Don't worry – be happy?

Paul Adam

School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2052

p.adam@UNSW.edu.au

ABSTRACT

The concept of grumpiness is discussed, and I suggest that matters of concern to scientists range from the everyday grumpiness common in the wider community, which includes issues which are serious matters of concern to many, through misgivings about the way science and in particular the field sciences are currently practised, to deeply held concerns about the longer term viability of the biosphere. Progress, or the lack of it, in addressing major environmental issues over the last half-century is discussed. It will be necessary to balance pessimistic messages with positive news about successes if members of the broader community are to remain active proponents working to reduce the ecological footprint of the human race.

Key words: scientific institutions, managerialism, short term focus, environmental issues

http://dx.doi.org/10.7882/FS.2013.016

Introduction

The BBC series *Grumpy Old Men* and *Grumpy Old Women* clearly struck a chord with a large section of their viewing audience, both in Britain and Australia.

The dictionary definitions of grumpy imply that being grumpy is a rather unappealing attribute; both the Oxford English Dictionary and the Macquarie Dictionary give – ill-tempered, surly. The usage in the BBC series carries rather more benign connotations, as perhaps an understandable feature of more senior citizens, and something which is tolerated, perhaps even admired, by younger cohorts. There is a long history of British writers and social commentators who have made part of their careers out of being grumpy, extending back at least as far as Dr Samuel Johnson. In more recent times the character Victor Meldrew (*One foot in the grave*) was predicated on being both grumpy and pessimistic. Grumpiness is a well-developed British characteristic, but is not unique to Britain.

In the context of these proceedings I suggest that there is a range of circumstances giving rise to concern amongst scientists, and a range of responses which they invoke. Grumpiness is only one end of the spectrum. The responses may range from mild concern to alarm (and even despair) but are not all ill-tempered or surly. These concerns arise not only in the old, but may properly be expressed across the ages. The old (a difficult term to define with any precision in the context of this discussion) do have advantages in participating in debate. Firstly they have a broader perspective and understanding arising from years of experience, and secondly, for those beyond retirement age, an obligation and greater freedom to speak out, both in the public good and in support of younger colleagues, who may perceive, not without justification, that speaking out on issues could be career limiting.

Grumpiness in the BBC's sense is a widespread phenomenon, not restricted to scientists. Going beyond grumpiness, as scientists we may have concerns about the state of current science and scientific institutions, and as citizens with scientific knowledge and understanding we may have concerns about the state of the biosphere and its future. Concerns in relation to the last two sets of issues go beyond grumpy; they are matters that are much more serious.

In discussing these concerns, matters canvassed in previous RZS symposia, most particularly *Science under siege*, will be revisited, but placed in a wider context.

Ordinary grumpiness

The appearance of many of the themes explored in *Grumpy Old Men* (and *Women)* can be explained by an inherent conservatism in most human populations and a dislike, sometimes even fear, of change which threatens long-standing ways of life. This can be seen not just at the present but has been obvious throughout much of history. Nevertheless there are some causes of current grumpiness which are perhaps different from those of the past.

One of these is the problems generated by modern urban living. Humans have lived at high population densities in towns and cities for centuries, but, although the density was high, the total size of the population centres was, by modern standards, small and the proportion of the total population which was urban was also small. The first of the megacities developed in the 19th century during the Industrial Revolution (although imperial Rome had a population of 1 million), by early in the 21st-century, for the first time in human history, the majority of the world population was dwelling in cities.

The social consequences of this shift to urban living have been profound and a source of a great deal of grumpiness.

Pp 71-87 in *Grumpy Scientists: the Ecological Conscience of a Nation*, edited by Daniel Lunney, Pat Hutchings and Harry F. Recher. Royal Zoological Society of New South Wales, Mosman, NSW, Australia. 2013.

One of the aspects of city life which generates stress is transport (or, more particularly, perceived inadequacies and inefficiencies in transport systems). Given the majority of major cities have grown like Topsy with planning processes struggling to catch up, widespread congestion and inadequate public transport are not surprising. Nevertheless Sydneysiders, for example, have some justification for thinking that successive state governments have made an art form of not addressing transport issues. In the nineteenth century congestion, noise and pollution from horse drawn transport became major issues for urban managers and planners around the world. By the end of the century it was predicted that within decades the accumulation of manure in streets would be such that city life would be untenable (Morris 2007). This did not occur because technological advances resulted in the replacement of horses by either electric power (trams and trolley buses) or motor vehicles. The visible signs left by horses were exchanged for the less visible, but possibly more pervasive, pollution generated by internal combustion engines. Although the number of urban horses was large, for the majority of city dwellers individual ownership of a horse was beyond their means. The availability of motor vehicles has given unprecedented access to independent transport, but at great cost to the environment and amenity.

Another source of grumpiness, not previously experienced, is the view held by those in the work force that they are time poor and there are too many demands and pressures placed upon us. International comparisons support for the view that working Australians work each week for longer than is the case overseas (Martin 2013). Many of the demands are imposed by modern electronic communications. Mobile phones and email have many useful purposes (and even though they represent a major change in technology, they have been adopted enthusiastically by most people) but do we really need to be accessible 24-hours of the day, wherever we are in the world? There is an expectation of instant responses, and failure to respond simply generates further and more insistent messages. What are referred to as the social media, Twitter and Facebook, have value in enabling dissemination of messages during emergencies, but under most circumstances can be responsible for a great deal of time wasting and the spread of incorrect or misleading information (a grumpy view clearly not shared by all, either young or old).

I would not wish to return to the 19th century when letter exchanges between colleagues in different hemispheres would take months, but instant responses are frequently regretted and the opportunity for reflection and consideration before reaching conclusions is increasingly under threat. I suggest that the cult of the instant is particularly inimical to good science. The alternative behaviour of never publishing is undoubtedly a worse failing, but the modern obsession of our managers with quantity of publications over quality is dangerous for two reasons. Firstly there are the stresses on researchers to publish even trivia, and secondly there is the problem of the explosion of 'information' which must be waded through for little reward.

The youth of today

A great many of the problems of the world are attributed by the grumpy to young people. They dress differently, have different tastes in music and don't show due respect to the elders and betters -- and for those of us who remember the 1960s they are far too conservative -- where is the spirit of protest? Twas ever thus. One particular complaint about the young is that they are poorly educated. In relation to scientific knowledge and literacy this has been a complaint since the 19th century (Adam 2012) but if it is a valid complaint then it is unfair to place the burden on the shoulders of the young themselves. Pedagogic practice in the design and content of curricula is determined, not by the recipients of education but by their teachers and administrators who are subject to changes in fashion, often based on untested theories or political whims.

At school level a particular source of grumpiness to those interested in the natural environment has been the steady decline, over many years, of natural history in the curriculum (Adam 2010). As part of this there has been a decline in fieldwork. There are many contributory factors to this decline, of which cost and concerns about occupational health and safety (OHS) have been prominent. No one could deny the absolute importance of providing a safe working and study environment, but the bureaucratic requirements for OHS are a prime generator of grumpiness, and discourage undertaking what used to be regular activities but which are now regarded as being high risk. Indeed it is possible to suggest that, by generating a false sense of security, OHS requirements might possibly in themselves lead to accidents (Lovelock 2000). OHS and the requirements of ethics committees are continuing causes of grumpiness in the working environment of many field-based scientists when commonsense and practicality come into conflict with political correctness and mindless bureaucracy (Recher 2013). Reintroducing rigorous natural history to the curriculum will not be easy; present teachers have not had experience of this as part of their schooling and subsequent training and the budget is always tight. The tertiary teacher training syllabus is unlikely to give natural history great attention. The culture has been lost and will not readily be recovered. The proposed national curriculum provides an indication that laboratory and field work will be favoured when the curriculum is instituted, but gives little indication of how, or what, is to be taught nor, importantly, how it would be funded.

A particular concern for the ecological and biological sciences is that they are frequently perceived as 'soft' options – biology is the token science you take at school if you're not a science specialist. This view, which is unfortunately shared by some in what are regarded as the 'hard' sciences (physics and chemistry), has long been evident in Australia (Turner 1948) and elsewhere. Turner was of the opinion that while most professional biologists working in the 1940s were originally naturalists, 'naturalists are born – not made'. He saw the need to develop another kind of biologist who would be experimentalists. However, the perceived dichotomy between field and laboratory scientists is largely a false one, the two approaches are ends of a continuum, and the initiation of experimental work starts with observations.

Low regard for biology is manifest in general ignorance of the field by opinion makers. This was well seen in an article in the *Weekend Australian* (March 9 – 10, 2013, pages 1 and 6) – *How Colossus of Canberra weighs down the budget* - over the byline of David Crowe – national affairs editor. The thrust of the article is that there are (federally) some 900 bodies said to add to spending and to slow down decision making and that many of these bodies should be abolished. Of the 900, five are singled out as being 'the obscure end of the bureaucracy'. Three of the five are the *Plant Breeder's Advisory Committee* coupled with the *Registrar of Plant Breeder's Rights* (the apostrophes are placed as in *The Australian* article –the journalist is not only biologically ignorant but is also a threat to the English language), *The Council of Heads of Australasian Herbaria (CHAR)* (said to 'discuss issues to do with preserving herbaria (sic) collections –' dried flowers") and Australia's funding to the *International Commission on Phytosanitary Measures*.

I doubt that Mr Crowe has any understanding of what these bodies do, other than providing him with opportunities for cheap shots which will doubtless play well to his audience. Certainly he does not seem to be aware of the importance of biodiversity and the increasing threats to biosecurity, (plant diseases, both in agricultural settings and in natural vegetation have emerged in recent years as growing international problems – see Elith *et al*. 2013 for an emerging Australian example) and that the Herbaria are amongst Australia's oldest scientific institutions. Most of the membership of CHAR is from state institutions, so funding for attendance comes from state coffers rather than federal sources, the various university herbaria are also represented. The diversity of research in herbaria, both taxonomic and ecological, is vital for the management of biodiversity. The collections (which go far beyond being just dried flowers) are vital resources underpinning our understanding of Australia's environment.

Nonsense such as that displayed in this article makes me grumpy!

One of the problems we face is that the name of our discipline, ecology, has been hijacked and given a wide amorphous definition in general circulation. Ecology, as a branch of biology, was born in the late 19th century. The world's oldest professional scientific society specifically focused on ecology, the British Ecological Society (BES), was founded in 1913 (Anker 2001, Ayres 2012) and is thus celebrating its centenary. In the half-century since BES's birth the discipline grew steadily; internationally the number of professional ecological societies increased, new ecological journals were launched and positions for ecologists became the norm in departments of zoology and botany. However, the broader public recognition of ecology as a science was low. In the 1960s with the development of the environmental movement, ecology took on broader, in some cases almost quasi-religious, connotations. The broader meaning of ecology developed in the 1960s still prevails in the wider community. The UK Equality and Human Rights Commission has issued guidelines to employers which allow workers 'to request not to have to fly to meetings, not to sit on a leather chair and not to have to work on important days in their religious calendar ' (Woolf 2013). The guidelines say that 'ecologists would be permitted to tell colleagues that it is wrong to drive to work because it damages the environment. They could also ask to be excused from duties that increase CO_2 emissions such as flying to business' (Woolf 2013). I would have welcomed a legally protected right to tell senior management that what they were doing was wrong! Nevertheless, listing the rights of ecologists along with those of, *inter alia*, Druids, pagans, vegans and vegetarians concerns me. If, as professional ecologists, we wish to educate the public and to participate in policy formulation, then our credibility may be impaired by public (mis)understandings of what ecology is. Various ecological scientists over the years (for example Eichhorn 2013) have expressed grumpiness about the misuse of 'ecology' and 'ecologist,' but collectively, the profession has never mounted a counter-attack.

State of the universities

In relation to tertiary education, Recher (2013) argued that the courses and curricula in the sciences in Australian universities do not equip graduates with the skills and perspectives necessary to address the problems of the world. He suggested that the Australian degree structure, derived from the English model, was inappropriate and that all graduates should also have a grounding in the humanities, so that the basic degree should be extended to 4 years to allow these deficiencies to be addressed. Disagreement about the relative merits of depth versus breadth in education has a very long history. I have sympathy with the concerns expressed by Recher, and agree that new graduates are poorly equipped to participate in policy preparation and administration. Equally, many non-scientists with management or economics backgrounds fail to grasp the concerns of their scientist colleagues. The liberal arts structure of many American first degrees has advantages over the English model. Nevertheless, while I understand the reasons for the changes advocated by Recher, I very much doubt that there will be any serious nationwide move for their adoption. The new model adopted by the University of Melbourne with a broad general education program at undergraduate level and vocational and professional programs available in postgraduate programs (Coaldrake and Stedman 2013) is a step down the Recher path, but it is not an approach which other institutions are seeking to follow, although the University of Western Australia has made steps in the same direction (Coaldrake and Stedman 2013). If there were a general shift to the Melbourne model, then there would be major budgetary consequences which the current model of public funding of higher education would not be able to address. While I think it unlikely that the Melbourne model will become the norm, there is a trend for increasing numbers of students opting for double or combined degrees (terminology varies between institutions), which provides for deeper study of two disciplines.

Scientists in the future will need to recognise that the solution to the world's problems cannot be provided by science alone, although science will be an essential component of the solution. Acquaintance with the

humanities during their training will hopefully make scientists aware of what the humanities can offer, and what particular disciplines they need to collaborate with. One of the advantages of exposure to the humanities as students is that it may make them aware of their limitations. They are not being trained as polymaths, but to appreciate that their knowledge is limited and there will be circumstances when they will need to seek more expert advice. Collaboration will be the way forward. Both the sciences and humanities need to maintain and strengthen their disciplines and not dilute them. Stephen Jay Gould in his final book (Gould 2003) argued for rapprochement between science and the humanities. At the British Ecological Society Centenary conference in 2013, leading researchers from the humanities argued persuasively for the major contribution that the humanities can make to the solution of complex problems (Ely 2013, Harper 2013b, Hulme 2013, Owens 2013). We also need to acknowledge that there are important issues where our current state of knowledge is such that there is no scientific consensus as to the most desirable solution and in those circumstances social and political considerations will be the major determinants of policy. We need to ensure that any policy will, in the future, be capable of evolving in response to new scientific input.

One of Recher's (2013) suggestions of how to provide the time within the first degree for greater breadth was to do away with honours. The Australian concept of honours differs from that in virtually all other countries and the Australian honours degree is not immediately understood elsewhere. Nevertheless I would be loath to see the research thesis based honours programs disappear. They provide valuable training in practical research, and often yield publications in peer-reviewed journals. Research by honours students has often opened up new areas of study, and contributed to the development of a vigorous research culture within departments. There are advocates for the replacement of honours by a Masters degree - either a Master of Philosophy (MPhil - a recent innovation in Australia) or a Master of Science; at present opting for Masters allows universities an extra avenue for access to the Commonwealth Research Training Scheme (RTS) funds. The RTS was never intended for this purpose and is not a bottomless pit, more money flowing to Masters is likely to result in less being available to doctorates. I agree with Crossley (2012) that the existing honours model should be supported, and that placing a Masters as the expected step between first degree and a doctorate is likely to be financially unsustainable and would also inappropriately lengthen the research training process.

Public universities worldwide face similar problems to those in Australia. For several decades governments and universities have struggled to define their role and purpose (Coaldrake and Stedman 2013), and to develop governance models. In Australia, there is the additional complication of universities being established by state legislation, which sets governance structures (given that each institution separately has its own Act there is not uniformity within, let alone between, states), but where the bulk of public funding is derived from the Commonwealth, which sets its own restrictions and reporting standards. Over the last few decades the proportion of university budgets met by the public purse has declined significantly but the amount of regulation has increased. Both from within and without the walls of academe the fog of confusion is disheartening – the system is in urgent need of revitalisation.

State of science

The rise of the managers

Many of us who have had practised our science in public institutions will have observed over our careers a marked change in the institutional culture. Recognising that over decades most institutions change, and that any change can be a trigger for grumpiness even if, objectively it is for the better, the changes in the institutional practice of science is seen by many of those with experience of them as retrogressive and likely to have long-term adverse impacts on the ability to conduct ecological science. These concerns are not restricted to the local scene but are widespread, as well expressed by Allen (2007).

'Academic life has changed over the last few decades. There used to be a large suite of different ethics: including medical, ecclesiastical and scholarly ethics. Now all have been replaced with the mercantile ethic, such that success in academe more or less requires vulgar careerism; we have to run it like a business.'

This is not to say that in the past careerism, vulgar or otherwise, did not feature in academe, it is a basic feature of human nature, but it was not so clearly favoured.

Before analysing the problems from my perspective, I doubt anyone would deny that expenditure of public money on research should be thoroughly audited, and the research should be managed so that it is conducted efficiently. We need to operate in a business-like manner, but that is not necessarily the same as running on the business model dictated by managers.

The big change in institutions over my career has been the growth of the number of middle managers and the development of a managerialist culture. In the case of universities, over the past 35 years there has been an increase in the number of students, but the increase in the number of managers across all aspects of university functions has been greater than would be expected if student number were the only driver. The Dawkins reforms were the trigger for the proliferation process, as greater reporting requirements were imposed on institutions by the Commonwealth, but the universities themselves have invented many new managerial positions. The increase in number of administrators is all the more remarkable considering that in the 1970s pen and paper record-keeping was still the norm, whereas today there are software systems for every activity. Indeed one issue designed to induce grumpiness is our subservience to software. Big software packages are one of the few things that when they are purchased are almost certain to be faulty. Around the world, throughout the public sector, there are numerous examples of failed software systems, and universities are no exceptions, including some of

those regarded as among the most prestigious (Evans 2010). These failures have adverse effects on morale, because of the extra work they generate, and because the large amounts of money involved could have been put to more useful purposes.

The extra layers of management have not come cheaply. Upper-level managers enjoy high salaries, often far higher than those of even the most senior of the workers. This is not just an issue for academia, it is now a feature across the public service. Not only does this mean that management is a significant component of agency budgets it strengthens the divide between 'us 'and 'them'. Once upon a time the career pathway may have permitted the possibility of rising through the ranks, so that the top of the hierarchy contained people who had an understanding of the technical issues of their agency. Today, managers know about management (or think they do) and their career movement is between, rather than within, agencies. Concerns about the high salaries and the detachment from reality of the highest levels of management are not unique to science and the public service. They are clearly apparent in the public's low regard for the heads of the banks. The party line response to criticism of high salaries is that the level is set by the market, which seems to me to be self-serving and more admission of market failure than a reason for praising our economic system. It seems to me that a system where the highest level public servants may have higher salaries than the ministers to whom they report is structurally flawed. If more appropriate salary levels applied, then the money saved could be invested in the core business of agencies, including research.

I would not argue that we can do away with management. An administrative section has always been a necessary part of universities and public agencies. Nevertheless the role of the administration should be to serve their institutions rather than to control every part of their activities. Murphy (2013) has documented the rise in management staff numbers within universities over the last three decades. His figures, however, perhaps underestimate the nature of the change. He based his analysis on the published figures of academic versus non-academic staff numbers. The non-academic staff numbers include technicians within science departments, and the amount of technical support provided for departmental and school core functions has declined considerably. In addition despite the growth the numbers of administrators, a considerable number of tasks have been shed by the central administration and now have to be performed by academics. The growth of the central administrations has seen a decline in the importance of collegiality in the day-to-day governance and management of universities. This leads to a sense of powerlessness amongst academics and a decline in morale. Given the prevailing expectations of our political masters on how organisations should be run (those elected by a democratic process seem to be remarkably reluctant to allow democracy to prevail elsewhere) it would be wishful thinking to anticipate a return to previous cultures.

One of the consequences of managers needing to be seen to be managing is the requirement to report on the performance of individuals and institutions. The concept of managers having responsibility for that which they manage is not, of itself, objectionable. Indeed it would be seen to be one of their prime duties. However, globally, managers in institutions have not grappled with the complexity of the task, but have sought refuge in simple metrics and a one size fits all approach. At the level of the individual researcher, measurement of impact of performance is reduced to numbers of publications and citations. The indices do not involve any assessment of quality or worth of the publications, and are vulnerable to manipulation by the cartel of international journal publishers. For taxonomic and ecological publications a further drawback is the narrow time window over which the impact is assessed whereas the value of good publications in these fields may extend over decades. Evaluating performance by the ranking of journals in which researchers publish is officially no longer on the agenda in Australia (Coaldrake and Stedman 2013), although the rankings of journals remain in the managerial memory. The official rankings took little account of the differences between disciplines, and many environmental and ecological journals were poorly treated. Although I have seen no analysis to confirm my impression, I suspect that the journals associated with the big publishing houses (even if nominally the outlet for particular societies) did better out of the rankings than those outside the grasp of the publishers. Although rankings may have dropped off the agenda, Impact Factors still play a role in decisions on where to publish and in the assessment of output. Within our own fields we are all aware that some journals have higher standards than others - although standards are not necessarily correlated with Impact Factor. We are also aware that the readership of different journals varies, and that to reach particular audiences some journals, regardless of their academic standing, are more appropriate than others. Impact Factors are based on citations, but many readers of ecological accounts are not in the publication game, so that a paper may be read by many (data which are not readily captured) but not necessarily generate citations. Again Impact Factors do not address the issue of longevity of certain types of publication, for example taxonomic works and descriptive ecological studies.

There is a particular problem for Australian ecological and environmental scientists, and that is the continuation (or resurgence) of the cultural cringe. Greater weight is placed on publications in international journals over those in Australian journals. This is despite Australia having a long history of local journals, with demonstrably high editorial and refereeing standards. Australia is a continent with a diverse biota and unique ecosystems. In evaluating a British academic, there would be no concern raised about publication in the *Journal of Ecology* (the journal of the British Ecological Society), whereas for an Australian, publication in *Austral Ecology* or the *Australian Journal of Botany* might raise eyebrows, publication in *Proceedings of the Linnean Society of New South Wales* or *Australian Zoologist* is close to a kiss of death. There is much Australian ecological research which is appropriately published in international journals, but there is equally much research which is directly relevant to identifying

and understanding our biodiversity which is unlikely to be seen as relevant to international journals but is appropriate for Australian journals. Prejudice against Australian journals could have adverse consequences for their survival, and for those journals linked to professional societies, the survival of those societies, with consequent damage to the collegiality of our disciplines.

Whatever scientific societies might feel about publication practices, they are increasingly being dictated by government. In both the United States and the UK the major government grant giving bodies require that papers derived from funded research must be published in open access journals. From 1 April 2013 Research Councils UK (RCUK – which is not the producer of expensive casual clothing) requires publication in journals compliant with their open access policy. Open (i.e. free) access transfers the cost of publishing from the reader to authors – there is no such thing as a free lunch and publishers are producing journals to make a profit. RCUK is providing funding to universities and research institutions to meet Article Publication Charges (APCs) (see http://www.rcuk.ac.uk/research/Pages/outputs.aspx).

The British Ecological Society has announced that its five journals will be compliant with RCUK's requirements (Hill 2013). The Society states – 'However, prior to acceptance there is no need to inform the journal that you intend to publish your article via an open access route, so all open access articles are treated in exactly the same way as other articles. They are all subjected to the journals' standard peer review process and will be accepted or rejected on merit alone' (Hill 2013).

I have no disagreement with research publications arising from government funding being accessible to taxpayers who provided the money. However, the irony is that prior to these new systems coming into place we did have open access in the form of libraries. While it may not have been possible for a member of the public just to walk in off the street to consult a journal in university libraries, it was possible to arrange for access. In the age of electronic subscriptions there is little point in going to libraries – hard copies do not physically exist. The contractual arrangements between institutions and the publishers restrict access only to those with approved passwords, and the institutions cannot provide electronic access to any interested Tom, Dick or Harry in the general public.

There has been discussion in Australia about the research councils instituting similar requirements but this has not yet occurred. Given overseas trends I suspect it will be inevitable.

Governments do not enter into open-ended commitments – the amount of money allocated to APCs will not be limitless. Will it be available on a first-come, first-served basis – in which case there might be pressure on authors to submit at the start of the financial year before the money runs out, or will institutions second-guess journals by setting up internal review panels, with only what are arbitrarily regarded as the best (i.e. will attract publicity to the institution) manuscripts will be permitted to go forward? I am particular concerned about the fate of submissions from those lacking grant funding and thus not eligible for APCs. Publishers are still going to require payment – will this mean that the active retired, honours students or self funded researchers, will be cut off from opportunities to publish?

The systems which have developed for open access publishing were designed particularly to address publication in fields such as medicine – where large profits may accrue to industry from exploiting research. There has probably been inadequate consideration of the diversity of circumstances across the whole of science.

The problems with performance appraisal based on publications without considering quality are perhaps even greater in disciplines outside science, and in fields where the monograph rather than papers is still a major avenue for reporting research. Coaldrake and Stedman (2013) point out that when the first research assessment round was conducted in Britain, the attention on publications and citations was intended to apply only to science and technology disciplines and the dangers of imposing the same regime on all disciplines were recognised. The humanities disciplines themselves sought out inclusion - a clear case of being hoist by their own petard.

Issues about changes in publications were discussed by Crowther *et al.* (2012) and Bryant and Calver (2012) and are given more detailed consideration in other contributions to these proceedings. Bryant and Calver (2012) express views about the adverse consequences of modern journal publishing regimes on natural history, and stress the continuing importance of regional natural history journals: I strongly endorse their position.

As well as ranking their staff, universities compete to gain high rankings as institutions. There are a number of world ranking scales; at its highest the process of deriving rankings is best characterised as pseudoscientific mumbo-jumbo, but the rankings are regarded as extremely important by vice- chancellors and politicians. One of the goals of the current federal government is to increase the number of Australian universities ranked in the top 100 of the world, a goal complicated by the existence of a number of indices which are not aligned (see Coaldrake and Stedman 2013 for a history of international rankings). There would be general recognition that some universities are more prestigious, and in some senses better, than others, but converting this general understanding into a single number which encapsulates everything about an institution is, as Sir Humphrey might say, courageous. Few institutions would be uniformly excellent, however excellence is defined, across all their activities. One of the reasons for the enthusiasm for rankings is that they are a selling point for attracting international students. Education (and particularly tertiary education) is a major export industry for a number of countries, including Australia. This will, I suspect, be a transient phenomenon. While I strongly support international exchanges by students, the standard of universities in China and Southeast Asia is steadily rising; a number are, at least in some disciplines, the equal to, or better than, most Australian universities. I would anticipate that over the next few decades the number of overseas students

undertaking the whole of their undergraduate education in Australia will decline. The reduction in the substantial revenue stream will have major consequences for the Australian higher education system.

One matter of concern is the focus on a short time frame, both in performance appraisals and project funding. There is recognition, in an arm waving sense, of the need for long-term environmental monitoring, but little concrete action to establish and maintain long-running programs. Grant giving bodies are unlikely to fund long-term monitoring, academic institutions are unlikely to have untied funds for such projects. There is a tradition of long-term monitoring at university field stations, but in times of budgetary pressure there are no guarantees that the facilities will be maintained. In terms of publication outputs, long-term monitoring does not rate highly. I have sites which I have been monitoring over many years. I have published one paper with 25 years worth of results (Adam 2000), and it is my ambition to achieve 50 years – but only two papers from a study over 50 years does not look good .

If long-term studies are difficult to mount from within Tertiary institutions, then might we entertain hopes that governments will assume responsibility? Individual scientists and government agencies see the need, but for programs to have validity there needs to be consistent adherence to an agreed sampling design. If budgetary constraints result in the number and frequency of samples being arbitrarily reduced, or if the skills necessary for taxonomic identification or other specialist aspects of the program are no longer available, then much of the value of monitoring will be lost. I have argued previously that in the future much necessary monitoring will need to rely on the availability of skilled amateurs (Adam 2010).

The decline in research capability of government institutions has many consequences. In recent years there have been extensive cuts in many government agencies and their research arms have not been insulated from change during this process.

Governments are faced with numerous demands on limited resources, and in a democratic society have the ability and right to make changes in priorities. However, it is not always clear that the long-term consequences of decisions have been appreciated, or that there has been a thorough cost benefit analysis. Scientific research cannot be turned on and off like a tap; loss of skilled staff and corporate knowledge following cuts has repercussions for years and cannot be instantly reversed even if funding is restored. New South Wales has a long history of scientific excellence in what may generally be referred to as the rural sciences. The Department of Agriculture was for many years probably the second largest scientific research organisation in Australia after the CSIRO. However, over several decades, investment in agricultural research and development in New South Wales has declined (Mullen 2013a, b). Declines and disruption of research in agriculture, forestry and fisheries compromises our ability to respond to the challenges of securing ecological sustainable management.

The Department, not surprisingly, has contested Mullen's view (Sheldrake 2013), suggesting that Mullen's focus is on production research and the research conducted by the Department covers a range of other topics. While there is some weight to this argument, production is still a vital area of study. I agree with Sheldrake (2013) that there are outstanding researchers in the Department, but loss of senior staff has occurred. Sheldrake (2013) also refers to the importance of the work done with partners, which illustrates another change in the conduct and organisation of research. Research in Primary Industries and in all other areas of research conducted by state government agencies is increasingly dependent on outside funding sources, and the proportion of the core budget funding allocated to research is declining. Undoubtedly partnerships are valuable, but a greater reliance on competitive outside funding increases the competition for limited pools (puddles might be a better term) of money, and creates uncertainty about long-term continuity of programs, and for those employed on outside (soft) money is an obstacle to establishing a career.

A particular cause of grumpiness is the managerial speak which accompanies any announcements of budget cuts. Frequently we are assured that the effects of any cuts would be outweighed by greater efficiency and increased productivity. While inefficient and wasteful practices should be identified and eliminated I have difficulty seeing how, on demand, scientists can become more productive (other than by removing the impediments imposed by managers) – instead of having one idea a day are we supposed to have two? While we can plan programs, there remains an element of serendipity and we must be able to recognise and respond to the unexpected – but the problem with the unexpected is that we don't know what it is in advance nor when it will occur. Importantly, there are no rapid response funding mechanisms to investigate ecosystem responses to major disturbances (such as cyclones, floods, fires or new disease outbreaks – Lindenmayer *et al.* 2009). Current funding mechanisms are such that it is likely to be eighteen months to two years before grants might be available so that the opportunity to gather data immediately post impact is lost.

The expression 'efficiency dividend' is an example of the managerial speak which has so corrupted our language; it is a cynical euphemism for cut, dressed up as a positive. A recent, and unanticipated, example, of an efficiency dividend is the cut to tertiary education funding to provide funding for the Gonski reforms of school education (Hilmer 2013a). Improvements to primary and secondary education are undoubtedly needed, but it has been a frequently stated policy objective of the present Commonwealth government to increase the numbers of students undertaking tertiary education. As Hilmer (2013b) points out 'It is an absurdity to seek to provide students with a better education at school by providing a worse experience at university.' How universities will adapt to the cuts remains to be seen, but it is unlikely that science will be quarantined from the pain.

The other cliche which is regularly used to justify cuts is that frontline services will be maintained. This implies that the frontline can function in the absence of a whole range of support services. In practice frontline staff will need to carry out the backroom support services reducing their productivity as providers of frontline services.

The new research culture

Notwithstanding the attention given to outputs from research in staff assessment, greater weight is probably attached to grant income, for all that in many cases grants do not cover the total costs incurred, so that subsidies from elsewhere in the institutions' budgets are essential. Research grants are the gifts which keep on taking.

There are decreasing amounts of internal funds to provide start-up funds to explore possible new avenues of research prior to seeking external funds, and probably no funds at all for long-term but low-cost projects.

Very large amounts of time, and, in terms of salaries, large amounts of money, are expended in applying for grants (Phillips 2013). Competitive grant schemes are just that -- competitive. The ability to apply for grants is not, nor should be, a licence to print money. Nevertheless, the success rate of the major Australian schemes is at the low end of success rates in equivalent schemes overseas, and the application process is complex (Phillips 2013). The post submission review process also takes up considerable time of reviewers; referees know that even if they say the proposal is the best they have ever seen there is no guarantee that funds will eventuate. If a referee thinks a proposal is exciting and novel, and may generate important results, but where there are some areas of the proposal which, in the referee's view could be improved, the referee is faced with a dilemma. Any criticism, however well intended, will almost certainly remove the possibility of funding being granted.

Within institutions there is pressure to increase the size of the bid in grant applications. Field-based sciences are criticised for not winning big enough grants. Part of the problem is that, in many cases, our needs are relatively modest; we rarely have a requirement for large, very expensive piece of equipment and what we might see as expensive pales into insignificance compared with the needs of disciplines such as high-energy physics or astronomy. The asset which we would most prize is time – time to spend sustained periods in the field – and this is difficult to obtain. Martyr (2012) has recently argued that the grant culture has profoundly changed, for the worse, academic practices in the humanities. She sees the main research need in the humanities is for time for the individual investigator to locate and read primary sources, but to satisfy the grant giving bodies successful applications are now modelled on those in the sciences. She advances, as examples for ridicule to support her case, recent ARC grants in several of the humanities. I recognise that there is a strong political ideological agenda behind this critique, but nevertheless I have some sympathy with her argument, and suggest that similar sentiments might be expressed in relation to the sciences.

If the research needs for a sustainable environment are to be considered, questions need to be raised about the overall structure of national research budgets. In awarding grants I hope that governments fund good science, while recognising that there are insufficient funds to permit all good proposals to be supported. Nevertheless ministers are politicians and need to be receptive to public opinion (although hopefully a broader public than that expressed through talkback radio). The range of areas funded must be broadly compatible with that supported by the public. The Minister may defend one or two controversial grants, but not a whole list. This means that over the years there is a broadly similar pattern to the structure of the package of successful applications, and this also influences the composition of the committees making recommendations, and their mindset in making the decisions.

This results in substantial funding for medical research, although less for research on public health issues, and physics (including astronomy). Molecular and genetic aspects of biology are relatively well funded, the field sciences less so, and this is been the case for a long time with few exceptions. That this pattern is not the only one possible is shown by history. In the 1960s the International Biological Program (IBP) was well funded and gave a considerable fillip to ecology.

A major focus of the IBP was on systems ecology – a field of study associated particularly with the Odums. Although the concepts of systems ecology are still central to introductory ecology courses, as a field of active research it has been relatively out-of-favour. However, it is an area where there is currently renewed interest.

One of the currently fashionable areas of research in ecology is 'big ecology', the analysis of large global metadata sets. Ineson (2013) has pointed out that some of the data underlying recent metadata analyses originated during the IBP period. He also pointed out that, when looked at closely, some of the data which have been used in metadata studies do not withstand scrutiny. Our ability to assemble and analyse large datasets should not lead us to forget the old adage – garbage in, garbage out. The lack of critical thinking by both researchers and editors is a cause of grumpiness.

Another area where data and concepts from systems ecology have again become relevant is understanding the relationships between species diversity and ecosystem processes (Mooney 2009, Cardinale *et al.* 2011).Being able to quantify ecosystem services and relate them to biodiversity will be important in justifying biodiversity conservation. Cardinale *et al.* (2011) postulate a number of possible relationships between species diversity and ecological functions; some of their hypotheses could be supported but in a number of instances there are insufficient data to address the questions. The research effort required to accumulate the necessary data will be considerable and many of the skills required will need to be re-learnt.

The necessary research will be multi-and interdisciplinary, and thus large teams of researchers will be required. The concept of having large teams of scientists engaged on single projects became prominent during the Second World War,

as for example in the Manhattan project and, in Britain, the major research effort to develop radar. In the case of the radar project scientists from a wide range of disciplines were engaged, and post-war some of the researchers involved were able to apply radar to biological problems, particularly in relation to migration of birds. Before the war, research was a less prominent feature of government expenditure, and university departments had only a few (normally only one) experts in each subdiscipline, and no armies of postgraduate students and post doctoral fellows. In the present age, team research tends to lead to multiple authorship of research papers. I must admit to a degree of scepticism about this trend. When the number of authors reaches double figures it is not clear to me how all can be actively involved in writing. Although modern protocols for the recognition of involvement and protection of intellectual property suggest, and possibly even mandate, multiple authorship, it would seem in many instances that recognition might more sensibly be given by inclusion in the acknowledgements section of the paper rather than as authors.

Despite the impact of TV nature documentaries in arousing interest in the environment, this does not seem to generate popular support for greater research on ecology. One possible factor in determining public support for funding of other sciences is the esteem associated with Nobel prizes; there is not a category prize for biology, the closest is physiology or medicine. The Nobel committee has given the medicine prize to molecular and genetic biologists; the only field biologists who somehow got over the line were the ethologists Frisch, Lorenz and Tinbergen who received the Medicine prize in 1973. The failure to include biology in the categories to which Nobel awards are made perhaps reinforces the impression carried forward from school that biology is a second-class science.

It is argued by proponents, justifiably, that research in physics and astronomy reveals, or has the potential to do so, the fundamental nature of the universe. An editorial in 'The Times' (20 April 2013) discussed the case for fundamental research in physics – 'In times of economic constraints, policymakers may wonder at the utility of such research. They deserve an answer. Cern's work advances knowledge through inquiry. It can have extraordinary technological benefits (the world wide web was invented by Tim Berners-Lee at Cern), but knowledge is its own justification. Darwin's theory of evolution by natural selection, at first understood by only a specialist audience, is integral to modern culture. Science is indispensable to understanding the human condition as well as the Universe of which it makes up so inconceivably small a part.' I would also defend academic freedom to pursue lines of intellectual enquiry, while remembering a zoological colleague whose laboratory door displayed a sign – 'my freedoms are purely academic.' Nevertheless, when the state of the global environment is considered I argue that we seriously need to question the patterns of research funding. We do not know how many organisms there are, we know comparatively little about much of the oceans (and researching oceans is one of the areas where biologists require big-ticket items of infrastructure for research). Is funding for the Hadron Collider or the Square Kilometre Array luxury we can no longer afford? Even if it were possible, I would not suggest an immediate large increase in research funding in the field sciences, which would not be cost-effective and could be counter-productive. There is a prior need to address the deficiencies in whole organism biology teaching identified by Hutchings (2012), and to build up the necessary skills for the taxonomy requires that its practitioners understand the biology and ecology of the group of organisms they study (the approach, as has been suggested to me by some managers – X works on a particular group of organisms, they can be instructed to work on nematodes where there is a greater need – is unlikely to be a profitable approach to midcareer researchers). We cannot wait for the ultimate catalogue of the world biota, many management decisions can, and will have to be, made in the absence of full information, but the more we know about biodiversity the better decision-making process will be. The decline in taxonomy has been a long one, and at least in part we can blame it on the lasting influence of Rutherford's division of science into physics and stamp collecting. The slur seems to have particularly stuck to taxonomy, but there are many other sciences for which cataloguing is still a vital process which does not attract adverse comment – geological mapping, mapping the stars or locating subatomic particles spring to mind.

I do not argue that fields such as nuclear physics or astronomy should not continue to be funded, but that the proportion of the research budget these topics receive might be reduced. If the funding for ecology and conservation research is increased it should not be at the expense of the budget for action – both should be increased. We should also adopt a critical approach to what research is funded.

One area currently attracting good deal of public attention is a possibility of bringing extinct species back to life (Zimmer 2013). There is increasing confidence among scientists involved in research that they will be successful (Zimmer 2013). I can appreciate the excitement of the research and the intellectual challenges involved but have serious concerns about whether it is an appropriate objective. A number of issues could be raised including whether there is any merit in reviving species if the factors responsible for the original extinction are still operating, or if the habitat and environmental conditions required for the species no longer exist. Should species be revived if their only future is in captivity? There is also the possibility that the potential to bring extinct species back to life may result in a diminishing effort to combat continuing extinction – why should we worry about extinction if it can be reversed? Resurrecting a species would not bring back its unique parasites and pathogens, should this be of concern? If it is possible to bring back species from extinction which species would be chosen? Would it be only the iconic charismatic species, which despite their interest may not be keystone or major players in ecosystems, or would invertebrates, bacteria or even viruses be candidates for resurrection? The majority of species which should become extinct did so without recognition, so their chance of ever being a candidate for revival is negligible. I would be reluctant to see public funds committed to research of this

nature, there are many other projects deserving priority funding. Of course philanthropic donations to support research cannot (and should not) be regulated in most circumstances. However, the conduct of the research would still require ethics approval and collecting permits. If the outcome of the research is that a species is revived there would nevertheless have to be processes in place to assess the consequences of release into the wild and to provide for mechanisms to regulate or prevent such releases.

Ecological research has undoubtedly benefited from advances in other sciences. The availability of greater computer power and new statistical methods have revolutionised our ability to analyse the large and complex data sets which ecologists collect. Radio tracking and analysis of sound signals (bat and frog detection, or whale song) have enabled study of often cryptic fauna. Remote sensing and GIS have revolutionised our ability to survey large areas and to monitor change - satellite imagery has been one of the great benefits of space programs, but manned space programs have not provided the cost -- benefits that unmanned exploration has yielded, although the early photographs of earth from space taken during the moon program provided a major wake-up call, illustrating the uniqueness and potential fragility of our planet, and are still powerful images today. In my own PhD I spent many hours feeding samples into that great Australian invention, an atomic absorption spectrometer. In those days it was almost obligatory for papers on plant ecology to contain detailed soil analysis and many insights emerged from this approach. This aspect of ecology is no longer at the cutting edge, but a variety of analytical techniques remaining important aids to research. Molecular biology has provided many new tools, the potential of which is still being explored by ecologists.

The state of the world – beyond grumpy

Many ecologists embark on their career with a desire to assist in addressing the world's environmental problems. In doing so they risk criticism from populist commentators, and other scientists, for displaying lack of objectivity in their approach.

I recall, from my undergraduate days, the furore which arose following the publication in 1972 of *A Blueprint for Survival* signed by over 30 leading scientists. This was attacked in the media, by other scientists and through letters to the editor; the prevailing sentiment being that scientists should stick to science and not comment on policy and social issues. Curiously, some of the critics would have appeared to have failed to see the irony of their argument, given their own advocacy of issues like nuclear power. With the benefit of hindsight some of *A Blueprint to Survival* appears utopian and unrealistic, but at the time the publication was an important contribution to debate.

Scientists have as much right as any other group in society to express their views – they should be prepared to receive robust criticism, but criticism derived from analysis and a factual basis, rather than assertion based on a particular ideological view of the world. The media today present environmental debate as being between left and right – this is a relatively recent view, historically, major advances in conservation and environmental policy were made by governments of a conservative bent. The philosopher Scruton (2011), argues the case for right-wing environmentalism. He is, in particular, an advocate for the importance of the local, and unlike some other conservative commentators clearly recognises the reality of anthropogenic climate change – although when it comes to a climate change solution he resorts to faith in an as yet unknown technological fix (he suggests that geo-engineering Goodell 2010) is likely to be part of the solution, despite not acknowledging the major risks and the global political issues flowing from one nation, or even one individual, taking actions which will impact on the whole globe. In Australia the Citizens Electoral Council views environmentalism as a global conspiracy orchestrated by Prince Phillip and the merchant banks! (see Figure 1).

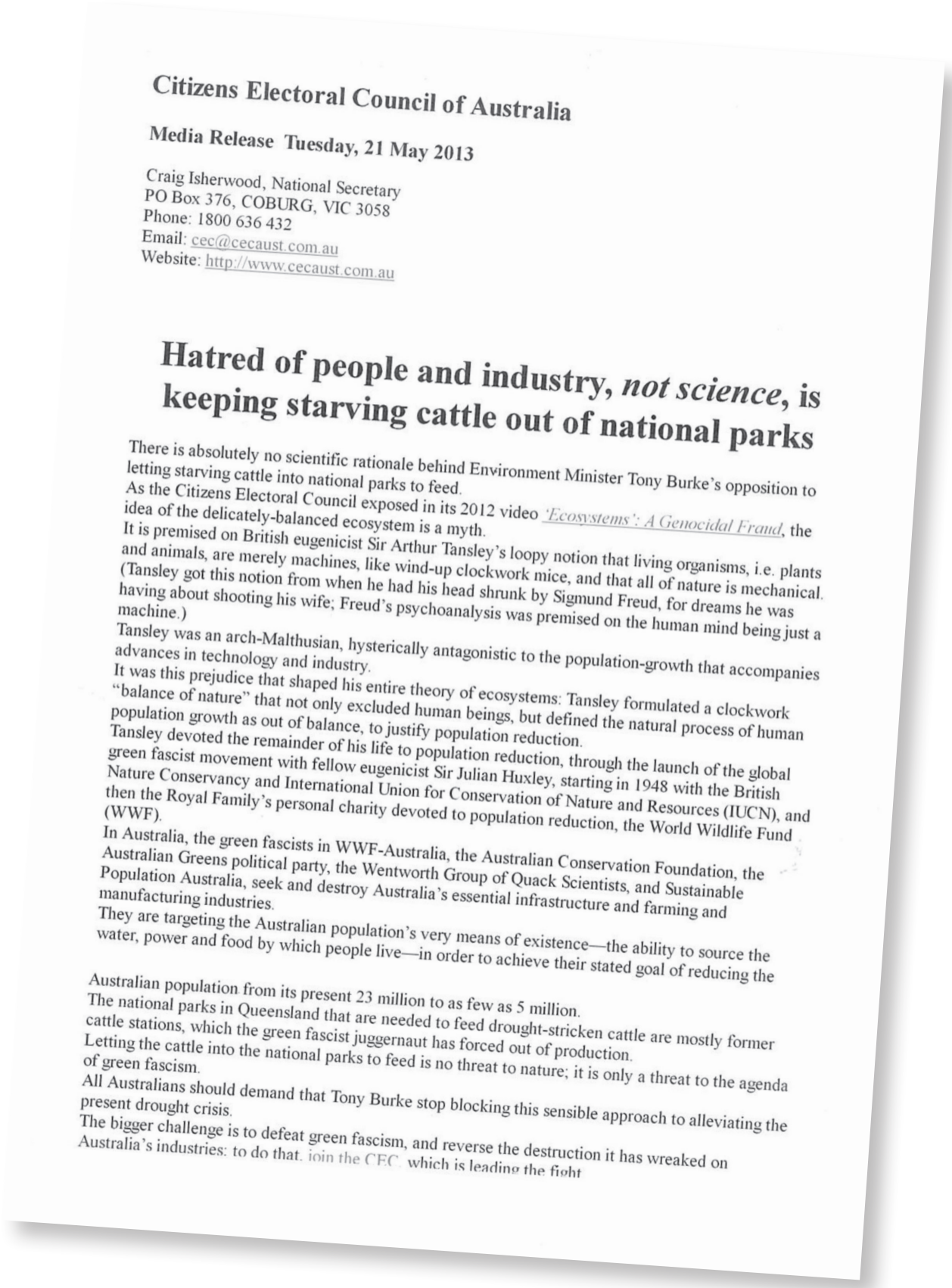
To be effective contributors to debate, scientists need to establish, through the peer-reviewed processes of publication, their credentials to be regarded as experts. They should apply the same rigorous analytical process to their contributions to environmental debate as to their scientific speciality but they should not be limited to commenting on their speciality, the analytical process can be applied to broader issues.

There are many issues on which minds may differ, but in regard to many of the environmental issues which are the subject of controversy there is a history of organised opposition which doesn't argue from the same premises as most scientists and is not interested in analysing factual and technical bases of difference. This is seen in debate about such issues as agricultural chemical use, human population, tobacco smoking and health, and climate change (in relation in particular to the last two issues see Oreskes and Conway 2010).

The birth of the modern environmental movement was triggered by the publication in 1962 of *Silent Spring* by Rachel Carson. Although Carson was subject to fierce, and often personal, attacks, orchestrated by the chemical industry (Lear 1997), the book was responsible for stimulating the introduction of legislation and regulation controlling pesticides in much of the first world.

Carson (1962) was the trigger, but there were other outstanding publications in the 1960s and 1970s which informed and guided the developing environmental movement, of which the most influential were Ehrlich's *The Population Bomb* (1968) and the Club of Rome report *Limits to Growth* (Meadows *et al.* 1972).Two Australian publications, probably little known beyond our shores and these days little known even within Australia, which in their time were influential are Marshall (1966) *The great extermination* and Webb *et al.*(1969) *The Last of Lands*.

Ehrlich (1968) and Meadows *et al.* (1972) were, and continue to be, subject to fierce attacks and criticisms, fundamentally because they were seen as subversively aimed at undermining prevailing economic and social



Citizens Electoral Council of Australia

Media Release Tuesday, 21 May 2013

Craig Isherwood, National Secretary
PO Box 376, COBURG, VIC 3058
Phone: 1800 636 432
Email: cec@cecaust.com.au
Website: http://www.cecaust.com.au

Hatred of people and industry, *not science*, is keeping starving cattle out of national parks

There is absolutely no scientific rationale behind Environment Minister Tony Burke's opposition to letting starving cattle into national parks to feed.

As the Citizens Electoral Council exposed in its 2012 video *'Ecosystems': A Genocidal Fraud*, the idea of the delicately-balanced ecosystem is a myth.

It is premised on British eugenicist Sir Arthur Tansley's loopy notion that living organisms, i.e. plants and animals, are merely machines, like wind-up clockwork mice, and that all of nature is mechanical. (Tansley got this notion from when he had his head shrunk by Sigmund Freud, for dreams he was having about shooting his wife; Freud's psychoanalysis was premised on the human mind being just a machine.)

Tansley was an arch-Malthusian, hysterically antagonistic to the population-growth that accompanies advances in technology and industry.

It was this prejudice that shaped his entire theory of ecosystems: Tansley formulated a clockwork "balance of nature" that not only excluded human beings, but defined the natural process of human population growth as out of balance, to justify population reduction.

Tansley devoted the remainder of his life to population reduction, through the launch of the global green fascist movement with fellow eugenicist Sir Julian Huxley, starting in 1948 with the British Nature Conservancy and International Union for Conservation of Nature and Resources (IUCN), and then the Royal Family's personal charity devoted to population reduction, the World Wildlife Fund (WWF).

In Australia, the green fascists in WWF-Australia, the Australian Conservation Foundation, the Australian Greens political party, the Wentworth Group of Quack Scientists, and Sustainable Population Australia, seek and destroy Australia's essential infrastructure and farming and manufacturing industries.

They are targeting the Australian population's very means of existence—the ability to source the water, power and food by which people live—in order to achieve their stated goal of reducing the Australian population from its present 23 million to as few as 5 million.

The national parks in Queensland that are needed to feed drought-stricken cattle are mostly former cattle stations, which the green fascist juggernaut has forced out of production.

Letting the cattle into the national parks to feed is no threat to nature; it is only a threat to the agenda of green fascism.

All Australians should demand that Tony Burke stop blocking this sensible approach to alleviating the present drought crisis.

The bigger challenge is to defeat green fascism, and reverse the destruction it has wreaked on Australia's industries: to do that, join the CEC, which is leading the fight

Figure 1. Sir Arthur Tansley was indeed a collaborator of Sigmund Freud, and wrote a number of publications about psychology. Nevertheless I do not think that the CEC interpretation of this aspect of Tansley's career withstands scrutiny.

paradigms. Meadows *et al.* was a pioneering exercise in computer modelling, and the techniques used would now be regarded as primitive. Nevertheless, Suter (1999) argues that in many respects the findings are still valid, and that the warnings should still be considered. Ehrlich (1968) and Meadows *et al.* (1972) both illustrate the difficulties of prediction but while predictions of dates for certain events have not been met, the overall scenarios are still highly credible. In the case of predictions of the consequences of population growth by Ehrlich (1968) developments in agriculture have delayed their occurrence. However, as global populations continue to grow, and as climate disruption has increasing effect, it is uncertain that future agricultural advances will continue to allow population growth and maintenance of acceptable nutrition and lifestyle. Unless there is a major unexpected breakthrough, the stage of diminishing returns for new innovations may have been reached.

Has the new environmentalism made any difference?

In the 50 years since *Silent Spring* have there been significant advances in protecting and managing the environment – should we be happy or should we still be worried? The concerns about use of agricultural chemicals which Carson raised were followed by regulations on use of many chemicals and improved assessment before release of new products, at least in the first world. Can we at least give a tick to this issue and proclaim that it is under control? Unfortunately I suggest not. Apart from the legacy of past uses still persisting, and instances of illegal use, the major issue is that regulators are still running behind the introduction of new chemicals into the environment. Chief amongst current concerns are endocrine disrupters, which are present in vast range of industrial products (Tyler and Goodhead 2010), pharmaceuticals (including, but not restricted to; antibiotics) and nanoparticles. Solid waste, particularly plastic fragments, is a major threat especially in the marine environment (Roberts 2012). The high hopes which might have been entertained in the 1970s following the first round of regulations have subsequently been dashed. Broader discussions of changes in the biota of Britain since the publication of *Silent Spring* have been presented by Maclean (2010) and Jameson (2012). Although these works provide examples of hope, overall the picture is still gloomy and in some instances worse than it was in the 1960s.

Currently there is a fierce controversy in the northern hemisphere over the use of neonicotinoid insecticides. This class of pesticides has been on the market for some years having successfully passed the mandated regulatory tests prior to registration. However, concerns about potential impacts on pollinating insects, particularly on honey bees and bumblebees have been raised (Carrington 2013). In the European Union, for example, oral and acute toxicity tests on honeybees are obligatory prior to registration of new pesticides but sublethal effects are not studied (Goulson 2010) and no studies on bumblebees are required. Goulson (2010) documented the toxicity of a number of insecticides to bumblebees and suggested that accumulation of some insecticides in nectar was a factor in the susceptibility of pollinators. Prior to the European Union voting on whether or not to impose a two-year moratorium on use of particular neonicotinoids governments were subjected to intense lobbying by the chemical industry, and UK ministers suggested that the science was uncertain and withdrawing the chemicals would lead to lower food production (Carrington 2013). The precautionary principle has not yet been universally embraced!

Insecticides kill insects -- that is why they are sold, and there is little species specificity in their action. Reduction in the risk of collateral damage may be achieving through the mode and timing of application, and changes to the instructions for use may substantially reduce the risk to bees. Given the importance of bees and other pollinators for the pollination of many crop species it is surprising that a need to examine impacts on pollinators had not previously been considered. Similarly herbicides kill plants, with again the risk of collateral damage. This damage may be to species not considered in the approval process. For example, it was not realised that even very low concentrations of triazine herbicides could affect marine microalgae, with consequences for ecosystem processes in intertidal wetlands (Mason *et al.* 2003). There is a case for greater consultation with ecologists in designing testing protocols prior to registration of agricultural chemicals, but even so the unexpected will occur. It cannot be assumed that registration is a universal guarantee that a chemical is 'safe'- there will need to be continuing vigilance.

In the 1960s a major pollution issue was that of oil in the marine environment. Although there were some major spills following shipping accidents there was more widespread chronic pollution resulting from the washing out of ships' tanks. International concern led to the development and adoption of conventions designed to prevent marine pollution (principally the London Dumping Convention). This has almost completely eliminated pollution from the washing of fuel tanks (although risk from accidents will be ever present), but other pollutants continue to be of concern.

In early 2013 two episodes of large numbers of seabirds affected by a sticky substance being washed up on the beaches in south-west England occurred (Aldred 2013). The compound was shown to be polyisobutylene (PIB) which has a wide range of industrial usages. It is thought that there had been released from a ship (or ships) (Aldred 2013). Despite the hazards presented by PIB, Aldred (2013) indicated that in certain circumstances discharge from ships could be illegal. If this is the case then strengthening of regulations may be required.

There are many examples of regulation lacking behind uses, but Australia is in the forefront of moves to be proactive by banning dumping of iron into oceans as part of commercial geo-engineering projects to increase uptake of carbon dioxide to ameliorate global warming (Arup 2013). Australia is seeking to amend the London Protocol whilst still permitting scientific research.

Over the past half-century how much progress has been made in addressing the range of other environmental issues which were prominent at the start of the environmental movement?

The conservation movement long predated the broad environmental movement. The world's oldest national parks date back to the late 19th century; numerous parks and reserves had been declared by 1960. The principal international NGOs, the IUCN and WWF, were established in 1948 and 1961 respectively. While both organisations can boast of impressive lists of achievements, their histories (Holdgate 1999, Schwarzenbach 2011) demonstrate that the issues which were prominent in the minds of the founders are still unresolved today. The WWF was formed with the specific intent of promoting conservation in Africa (Schwarzenbach 2011), but across that continent the burgeoning human population (resulting in land clearing for agriculture and greater harvesting of bush meat), continuing civil wars in regions of high conservation value and increasing illegal trade in wildlife and wildlife products mean that the future of African biodiversity cannot be regarded as rosy.

There have, however, been some changes that that can be regarded as successes. There has been the adoption of a number of international treaties with environmental themes. In Australia these international treaties have particular relevance given the peculiarities of the constitution and federation. As the Commonwealth is a signatory to the treaties this provides the national government with the ability to develop and apply environmental policies across the country, and, in certain circumstances, to override states. Within individual countries there has been the development of environmental laws, and the interpretation and application of these laws by courts, leading to stronger environmental governance. Nevertheless, what politicians do they can also undo, and when the consequences of laws threaten particular interests there have been examples of special-purpose legislation to overcome these 'difficulties'.

The development of models for triple bottom-line accounting gives rise to the possibility that the environmental costs of economic activity will be transparently documented, although when faced with this information it is not yet clear how decision-makers will respond.

One of the major conceptual advances in the last half-century has been the introduction of the concept of biodiversity, which provides a unifying context for discussion about the natural world. It is also led to the development of important concepts such as ecosystem services.

I have expressed concern (Adam 1998) that the broad concept of biodiversity was being lost, and that legislation was tending to promote a narrow view that conservation of biodiversity could be reduced to listed threatened species (and communities) and the conservation of all biodiversity risked being downplayed. I still have the same concern -one of my personal examples of what leads to grumpiness!

Did the new environmentalism make a difference?

Think globally – act locally

One of the mantras of the environment movement from the 1960s onwards has been *think globally – act locally*. This could be regarded as the converse of the concept of the tyranny of small decisions (or death by a thousand cuts) – the accumulative effect of numerous small actions will result in positive global change. The expression could also be regarded as the rewording in an environmental context of the old aphorism – look after the pennies and the pounds will look after themselves. There can be no doubt that local activists have been empowered and that many initiatives have had positive social and environmental benefits at the local scale. In the field of nature conservation an example of the power of local activism has been the success of the county naturalist trusts in the United Kingdom. While the oldest of the county naturalists organisations date back to the early 20th century, the great growth in the movement commenced in the 1960s. The success was due to the dedication of thousands of volunteers, but as Sands (2012) makes clear the importance of support from charismatic national figures was critical. Sand's history is replete with images of one or other of the two Davids (Attenborough and Bellamy) launching initiatives at local reserves. (Indeed, one of my own memories is of the two Davids headlining a county trust event in the splendour of the Sunderland Empire). If nature conservation in the United Kingdom was solely a function of the central government, the reserve network today would be substantially smaller and less representative. One of the interesting changes in Australia over the last decade or so has been the emergence of NGOs as significant holders of land for conservation, whereas in the past there was a tendency to see conservation as solely the prerogative of government.

One Australian form of localism which thrived in the 1970s, and which attracted international attention, was Green Bans, stop work bans imposed by trade unions on development – often at the instigation, and with the support of, local resident groups. The Green Bans changed public opinion in relation to development, and led to changes in government policy. Under current industrial laws, and in the current economic climate, it is very unlikely that unions would, or could, take similar action today.

Those who fight for their local environment run the risk of being accused of nimbyism. This is always seemed to me an inappropriate label. Firstly, not everyone starts by thinking globally and acting locally. Local activism can lead to understanding of underlying issues and recognition of global issues. Secondly, as Scruton (2011) points out connection to locality is an important human trait. It is natural that people will try to defend their 'back yard' -- and, if they don't, who will speak up for it? Those who use nimby as a term of abuse are taking the easy way out. Sometimes the arguments advanced by local residents, while well meant, do not have any defensible basis, but often they raise matters which require consideration and considered response, and not automatic rejection as being driven by narrow self-interest.

There is clearly a range of issues were local initiatives can be translated into national and international outcomes. However, when it comes to those issues where collective international action is required then thinking globally has not resulted in too many successes. Governments have shown the ability to collaborate over environmental issues at both continental and global scales. Two examples which illustrate this are the reduction in acid rain, where discharges in one country had adverse consequences for long distances downwind, and the implementation of the Montréal protocol to phase out CFCs. Thinking and acting globally is thus not impossible, but many other issues demonstrate failures to achieve this. The most obvious example is probably over greenhouse gases and climate change. The optimist might argue that there has been progress, but it has been slow and partial, and the inexorable rise in atmospheric greenhouse gases bodes ill for the future. (One problem in public perception is that the current projections for change extend out to 2100, creating an impression that this is going to be as bad as it gets, whereas there will be continuing, and perhaps accelerating change beyond 2100).

There has been a rapid change in the global situation which has caught us unawares, and that is the exploitation of unconventional gas resources (both coal seam and shale gas sources). The sudden increase in activity in this area was not predicted (Krauss 2013), and regulators are struggling to close the stable door after the horse has well and truly bolted (Manning 2012). Many of the issues raised by the gas exploitation are controversial – the consequences of fracking, the effects of extraction on long-term water supplies and the impacts on ability to use land within extraction fields for agriculture (Manning 2013) – and I do not discuss these matters in this contribution, although clearly they require more research.

A few years ago gas was seen as a transition fuel, to bridge the gap between phasing out of coal and the extensive use of renewables. It is now clear that the vast reserves in the USA and many other countries will be mainstream power supplies (Krauss 2013). Whether or not these gas resources produce less greenhouse gas than combustion of coal depends on whether the estimates of fugitive emissions from gas sources are accurate or underestimates, but, regardless, gas use will still generate greenhouse gases, and a growing population and greater energy consumption per head will add to the greenhouse effect. The likely cheapness of these new gas supplies could act as a strong disincentive to the adoption of renewable energy, unless governments are prepared to require its use. History, and, at a global scale, the economic might of the major fossil fuel energy companies, does not fill me with hope that we will have a low greenhouse renewable future.

The biggest challenge, clearly identified in the 1960s but remaining unaddressed, is that of human population. Governments have shown a great reluctance to promote discussion of the issue, let alone take action. Concerns about human population growth have long been expressed by ecologists (see Figure 1).The founding fathers of the WWF (Max Nicholson, Peter Scott and Julian Huxley) were very clear that the growing human population was the major challenge for conservation. At the end of his life Scott was arguing this case even more strongly (Huxley 1993). Ehrlich (1968) raised the issue in the consciousness of the wider community, and many conservation leaders in the 1960s and 1970s were strong advocates of population limitation. What is surprising and puzzling is that the policy platforms of major conservation NGOs today do not make human population a high profile issue. Individuals (for example, Smith 2011) still try to interest the public and politicians in the issue, but without response from politicians. Letters to the editor raising population issues demonstrate that they are still a great concern amongst the general public, but governments appear to be impervious to change, and the lack of a clearly articulated position from NGOs means that politicians do not have to adopt a new position.

A few countries which have attempted to control populations have employed Draconian measures which are, properly, an anathema not only to the populations affected but to the much wider global community. It is clear that the most effective way to reduce population growth is through the empowerment of women as a result of education and economic development, and this is the case even in predominantly Catholic countries such as Italy (Smith 2011, Harper 2013a). Although the demographic transition can occur in what is, on a geological timescale the blink of the eye, from a human perspective the change will extend over decades during which, even if the growth rate is slowing, there will still be considerable population growth. Greater economic development will result in burgeoning middle classes and increased consumer demand, so that even if the population stabilises, consumption (and the ecological footprint) will continue to grow, and the ability of the environment to meet the demand for consumption will be severely challenged. It is inconceivable that the world could sustain a global population with the lifestyle and consumption patterns of the United States (or Australia), but how realistic targets can be set, when they would require a significant reduction in consumption in many first world countries, even if this would not necessarily equate to a declining standard of living, is a challenge which governments are unprepared to meet.

The reluctance of governments to contemplate reduction in population growth, let alone population reaching stability or even decline, arises in part from concern about the consequences of a substantial change in population age structure during the transition period. How can social services for pensioners be funded from a proportionately smaller workforce? A declining population with a reduced life expectancy is not the pathway countries would choose, although as a result of rampant alcoholism this is currently the fate of Russia (Bullough 2013). Most projections of future populations in first world countries are predicated on continuing increases in average life expectancy. However, the current generation might possibly be the first to have lower life expectancy than their parents, as obesity and other life style diseases take their toll (Orshansky *et al.*2005).Could it be a case of – eat a hamburger and save the planet? While the demographic transition is associated with improved economic circumstances, population decline at the national level may occur

because of adverse economic conditions. The population of Spain is predicted to decline by 10% over the next few decades as a result of declining birth rate and emigration at a time of economic stress (Campbell and Pancevski 2013). Emigration does not address the global population problem but simply relocates it.

One could ignore the problem, and say 'why should I worry about the future – what has it ever done for me', but many people alive today will be directly faced by the issue a few decades hence. The views of politicians such as Mrs May, the United Kingdom Home Secretary, who proclaims that she will not set limits on population (Beckford 2012) even though through immigration and natural growth the British population is now increasing at a rate higher than it has been for many years, makes me very grumpy. The natural environment of what is a small country will be even more stressed, maintenance of the population will require resources from other countries and lack of a population policy sets an example which may encourage other countries not to address population issues.

Grumpiness or happiness?

Even though there are many grounds for being grumpy and pessimistic about the future, and these messages need to be expressed, they also need to be tempered by positive, encouraging stories. Consistently negative approaches carry the danger of being ignored and regarded as alarmist. In classical mythology Cassandra's prophecies were not believed because they were always negative, and Marris (2011) in her analysis of Dr Seuss's *The Lorax*, a book with a very strong ecological message, sees it as gloomy and 'a parody of a misanthropic ecologist' who failed to save the truffula trees because the message was so much doom and gloom. Expressing concern for the survival of the biosphere is not misanthropic – rather it is because *Homo sapiens* is part of the biosphere and cannot live independently of it, and survival of *Homo sapiens*, or its evolutionary successors, is something to be aimed for. We do need to acknowledge successes, both small and large, in order that the public can be sufficiently encouraged to continue to address the large problems which are still outstanding.

There is much we can be happy about, but there are many problems of greater magnitude to address. Tackling the problems will require science, so that any decline in our scientific capacity is properly a cause of grumpiness, but science of itself is not the solution, rather it will be an aid to the solution. The solution will have to emerge from the social, political and economic spheres. When I look back over my lifetime the successes are overwhelmed by the challenges still to be addressed, and our progress has perhaps been too little, too late.

Scientists need to give greater thought to how we engage with policy-making. We cannot just say –'I am a scientist, this is what you have to do.' Outside the environmental field, Turner (2013) has argued, in the context of opposition from some sectors of the community to childhood vaccination, that hectoring will not be successful in winning over minds, and the same applies to environmental issues. Pielke (2007) has been critical of the role of scientists in policy development. He has developed a typology of scientists involved in policy debate. He is concerned by the number of scientists whom he categorises as 'Issue Advocates', and urges that the most appropriate model for scientists to follow is as 'Honest Brokers of Policy Alternatives'. Pielke's model is not without critics (Jasanoff 2008). I do not consider that scientists should be prevented from being advocates, provided that they are transparent about their affiliations, and the evidence which leads them to their position is clearly identified and critiqued.

Given that the solutions to environmental problems must arise from within the political sphere, there needs to be a constituency which not only sees that addressing environmental issues is essential and urgent but also sees hope for solutions. To maintain this constituency the messages it receives should both encompass the threats and the successes – a difficult, but hopefully not impossible, challenge.

Acknowledgements

I thank the referees and editors for their comments and Jacinta Green for her assistance.

References

Adam, P. 1998. Biodiversity – the biggest of big pictures. Pp 6-14 in *Is the biodiversity tail wagging the zoological dog?* Edited by Lunney, D., Dawson, T. J. and C. Dickman, Royal Zoological Society of New South Wales, Mosman, NSW.

Adam, P. 2000. Morecambe Bay saltmarshes; 25 years of change. Pp 81 – 107 in *British saltmarshes*. Edited by Sherwood, B.R., Gardiner, B.G. and Harris T. Linnean Society of London, London.

Adam, P. 2010. The study of natural history – a PPP. Pp 1-15 in *The natural history of Sydney.* Edited by Lunney, D., Hutchings, P. and D. Hochuli, Royal Zoological Society of New South Wales, Mosman, NSW.

Adam, P. 2012. Our own worst enemies? Pp 69 – 78 in *Science under siege: zoology under threat*. Edited by Banks, P., Lunney, D. and C. Dickman, Royal Zoological Society of New South Wales, Mosman, NSW.

Anker, P. 2001. *Imperial ecology. Environmental order in the British Empire, 1895 – 1945.* Harvard University Press, Cambridge, Mass.

Ayres, P.G. 2012. *Shaping ecology: the life of Arthur Tansley.* Wiley, Chichester.

Aldred, J. 2013. Seabirds affected by second wave of sticky pollution 'could number thousands'. http://www.guardian.co.uk/environment/2013/apr/17/seabirds . Accessed 21 May 2013.

Allen, T. F. H. 2007. Foreword. Pp xiii – xiv. in *Comparative plant ecology. A functional approach to common British species*. Grime, J.P., Hodgson, J.G. and Hunt, R. Castlepoint Press, Dalbeattie.

Arup, T. 2013. Australia seeks to limit ocean 'geoengineering'. *The Sydney Morning Herald* 16 May 2013 p.10.

Beckford, M. 2012. I won't limit population to 70m, May declares. *The Telegraph (UK)* September 12-18, p.9.

Bryant ,K.A. and Calver, M.C. 2012. Adaptive radiation in Australian journals in the Arbustocene ERA: an empty niche for JANCO. Pp 140 – 149 in *Science under siege, zoology under threat*. Edited by Banks. P., Lunney, D. and C. Dickman. Royal Zoological Society of New South Wales, Mosman, NSW.

Bullough, O. 2013. *The last man in Russia, and the struggle to save a dying nation.* Allen Lane, London.

Campbell, M. and Pancevski, B. 2013. Spain shrinks as crisis puts babies on hold. *The Sunday Times*. 7 April 2013. thesundaytimes.co.uk./sto/news/world_news/Europe/article1241915.ece. Accessed 21 May 2013.

Cardinale, B.J. and eight others. 2011. The functional role of producer diversity in ecosystems. *American Journal of Botany* **98**: 572 – 592.

Carson, R. 1962. *Silent Spring.* Houghton Miflin, New York.

Carrington, D. 2013. Insecticide firms in secret bid to stop ban that could save bees. *The Observer*. 28 April 2013 p.5.

Coaldrake, P. and Stedman, L. 2013. *Raising the stakes. Gambling with the future of universities.* University of Queensland Press, St. Lucia.

Crossley, M. 2013. Credential creep a luxury too far. http;//newsroom,unsw.edu.au/news/general/credential-creep-luxury-too far. (originally published in *The Australian* 16 Jan 2013)

Crowther, M.S., Lunney, D. and Parnaby, H. 2012. Are impact factors another key threatening process for Australian fauna? Pp 134 – 139 in *Science under siege, zoology under threat.* Edited by Banks, P., Lunney, D. and C. Dickman. Royal Zoological Society of New South Wales, Mosman, NSW.

Ehrlich, P. 1968. *The population bomb.* Ballantine Books. New York.

Eichhorn, M. 2013. Rant and rave. *The Bulletin of the British Ecological Society.* April 2013, 60 – 61.

Elith, J., Simpson, J., Hirsch, M. and Burgman, M.A. 2013. Taxonomic uncertainty and decision making for biosecurity: spatial models for myrtle/guava rust. *Australasian Plant Pathology*. DOI 10.1007/s13313 – 012 – 0178 – 7

Ely, A. 2013. Knowledge and innovation for sustainability. Presentation at 'Global change and biosphere interactions' . British Ecological Society and York Environmental Research Institute. University of York. 9 April 2013.

Evans, G.R. 2010. *The University of Cambridge. A new history.* I.B. Tauris, London.

Goldsmith, E. and Allen, R. 1972. A blueprint for survival. *The Ecologist* **2**(1) (http://www.the ecologist.info/page 34. html).

Goodell, J. 2010. *How to cool the planet. Geoengineering and the audacious quest to fix the earth's climate.* Houghton Miflin Harcourt, New York.

Gould, S.J. 2003. *The hedgehog, the fox, and the magister's pox*. Harmony Books, New York.

Goulson, D. 2010. Bumblebees. Pp 415 – 429 in *Silent summer. The state of wildlife in Britain and Ireland*. Maclean, N. (ed). Cambridge University Press, Cambridge.

Harper, S. 2013a. *Population challenges for the 21st century.* Oxford University Press, Oxford.

Harper, S. 2013b. Size, density, distribution and composition of future populations. Presentation at ' Global change and biosphere interactions' . British Ecological Society and York Environmental Research Institute. University of York. 8 April 2013.

Hill, C. 2013. BES journals compliant with RCUK's new open access policy. *The Bulletin of the British Ecological Society*. April 2013, 64 – 65.

Hilmer, F.G. 2013a. Raiding tertiary to pay secondary makes no sense. www.smh.com.au/comment/raiding-tertiary–to pay-secondary. Accessed 17 April 2013.

Hilmer, F. G. 2013b. Strong stance against university funding cuts. Email memo to all staff at UNSW, 16 April 2013.

Holdgate, M.W. 1999. *The green web: a union for world conservation*. Earthscan, London.

Hulme M. 2013. 'A safe operating space for humanity': do people's beliefs need to change. Presentation at ' Global change and biosphere interactions' . British Ecological Society and York Environmental Research Institute. University of York. 9 April 2013.

Hutchings, P. 2012. Death of life sciences a personal perspective. *Australian Zoologist* **36:** 242 – 246.

Huxley, E. 1993. *Peter Scott. Painter, naturalist*. Faber & Faber. London.

Ineson, P. 2013. Global change: working together on the evidence base. Presentation at ' Global change and biosphere interactions' . British Ecological Society and York Environmental Research Institute. University of York. 9 April 2013.

Jameson, C. M. 2012. *Silent Spring revisited.* Bloomsbury, London.

Jasanoff, S. 2008. *Speaking honestly to power*. www.americanscientist.org/bookshelf/id.3599.central.true.ccs.print/bookshelf.aspx. Accessed 29 May 2013.

Krauss, C. 2013. US gas exports pose problems. *Portfolio* **87:** 44 – 47.

Lovelock, J. 2000. *Homage to Gaia: the life of an independent scientist*. Oxford University Press, Oxford.

Lear, L. 1997. *Rachel Carson: witness for nature*. Henry Holt, New York.

Lindenmayer, D.B., Likens, G.B., Franklin, J.F. and Muntz, P. 2009. Opportunity in the wake of natural 'disasters'. *Science* **324:** 463.

Maclean. N. (ed) 2010. *Silent summer. The state of wildlife in Britain and Ireland.* Cambridge University Press, Cambridge.

Manning, P. 2012. *What the frack? Everything you need to know about coal seam* gas. NewSouth QuickEs, Sydney.

Marris, E. 2011. The Lorax. *Nature* **476:**148-149.

Martyr, P. 2012. Taken for granted. Funding arts and humanities research in Australia. *Quadrant* . no 490, 74-80.

Marshall, A.J. (ed). **1966.** *The great extermination. A guide to Anglo-Australian cupidity, wickedness & waste*. Heinemann, Melbourne.

Martin, P. 2013. Still the lucky country, but some work too many hours. *The Sydney Morning Herald* 29 May 2013 p. 2.

Mason, C.F. and nine others. 2003. The role of herbicides in the erosion of salt marshes in eastern England. **Environmental Pollution 122**: 41 – 49.

Meadows, D.H., Meadows, D.L., Randers, J and Behrens, W.W. 1972.*The limits to growth*. Earth Island, London.

Mooney, H.A. 2009. The ecosystem-service chain and the biological diversity crisis. *Philosophical Transactions of the Royal Society B*. **335**: 31 – 39.

Morris, E. 2007. From horse power to horsepower. *Access* **30**: 2 – 9.

Mullen, J. 2013a. Paying the price for R and D slowdown. *The Land* 14 March 2013, p. 25.

Mullen, J. 2013b. R and D dollars down. *The Land* 28 March 2013, p. 22.

Murphy, P. 2013. The rise and fall of our bureaucratic universities. *Quadrant* no 496: 48 – 53.

Oreskes, N. and Conway, D.M. 2010. *Merchants of doubt: how a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. Bloomsbury Press, London.

Olshansky, S.J. and nine others. 2005. A potential decline in life expectancy in the United States in the 21st century. *New England Journal of Medicine.* **352**: 1138 –1145.

Owens, S. 2013. Great expectations? Science and environmental sustainability. Presentation at ' Global change and biosphere interactions'. British Ecological Society and York Environmental Research Institute. University of York. 9 April 2013.

Phillips, N.2013. Scientists wasted 400 years chasing cash for research projects. *The Sydney Morning Herald.* March 21, p. 14.

Pielke, R.A. 2007.*The honest broker: making sense of science in policy and politics*. Cambridge University Press, Cambridge.

Recher, H.F. 2013. What makes this old scientist grumpy. Pp x-x in *Grumpy Scientists: The Ecological Conscience of a Nation*. edited by D. Lunney, P. Hutchings, and H. F. Recher, Royal Zoological Society New South Wales, Mosman, NSW, Australia.

Roberts, C. 2012.*Ocean of life .How our oceans are changing*. Allen Lane, London.

Sands, T. 2012. *Wildlife in trust. A hundred years of nature conservation*. Elliott and Thompson, London.

Schwarzenbach, A. 2011. *Saving the world's wildlife. WWF - the first 50 years*. Profile Books, London.

Scruton, R. 2011. *Green philosophy. How to think seriously about the planet.* Atlantic Press, London.

Sheldrake, R. 2013. R &D critical. *The Land*. March 21, 2013 p.27.

Smith, D. 2011. *Dick Smith's population crisis. The dangers of unsustainable growth for Australia***.** Allen & Unwin, Sydney.

Suter, K. 1999. Fair warning? The Club of Rome revisited. http://www.abc.net.au/science/slab.rome/default.htm

Turner, J. 2013. Hectoring won't persuade the MMR – deniers. *The Times* 27 April 2013 p.25.

Turner, J.S. 1948. Foreword. Pp v – vii in Curtis, W.M. *Biology for Australian students*. Oxford University Press, Melbourne.

Tyler, C.R. and Goodhead, R.M. 2010. Impacts of hormone – disrupting chemicals on wildlife. Pp 125 – 140 in *Silent summer. The state of wildlife in Britain and Ireland.* edited by N. MacLean**.** *Cambridge University Press, Cambridge***.**

Webb. L.J., Whitelock, D. and Brereton, J.L.G. (eds) **1969.** *The last of lands. Conservation in Australia*. Jacaranda, Milton.

Woolf, M. 2013. Vegans can milk equality rights. *The Sunday Times.* 7 April 2013 p.9.

Zimmer, C. 2013. Bringing them back to life**.** *National Geographic* **233 (4):** 28 – 43**.**