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The place of science in environmental policy and law

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It is indeed an honour and a pleasure to be here this evening and I thank the RMLA for their kind invitation to give this address. Peter Salmon's contributions to New Zealand's legal environment and the environment itself are well worthy of much respect and recognition. Today I want to clarify a number of points and very likely misperceptions and mis*con*ceptions about the role of science and indeed its very nature with respect to environmental policy, legislation and regulation.

I will argue that there is often a mismatch between the changed and changing nature of contemporary science, including the types of questions it is called upon and expected to address – and environmental policy and regulatory structures that seem to rely on somewhat outdated assumptions and notions of how science is practiced and what it can and cannot do.

Fundamentally, with science and the law we are dealing with two very different epistemologies and this difference, and the difficulties it sometimes creates flow into the regulatory and policy space.

Law is largely based on dealing with issues of societal and personal values - and in particular how to live with each other in social groups by creating values based rules that deal with behaviour, property and resources. Over the years, societies have codified the processes and procedures in ethics and moral traditions and particularly through the law to achieve this, but fundamentally, these are all grounded in social values, which themselves must be tested and re-tested from time to time through parliament and/or the courts.

Science on the other hand is a formal set of processes to develop relatively objective information about the world around us and within us. Science is not values-free particularly in the questions that scientists choose to address, but the processes of science are designed to eliminate (or at the very least render explicit and mitigate) the impact of values from the collection of data and analysis. But of course *how* science is used is a value-rich domain and thus is a matter for society not science.

But the distinct place of values within these two epistemologies is an essential difference between science and law that cannot be ignored.

The differences between the two epistemologies are most clearly seen in how law and science deal with the nature of doubt and, by inference, with truth. Indeed the word truth is not generally used in science but is a core concept in law or at least in its popular construction. Put simply science does not reveal truths, science is about reducing uncertainty but, paradoxically, in doing so it actually reveals more uncertainty. By contrast, law is largely about creating a decision based on presumed certainty - the phrase "beyond reasonable doubt" comes to mind. But in practice, when law turns to science for input, it generally expects science to obey the traditions of law and yet the very situations on which science is increasingly called upon to assist – particularly those that make their way to *your* domain of interest – are those for which there is inherent uncertainty.

This is a complicated interface indeed!

With this introductory overview in mind, let me now illustrate these statements by way of two examples, drawn more from your world than from mine, but which nevertheless fit squarely at the intersection of science, policy and law: The use of expert witnesses in environmental court proceedings and the use and interpretations of the precautionary principle within environmental legislation and related regulation. To do so it is important first to appreciate the changing nature of science – from the types of questions it can address, to the methods it employs and the types of results or answers it can offer.

We live in what has sometimes been called the age of 'post-normal science' – a term first used by Ravetz and Funtowicz1 in the early 1990s. Among the hallmarks of post-normal science are new and unprecedented operational and methodological realities which highlight and embrace uncertainties, contingencies, and interdisciplinary approaches. It deals with complex and interdependent systems and feedbacks, and its explanatory power is more probabilistic than mechanistic.

Post-normal science is also characterised by research in areas of high public interest and urgency meaning that it inevitably must intersect with diverse and often irreconcilable individual and societal values which are reflected in deeply entrenched debates in which these values are in dispute. Social issues, climate change, biodiversity, genetic modification and indeed much of environmental science are all examples of post-normal science. Virtually every issue of public and political contention with a scientific dimension fits within a framework of post-normal science. Given this list, I would add that another hallmark of post-normal science is its vulnerability to being used as a proxy for debates that are really about values and not science at all.

Arguably, much of science as we know it today looks quite different to the science of the post-war years when the broader public investment in the sector was taking shape. It is even quite different to a generation ago when I undertook my training.

[1] Funtowicz, S. O., & Ravetz, J. R. (1993). The emergence of post-normal science. In *Science, politics and morality* (pp. 85-123). Springer Netherlands.

For the bulk of the 20th century, which was dominated by the chemical, physical and mathematical sciences, the questions that science and engineering addressed were essentially linear: what was the structure of an atom; how to make a plane go faster; how to land a man on the moon? In the last 40 years however, change has come quickly: computing power and statistical methods have grown in volume and sophistication; Biology has moved from descriptive to insightful and experimental with the understanding of the structure of DNA and the explosion of molecular biology, for instance. With these and other influences, the nature of public science changed and continues to change. (The concept of data-mining for instance is fundamentally changing how researchers generate hypotheses to test).

Thus, from studying linear questions that tended to have single solutions, science moved into the study of complex systems – in human biology, in ecology and of course in environmental sciences. Here the emerging understanding of the complexity of non-linear systems with multiple and intersecting feedbacks and with many inherent unknowns now means that answers can generally be expressed only in probabilistic terms. And as we understand more of each of these complex systems, we merely uncover more layers of uncertainty, albeit at different levels of organisation.

While linear science is still the focus of many scientists and engineers in their individual research, they are primarily contributing their observations to the development of a systems approach. This is particularly the case in the environmental and biological sciences. And with this move to a more systems-based approach, there is a much more sophisticated understanding of science's relationship with certainty and, more specifically, with uncertainty. Scientific uncertainty – doubt – is inevitable. Indeed, the best results that science can ever produce for the types of multi-layered, multi-variable, multi-timescale and nested problems we throw at it is to offer probabilities, not certainties. Scientists are very comfortable with this. It is what drives us to continue asking ever-more refined questions, until we can reach a professional consensus about the nature of an observed event or pattern.

However it is this concept of uncertainty and doubt that is perhaps one of the most misunderstood aspects of science to a lay audience. Indeed, it contrasts quite markedly with the idea and use of doubt in the legal arena. Whereas a legal decision may rest on 'a shadow of doubt' or the 'absence of doubt', at a point in time, the scientific perspective is much more comfortable with probabilities and the gradual refinement of these as new knowledge is generated and old understandings are refined.

Similarly, the concept of a scientific consensus is often misunderstood by the non-scientist. It is not the same as the consensus of civil society, which is to say "a statement that everyone can live with." Rather it is a statement of the provisional scientific conclusion that the scientific community has reached. Recall here that the nature of science is such that most scientific conclusions are necessarily provisional.

How is it possible to have scientific consensus in the face of uncertainty? Surely this must be a conspiracy among scientists. Of course it is not, but nor is it intended as a ‘case-closed’ notion of finality. Rather, it is the collective assessment by experts about the general direction of travel in the tendencies and patterns observed in the data over time. That is, what we can say with some assurance, even when we know there are still, and always will be, knowledge gaps.

These concepts – scientific uncertainty and the necessarily moving target of scientific consensus – are obviously amplified in the context of post-normal science, which is precisely the type of science that is called upon to inform public policy and regulatory questions. Yet with the societal pressures on decision-makers, policy-makers, regulators and those involved in regulatory compliance, the search for certainty is understandable, if impossible. You can see where there is a mismatch of expectations.

But there is a further and even more complex dimension: Remember that post-normal science is characterised by addressing issues which have a high values component and those values are inevitably in dispute. Often values are based on deeply held beliefs which may be unresponsive to science-based logic. This is the nature of so-called wicked problems. I shall return to this issue.

But let me first illustrate these tensions before turning to how we may view a path to resolution.

Consider the issue of the expert witness and more specifically the expert witness in NZ’s environment court system. Section 7 of the Environment Court Practice Note of 2014 clearly establishes that an expert witness has an overriding duty to impartially assist the Court on matters within the expert’s area of expertise (7.2a) and that they must not act as an advocate for the party who engages them (7.2b). Section 7.3 goes on to advise on how the idea of insufficient data or scientific doubt must be acknowledged and dealt with by the experts. This is all very encouraging and demonstrates understanding and an ideal scenario in the face of post-normal science.

But then we come to the cross examination…

This is where it is the legal counsel’s job to critique expert testimony and, assuming the professional credibility of the expert in the first instance, then the most obviously vulnerable place to start an attack is to critically examine what we really know and what we don’t from a scientific perspective; what we can never know and what we cannot say for certain. Thus, doubt and uncertainty, which are *accepted norms* (in fact required standards) of scientific practice become and easily exploited target in the legal context – not to mention the ‘court of public opinion’.

From the perspective of science, the notion of cross-examining an expert witness with the intent of anything other than seeking points of clarification or identifying bias (and scientists do have both conscious and unconscious biases which the scientific process attempts to overcome) seems counter-intuitive and even misguided. Yet the adversarial arrangement encourages discrediting of testimony. Isn’t science an international framework for knowledge?

Shouldn't one expert's testimony echo another's provided their expertise is equally established and their methods meet peer-reviewed international standards including the elimination of bias? Yet we can all tell a tale of the scientist-advocate who cherry-picks evidence and appears to offer a seamless narrative in one direction or the other. Indeed lawyers and interest groups may often seek such individuals out. You can see how the tensions and stakes escalate when the challenges of post-normal science combine with the types of issues that end up in court.

My second example takes a step back from the courtroom to consider the more upstream activities of regulating. Here the mismatch I have alluded to can play out, for instance, around understandings and expectations of the *Precautionary Principle*.

Placed at the heart of much environmental law and regulation globally since the Rio Convention in 1992, the Precautionary Principle has long been a target for confusion and controversy. Many pieces of legislation (not least in NZ) give only a vague description of 'proceeding with caution' in the face of uncertainty about potential harm. There is little or no guidance offered about how to do this within associated regulations.

By way of example, an admittedly simplistic keyword search of legislation in NZ shows that at least 14 of our current laws make mention of the Precautionary Principle, but a closer look reveals how undeveloped the usage truly is. The Fisheries Act (1996) has 10 mentions, with most appearing in a schedule taken directly from the UN Convention on the Law of the Seas, though there is some description of setting appropriate targets for monitoring.

The HSNO Act contains 4 mentions, mostly all within the reference taken from the Stockholm Convention on Persistent Organic Pollutants and the Rio Convention. But in contrast to Fisheries, HSNO's only technical reference is to "take into account the need for caution in managing risks." This offers no insight into what is expected in practice and leaves wide open the space for interpretation through both regulation and legal action. The other laws mentioning the Precautionary Principle all contain only a single reference each, which I daresay seem unreflective, uncritical and certainly unexplained. I doubt there is any more detail or guidance within the regulations, but my staff have not had the time to research this adequately.

The problem is in the multiple and, at times, conflicting interpretations of the Precautionary Principle. The noted STS scholar Michel Callon provided a thorough analysis of this problem as early as 2001. In our current context of post-normal science and the growing urgency of climate change, issues of food security and public health challenges such as the non-communicable disease epidemic, Callon's analysis demands even greater attention today.

The Precautionary Principle was initially intended as a framework FOR ACTION in the face of scientific uncertainty – that is, not using the absence of evidence as reason not to act - for example on climate change. But Callon pointed out that, when applied to the innovation space, the Precautionary Principle was being wrongly framed as a reason for abstention and inaction. In doing so, he reminds us that its purpose was and is to allow decision-makers to take MEASURED action even when all the facts are not yet known. It calls for a dynamic approach that requires regular monitoring and checking against agreed thresholds of risk and thus revision of the regulatory framework. But without more descriptive regulatory advice as to its meaning, the Precautionary Principle cannot guide measured and responsible action. The default position has insidiously shifted to an interpretation that allows nothing in the face of any uncertainty, which by definition must exist. And so the misuse of this principle has become a guiding tool for advocates trying to stop any particular innovation.

What is needed are the key sign-posts for regulators: what should trigger the precautionary approach? When do we realise that we don't know enough and should proceed with caution? How often should we review the position taken? Certainly we must be willing to look at new evidence as it is produced rather than creating an absolute position fixed at a single point in time. What are the targeted measures and indicators to choose so that we can effectively monitor as we proceed? Have we defined our thresholds of risk as a society? Do we know what levels of risk exposure we are willing to accept? And what does risk mean and to whom and how is it perceived – that is a whole lecture in its own right

But without diverting too far into the topic of risk let me quickly summarise. Risk is the product of hazard, exposure, resilience and vulnerability. Risk assessment is an actuarial exercise to calculate the likelihood of an event occurring and the magnitude of its impact. Risk management is policy exercise largely about identifying and removing hazards, reducing exposures or promoting resilience. Thus while risk can be presented in actuarial or probablistic terms, because there is a values component, that is not how most risks are perceived by most people. Rather a whole set of innate cognitive biases lead each of us to interpret risk based on prior experiences, prior belief and sense of personal benefit or loss, amongst other factors. The result is that the individual perception of risk is very variable and not easily subject to revision. And yet we need constructive and civil discourse about many of the very issues where concepts of precaution and risk are at the heart of the debate - but these too often remain very inchoate discussions, if they are happening at all.

And certainly, they are not discussions that should be had among scientists alone. When scientists *do become* involved, it is desirable to clarify whether they are speaking as knowledge brokers or as issues advocates. For we are dealing here with values-based questions for which science can clarify the actuarial probabilities and shed light on the range of consequences (including of doing nothing), but the societal solutions are based on more than science – these are normative societal debates.

But all too often it seems an easier path to debate the science rather than debating the values dimensions - that is, exploiting the inherent complexity or the uncertainty of science to press what is a values-based agenda. When science is used this way as a proxy to avoid real debate on the underlying values issues, society is the loser. Science has been terribly misused as a proxy for debate over climate change where the real debate is over issues such as intergenerational equity – does this generation have to incur economic costs to reduce the risks of catastrophe in subsequent generations?

But to return to my main theme: Often, in the absence of any real public discussion in the this space, and without the clear acknowledgement of the shared roles of scientists and society, policy makers and regulators are left with a blunt instrument that makes assumptions about what regulatory science should offer and may be convenient for one party or another. More often than not, they are forced to consider the risks at a precise moment in time, without a view to the more supple adaptive management potential that the Precautionary Principle, as properly interpreted and applied, offers.

The Canadian STS scholar Marc Saner has proposed that one way through this is to bring regulatory scientists and decision makers closer together, rather than the more typical practice of shielding them from each other to protect the independence of analysis. Saner has argued that regulatory science, often which is inevitably focused on post-normal issues, would benefit from closer discussions about what precisely decision-makers (as a reflection of societal interests) want to know; where might they have unfounded assumptions; and what do they feel are the greatest perceived risks so that these can be appropriately tested for?

The application of the Precautionary Principle, as it was initially formulated, allows for precisely this. It takes a dynamic, rather than static view and it requires better discussion in order to provide regulatory scientists with the targets to help broadening the available information on which to base decisions. Here in NZ, our Fisheries Act does seem to do this best with some of the clearest guidance about when precaution is triggered and the setting of monitoring targets. It's also worth noting that NZ Fisheries regulators also benefit from some of the most robust guidance around how to judge the quality of the science for monitoring those indicators. But I'm not sure the same might be said for HSNO or the RMA for that matter.

So why does this mismatch in the multiple understandings and applications of precaution persist? In his recent book, the Battle for Yellowstone, the American cultural sociologist Justin Farrell suggests that fundamentally these issues come down to a clash of worldviews. The scientific worldview, with knowledge derived from standard and accepted methodologies, by definition largely excludes the deeper cultural, spiritual and moral commitments that can drive conflicting positions in the first place. What's more, using examples like the contentious ecology-driven projects of repopulating Yellowstone Park with wolves to rebalance biodiversity, and allowing bison to roam freely beyond Park boundaries, Farrell showed how cultural conflicts between 'old west' American values about taming and controlling nature were in conflict with 'new west' values imported from elsewhere and grounded in evolving societal concepts of environmental consciousness. When all of this this is unpacked, Farrell shows that the entrenched positions are not be about the scientific facts at all, but about what makes these facts meaningful to people – in a sense religion with a small "r". Conflicts persist and problems become entrenched and 'wicked' when it seems there is no common standard or metric by which to compare or balance what Farrell calls these 'moral orders' or worldviews.

It is in this way that scholars of technology assessment such as Bogner and Torgersen in Austria have shown that the particular framework or dominant lens that one applies to policy making or regulation will change its ultimate effect. With new technologies for instance, should we apply mainly a health/environmental risk lens, an ethics lens or an economic development lens? And in each of these, how do we determine the targets that regulatory scientists should be monitoring? Depending on the lens that one privileges (and this is a societal and political decision), the regulatory outcome can be quite different. We can think of apt examples here in New Zealand: the Ruataniwha reservoir project; how to deal with obesity in our population or how we might wish to proceed in a world that is increasingly trialling new genetic technologies for healthcare and land-based industries.

It would do no good for science alone to suggest a way forward, just as it would be naïve to make decisions that could affect the health and economic well-being of subsequent generations without the benefit of scientific input. But testing and understanding what that input means requires a two-way conversation that is all the more urgent when the uncertainties of post-normal science are misunderstood or wilfully misconstrued.

But for all its contingencies, complexities and uncertainties, science can still help to provide a way through this mismatch. Indeed, it is the complicated hallmarks of post-normal science and its understanding of what it can and cannot do that are its biggest assets in the face of contentious, inconclusive and intractable issues. In seeking a better understanding of both the underlying environmental and biological systems, without ignoring the human element of today's complex and pressing issues, and indeed by incorporating social sciences into the framing of scientific investigation and commentary, the scientific enterprise is more publically accessible and engaged than at any other time in history. Yet there is still a long way to go and the relationships between science, society and policy are complex and still evolving.

If we can achieve a more scientifically engaged public and a more publically engaged science sector (as New Zealand's new strategic initiative for promoting public engagement in science *'A Nation of Curious Minds'* puts it), then we can go some way towards optimising the role of science in our legislation, regulations and public policies. As science becomes increasingly accessible and efforts are made within the sector to understand the social contexts of scientific information, we have a chance to more widely promote the robust framework of analysis and the ways of thinking about problems that science offers. Science can play a proper and critical role in assisting society through the challenges of balancing human, environmental and economic interests in a marvellous democracy that must celebrate a diversity of worldviews, yet must act in the interests of all.