Soil science in New Zealand: requiem or renaissance?

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Annus horribilis

The 51st year of the New Zealand Soil Science Society, 2003, was the nadir of soil-science research in New Zealand.

The agency that purchases research and development on behalf of the New Zealand government, the Foundation for Research, Science and Technology (FRST), announced its funding decisions on 8th August 2003. These funding decisions were for 6-year proposals that would run through until 2009. Soils-based proposals fared badly, whether emanating from the Crown Research Institutes (CRI), who themselves have no base funding, or whether originating from the Universities.

The Editorial on 5th September 2003 in the *New Zealand Herald*, our largest daily newspaper, based in our largest metropolitan area of Auckland, commented "It is hard to imagine more productive uses of science in this country than research into soil. Our economic dependence on agriculture remains undiminished by a 30-year quest for a more diverse range of exports. And our soil is not a resource that can ever be taken for granted. Its constant requirements for fertiliser and its tendency to erosion are reasons alone to maintain efforts to improve the soil's quality and stability. So it is hard to understand why the Government's granting agency, the Foundation for Research, Science and Technology, has suddenly halved the money it allocates to soil science, and easy to understand the dismay of scientists whose work will be cut short, or taken overseas".

Was this editorial the requiem for New Zealand soil science?

In late 2003, the four CRIs worst hit by these funding decisions, namely AgResearch, HortResearch, Crop & Food Research and Landcare Research, initiated a collaborative process to assess their existing capability bases, and to consider future research requirements for soil-based skills. As well, discussions were initiated between the CRIs and FRST, along with the Ministry of Research, Science and Technology (MoRST), the Ministry of Agriculture and Forestry (MAF), the Ministry for the Environment (MfE), and a representative from New Zealand's thirteen Regional Councils and four Unitary Authorities. The possibility of a Cooperative Crown Centre (C^3) for coordinated soil-research provision was considered. As well, FRST advocated to Treasury that money be released in the Government's 2004-05 Budget to reconsider funding of meritorious soil research that was overlooked in the 2003 FRST bidding round.

To guide any ensuing R&D purchase process, MoRST, the Government's science-policy agency provided funding for the collective of CRIs to write a report on "*Soil Management and Land Use: Priorities and Science Imperatives*". The CRI team comprised Brent Clothier (Chair) and Ian McIvor from HortResearch, Liz Wedderburn and Alec Mackay of AgResearch, Crop & Food Research's Mike Beare and Glyn Francis, and Maggie Lawton and Murray Jessen from Landcare Research. The nub of their case is described here.

Agriculture and horticulture in the New Zealand economy

Pastoral and arable agriculture, along with horticulture are responsible for 50% of New Zealand's export receipts, and over 25% of our gross domestic product. This continuing source of national wealth comes from the top 150 mm of our soil.

MAF reports that the primary sector's contribution to our economy will continue to grow as a result of increased primary production, along with new products coming from innovative land-uses and intensification of existing land-uses. This, combined with new biotechnology ventures, will ensure that New Zealand's
Economy grows at 4% so that New Zealand can achieve a first-world living from its soil. The NZ Institute of Economic Research (NZIER) has demonstrated that the primary sector is New Zealand's comparative advantage. MAF stresses that the innovation system is the key-driver of the strong performance of this sector. Soil science is at the core of the innovation system.

In the CRI report, a new paradigm of soil and land-use management is described that incorporates an increasingly complex range of drivers determining intensification and land-use change. The forces that shape land-use and enterprise-management decisions were considered by the CRI team, in order that the key priorities for new research under this new paradigm were identified. Agriculture dominates the New Zealand landscape. The biophysical functioning of soil is a key to maintaining the integrity and health of the New Zealand environment.

The Twenty-First Century Paradigm
Intensification and the development of new land-uses have been the hallmarks of post-1980s agriculture and horticulture in New Zealand. Agricultural productivity has increased at a cumulative rate of 4% p.a. since 1985. Industry targets are for this growth to continue. The value added to New Zealand's GDP by the agricultural sector was approximately $6.5 B p.a. in 2002. Environmental and social factors will place constraints on the ability to achieve these targets, unless solutions to emerging problems are found.

The long-term sustainability of new systems of land-use, modern biotechnology ventures, and intensive production systems, as well as those to be implemented in the future, is unknown. Our land and water resources are fragile and under ever-increasing pressure. Most of New Zealand's soils have some limitation to intensification. Soil-science capability is required to mitigate and alleviate these growing pressures. Failure to sustain our soil and water resources would negatively impact on the primary-sector GDP by up to 10%, putting at risk some $2.16 B of our total GDP. Also, future sector-growth could be slowed by 20% if the innovation system is weakened, at a cost of $160 M to the economy.

Since 1980, the electoral power has shifted to an urban constituency, and agriculture has lost its political leverage. Science is now its ally. The market focus has shifted from commodity to added value. The style of farm management is moving from 'command & control' exploitation of natural resources, to that of managing and accommodating change. New Zealand agriculture now seeks to supply quality products, or products with unique traits, to a discerning market at premium prices.

Since the 1980s, greater emphasis has focussed on the need to address concerns raised by the impact of land-use on managed ecosystems, whether these be within, or beyond the farm gate. There has been greater appreciation of the value of the services that managed ecosystems provide. These services include: maintenance and regeneration of habitat, provision of shade and shelter, pest control, maintenance of soil health, maintenance of healthy water-ways, filtration by soil and control of soil erosion, sustaining the productive capacity of soil, regulation of greenhouse gas emissions, and moderation of climate change. A new economy is developing around the provision and supply of natural resource capital, as for example with water rights, carbon credits and nitrogen debits, as well as the leasing of land. New knowledge is required to underpin this emerging market.

Intensively managed landscapes are inherently leaky systems, due to the rapid cycling of nutrients and organisms through the soil-plant-animal system. There is increasing recognition that solutions to surface-water quality problems lie in managing these nutrients, agrichemicals and faecal organisms in the soil of the rootzone.

The outcomes now sought from agriculture and horticulture are
1. Clean and durable receiving environments
2. Biodiversity
3. Sustained rural communities
4. Sustaining the natural capital of soil and water
5. Rural playgrounds
6. Increased profit per unit production
7. High value products from new enterprises.

The time-scale between input changes and outcome response is now much longer. The future sustainability of these outcomes is currently unknown. The end-result of new input changes cannot be predicted.

Meanwhile, there has been an increasing awareness of the need to address issues raised by the spectre of changing weather patterns and a varying climate.

These new externalities have led to a need for adaptive management strategies for managing our productive lands. The feedback loops that result (Fig 2), have created a need for new science so that NZ can sustain its natural capital, and preserve its competitive advantage.

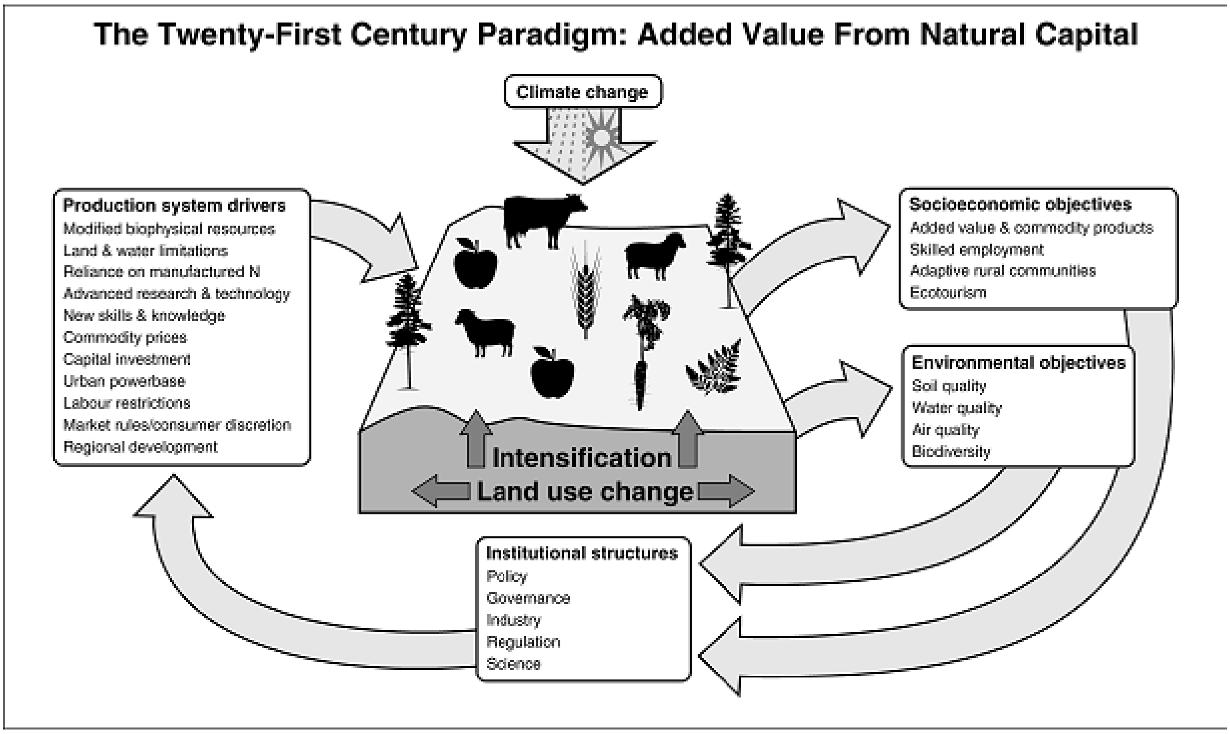

Figure 1. The drivers of todays managed ecosystems and how the impact on environmental services can lead to changes of land-use.

The Five Land-use Priorities

Land-use changes and intensification of productive environments are occurring rapidly within the context of changing climate, changing national and international economies, and shifting social and environmental paradigms. Responding to these challenges requires new science, as well as a new alignment of institutional frameworks and behaviours towards sustainable goals.

In the CRI report, a list of the 5 priority issues that impact on land-use and its management across New Zealand was provided, and these priorities were discussed in terms of target outcomes to establish those critical areas that will benefit from new soil-science.

Five target-outcome priorities that will benefit from new soil research were found to be:

1. *Intensification and Soil Functioning:* The ability of soils to continue to function and to provide ecosystem services is being threatened by the increasing pressure from inputs used to intensify land-use systems beyond current use.
2. *Managing Land-use Change:* The performance of land-use conversions on soils not traditionally used for those purposes cannot be reliably predicted. The quest for new product-characteristics to build new markets requires new knowledge of how plants function on soils in niche locales. Legacy issues from past land-use will also require remedying.
3. *Resilience under Change:* Current management practices are failing to sustain our soil and water resources, and these are increasingly being exacerbated by increasing climate variability and extreme-weather events. Therefore new system designs are needed to address the complexity of the services now sought from a mix of intensified uses of our soil and water.

4. *Valuing the Natural Capital of Soils:* Land use and management decisions that exceed current knowledge threaten the natural capital of the soil and water resources that comprise the base of our productively managed ecosystems. Our soil and water resources are our competitive advantage and we must sustain these productive bases for the future. A challenge for science is to assign value to this natural capital of our soils so that we can underpin land-use decision-making and resource allocation by industry and policy makers.
5. *Landscape Designs:* As yet, we cannot integrate or scale-up our understanding of enterprise and sector behaviours across the mosaic of landscapes for equitable resource allocation, and usage. We must achieve sustainable coexistence of the patchwork of managed and natural ecosystems. Linking is required to up-scale enterprise-level knowledge to permit integrated catchment-management.

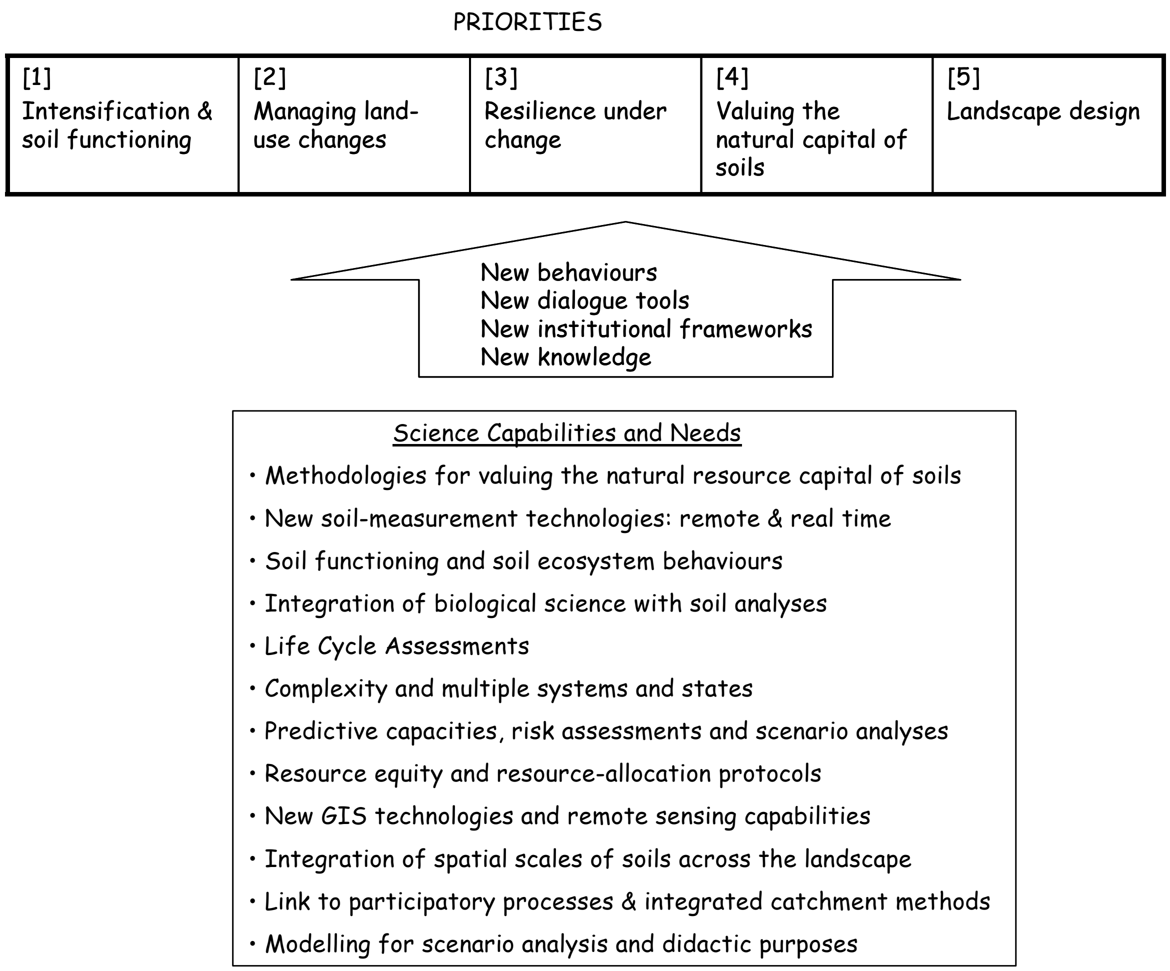

Figure 2. The five land-use priorities and their link to science needs and capabilities.

Our CRI report complemented and updated the Chamberlain report of 1995 on “Science for Sustainable Land Management: Towards a new agenda and partnership” (MoRST 1995). That earlier report documented widespread evidence of unsustainable land-use practices, and identified the marketplace for environmentally friendly products. A decade ago, the Chamberlain report found a lack of research leadership, no effective overall scientific coordination, and a failure to fund complex multidisciplinary research at the large scale over longer time horizons. Sadly, we found that little has changed.

Sustainable outcomes will flow from implementation of coordinated research results through a participatory process with central government agencies, Regional Councils, grower organisations, exporters and private companies. A unified scientific capacity would make this participatory process more effective through a ‘single-door’ approach to national research-provision. Governance of this research capacity by stakeholders and end-users would ensure an appropriate agenda-for-action to achieve intermediate outcomes. Integrated soil biophysical research, along with social and policy research, would be able to lead to new tools that land managers and regulators could use to implement and achieve these intermediate outcomes.

The five priorities and their link to science
The 5 priorities are listed and linked with their underlying science capabilities and new research needs in figure 2

Existing soil science provides a strong foundation. From this, new measurement and management technologies, plus advanced modelling frameworks would be able to provide predictions of future behaviours and decision support tools to guide land-use planning and enterprise management for sustainable outcomes.

Paradise postponed?

Agriculture and horticulture in New Zealand are undergoing rapid changes as intensification occurs, and as new land-uses are being established in non-traditional areas. The long-term sustainability of these developments is unknown, and in an alarmingly increasing number of cases, we are witnessing failures.

Armed with knowledge tools from new research across these five priorities, scientists would be able to engage in participatory processes with land-users, industries, regulators and conservators to implement integrated sustainable practices. If New Zealand agriculture and horticulture engages science, it will enhance its ability to earn a first-world living off its soil.

Will there be a renaissance of soil science in New Zealand?
How the case put forward by the CRIs fared with FRST will be discussed.