potential efficacy, or perhaps inefficacy, of the Comprehensive Regional Assessment (CRA)/ Regional Forest Agreement (RFA) criteria and process guidelines (ANZECC/MCFFA 1997)* used by the NSW Department of Land and Water Conservation and the Southern Mallee Regional Planning Committee (NSW-DLWC/SRMPC 1997), as well as by the CSIRO, in deciding on the proposal. The RFA process has not been without robust debate (see e.g. Australian National University 1998).

It is my view that in such an evaluation an assessment of the affect on the Malleefowl *Leipoa ocellata* may be remarkably interesting and useful. Frith (1962), provides data and observations that convincingly indicate that this species is highly dependent on habitat of better quality soils. The Malleefowl is one of Australia's iconic fauna species. It is listed as endangered in the *New South Wales Threatened Species Conservation Act 1995.*

* ANZECC/MCFFA - Australian and New Zealand Environment and Conservation Council/Ministerial Council on Forestry, Fisheries and Aquaculture.

[4]As early as 1936 R.G Menzies (1967), a 'British Empire man to his bootstraps', is on record as strongly of the view that Australia must grow its population and develop its natural resources:

. . . a secure British world requires Dominions developed to the utmost in point of population, production, manufacture and all the resources of civilization.

However, lest it be construed from this that CSIRO's research activities of that era were aligned solely with Menzies' Coalition (Liberal and Country or National Party) policies on Australia's national development, we see this statement in a paper by a later Labor Party Prime Minister, E.G. Whitlam (1957):

(e) Commonwealth Pioneering Enterprises

Australians will not fulfil their heritage as a nation and discharge their obligations to mankind until they develop and use the whole of their continent . . . . . .

Quick surveys at the rate of 3500-4500 acres a day distinguished non-arable land, while arable land was surveyed at the rate of 300-500 acres a day.

P.H.T. Beckett and S.W. Bie. (1978)

Experience, we usually find, shows that we should be wary of arguments by apocalypse. Malthus' dire warning of the early nineteenth century, for example, that the human population must eventually exceed the available food resources has not yet come to pass. Nonetheless, the above outline indicates the level of incentive and the forces operating in our drive to identify and to convert land suitable for agriculture to that purpose. At stake has been our social and economic well being. No greater incentive could have been provided to apply our ingenuity and whatever resources were available to the task. As Evans (1998) has indicated, sooner or later the global supply of land suitable for agriculture that remains undeveloped, but could be developed to produce more food, will be exhausted. In the Amazon Basin of Brazil, for example, we see a looming problem if Fearnside's (1990) assessment, below, is correct. In recent decades the extensive agricultural land developments in that region of the globe have come to focus increasingly on land less than ideal for the purpose. It is not difficult to speculate about the environmental consequences of such development, not to mention the eventual plight of the farmers. A similar more recent and unhappy prognosis has been made concerning United Nations sponsored re-settlement of people in central African forest areas (Barnes and Lahm 1997).

Land settlement in Rondonia, Brazil

Percent Area of Land in Settlement Schemes Classified as 'Good for Agriculture'

Schemes Established in:	
Early 1970's	42%
Early 1980's	15%
Early 1990's (Planned)	0.13%

Data from Fearnside (1990)

For a successful technology, reality must take precedence over public relations, for nature cannot be fooled.

Richard P. Feynman (1986)
Minority Report to the Space Shuttle Challenger *Inquiry*

In all this, it seems to me, there lies a most significant global problem in biological conservation. To talk of land clearing *per se* as the problem largely misses the point. For the reasons most aptly described by Columella nearly 2000 years ago, the clearing of land for agricultural and pastoral pursuits has always been, is, and in future will be, as the priority, highly directed towards the lands available of the best soils.

Thus, I think it is not unexpected to find agreement, either explicit or implicit, on the problem of land clearing by people of widely disparate ideology. We see, for example, as early as 1848, Marx and Engels' anxiety:

The bourgeoisie, during its rule of scarce one hundred years, has created more massive and more colossal productive forces than have all preceding generations together. Subjection of nature's forces to man, machinery, application of chemistry to industry and agriculture, steam navigation, railways, electric telegraphs, clearing of whole continents for cultivation, canalization of rivers, whole populations conjured out of the ground . . . .

Karl Marx and Friedrich Engels (1848)[5]
The Communist Manifesto

The sentiments are not dissimilar to the much more recent observations of a person who, as previously noted, is a renowned doyen of capitalism and capitalist methods:

Aware that we are living in the midst of a technological revolution, we are becoming increasingly concerned with its meaning for the individual and its impact on freedom, on society, and on our political institutions. Side by side with messianic promises of utopia to be ushered in by technology, there are the most dire warnings of man's enslavement by technology, his alienation from himself and from society, and from destruction of all human and political values.

Peter Drucker (1993)
The Ecological Vision

Summing up Theme 1 we see that to service the increasing social and economic needs of the expanding human population there will be, firstly, increasing and inexorable pressure to continue clearing native vegetation from land of the better soils. With the clearing will go a concomitant adverse effect on the fauna dependent on such habitats. Secondly, because numerous elements of Australia's native fauna are common to both forests and woodlands the problem of intergenerational equity, of the conservation of this fauna, is not constrained solely to the forests. In this context the conservation requirements of the Koala *Phascolarctos cinereus* provides a particularly good example. The Koala is a species characteristic of woodland rather than of forest environments (Braithwaite 1993; CSIRO 1997; see also e.g. Munks *et al.* 1996; Martin and Handasyde 1998; Sullivan *et al*. 2003).

Theme 2. The forest biota and its ecological requirements

In 1977, when I commenced my research into the question of the potential impacts on fauna of forestry management, there had been relatively little scientific study of the subject. In the Eden forests the Forestry Commission of New South Wales (FCNSW), later State Forests of New South Wales (SFNSW), had initiated work in 1975 in collaboration with the Australian Museum (Recher *et al*. 1980). Integrated logging operations, including woodchipping, had commenced in the Eden region in 1969 (FCNSW 1982). In 1977 there was some debate within the CSIRO as to whether the Eden forests may be the most appropriate locality in which to initiate a CSIRO research program on the fauna of Australia's forests. The question was soon resolved. A specific request by the FCNSW

[5]Quoted from Heilbroner (1995).

for CSIRO involvement in fauna research at Eden, plus political realities, determined that the Eden forests, and not elsewhere, was the place to begin. By the early 1970's the perceived environmental impacts of the woodchip industry had been elevated to an issue of major national concern. Elsewhere, in forests not utilised for woodchips, logging operations in native forests were drawing relatively minor attention. Prominent in assisting raise the issue of forest conservation and the potential impacts of woodchipping in the national consciousness was the publication of Routley and Routley's (1975) book *The Fight for the Forests*. The Routleys' objective (in which they were highly successful) was to increase public awareness of the aesthetic and amenity values of public forests *vis-à-vis* economic values. The following sentiments of John Stuart Mill, which they quoted, reflect the Routleys' empathy and passion:

> *Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings, every flowery waste or natural pasture ploughed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture.*
>
> John Stuart Mill (1848)
> *Principles of Political Economy*[6]

I have summarised much of the history and the results of CSIRO's involvement in fauna research in the Eden forests in Braithwaite (1991). The research effort was a collaborative one with staff of SFNSW's Wood Technology and Forest Research Division (WTFRD, later the Forest Research and Development Division). Initially the research was 'broad brush' encompassing the fauna of a range of faunal groups, amphibians and reptiles, birds, small and medium sized to large ground mammals, and arboreal marsupials. The arboreal marsupials soon became the principal focus. Preliminary investigations plus prior thought and study on questions of the potential impacts on fauna by forest management (Tyndale-Biscoe and Calaby 1975) suggested that any impacts were likely the more serious for this group than any other.

> *If you can't measure it, it's not science.*
>
> Lord Kelvin (1824 – 1907)
> Attributed

Determining the impacts of forestry management on fauna presents a multi-dimensional problem. The pre-requisite for any assessment is information on fauna density distributions. However, the direct survey of fauna utilizing an entire forest of some thousands, if not tens or hundreds of thousands of hectares, is an impossible task. The mammals in particular present special problems. Most are nocturnal and are not conspicuous – a principal reason why, from the time of European discovery until quite recent decades, knowledge about most of Australia's mammals has accumulated but slowly (Calaby 1969). So the assessment of what animals occur in a forest has to be done by indirect means, by survey sampling and then prediction as to where animals are likely to be and in what relative numbers. The difficulty is in then designing appropriate sampling strategy and techniques, and here we run into serious problems of scale. If taken at a fine scale, say hectares or tens of hectares, there is the problem that species' populations are not static. Animal densities vary naturally in a dynamic mosaic – dynamic in both space and time, and in time both seasonally and from year to year according to episodic events such as unusually heavy rain, drought or fire or the flowering cycles of the eucalypts. In this context, and in wildlife conservation management generally, an important concept is that animals are found to occur in so-called 'source' and 'sink' sub-populations - the 'source' sub-populations, which are self-sustaining, occur in habitats most productive of the requisites of food and shelter for a particular species, the 'sink' sub-populations, which are not self-sustaining, occur in habitats typically poorly productive of these necessities (Pulliam 1988; see also Howe and Davis 1991)[7]. So sampling has to be done at an appropriately broad scale to yield information of practical use. With that objective in mind the area then available for logging in the Eden forests, some 405 000 hectares, was selected as the study area and used to predict the broad-scale distribution of arboreal marsupials. In May 1980 I commenced collecting information on the occurrences of the animals found dislodged from the trees by the logging crews. There were 36 crews operating in these forests. Concomitantly, I was recording, or otherwise obtaining from Forestry Commission records and other published material, environmental information on the logging coupes in which the crews were working – information on species and size of trees, topography, fire history, prior logging history, if any, and so on.

In the initial months of this study, from the stream of information coming in, there seemed to me no obvious link between the presence (or absence) of animals and any particular environmental attribute. There were few or no animals in much of these forests. However, animals were present in some heavily timbered forests, absent in others that were heavily timbered; present, even abundant, in some lightly timbered forests, absent in others that were lightly timbered; present in some forests in which there was a luxuriant understorey, absent in others with a dense understorey, etc. By August 1980 there seemed only one seemingly minor unifying environmental feature to those areas of forest which supported animals. Wherever there were animals there were, frequently, also trees of the peppermint group of eucalypt species – a group that was then regarded as a complex of species or sub-species including Narrow-leaved *Eucalyptus radiata* and Broad-leaved Peppermint *E. dives*. Wherever animals occurred, one or both of these tree species were present, forming at least a minor, often a major, component of the canopy trees present.

The date was 15th August 1980, and the venue was a meeting of SFNSW and CSIRO staff in the conference room of the Fishermen's Club in Eden to discuss the research. At that time I had made no attempt to have the

6 Quoted from Routley and Routley (1975) (Chapter 1. *Wood Production Ideology.*)

7 Pulliam's (1988) thesis is similar to the underpinning principle I earlier used in advising on the selection of conservation areas for arboreal marsupials in the Eden forests (see Braithwaite 1984).

survey data statistically analysed. When asked what link, if any, I could detect between the occurrence of animals and the forest environment, my comment was that the only consistent feature seemed to be the presence of peppermint eucalypts. John Turner, who was researching the nutrient dynamics of the Eden forests, promptly drew my attention to the WTFRD chemical analyses of the leaf nutrient levels of the various eucalypt species. The nitrogen (N), phosphorus (P) and potassium (K) values of the peppermints were high relative to the majority of tree species comprising the Eden forests.

With that insight it was then a relatively simple matter to formulate the appropriate statistical variables reflecting leaf nutrients for incorporation into analyses of the survey data. The analyses were run by George Dudzinski of the CSIRO Division of Mathematics and Statistics, later the Division of Wildlife and Ecology. The significance of the levels of leaf nutrients in determining the density distribution of the animals was clearly indicated. Figure 1, from Braithwaite (1991), shows the relation for leaf potassium (the relations for leaf nitrogen and leaf phosphorus are similar) in a more simplified form than that presented in the original analyses (Braithwaite 1982; Braithwaite *et al.* 1983).

These results precipitated a major re-think on my part as to priorities in the conservation management of the fauna of the Eden forests specifically, and then of forests in general. If an analogy can be used, it seemed to me that what I had thereto been engaged in was possibly not dissimilar to John Locke's investigator of clock springs:

> *He that was sharp-sighted enough to see the configuration of the minute particles of the spring of a clock, and observe upon on what peculiar structure and impulse its elastic motion depends, would no doubt discover something very admirable; but if eyes so framed could not view at once the hand and the characters of the hour plate, and thereby at a distance see what o'clock it was, their owner could not be much benefited by that acuteness, which, whilst it discovered the secret contrivance of the parts of the machine, made him lose its use.*

John Locke (1706)
An Essay Concerning Human Understanding

> *The genie is out of the bottle, and cannot be put back.*

Sir Gustav Nossal (1982)

Though I had been aware of at least some of the extensive documentation on the relations between soils and vegetation, I had not appreciated the possible significance

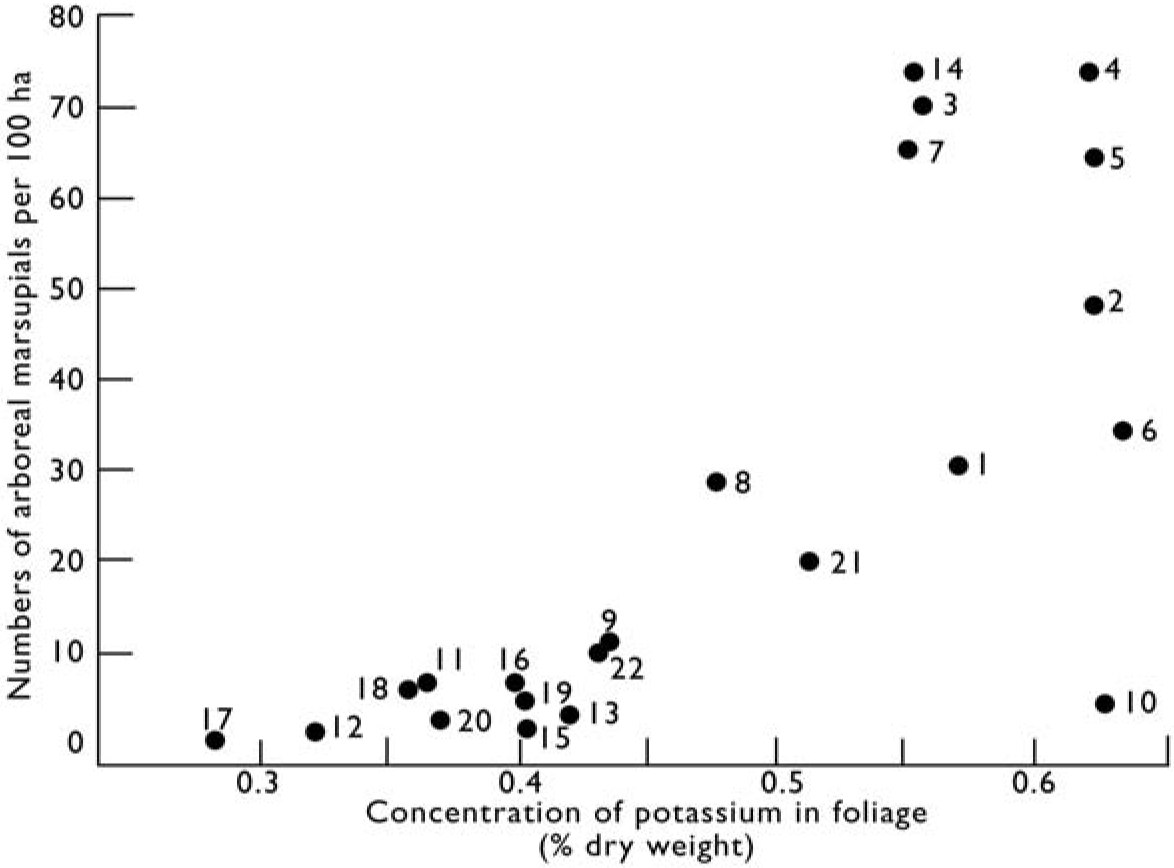

Figure 1. Arboreal marsupial density (total of all species) plotted against foliage potassium concentration. Data on foliage potassium are the means of indices of plots in logging coupes classified according to the tree species communities. Numerals identify the community (predominant tree species only): 1. *E. fastigata, E. obliqua;* 2. *E. fastigata, E. fraxinoides, E. elata;* 3. *E bridgesiana E. globoidea;* 4. *E. dalrympleana, E. dives;* 5. *E. viminalis, E. radiata;* 6. *E. radiata, E. cypellocarpa;* 7. *E. fastigata, E. cypellocarpa;* 8. *E. obliqua, E. cypellocarpa;* 9. *E. obliqua, E. radiata;* 10. *E. cypellocarpa, E. bosistoana;* 11. *E. consideniana, E. globoidea, E. radiata;* 12. *E. consideniana, E. globoidea, E. sieberi;* 13. *E. globoidea, E. sieberi;* 14. *E. fastigata, E. maidenii;* 15. *E. sieberi, E. globoidea;* 16. *E. sieberi, E. consideniana;* 17. *E. consideniana, E. agglomerata;* 18. *E. sieberi, E. agglomerata;* 19. *E. agglomerata, E. sieberi;* 20. *E. agglomerata, E. muelleriana;* 21. *E. muelleriana, E. sieberi;* 22. *E. muelleriana, E. sieberi.*

of this insofar as the distribution and the conservation management of fauna was concerned. That is, until I read the following comment and advice concerning Narrow-leaved Peppermint in CSIRO's *Forest Tree Leaflet* series. On reading this piece I instantly connected the contained advice with the spectacularly graphic evidence of the advice's application to the forested landscape at Bombala:

Narrow –Leaved Peppermint Eucalyptus radiata

Narrow-leaved Peppermint grows on a wide range of soils which include both the better skeletal types and somewhat heavy volcanic loams. Wherever the mature trees are over 60 feet in height and of at least moderately good form the soil is usually considered suitable for the establishment of pine plantations, especially Pinus radiata.

CSIRO (1980)
Forest Tree Leaflet Series

In the Bombala District of the Eden Forestry Region the SFNSW (previously the FCNSW) had had a longstanding policy, dating back to 1927, of clearing land characterized by the presence of peppermint eucalypts, which were not highly valued for timber production, to plant the exotic Radiata pine *Pinus radiata*. The advent, in 1969, of the woodchip industry based at Eden had seen a rapid acceleration in this process. Much low-grade timber from the land clearing operations, rather than being burnt, could now be sold to the woodchip mill to defray some of the costs of the clearing. In 1980 the clearing of the native forest from extensive new areas of both public and privately owned land was well under way (FCNSW 1982).

From the viewpoint of the research on fauna the next step was thus obvious - an evaluation of the relation between soils, or rather soil parent material, vegetation, including leaf nutrient levels, and arboreal marsupial density in the Eden forests. Joe Kelly of WTFRD collated the data available on soil parent material type for the areas (coupes) that were sampled for animals. The analyses are presented in a simplified form (Figure 2) from the original (Braithwaite *et al.* 1984b). Details of the relations between soil parent material type, soil fertility and tree species characteristic foliage nutrient concentrations in these forests had already been analysed and spelled out by WTFRD researchers who noted, in part:

. . . significant relations were found between foliar phosphorus, nitrogen, calcium, potassium and sulphur levels and soil chemical properties. The species with the higher foliage nutrient concentrations were clearly associated with the more fertile soils.

Marcia Lambert and John Turner (1983)

The forest tree communities (or 'associations', since the tree species 'communities' were determined by classification analysis of the species of trees occurring in the logged coupes) supporting the higher densities of arboreal marsupials are shown in the Figure to the right of, and including, Vegetation Community No. 3. As the soil parent material type indicates, the communities are characteristic of the better soils. In this survey the areas sampled of forest of these associations had been cleared of their native tree cover and were assigned for replanting with radiata pine. For those areas sampling forest with the vegetation communities shown in Figure 2 to the left of Vegetation Community No. 3, i.e. of the lower nutrient trees, the forestry practice then, in the early 1980's (and as it remains today), was alternate coupe logging. Once logged, each coupe is allowed to regenerate its natural forest cover with proposed thinning and selective logging operations to then continue indefinitely.

In the early 1980s what we see is a forest management policy in place that was highly damaging to the arboreal marsupial fauna. The areas of natural habitat of better soils (on which the animals were most dependent) were being removed and replaced with plantations of a non-native tree species which are useless for this group of fauna. The FCNSW was advised of the problem. The policy of clearing native forest on public lands and replanting with exotic pine ceased. Subsequently the SFNSW/FCNSW policy has been to use these forests for the production of native timbers only.

At this time, the mid-1980s, Turner and Lambert from the WTFRD published the preliminary findings, including the following insight, from a study of grazing activity by wildlife following a wildfire in the Eden forests. Details of the work were later published in Turner and Lambert (1988):

A range of wildlife is dependent upon the growth of plants within a forest. The trees, the understorey, roots, or litter may all be utilised, and the forests high in nutrients maintain the highest animal populations. In the Eden area this has been shown to he the case by direct study of the arboreal wildlife. In the same area, indirect studies on quantities of vegetation consumed have shown virtually no grazing of dry ridge forest communities. By comparison, more than half a tonne of organic material per hectare was consumed in less than six months on the fertile gully sites. That is, fertile sites support specific forest types high in nutrients and these support large populations and diverse communities of wildlife.

John Turner and Marcia Lambert (1986)

The 'half a tonne of organic material per hectare [that] was consumed in less than six months on the fertile gully sites' in these forests is likely attributable to grazing by species such as the Emu *Dromaius novaehollandiae*, Common Wombat *Vombatus ursinus*, Eastern Grey Kangaroo *Macropus giganteus*, Red-necked Wallaby *Macropus rufogriseus* and Swamp Wallaby *Wallabia bicolor* (see Braithwaite *et al.* 1984a). Thus highlighted seemed several facts:

Fact 1. We have evidence that many grazing species of Australia's native ground-dwelling fauna may be critically dependent on areas of better quality soils.

Fact 2. We know that these conditions - better quality soils with hence better quality graze – are characteristic of areas that were selected for settlement and subsequent development, including land clearing, the provision of artificial watering points and the extensive grazing of stock by the settlers in the 19th Century using sheep as an effective 'bio-indicator' of such conditions.

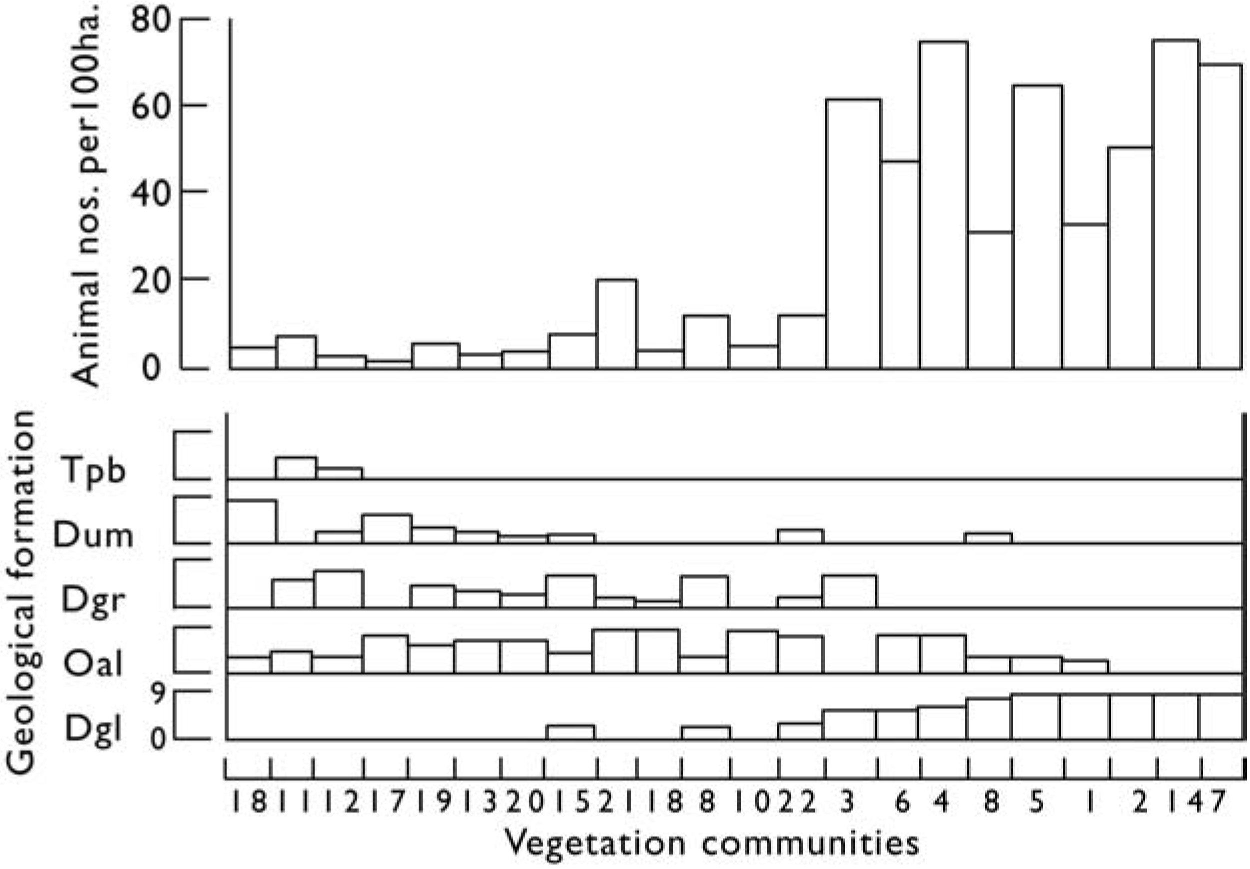

Figure 2. Plots (bar graphs) of the density of arboreal marsupials (all species) for each of the 22 tree species communities, identified as in Figure 1, against an ordination of the relative proportions, by area, of the 22 communities, on 5 soil parent material (geological substrate) classes. The 5 classes are: **Tpb.** Tertiary and recent gravels and sands; **Dum.** Upper Devonian conglomerate, sandstone and red shale; **Dgr.** Middle Devonian granite, Devonian granite or granite/adamellite; **Dgl.** Devonian biotite granodiorite, hornblende granodiorite or tonalite; **Oal.** Ordovician hornfels, greywacke, sandstone or shale. (Braithwaite 1991, adapted from Braithwaite *et. al.* 1984b).

Fact 3. From sheep numbers in Australia, some 100 million before the end of the 19th Century and 180 million by 1970 (not to mention the tonnage of other grazing animals, cattle, rabbits, goats, etc.), we are provided a measure of the magnitude of the impact of sheep (plus cattle, etc.) on priority habitats of many of Australia's native fauna. It is an impact, moreover, that is presumably further and substantially aggravated each time there is widespread drought and the numbers of sheep, etc., collapse.

With a serious fauna conservation problem in the management of public forests thus identified, the question immediately raised was, what was happening on freehold land? As mentioned, the extensive clearance of private land was under-way, subsidised by the substantial tonnages of timber being sold to the chip mill. A document prepared by the woodchipping company, Harris-Daishowa (1986), provided this information on the timber resource supplies from freehold land:

> *This total (3 281 000 tonnes) at an annual harvest rate of 90 000 (tonnes) provides a possible 36 years of resource life remaining.*
>
> Harris-Daishowa (1986, Appendix 1C)

And:

> *Depending on the landholder's intentions for the future of the land this can represent a cash income if the land is to be regenerated. If the intention is to clear the land for agriculture or pine establishment, pulpwood harvesting removes timber which would otherwise impair such activities and provides cash to contribute towards the cost of clearing operations. Contractor-built roads, established to extract pulpwood, remain for the landholder to utilise. Such roads can represent an asset to the landholder, especially on those properties where little previous development of bush blocks has been undertaken.*
>
> Harris-Daishowa (1986, pp. 4.53-4.54)

The evidence was that the extraction of timber from freehold land was having a highly damaging affect on fauna values. With Doug Binns of the SFNSW WTFRD and Bob Nowlan of the SFNSW Eden Region Office, I had a closer look at this issue with the result shown in Table 1.

My concerns seemed validated. The timber being harvested from freehold land as a by-product of land clearing operations was of tree species characteristic of the better soils and of important arboreal marsupial habitat.

Table 1. Eden forestry region
Percentage area of forest types, or of timber tonnage harvestable, of different forest types according to land tenure

Forest type	**State forest** (% area)*	**Freehold** (% tonnage of timber)#
Forest types characteristic of poor soils supporting low arboreal marsupial densities		
Stringybark - ash – messmate[1]	80	18
Forest types characteristic of better soils supporting high arboreal marsupial densities		
Peppermint – gum – brown barrel[2]	12	82

* Other forest types comprise 8% of the area.

There was no data available on the *area* of private property logged and cleared.

[1] Forest types with predominant species typically including, *E. consideniana, E. agglomerata, E. globoidea* or *E. obliqua.*

[2] Forest types with predominant species typically including, *E. radiata, E. dives, E. ovata, E. maidenii, E. viminalis, E. dalrympleana* or *E. fastigata.*

From Braithwaite *et al.* (1988a)

Though the issue of the impact on fauna values of the clearing of private land was acknowledged by the woodchipping company at the time, the nature and the significance of the problem had still to percolate into official government decision-making processes. It seemed that several facts had still to be fully appreciated:

Fact 1. Much of the forest fauna was constrained, for good biological reasons, to land of the better quality soils.

Fact 2. The better quality land was probably supporting the 'source' sub-populations of fauna of many species.

Fact 3. It was the land of this kind that, since settlement, had been keenly sought, and was still actively sought after, for clearing for productive purposes.

The originality of the insight into the significance of this may be gauged from a comparison with a report, published in 1978, of a comprehensive CSIRO study into land use on the NSW South Coast (CSIRO 1978). Examination of the report shows the CSIRO at that time did not identify land use allocation, and therefore subsequent land use management, *per se*, as a significant issue in biological conservation. Official cognisance of its possible significance first, and then only tentatively, appears in 1990 in a review of conservation requirements in the south-east forests of NSW by the Joint Scientific Committee to the Commonwealth and NSW State Governments. The following comment, made as an aside in the conclusion to the report is revealing. This especially so as this inquiry was charged with, as its title indicates, an examination of conservation issues:

> *The Committee is disturbed by the suggestion that wood resources from private property are likely to be exhausted early next century as there is considerable potential for private lands to contribute to conservation objectives so long as those lands remain forested.*
>
> Department of Primary Industries and Energy (1990)
> *Biological Conservation of the South-East Forests*

The 'ball', nonetheless, had now 'begun to roll'. A number of researchers became interested in various aspects of the relations between soils, vegetation, leaf chemistry and fauna and in this context, the possible significance of the land use allocation (i.e. land tenure) issue. The significance of land tenure in evaluating conservation reserve needs was subsequently taken up in some detail by Pressey and his colleagues (Pressey and Tully 1994; Pressey *et al.* 1996, 2000). In relation specifically to fauna conservation, past work was re-examined in a new light and new research was initiated. Tanton (1994) has reviewed much of the information. Other than information on the arboreal marsupials of eucalypt forests, reviewed in 1996 (Braithwaite 1996), positive correlations have now been established between soil quality and/or leaf nutrient levels and the abundance in forests of birds (Braithwaite *et al.* 1995), of native ground mammals, especially small ground mammals (Catling *et al.* 1998), of arboreal marsupials in the rainforests of North-East Queensland (Kanowski 1999; Kanowski *et al.* 2001), and of bats (Richards 2002). Significant studies by Majer *et al.* (1992) and Recher *et al.* (1996) show that a positive relationship exists between the leaf nutrient levels of different eucalypt species, the diversity and abundance of foliage arthropods and the use made of the different eucalypts as foraging substrate by birds. In hindsight, the results of all this research seem nothing more than common sense. There is an extensive and longstanding literature on the importance of N (protein) in the nutritional economy of animals in general, from and including insects to domestic stock (White 1993). In relation to humans, Evans (1998) has pointed to the health issues that have emerged for many of our burgeoning billions can be related to the inadequate availability of dietary protein.

To return to the land use allocation and land use management issue. The next logical step involved an analysis of the tenure holdings of native forest of different soil quality. The opportunity arose with a major CSIRO study of the forests of the Batemans Bay area of NSW (Cocks *et al.* 1995). The study was confined to what was called the 'forest domain' – primarily forested country that *excluded* remnants of forests within otherwise cleared country. With colleagues at CSIRO and using information provided by SFNSW, I analysed the relative tenure holdings of the remaining forested estate according to site productivity class[8]. The result is shown in Table 2.

Much of the remaining forested estate on soils of the highest productivity classes is shown to be held in freehold tenure, and is therefore in the category of tenure conferring the maximum risk of eventual loss due to land clearing. Notably, the forests of this area lie well within the timber supply zone for the Eden chip mill (Harris-Daishowa 1986). The point, and as noted above, is that this particular analysis excluded land that was, at the time of the study, already predominantly cleared but that may have supported remnants of the original native vegetation – land that can be assumed, on that basis, to be predominantly of better soil quality. Any forest remnants on this land could thus be assumed also at high risk of clearing.

This general strategy of identifying conservation priorities was next applied by Tanton (1994) in an assessment of fauna conservation issues in relation to forestry operations in SFNSW's Eden forests. Using, for example, three classes of low, medium and high for variables such as mean average rainfall, mean annual temperature, landform relief, soil fertility, etc. the landscape of the Eden area was apportioned to a series of 'environmental domains'[9]. In this kind of analysis, because there are many variables, and two or more classes within each variable, a large number of 'environments' is thus generated. Each 'environment' represents a unique combination of variables and classes. For convenience of analysis, the number of 'domains' used is thus usually arbitrarily fixed at some number less than the number of unique environments. In his analyses Tanton (1994) used what he termed a 16-level 'Domain' and a 64-level 'Stratum'. In Tanton's analyses the areas of land of different tenure and of environment included land which had, all or in part, been cleared of its native vegetation. We see, nonetheless, from the examples in Table 3 the extent to which freehold land comprises land of the better soils. Notably, very little of the better quality land is held in conservation reserves (i.e. National Parks).

The next logical step with analyses of this kind was to examine the relative tenure holdings, not of all land regardless of whether it was cleared or was deemed solely as 'forested', but of the land retaining its native vegetation cover of whatever description, including 'forest'. This was done in the CSIRO's study of the fauna of the Murwillumbah area of North-East New South Wales, a study undertaken on behalf of the SFNSW. At the time of this study there was no readily available data-base on the soil or soil parent material types of the area. In these analyses no differentiation was thus possible of environments according to (relatively) 'low' or 'high' soil fertility. However, most of the soils of this area are of volcanic origin with those of basic volcanic origin being exceptionally fertile. Those derived from acid volcanic rocks are less fertile. The environmental variables used in analyses were a measure of landform relief ('Land Relief', see Table 4) mean annual temperature ('Temp'), and mean annual rainfall ('Rain'). Each variable comprised, as shown in the accompanying table, three classes, low (L), medium (M) and high (H). The classes were thus, 'low' landform relief, 'low' rainfall 'low' temperature, etc.

What the collation of data in Table 4 reveal is that the majority of land of environmental categories of relatively low relief has been cleared of its native vegetation cover. Those categories of high relief, i.e. the rugged country, generally retain their cover. Of the native vegetation cover remaining, in all but one of the environmental categories, the majority of the area is in freehold tenure – the tenure category conferring maximum risk of clearing at some time in the future. In some environmental categories of tenure holdings conferring the minimum risk of clearing in the future (e.g. State Forest and National Park), the public holding of remaining native vegetation cover is low – often less than five percent.

Table 2. Land tenure and site productivity class, remaining forested estate, Batemans Bay region

Site productivity class	Percent area of remaining forest cover* in:		
	State forest	National park	Freehold
1 (lowest)	2.8	17.8	66.9
2	19.9	41.4	25.0
3	55.1	19.9	22.5
4	57.8	12.7	25.4
5	45.1	13.0	40.9
6	44.7	7.7	47.1
7 (highest)	19.7	0.8	79.2

* Excludes Leasehold and Vacant Crown Land tenure categories

From Braithwaite *et al.* (1993)

[8]From the example studies in the Eden and Batemans Bay forests timber productivity class is shown closely dependent on soil fertility and in turn closely dependent on soil parent material, e.g. data supplied on soil parent material type and soil fertility by Turner *et al.* (1978) cf. tree species and characteristic size and timber volumes in the Eden, NSW forests by Braithwaite *et al.* (1984a); Cocks *et al.* (1995); see also e.g. Turner and Holmes (1985). Exceptions to this direct relation of timber productivity to soil fertility seem evident where the natural 'forest' is of a more open, 'woodland' type, such as that of Red Gum *E. tereticornis* in the Bega Valley.

[9]The Eden Study Area comprised, in 1994, 783 000 ha including 400 000 ha of publicly owned forest.

Table 3. Land tenure of forests in the Eden region according to environmental domains

Environment	Percent area of land of each environment (domain and stratum) in: State forest	National park	Freehold
Environments of 'low' soil fertility			
Domain 1, stratum:			
10	89.9	9.3	0.8
Domain 6, stratum:			
3	91.5	5.2	3.3
7	88.7	2.0	9.3
Environments of 'high' soil fertility			
Domain 8 stratum:			
40	1.4	1.9	96.7
42	0.5	0.3	99.2
Domain 16, Stratum:			
23	0.9	1.1	98.0
33	0.0	0.0	100.0
34	0.0	0.0	100.0

From Tanton (1994)

Table 4. CSIRO Murwillumbah fauna survey Land tenure and environmental categories of remaining natural vegetation cover (nvc) ('Disturbed' native vegetation cover included in analysis)

Environmental category*			% Environmental category with remaining native vegetation cover#	Percent area of remaining native vegetation cover in:		
Land relief	Temp	Rain		State Forest	National Park	Freehold
L	L	L	30.1	9.0	5.6	85.4
L	L	M	48.7	2.0	1.3	96.0
L	L	H	49.9	1.3	0.0	98.7
L	M	L	13.7	1.7	0.9	97.1
L	M	M	38.9	2.0	0.5	97.2
L	H	L	15.2	0.0	10.0	81.0
L	H	M	26.9	0.5	3.0	90.8
M	L	L	42.1	7.2	0.0	92.1
M	L	M	66.3	6.0	0.3	92.9
M	L	H	81.9	5.0	0.7	93.1
M	M	L	21.6	2.9	0.3	96.6
M	M	M	48.1	4.7	0.2	95.0
M	H	L	24.8	1.9	0.0	97.5
M	H	M	51.0	3.2	0.0	95.2
H	L	L	41.9	12.1	1.3	86.4
H	L	M	80.3	19.1	23.9	56.2
H	L	H	93.3	30.5	27.7	40.8
H	M	L	33.3	11.3	0.2	88.5
H	M	M	62.4	13.7	0.9	84.5
H	H	L	61.6	8.9	1.1	88.3
H	H	M	62.6	4.9	0.4	91.7

* L = Low; M = Moderate; H = High.
# Percent of each environmental category with remaining natural vegetation cover.
From CSIRO (1996)

From the viewpoint of forestry management, the forests of Murwillumbah region of north-eastern New South Wales present special difficulties. As Table 5 shows, the region is, faunisticaly, one of the richest in Australia. Every piece of country that retains its natural vegetation provides, or can be expected to provide, habitat for one or more of the fauna species listed in the NSW *Threatened Species Conservation Act 1995*.

What we see created is a paradox. On the one hand we have much of the native vegetation cover, with its attendant native fauna, occurring in freehold tenure – a tenure category conferring at least some liability of loss of its native vegetation, and hence of its native fauna, as a consequence of land sub-division and clearing. This part of Australia is characterised by a rapidly increasing human population so the pressure for land development is substantial[10]. The dilemma is of course, because of political, financial and legal factors, governments in Australia are typically reticent about seriously intervening over the land clearing issue[11]. That is on the one hand.

On the other hand, insofar as the public forests are concerned, the number of fauna species present, and also listed in the NSW *Threatened Species Conservation Act 1995*, make planning and implementation of forest management a difficult, if not an impossible, task. The occurrence in these forests of just one species on the threatened species list, the Koala for example, can, and does, cause substantial difficulty for the SFNSW in planning and implementing logging operations. This is irrespective of the facts that, firstly, the Koala, as previously emphasised, is *not* a species characteristic of forest environments. Secondly, many millions of dollars have been spent on Koala research by government and private institutions with the implicit, if not explicit, objective of furthering its conservation. Typically, researchers contend that there is still much that is relevant to be learnt about the biology and ecology of the Koala in relation to the impacts of logging. In this circumstance, requests are usually put forward that the Precautionary Principle be applied - that in the absence of full scientific understanding developments such as a planned logging operation should therefore not be approved. The practical effect of the application of the Precautionary Principle, which is embedded in Australian Environmental legislation, is to justify preservation without the need to present or argue a logical basis for preservation. This means that with 50 or so species of fauna listed as threatened and occurring in these forests, it does not require an Einstein to recognise there is sufficient opportunity to raise for an eternity questions relating to the possible impacts of forestry operations - to thereby delay and add substantially to the costs associated with any extraction of timber.

The consequence is as expected. Much forest becomes excluded from productive use. What is thus achieved, from a perspective of the needs of the broader community and as it seems to me, are less than desirable outcomes of two worlds. Neither conservation nor economic objectives are being well served. Tanton (1996) aptly summed up the situation in this comment on the CSIRO's Murwillumbah fauna survey report:

> *In this document the authors' approach to conservation is reflected in the treatment and analysis of habitats in the profile for each species. The preoccupation with forests on Crown lands, particularly those in SFNSW tenure, on the part of government, conservation bodies and individuals, is trifling with, or playing at conservation.*
>
> M.T. Tanton (1996)

How to resolve the dilemma presented by all of this? It has seemed to me that the application of some of the personal (Popperian) philosophy of someone renowned globally for his self-attained wealth may provide a useful first step:

> *The total sum of my wealth has never been of concern to me. What have always been of concern to me are the portions of it that I have lost, and the reasons why.*
>
> Jean Paul Getty
> Attributed

Table 5. CSIRO Murwillumbah Fauna Survey 1994-1996 Number of species of each taxa recorded (Numbers in brackets indicate potential number present)

	Amphibia	Reptiles	Birds	Mammals except Bats	Bats	Total species
Total species recorded	23 (33)	44 (54)	212 (314)	35 (45)	26 (31)	340 (477)
Species in forests	22 (26)	44 (49)	128 (160)	34 (45)	25 (31)	253 (311)
TSC Act species* in forests	3 (5)	2 (2)	18 (19)	7 (13)	16 (17)	46 (56)

* Species listed in the *NSW Threatened Species Conservation Act 1995.*

From CSIRO (1996)

[10]A report on land clearing in New South Wales (Environmental Research and Information Consortium 1998) indicates that in this general region of the state some 1100 ha were cleared of its natural vegetation in the years 1995-97. (The total for the state cleared in the three years was estimated at some 30 000 ha.) The figure of 1100 ha for the Murwillumbah region translates, possibly, to 1-2 percent of the native vegetation that, in 1994, remained of those environments under greatest pressure from development. The loss of 1-2 percent may thus not seem an appreciable amount. However, it is a loss over only several years that, if continued at that rate over a period of 50-100 years or more, would be substantial.

[11] For those interested in details of the legislation and in the difficulties that governments face concerning regulation of land clearing, the Resource Assessment Commission's (1992b) report is informative.

My perspective is a conservation strategy based on documentation of the tenure holdings of land of different environments that has retained its cover of native vegetation provides a workable approach. By this means the nature and the location of those elements of Australia's fauna and its habitats that seem most liable to loss to future generations can be identified. The relative extent of past loss of native vegetation cover of land of the various environments provides, it seems to me and as outlined by Pressey and his colleagues (e.g. Pressey and Tully 1994; Pressey *et al.* 2000), a guide as to the present potential for further loss. As Heilbroner (1995) surmised, we can reasonably expect that the future may be like the past. It seems reasonable to assume that the level of pressure for land clearing in different environments is likely in direct relation to the extent of each environment already cleared. Presumably, also, the characteristics of environment provide a guide as to the possible uniqueness or otherwise of the biological attributes of various areas of landscape. With priorities thus focussed, means might readily be found to minimise further losses of the Australian native biota on land of both freehold and public tenure. Moreover, it seems to me, there is good evidence and sound biological reason why this thinking might profitably be applied elsewhere than in Australia.

The perspective of priorities in biological conservation to which I have arrived is the antithesis of the central ideas advocated in Australia and especially overseas by Huston (1993, 1994, see below statement). Despite noting that, on a global scale, '. . . primary productivity of terrestrial vegetation is positively correlated with plant species diversity' and also providing data showing faunal species richness is positively correlated with potential plant evapotranspiration (a measure of plant productivity) Huston (1994, pp. 30-31) arrives at the conclusion that, since a generally negative relation exists between the diversity of plant species and potential agricultural productivity, the preservation of areas of high plant biodiversity does not require the sacrifice of productive agricultural land. Huston extrapolates from this conclusion to this final view concerning the conservation of biological diversity in general:

> *Thus, there is no inherent conflict between the preservation of biological diversity and the economic improvement of the human condition.* (underlining Huston's emphasis)
>
> Michael A. Huston (1994, p. 560)
>
> *Biological Diversity: The Coexistence of Species on Changing Landscapes*

The advocacy of such sentiment, to my mind, is highly dangerous. How else might the 'economic improvement of the human condition' be achieved, as Evans (1998) has pointed out, without making the most efficient use of the global resources of land best suited for the purpose? I can only reiterate what I see as the priorities. To me what is obviously *not essential* to know is the total sum of the biological resources for which we, as this generation of humankind, have custodianship responsibility. There are extensive areas of Australia, and the globe, that though these be 'biodiversity rich', are at present of minimal economic interest to ourselves. The biological resources of such areas are thus under minimal threat of loss, again at least for the present. What is critical is knowing that *portion* of the total of resources for which we are not only the custodians, but over which we *also* hold the discretionary power to decide the extent to which we will, or will not, be handing the resources of that portion on to future generations.

Concluding comments

So we come finally to the question initially posed in this contribution. As regards fauna, do current forestry practices threaten the native fauna of our forests? To me, Tukey's aphorism given at the beginning of this paper indicates the most appropriate means of responding to the question. The many difficulties inherent in addressing this question, including the requirement for proof of the negative, the extent of the fauna involved and the problems of time frame and of scale in obtaining definitive information on many species, render the question impossible to answer specifically. As I see it, regarding the future of the biota of our forests, our thinking on this issue should revolve around identifying those things that we have now but that, on account of our current and foreseeable resource use activities - activities which are being driven, with increasing intensity, by the escalating pressure of our burgeoning human population - will likely *not* be handed on to future generations.

As a participant and contributor to a number of CSIRO consultancy fauna survey activities (e.g. Braithwaite *et al.* 1988b, 1991; CSIRO 1996), including forest areas highly disturbed by selective logging and stock grazing activities, it is my general observation that the native fauna of these areas seem, over the long term, i.e. 100 to 150 years, highly resilient to such disturbances to their habitat. The important proviso is that the habitats concerned are those of the better quality soils. I consider this perspective is supported by, for example, the results from studies by Menkhorst (1995) and Downes *et al.* (1997) of the native mammals in Victoria that occur in fragmented and disturbed landscapes of otherwise good quality agricultural country. So while available specific information regarding the topic question to this contribution is greatly limited, it is nonetheless suggestive.

Looking back on my experience of 20 years or so of researching and on advising on the fauna of our forests I see little in current forestry management practice, *per se,* in our native forests that causes me concern over the future of our native fauna. That is not to say issues, of which I am at present unaware, may exist and in the future may be determined as serious. Vigilance is essential.

The point has been noted that any timber harvesting industry that accepts resource from land clearing operations and is subsidising in one form or another the clearing process has, or may have, a substantial adverse impact on native fauna values – on the potential for our fauna species to persist into the future for the enjoyment of future generations. All the evidence so far is that any government decision or policy that encourages or condones the clearing of the native vegetation of lands of better quality soils has been, is, and, if it continues, will in future most likely have, the most damaging of impacts on Australia's native fauna. That this is a process driven by our ever-increasing human population, is obvious. Therein, it seems to me, is the essence of our over-arching problem of ensuring intergenerational equity.

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