



Keynote Address to New Zealand Society of Soil Science Conference

Napier Conference Centre
6 December 2018

- I accepted your invitation because I had fully expected to have issued, by now, a report I am writing on Overseer, the model. The address would have written itself. It hasn't turned out that way. The report will be released next Wednesday. So I am afraid you are stuck with a Commissioner without any findings – at least for the moment. I apologise if what follows will be downright boring.
- Let me instead use this opportunity to ask you as a scientific community what our national priorities for soil research and soil conservation should be. I could stop right there and listen to your thoughts but you would probably feel that I was not earning my keep, so let me explain my question by telling you why my interest has been aroused.
- Very simply, I keep running across soil. I mean that literally – I am a trail runner because it is all about running on soil. I decided in my early fifties that I wouldn't have any working joints left if I kept pounding around on pavements. So I spent my most recent seven-year stint in Paris running on the incredible network of paths that exist in the Ile-de-France. Within 80km of Paris there are roughly 7000km of trails. I have run over 5500 of them. I have continued back home in Wellington. The choice is more limited and the vertical scale much more rugged. But the views are worth it.
- But I also keep running across soil professionally. Obviously the Overseer review that comes out next week has had a great deal to do with soil. One of the reasons I felt confident to undertake the review was having a staff member who is a soil scientist.
- But soil crops up in the review that will follow the Overseer review, which is about the treatment of biological sources and sinks in the context of climate mitigation policies. The contribution of soil to solving our problems is unlikely to feature heavily in my report. I am not in the camp that believes that increasing soil carbon by 4% a year represents even part of a solution to our real problem and that is: emissions from the combustion of fossil fuels.
- Fossil fuel emissions have to go to zero and we cannot safely get around that by trying to park that fossil carbon in various corners of our terrestrial and oceanic ecosystems. When I read that the total fresh weight mass of organisms below temperate grasslands may equal or exceed above-ground biomass, I'm acutely aware of the risks we run if we ignore the fate of soil carbon and the risks that climate change itself may pose to that pool of carbon.
- And then soil crops up again in a third review I'm undertaking, which is into the approach to environmental reporting that we have taken under the Environmental Reporting Act 2015. By early next year, we will have completed the first full cycle of six domain reviews and a synthesis report. So it will be a good time to ask if we have it 'right' – in terms of domains, frequency of reporting and, more broadly, what we're trying to achieve.
- The most recently released domain report was entitled *Our land 2018*¹ and covered a somewhat heterogeneous bundle of topics: physical processes, the land-based impacts of climate, how human activity affects the land, the state of our biodiversity and ecosystems and – you guessed it – the state of New Zealand soils.

- May I ask you to put your hand up if you have read the report or parts of it? I asked the same question of roughly 300 people gathered for the NZ Grasslands Association conference in Twizel a couple of weeks back. I was mildly staggered when only two hands went up. It would be hard to imagine a user and scientist audience more directly invested in the state of our land. It certainly provided a new motivation for me to ask why we are gathering this information and what difference it will make.
- The report is a fascinating – and disturbing – read on many fronts. For instance, we learn that the last version of the land cover database came out in 2012 and that *“options are currently being investigated to fund the production of LCDB5 and LCD6”*. For a country that relies on its land for a living (both agriculture and tourism) and is trying to manage severely perturbed terrestrial ecosystems, it is incredible to me that regular updates are not a core recurring expenditure item. We should not be relying on six-year-old data when satellites are just about able to monitor in real time what is happening on the ground (cloud permitting).
- There is no single, comprehensive, robust dataset that characterises land use or land use intensity; there is no measure of habitat fragmentation; we lack a nationally agreed, quantitative and scalable ecosystem classification and monitoring system. Unsurprisingly, it means we don't really have high quality information on the impacts of the change in state of soils and biodiversity on our economy, culture and recreation. All this comes from Table 4 of the report – the data gaps table – which states, rather laconically: *“In this report we rely heavily on additional sources or express these descriptively through case studies. A systematic approach and data to better quantify impact is required.”*
- The chapter on the state of New Zealand soils (which at least some of you appear to have read) starts promisingly with the statement that *“there's more to soil than meets the eye. Soil is a living mixture of organisms, minerals, organic matter, air and water. It is an ecosystem in its own right, like a forest or an ocean.”* And we are then introduced to the wide range of ecosystem services soils provide.
- But that's about where it stops. Because it seems that what we *don't* know far outstrips what we *do* know. The complexity shrivels down to a handful of indicators that are largely related to productivity (from a farming point of view) and two environmental indicators: phosphorus content and macroporosity.
- The soil quality indicators (fertility, acidity, physical status and organic reserves) don't comprise a comprehensive national series. The collection of this data is voluntary and, incredibly, according to the report, it appears that Northland, Taranaki, Otago and Southland don't collect it. The last time I heard, these were provinces whose economies are heavily dependent on the land. Just what is going in these regional councils? To the credit of those regional councils that are interested, I'm aware that the Land Monitoring Forum produced, in 2013, a report on the next generation of soil quality indicators.²
- For a land-based economy, the national level gaps are equally embarrassing. According to the report we don't have:
 - comprehensive up-to-date mapping of soil types (S-map covers just 30% of New Zealand)
 - a comprehensive national erosion monitoring programme
 - a clear understanding of what proportion of eroded material is from natural as distinct from human-induced sources
 - a clear idea of the contribution of erosion to carbon loss
 - a comprehensive picture of the state of soil biodiversity and ecosystem health under different land uses
 - an understanding of the composition and size of soil microbial communities and how changes in these can affect a wide range of ecosystem processes with profound consequences for wider ecosystem function including, of course, those ecosystem services we benefit.

2. Mackay A, Dominati E, Taylor MD. 2013. Soil Quality Indicators: The Next Generation. Report prepared for the Land Monitoring Forum of Regional Councils. <http://www.envirolink.govt.nz/assets/Envirolink/Soil20Quality20Indicators-20The20next20generation-Final-June16-ED.pdf> .

- I understand that MfE and regional councils have been working for some time on indicators for soil quality and trace element monitoring, but whether this will lead to a national overview and a common approach including all regional councils, not just 12 of them, isn't clear to me. I do hope the Ministry can move this forward.
- None of this, I expect, is news to you. But we need to keep asking the question: *how can a biological economy like New Zealand's afford not to know some of this stuff?* It's not an entirely rhetorical question. The costs of ignorance looking forward to a changing world in which resilience and adaptation will be essential for survival really would be plausibly quantifiable if someone took the trouble.
- But I will leave that to one side and ask a slightly different question: *Why is it that we seem to have trouble understanding the crucial importance of our soils?*
- I think the problem may lie, in part, because many people aren't quite sure what soil is. For most people it's the stuff in the garden or the stuff the farm grass grows on. Sometimes it's the stuff clogging up rivers and estuaries (at which point it's called silt or sediment). People also know about stuff you put in soils – compost, fertilisers – which vanish and do something to the soil. And they know what when you get into truly alpine territory – or Antarctica – there is vanishingly little of it. But it's a vaguely understood commodity despite its ubiquity and our total reliance on it (although if you're a reader of Margaret Atwood-style dystopian fiction you will have probably encountered gated communities in ruined worlds taking their food from gleaming test tube farms).
- While a growing community of people interested in the health of what they eat know that soil is a substrate that is filled with life, I expect an alarming number of people think of soil as just inert stuff. And even when they realise its value – for something like food production – they don't necessarily regard it as a living thing itself. Perhaps it's not surprising then that when we do take a policy and data collection-related interest in soil it's about things like erosion and so-called versatile land and high class soils.
- Our environmental law assumes we know what soil is. There is no definition of it in the Resource Management Act. Section 5 (2) (c) enjoins those exercising powers under the Act to safeguard *"the life-supporting capacity of air, water, soil, and ecosystems."* Put together in this way it's an interesting list. Two items – air and water – are abiotic. Water gets three definitions, probably for spatial management reasons: there's fresh water, geothermal water and coastal water. (Lakes and rivers by the way also get defined.) But air, soil and ecosystems miss out.
- Interestingly *minerals* get defined using the definition of section 2 of the Crown Minerals Act 1991. I'll read it: *"mineral means a naturally occurring inorganic substance beneath or at the surface of the earth, whether or not under water; and includes all metallic minerals, non-metallic minerals, fuel minerals, precious stones, industrial rocks and building stones, and a prescribed substance within the meaning of the Atomic Energy Act 1945."*
- Do we take it from this that legally, soil isn't a mineral? Perhaps that's because it's organic. But what about the inorganic components of it? The closest the lawyers get to an understanding of soil that starts to sound right is the RMA's definition of *soil conservation* which reads: *"soil conservation means avoiding, remedying, or mitigating soil erosion and maintaining the physical, chemical, and biological qualities of soil."*
- It's that combined reference to the physical, chemical and biological qualities of soil that starts to get a bit closer to the mark. The Resource Management Act doesn't define ecosystems although it does come up with a billowingly inclusive definition of the *environment* which includes *"ecosystems and their constituent parts, including people and communities"*.

- To refresh my memory of how an *ecosystem* is defined I went, as one does, to Google and came up with the following: “An ecosystem is a community made up of living organisms and non-living components such as air, water, and mineral soil”. On that basis, soil is an ecosystem. And it is an ecosystem of mind-bending complexity.
- And to answer my question – *why is it that we seem to have trouble understanding the crucial importance of our soils?* – the answer might lie in the fact that there’s a huge gap between that complexity, especially the biological element of it, and the simple and very narrow uses or problems we associate with soil. Stuff you use to grow tomatoes or busy Lizzies, stuff that grows grass, stuff that leaves hillsides and ends up in rivers. We are busily developing ever more sophisticated indicators of water health – no doubt because we worry about drinking and swimming in the stuff. But soil indicators don’t seem – at least to date – to have triggered a similar concern. Soil is so much more complicated to understand than water.
- With all this in my mind, I was delighted to be directed to a 2013 paper by Jackie Aislabie and Julie Deslippe entitled *Soil microbes and their contribution to soil services*. I hope they’re here because I’d like to thank them personally for such a useful overview paper for a person like myself. It opened, for me, the world of bacteria, archaea and fungi with such wonderful names as *Neocallimastigomycota* and the sinister sounding *Bdellovibrio*.³
- The paper usefully summarises recent trends in soil microbial diversity research and gaps in our knowledge of microbial diversity and functioning in New Zealand. There is, apparently, little information about the microbial phylogenetic diversity of our soils. And we know little about how land use and climate change will affect the long-term maintenance of our microbial resources.
- The paper points out that we don’t know how increasing inputs of nutrients affect microbial diversity and functioning. Does all that remarkable diversity mean there is huge resilience or not? We certainly pour a lot of stuff onto or into our soils: about 400,000 tons of N per annum, 150,000 tons of P, 100,000 tons of K.⁴ Then there’s zinc from facial eczema dosing, and cadmium, fluorine and uranium from phosphate fertilisers.
- In the last year, we have imported 93,000 litres of herbicides containing atrazine and simazine⁵ – I assume we import it to use it. The volume of glyphosate will be much higher but there are no volumes available in the public sphere. Again, do we know what impact these and many other substances have on soil microbial communities?
- The Aislabie and Deslippe paper notes that we have at present just a single biological soil indicator (anaerobic mineralisable nitrogen). I understand that a replacement for this is currently being developed. A recommendation by the Land Monitoring Forum to explore adding earthworm diversity and abundance as an additional indicator of biological health is proving problematic.
- It would be unthinkable to leave so much of our terrestrial above-ground ecosystems in the dark. That, of course, is because they’re there in broad daylight. We seem to assume that what we can’t see doesn’t matter or that its absence can’t hurt us. This applies almost as much in marine and benthic settings as it does in this vast, subsurface terrestrial jungle.

3. Aislabie J, Deslippe JR. 2013. Soil microbes and their contribution to soil services. In Dymond JR ed. Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.

4. Approximate values for 2015, http://www.fertiliser.org.nz/Site/about/fertiliser_use_in_nz.aspx. Accessed Dec. 2018

5. Herbicides registered on imports for 2017-2018. Information specific to atrazine is not available. StatsNZ Infoshare portal, <http://archive.stats.govt.nz/infoshare/>. Accessed Nov. 2018.

- And yet when you consider that food supplies, clean water, nutrient cycling and carbon storage are all reliant on healthy soil, which is home to more than a quarter of the world's biodiversity, our ignorance appears foolish. That we have got away with it for so long is testament to the resilience and diversity of that substrate. But with 7.7 billion of us laying claim to an ever-rising share of our soils' ecological services, we are surely running risks.
- Which leads me to re-ask the question I asked at the outset: *what do you, as a scientific community, consider that our national priorities for soil research and soil conservation should be?* And if, as Parliamentary Commissioner for the Environment, I was to shine a light onto a pressing issue of soil health and environmental quality, what would it be? I'm interested in any view people want to express now. I'm even more interested in any considered views your association may wish to offer. I don't guarantee to follow up any of them but either way it is important to understand your view of where the land – and the soil – lies.