



Simon Upton address to Capital City Complex Systems Symposium 2026 | 25 February 2026

Communicating Environmental Complexity for Effective Decision-Making

Introduction

I am not a complex systems expert. However, throughout my professional life, I have been aware that systems can be complex. More recently, I have become aware that there are people like yourselves, who describe themselves as complex systems experts. I'd like to talk about how you communicate complexity without it being an instant barrier to public understanding. Because it can be. Researchers can be as tactical – or indifferent – as anyone in the way they talk about their trade.

I was reminded of this a couple of years ago when I was invited to a function run by the Royal Society to mark a significant anniversary of the Marsden Fund. In preparation, I took a look at the titles of all the successful proposals since the fund's inception. They provided some interesting insights about how much their authors were – or weren't – troubled about communicating their work. My triage threw up at least three paper title strategies:

- There were those who believed that the label on the lid should match the contents in the box: straightforward descriptions like, *How do bacteria adapt to evade effective and ineffective antibiotic treatments?*
- Then there were authors who felt the need to resort to catchy marketing, perhaps to overcome a fear that their research was too abstruse or uninteresting to be communicated. Many involved sigh-inducing puns or sexual innuendo like, *Hot Entanglement with Cold Atoms, or Methanotroph's dirty little secret: they are not metabolically monogamous.*
- Finally, there were researchers who were apparently unconcerned about whether anyone other than people in the lab had a clue what they were writing about. Snappy titles like *Widely-tunable optical microresonator parametric oscillators.*

Now, if you wanted to garner interest in your work, the last-mentioned example would have to be a bit of a showstopper. Perhaps that was the intention – leave me alone and let me get on with my work. It reminds me of the reply Professor Vaclav Smil once gave me when I asked him why he had spent his professional career at the University of Manitoba. “Because the phone never rings”, he replied laconically. (Smil has, by the way, been a really good communicator of the complexity of natural and human systems.) I should record that one Marsden grantee had the candour to entitle her paper: *It's complicated: experimentally tracking the evolution of endosymbiosis.*

Your invitation made me wonder – again – whether the way we talk about complex systems isn't something of a turn-off. “What do you do?” “I 'm a specialist in complex systems.” It can be a bit daunting if the most complex thing you've recently been grappling with is the latest useless Microsoft 'improvement' to the way Outlook is displayed.

We are all tempted to use the shield of complexity as a get-out-of-jail-free card. I was amused by the reply of Minister Chris Bishop to an MP who asked about the proposed regulatory relief regime that has surfaced in the legislation designed to replace the Resource Management Act.

“Um, so, yeah, I mean the short answer is it's complicated, and it depends”, he ventured.

There are a lot of things about the environment that are complicated and depend. And the answer to your question will often depend on how that complexity can be unpacked. I think we can all agree that the environment in which we live epitomises a complex system or even a complex system of complex systems. Nature hides all of its secrets in relationships, and it is these relationships that generate complexity. Natural systems are characterised by numerous interacting components, non-linear relationships, feedback loops and scale-dependent processes, which collectively determine the system's overall behaviour. This structural intricacy means that external human-induced pressures, such as pollution or climate change, often result in unpredictable, disproportionate or delayed responses within the system.

Recognising this complexity is foundational for moving beyond simple cause-and-effect models toward integrated, adaptive environmental governance. It is crucial for decision-makers and strategists to understand the interplay between the environment and their sphere of influence.

That's all fine for this audience. But delivering that little lecture to our elected representatives would, I fear, induce a sense of desperation. Telling them something is complex isn't very helpful. My job as Parliamentary Commissioner for the Environment is to help MPs understand the environmental consequences of policies and the effectiveness of the laws and agencies we maintain to manage the environment. MPs are elected to represent the public, and they come from all walks of life. Some may be trained in fields of complexity. But unless they happen to be ecologists, the demands environmental problems make on their band-width can often be a bit overwhelming.

'It's complex and it depends' might work if you trust experts. But it might produce an equal and opposite reaction of 'don't confuse me with complexity: I just want the facts'. Public trust in institutions has waned in recent decades. And, paradoxically, oversimplification – intended to reassure – often erodes trust further. When reality inevitably deviates from the simplified narrative, people feel deceived.

There is a mismatch between the fast-paced, quick decisions required in our political economy and the long-term, delayed and uncertain perspectives needed to make sound environmental decisions. Environmental systems are interconnected, institutions often fragmented. Individual budgets, expertise, operational outcomes, and philosophies can lead to systemic problems and piecemeal responses. Environmental science is often treated as 'external' – compliance, reporting or ESG disclosure, the job of a specialist department. It is not an embedded factor in organisational decision-making.

This is likely true for all complex systems; it is the very nature of complexity that makes them difficult to manage with traditional approaches, and we need to create space for all the weird and wonderful behaviours that emerge from complexity.

Trust is built, not through certainty, but through candour. When we say, "Here is what we know, here is what we don't know, and here is how we will adapt as new information emerges", we invite the public into a process of learning, rather than presenting them with a polished illusion. Complexity, communicated well, should not undermine trust. It should be the foundation of it. But communicating that complexity well is a challenge.

It is in the nature of complex systems to throw up counterintuitive outcomes – outcomes that cannot be explained by linear cause-and-effect reasoning. Complexity, left unexplained, is quickly filled with assumptions and oversimplifications that bear little resemblance to the system itself. If we want people to leave space for nuance, rather than jumping to the first simplistic "solution" that comes to mind, we need to build trust in the idea of complexity itself. We need to help people understand that the world is not a set of isolated problems, but a set of interconnected systems whose behaviour emerges from the interactions between them.

The environment lends itself to storytelling, if we can get ‘inside’ it. It is a rich source of metaphors. But one of our challenges is that people have fewer unmediated interactions with the environment. Lives spent indoors in cities exploring virtual worlds will miss many of the cues that make the complexity of the environment comprehensible. Yet these were cues to which we were once acutely sensitive. We have removed ourselves from nature to the point where we often treat ourselves as exogenous to the systems, we are very much a part of and depend on. If you want to read a heroic assault on the supremely blinkered confidence of twenty-first century humanity, try reading, *Being A Human*, by Charles Foster.¹ It is a brave attempt to re-engage with the palaeolithic mind – and a warning, both caustic and funny, of how narrow our perceptual capabilities have become.

More accessibly, let me cite a recent column by Jonathan Last in, *The Bulwark*,² who wrote: “humans don’t think enough about systems and the easiest way to introduce the concept of a system is to talk about local environments. Get kids thinking about how an ecosystem works and they can learn how a financial market, or an industry, or a network functions. It helps them understand stable-states, and systemic shocks, and evolutionary change. There’s a lot to learn. One of the big lessons of ecology is that complex systems are tremendously resilient and adaptable if the change comes slowly enough. Complex systems are not vulnerable to change so much as they are vulnerable to shocks – sudden, rapid change.”

Aspects of complexity

With those musings in mind, let me identify three properties of complex systems that the environment throws up that are not always understood well, but can be a source of fascination in their own right and are essential for helping us to understand and re-engage with the world around us.

Stocks and flows

Stocks are accumulations; flows are rates of change. People know the difference between speed and distance, but often not energy and power. Our understanding of stocks and flows is intermittent at best. We appear to understand the difference in certain contexts only.

I’ve had plenty of practice explaining the different contexts of New Zealand’s split gas target under the Zero Carbon Act. Carbon dioxide is a long-lived gas that accumulates as a stock in the atmosphere. By contrast, methane is relatively short-lived, so its warming impact is more readily influenced by the **rate** at which methane enters the atmosphere. As most developed nations don’t have such a large agricultural sector, this important distinction has often been overlooked in international policy debates on climate change. Methane has been homogenised into a carbon equivalent using its Global Warming Potential over 100 years – roughly 25 times that of carbon. However, depending on your timeframe of interest, methane can either be more or less potent than that. What really matters is not our emissions per se, but the **total** impact of our emissions on warming over time.

Thanks to the need to explain our emissions targets to farmers, we have a better understanding in New Zealand of stocks and flows – at least in respect of CO₂ and methane. The stocks and flows explanation provides a useful entry point into the much more complex climate system story.

¹ Foster, C., 2022. *Being a Human*. London: Imprint Books.

² Last, J., 2026. We Can Choose Not to Let AI Destroy Us. *The Bulwark*, 14 February 2026.

https://www.thebulwark.com/p/we-can-choose-not-to-let-ai-artificial-intelligence-destroy-us?utm_campaign=email-half-post&r=4sg7bz&utm_source=substack&utm_medium=email

Emergent properties and stability

Emergence is the phenomenon in which the whole exhibits behaviours that none of the parts can produce independently: simple things that come together to form complex things, which have properties or behaviours that the components do not have on their own. The wetness and surface tension of water are properties that can only arise through the interaction of water molecules, not from any of the molecules on their own. Consciousness arises from the vast interactions between neurons in the brain, yet no individual neuron could be considered conscious.

If you let atoms play their galactic game of billiards for a few billion years, eventually they form stars and snowflakes, people and planets, galaxies and hot dogs. Emergence is difficult to study and predict with standard scientific tools, but it is somewhat intuitive when you see it. Bee colonies, coral reefs, starling murmuration – these are not just ecological curiosities. They are demonstrations of distributed intelligence, of autonomy interacting with constraint, of order arising from the apparently random.

The ‘hive-mind’ is a textbook example of emergent behaviour. You will all be familiar with how bees function in a collective way to optimise the hive, even to the detriment of the individual. Almost all will slave away with no chance of ever reproducing, yet they all contribute to the survival of the hive – a superorganism in its own right.

I have been following, with great interest, the recent incursion of yellow-legged hornets in Auckland, watching from the sidelines as Biosecurity New Zealand grapples with an awe-inspiring but unwanted foe that exhibits remarkable emergent behaviour. MPI has successfully engaged a large urban community to help the eradication effort. It turns out that people are captivated by emergent systems – especially ones that can sting. They intuitively grasp that something extraordinary is happening, even if they cannot articulate the underlying mechanics. This is an opportunity. It shows that people can engage with complexity without needing to master its mathematics. They can appreciate the power and beauty of emergent behaviour even if they cannot model it.

Yet within complex emergent systems, there is often an inherent simplicity. Parts interact according to set rules. These interactions build up to form feedback loops that reinforce or counteract change. Predator–prey dynamics maintain ecological balance. Homeostasis keeps the human body within narrow physiological bounds. These feedback mechanisms are the quiet custodians of stability.

That stability, of course, depends on where we draw system boundaries. If we take a reductionist view of the world, interrelationships and feedback disappear, and so too does our understanding of the bigger picture.

Environmental inertia and delays are also baked into the biophysical realities of the natural world. They make the links between cause and effect opaque. They create the illusion of stability even as the foundations move beneath us. They allow decision-makers to justify simplistic narratives because the consequences have not yet materialised. And when ecosystems shift, they can do so rapidly and often irreversibly. Predicting these tipping points in advance is difficult. Understanding them is not about catastrophism. It is about recognising that systems can absorb disturbance – until they can’t.

Uncertainty

Complex systems harbour uncertainty. Uncertainty is not ignorance. It is information about the limits of prediction. The very nature of complex systems means they have a degree of uncertainty about them. They are not designed to optimise or solve a particular problem. In fact, they are not designed at all. It is more the apparently random fumbling of nature or societies that produce outcomes we never expected. Therefore, these systems will always

operate in a way that we may be tempted to describe as suboptimal. That's because we conjure up a system 'goal' that meets our purposes. But that is unlikely to be an outcome that can maintain complex stability.

Complex systems engage balancing forces that make them resilient. But that depends on redundancy. If we try to "optimise" complex systems, we risk viewing redundancy as excess capacity to be exploited, which erodes our resilience to disruptions.

Marine ecosystems are a good example. For some people, New Zealand's fisheries management system is a globally recognised story of sustainability. For others, that claim does not match reality. Our Quota Management System sets out to manage our fisheries based on the abundance of individual species. We set extractive limits for these target species in a way that is seemingly incapable of considering their interactions with the wider ecosystem of which they are a part. For example, in a healthy ecosystem, large snapper and lobster keep kina in check. This, in turn, allows the kelp forest to thrive, which provides habitat for young snapper and lobster. The visually striking kina barrens that carpet some regions today are primarily a result of overfishing. The boundaries of our management systems are narrow and certain, while those of nature are broad and fuzzy.

Trying to manage complex natural systems like fish stocks brings us face to face with the risk that we intervene to favour a particular parameter, without knowing what the knock-on effects for the system as a whole will be. In decision-making, uncertainty and risk are inseparable. And uncertainty imposes a cost. It demands redundancy. It demands safety margins. And of us, it demands humility. When we frame uncertainty as a space for adaptive decision-making, people feel empowered rather than paralysed. Again, a practical environmental management decision provides a way for people to embrace complexity rather than recoil from it.

Helping people to understand how complexity arises – and why uncertainty is intrinsic to it – helps build trust in expert judgement. It allows people to accept that clarity and uncertainty can coexist.

Conclusion

You know all this – at least within your specialised fields. The public has an inkling of it but can't often find the means to make sense of it. They need a 'way in'. I've suggested to you that the environment in which people live – and which they are part of, notwithstanding our increasing tendency to live in an *in silico* world – is a textbook entry point for a greater public appreciation of complex systems.

So next time you introduce yourself as an expert in complex systems, I suggest you start somewhere else. Unfortunately, we are living through a period of retreat from complexity. A rejection of knowledge. A post-truth era. These forces erode trust. In times of stress, people turn inward. These are precisely the moments when understanding how things are connected becomes most important – and most difficult.

People need to be able to comprehend complexity as householders, consumers, investors, builders and citizens navigating a rapidly changing world:

- When a councillor votes on a freshwater plan, they are making a decision shaped by time-lags, thresholds and cumulative effects.
- When a family chooses where to build a home, it is implicitly making decisions about flood risk, soil stability and climate futures.
- When a business invests in new technology, it is making a bet on long-term system dynamics, not short-term trends.

- When any of us chooses what to buy, how to travel or how to heat our homes, we are participating in systems that extend far beyond our immediate field of view.

Effective communication of the ideas within your discipline gives people the tools to understand these interdependencies. They help us see that our choices are not isolated acts, but nodes in a wider network of consequences.

As we confront climate change, biodiversity loss, freshwater degradation, and the cascading uncertainties of the future, our greatest challenges are not technical, but challenges of communication and understanding. We must resist the seduction of claiming artificially simple solutions or a linearity of causation that can't be delivered. In the end, communicating environmental complexity is not about making the world simpler. It is about re-engaging an appreciation of complexity that – as we have distanced ourselves from nature – we have lost. We need to win it back.