OFFICE OF THE PRIME MINISTER'S SCIENCE ADVISORY COMMITTEE

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Too much complexity: climate change and other ecosystem challenges for the policy maker and scientist

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Thank you for the kind introduction and the opportunity to engage in a conversation with you.

To put my comments in perspective, I should perhaps first describe my role as Chief Science Advisor to the Prime Minister of New Zealand. Different countries employ different ways of marrying science with policy, and the role I have is new and emerged from discussions initiated by a committee of the Royal Society of New Zealand which the incoming new centre-right government in 2009 then adopted. It filled a gap that at the time was not apparent. There are various equivalent roles in other jurisdictions, which may be filled by individuals – as in Ireland and Britain – or by committees – as in Denmark – or both, as in the USA and Australia.

The key features as we have evolved it in New Zealand are that it is advisory, not managerial; thus it does not have operational responsibility for the science system. That lies with a Minister of Science & Innovation and a corresponding ministry which develops policy for innovation and operates the publicly funded science and innovation system, including both research institutes and granting systems.

In my role I report directly to the Prime Minister. Constitutionally I am established as an advisory committee to the Prime Minister, although that committee has only one member. This arrangement has ensured independence – both of advice and from the civil service. However, administratively I operate out of the Department of Prime Minister and Cabinet, which is analogous to your Privy Council Office.

There are regular meetings between myself and the Prime Minister, with his Chief of Staff, and a very close liaison between my Office and those of both the Minister of Science & Innovation and the Chief Executive of that Ministry. I also meet regularly with other ministers and chief executives – I think you call them deputy ministers – in key ministries such as Foreign Affairs and Trade, Agriculture, Environment, Education, Social Welfare and so forth. My office has evolved to have five primary functions:

1. To promote an understanding among politicians, officials and the public about the role of science in matters affecting them. This involves many meetings as well as maintaining a high public profile, but it is the nature of how that profile is maintained that I will return to in the main part of this talk. In the past year I have found myself dealing with matters ranging from earthquakes to climate change to the problems of adolescence. I mention the last because one of the goals I gave myself was to enhance the use of well-conducted social science within government.

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2. To advise the Prime Minister on policy for science, which extends well beyond just the Ministry of Science & Innovation, and to assist in whole-of-government science issues.
3. To advise the Prime Minister on how we can improve public policy by better use of evidence during policy formation and implementation. This is very much in the early stages and is the basis of an important discussion paper and dialogue that I have initiated. The discussion paper is entitled *Towards Better Use of Evidence in Policy Formation* and can be found on my website. Much of its philosophical base will emerge in this presentation.
4. I advise the Prime Minister about specific matters of science at his request, and in some cases will set up working groups to assist.
5. And increasingly I assist the Government's needs in employing science for diplomatic ends – we are increasingly recognising how key science is in aiding diplomacy and *vice versa*; this is particularly important for a small nation.

Two other sets of background comments may be useful by way of introduction. New Zealand has been late to recognise the importance of science and innovation to economic growth outside of agriculture. But on the other hand New Zealand prides itself on its environmental ethos. This spans the political spectrum, although there is the inevitable tension that plays out between environmental protection and economic growth.

But what is rewarding is that, unlike the slightly depressing view that Nina Fedoroff expressed in her opening speech to the AAAS meeting in Vancouver last week, we have not seen the rise of anti scientism per se, except possibly on the edges of the climate change issue. Each of these issues reflects on the changing nature of science and its application, and thus on the nexus between knowledge, values and the understanding of risk. It is this nexus that is the focus of my comments today and is at the heart of the way in which I have tried to develop my Office.

The nature of science has, of course, evolved over the last 100 years and this raises challenges for the public scientist such as myself charged with talking to both the public and the policy makers. This in turn leads to two related questions that need to be addressed:

- Do science and evidence-based knowledge have a privileged place in policy formation within a modern democracy?
- And does the changing nature of science affect the way in which it is integrated into the policy process?

The nature of policy formation in democratic societies is based on many inputs, including fiscal considerations, societal values, prevailing public views, and the ideology and ambition of the government of the day. While in social democracies, subject to staying within their ideological framework, governments generally want to make good decisions; tension between short term electoral ambitions and desirable long term outcomes is inevitable. It is easy to get cynical about this, but it is the price of democracy – the maturity of the electorate, the impact of media and the skill of political leaders all contribute to setting the balance.

Of course I would argue that the use of high quality information and evidence should be at the core of good decision-making for good outcomes. Anything else can only be made on the basis of either anecdotal experience or belief and dogma.

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Indeed, politicians often rely on anecdote and experience. There is now a large body of commentary, much from decision theorists like Daniel Kahnemann, that illustrates the problem of bias in decisions made on the basis of 'common sense' and points out the ways in which so called common sense can be in conflict with evidence.

Someone once said that the art of politics is not making everyone think the same but making people who think differently act the same. That relies on the process of policy formation developing a range of options on which the political process acts. So how science fits into that process is highly relevant to the climate change debate and will be to the other environmental tensions that will emerge as countries such as yours and mine balance economic growth against other electoral concerns such as the environment. In practice often policy makers cannot wait and decisions have to be made on the basis of uncertain evidence or sometimes even absence of evidence. Social programmes introduced in response to electoral demands often have that characteristic.

The nature of democracy has also evolved, and that too plays into the decision making process. This process is now less paternalistic and the electorate more 'informed', although the sources of the latter's information are mixed, meaning that the boundaries between reliable and non-reliable information are now totally confused. The non-expert becomes the self-expert and the interplay between politician and the public has shifted from the electoral cycle to frequent media reporting and instant polls. This creates a real challenge for scientific advice, for such advice can, at least in the minds of the scientific community, be seen to have a privileged place in the definition of what is knowledge. The key issue, however, is not having the arrogance to assume that science can answer everything or is the sole basis of policy formation. Indeed scientific advice is more likely to be successful with both public and the politician if such hubris is avoided and we stick to several criteria which I will discuss shortly.

But before we go there we have to consider briefly how science has changed since the basis of science appeared during the enlightenment followed by the Baconian and then Popperian models of knowledge acquisition.

Initially the dominant sciences were what we now know as chemistry and physics, supported by mathematics. These sciences were characterised by a mechanical view of the world and a belief that reductionist accuracy was possible. Mechanical cause and effect and effectively linear systems were studied, and uncertainty was seen as being eradicated by removing experimental error. Science became authoritative and definitive and was largely accepted by a rather submissive population in earlier democratic systems. I will call this kind of science "linear science".

Much science still continues in this way – have birds descended from dinosaurs, do hormones always work through receptors? But even some of these questions show an underlying weakness – what appears definitive may not be. Twenty years ago it would not have been accepted that birds are descended from dinosaurs or that hormones could have receptor-independent action.

Indeed a classic revision has been made to the central dogma of molecular biology. In a very linear mechanical fashion, it was seen that DNA coded for RNA which coded for protein – it was a one way street. But now we know that the dogma is wrong, or at least incomplete – RNA sequence can be incorporated into DNA and the relationship between DNA, RNA and protein is anything but linear with all sorts of complexities, such as splicing, post-translational modification and reverse transcription. And much DNA codes for RNA, but that RNA is regulatory for gene expression rather than being translated into proteins.

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Thus through the later part of the 20th century, much science underwent radical change as a result of increasingly being required to deal with complex non-linear processes where certainty cannot be possible and answers are defined in terms of probabilities and risk.

The point is that we have come to realise that much of biology and the physical world is a mass of complex interactions, many are non-linear and involve feedback and feed forward loops, often within the same system. When one looks at the many challenges we face we see that many involve non-linear systems such as food chains, advanced medicines, environmental security, water quality and of course climate change. In environmental science these issues are immense, whether we look at a global, regional or local level.

The problem that arises is that public understanding of inevitable risk and probability in science is often limited and this makes the job of the policy makers more difficult. I do not need to dwell on this point – there have been a flood of books on the subject in recent years.

An example of recent concern to me personally has been that of earthquakes and earthquake prediction. We still have enormous gaps in our knowledge of plate boundary earthquakes even though they have been the subject of intense study. But further to this the Christchurch earthquake series that started in September 2010 have been complex, in that it is not on a plate boundary and represents a much less studied form of earthquake.

Against such background the earthquake scientists have continued to want to be able to assist the public and policy makers in knowing how the future will unfold, but there arose serious issues in public communication such as how to explain an earthquake where many uncertainties abounded. With this, there was a tendency for the press to magnify scientific debate and uncertainty in a way that added to the considerable confusion for the public and politicians.

A major task I had to undertake was to work with the scientific community to encourage its members to simplify their message to make it understandable, and so avoid the media conflating normal academic debate on minor details with the fundamentals of what was happening kilometres under Christchurch. Things were then enormously complicated by the appearance of a folk-weather-forecaster who used astrological approaches to his weather forecasting and applied the same to earthquake forecasting. He predicted, based on the position of the moon and sun, a major earthquake one month after the disastrous 22 February quake that caused the tragic loss of life and most of the damage.

The result, fuelled by the media, was that many people stayed away from Christchurch and children were kept out of school, thus delaying the early steps in their psychological recovery process. Of course the logic of his approach could be refuted, but no scientist could say categorically that there would not be an earthquake on that particular day in March, merely that the risk was no different that day to any other day in an earthquake sequence that was probably ameliorating. This was difficult, and the major tool we had in encountering this nonsense was the trust that the public had in the scientific process.

How this trust has been achieved is the focus of much of the remainder of this talk as we drill down on climate change. However, there is another stage in the evolution of the nature of science. For complex science there is often another dimension which involves a strong values component. Typical examples of this value-laden consideration include food security, the use of genetic modification, dealing with adolescence or the ageing population, and of course, climate change. Such are the issues of high public concern and political complexity and indeed these are the very matters on which governments turn to science advisors.

Such science has been termed “post-normal science” as introduced by Funtowicz and Ravetz, which they defined as the application of science to public issues where facts are uncertain, values are in dispute, the stakes high and decisions urgent.

So by the very nature of these characteristics, such science is now intimately linked to and intertwined with the values and concerns of the public and body politic.

Coincident with this shift from linear to post-normal science has been greater public access to information of varying quality and reliability that has resulted in greater expectation by the public to be engaged in decisions involving science and technology. Effectively this is a shift from an authoritative position of science and scientists to one in which many other voices are also heard – the evolving co-production paradigm.

Obviously the scientific process of obtaining the results and interpreting any set of observations must be value-free as this is core to our understanding of the processes of modern science and is the focus of efforts to sustain scientific integrity.

But an additional values-laden factor now arises, as the philosopher of science Heather Douglas makes clear in her outstanding book *Science Policy and the Value Free Ideal*, and this is how much uncertainty is acceptable when using knowledge as the basis of an action or policy. This decision is never value-free. I am not saying that values compete with or replace evidence, but rather that they determine the importance of the inevitable inductive gaps left by the evidence. Thus in Douglas’s view the key question becomes: When is a particular body of scientific work adequately ‘sound’ to serve as the basis of policy? This requires values judgements about how much evidence is sufficient and how reliable the studies are that underpin the evidence.

Further the science advisor must also pay particular attention to the question: What are the risks associated with an erroneous conclusion in either direction? Because of this intertwining of values with knowledge, a further complexity arises. Science can also become the proxy for a values debate which is essentially independent of the science. I think we have seen this playing out in the climate change debate in a big way.

So let us look at climate change through this lens.

Climate science is primarily not based on experimental science involving active manipulations to see what happens. Rather it is one of those sciences which are almost entirely observational – and often that observation has to be historical. Geology, palaeontology, taxonomy and much of evolutionary biology fit in that category. Climate change science has similarities to those disciplines in that the data must by definition be retrospective or at best current, but there is one important difference – the hypotheses and models being developed are used to predict the future. It is this unique positioning of climate change science as a predictive science that has created some discomfort for a number of non-climate scientists, especially those from observational and linear disciplines. Such individuals see science best expressed only in terms of what is observed experimentally and debate philosophically the validity of the use of historical science to predict future events and trends.

The key to climate science is the much talked-about model systems. What has evolved over the past 30 years began as scientists studying the possibility of a nuclear winter. The models have, of course, become increasing complex in their endeavour to determine how the global climate changes and how it is affected by a multitude of factors including sunspots, reflection, pollution, volcanic activity and of course greenhouse gases. Over time, as more and more knowledge is obtained, bottom-up components of climate regulation are

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integrated. Such models are then tested repeatedly against past data and where the fit is good they are then used to predict what might happen in a variety of scenarios depending on whether active mitigation strategies are applied or not. Model predictions in the early days showed considerable wobble as more and more factors were taken into account, but in recent years they have become remarkably stable – the fit to past observations remains very good and it is this fit that gives the basis for future predictions.

I want to explore why there is a debate and its implications about this. But suffice to say that the scientific community has accepted the weight of evidence that anthropogenic climate change is highly probable and that at some time in the not too distant future it will have significant impact on the planet's biota. This is a consensus view of every significant scientific body that has examined the question. True, there remain uncertainties as to how fast warming will occur and to what degree, and there also remain many technical questions. The general view, however, is that sometime in the next 50 years the mean global temperature will rise by more than 2 degrees Celsius. The result will be a significant change in ecosystems and the physical landscape.

But this view has been widely debated, dominating both domestic and international politics for the past decade. The question has to be why has this debate been so vociferous and why has it meant that we face the risk of a tragedy of the commons. It is of course a classic case of post-normal science where the facts are uncertain; it is a matter of high urgency for action, for if the scientific consensus is correct the action is overdue; it is certainly of high public interest; the stakes could not be higher; and yet there is a problem.

Why?

It is not a matter of the science; the science may change a bit but it will always be expressed in terms of probabilities, and we will not have certainty over planetary conditions in say 2050 until we look back retrospectively in 2051.

The first values dimension is that of sufficiency of evidence: here we have had numerous bodies including the IPCC and many national academies conclude with remarkable unanimity that although there are inductive gaps, the estimates of probability are such that urgent action is justified. They have reached the conclusion that the risks of inaction are far greater than those of action.

This can be simplistically modelled using the Douglas paradigm.

Recall her key question: When does a particular body of scientific work become adequately 'sound' to serve as the basis of policy even though a high level of uncertainty remains? And her derivative question – what are the risks associated with an erroneous conclusion in either direction? However this question is more complex than it sounds because of the problem of the interpretation of the concept of risk.

Let us simplistically use the two counterfactual hypotheticals. If the scientific conclusion is that there is a significant risk to the human and planetary condition through global warming, and actions are taken and yet it turns out to be incorrect, what has been the risk? Clearly there has been a 1-2% effect on global GDP and many socioeconomic changes with a shift to a low carbon economy, changed employment etc, but there are collateral benefits in terms of moves to sustainable energy, new technologies, and less environmental degradation.

If on the other hand the conclusion reached from the science was that no mitigation was needed because anthropogenic climate change was of minor significance, then the consequences of error if the conclusions turned out to be wrong would be so much higher –

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the human and global condition as we know it would be in serious trouble. Clearly the outcome of which decision is taken is asymmetrical.

But progress has been slow. Why?

In my view it is because we have not really flushed out the true nature of the debate. Science here is being used as a proxy for the implicit embedded values debate. This has happened before in the tobacco wars but the values debate this time is different.

What is really being debated is a matter of intergenerational equity, and this is not primarily a scientific matter but one for the public, politician and policy maker. That is, does this generation have to make some economic sacrifices to change the trajectory of greenhouse gas emissions so as to benefit later generations, or can we leave it to a later generation to deal with whatever happens? Human nature is such that unless the issues are well explained it is inevitable that some segments of the community will favour the former – all said and done, economic growth drives the immediacy of how we live our lives, namely whether we have jobs and whether we can meet our own aspirations. It is indeed easy to see how that can play into the political process.

But perhaps science could enter into it, because in considering intergenerational equity, one's view might be influenced by advice as to the likelihood of successful mitigation by technology. But to what extent is that argument largely being used as an excuse to avoid decision? And even if technology could solve it, one suspects that the issues around, say, geoengineering will uncover another values debate.

We scientists need to accept that this is a proper discussion for a democracy to have, and that it is a values debate. While climate change is the obvious example, there are many others: one which has been more intense in New Zealand has been the issue of genetically modified food and genetically modified forage for cows and sheep.

These concepts have critical implications for a person such as myself and how I choose to undertake my role. I see my role as to explain what we know as scientists and what we do not know and what does this lead us to infer about probability and risk. This cannot be done without talking through the scientific process. But most importantly I must explain where science and values intersect and be clear that it is for the public and politician to opine on the latter. By being careful not to stray into that domain I have been able to engender trust in science and in science advice, and thereby argue for its proper position in the process of policy formation.

Further to this Roger Pielke in his book *The Honest Broker* distinguished between two kinds of advice surrounding complex science: that of being the issues advocate and that of being the honest broker.

The problem is that while an expert may become an issues advocate because he or she has entered into the values domain of policy formation, that person will soon be perceived as a lobbyist and credibility may not be sustained. This has been well documented in books about both climate change and the health effects of tobacco.

The honest broker on the other hand takes another approach. The evidence is summarised in a values-free way – by that I mean the limits of knowledge are acknowledged, the inferential gap is acknowledged and the policy maker is left with options to take based on those values dimensions that it is proper for the policy maker to take into account. Inclusive democracy is maintained.

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For example, it may be pointed out what genetic modification means and what is known and not known about GM food from the perspective of human health. The same applies to what is known about the impact of genetic modification on ecological systems. Values perspectives associated with the naturalistic views of what it means to be natural or organic or clean or green in this context are not directly for the science advisor. Actually of course it is more complex than I have put it, for how science itself is communicated to the public can influence the values that the public and political consensus associate with such matters.

My experience is that a science advisor must not usurp the role of the policy maker or take decisions away from the public and politician. By being clear about the limits of the advice that can be given, one engenders trust and confidence – and in building that trust and confidence, better decisions are more likely.

Thus science advisors must be explicit about the assumptions, limitations and uncertainties underlying the evidence and present technological options in ways that allow the full range of their possible benefits or adverse effects to be appreciated. Remember no science advisor is expert in everything they must advise on; indeed that is not their role. Rather they are a broker between the science community and the policy framework. It is how that brokerage is conducted that is itself a key issue.

The science advisor must be honest in admitting the limits of knowledge and be informative about the implications of what is known and unknown. At all times the advisor must be conscious of where values can enter into consideration and when they do not. In the end the key is to provide the scientific basis for options and provide the base from which the policy processes proceed. Well presented, the knowledge can then allow the appropriate values debates to reach a decision that has a coherent logic to it.

The science advisor must also acknowledge that many decisions that governments have to make are developed in an environment of limited available information or where the use of science is unable to resolve competing policy options. There can be a seductive trap of being drawn into matters where science cannot provide answers. Abortion is such an example.

The science advisor must also be honest about the values dimension and act as an 'honest broker' providing options. It is how that is done that determines whether the advisor can maintain the trust of the public and the policy maker. It requires skill on the part of the advisor and a good understanding and integrity of official and politician as well. But it must be achieved, for at the end policy formed in the absence of knowledge or without considering relevant knowledge is simply dogma and cannot serve the public well.

So where is New Zealand in the matter of climate change? Both major political parties have supported an emissions trading scheme for carbon, although there are some differences around its rate of application. While there have been and will continue to be deniers and sceptical elements, they have not had much influence on the political process.

New Zealand has a very unusual pattern of greenhouse gas emissions for a developed country – nearly 50% of our emissions come from agriculture, and already 70% of our electricity generation is from renewables. We have little heavy industry and our transport costs will always be high. So we must focus our emissions reductions on agriculture, but we also must produce more food – it is at the heart of our economy and food security is a looming issue in our backyard.

So we have invested in a major research effort on how to mitigate greenhouse gas emissions in agriculture. This extended internationally when New Zealand promoted the development of the Global Research Alliance on agricultural greenhouse gas emissions of which Canada is

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an active member. This is a research-led and very active cluster of 32 countries including all of the major economies and food producers whose scientists are increasingly cooperating in research to reduce greenhouse gas emissions in agriculture while increasing production. Several working groups exist, and last year New Zealand funded an international grand challenge approach to address the issues nearest to our needs: those associated with pastoral agriculture in a temperate climate. The first round is in assessment and there will be another round next year.

I thank you for listening and look forward to some discussion.

Thank you.

ENDS

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