Article

Science Trifecta: Role sharing, role exchange and regional placement for grand problems

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Author's Statement

This is an opinion piece formed from our experiences and conversations with colleagues, the similar works of others (Aung et al., 2022; Fazey et al., 2020; Funtowicz and Ravetz, 2020; Kläy et al., 2015; Urai and Kelly, 2023), and ideas encountered through the Te Ara Paerangi (Ministry of Business, Innovation, and Employment, 2021, 2022) consultation. Simply to say, this work is the result of inspiration taken from many people and places, and we endeavour to reference sources when existing.

In this work we present a perspective on the structural challenges facing the science system and reforms which, to our knowledge, have not been comprehensively tested or reported. Rather than pushing an agenda of specific change, our goal is to widen the discourse and thinking on the science system. We want the reader to ask themselves: is the science system sufficiently inclusive, connected and adaptive to effectively address the grand problems of the future, and if not, what changes might help better prepare it?

Our audience is everyone, but our perspective is only as two early-career Pākehā working in the Aotearoa-New Zealand science system, at Te Pū Ao - GNS Science (noting that this work does not reflect the opinion of Te Pū Ao).

Introduction

Scientific research has progressed our understanding in the natural and social worlds, and many steps have been taken to integrate our learnings to make positive changes for our society. In the course of its development, the science system (where scientific research occurs) has developed hierarchical organisational structures with central decision-making authorities and highly specialised working groups. These developments have been efficient for most scientific research to date, characterised by:

- Working groups of individuals with similar expertise,
- Focused work to manage complexity,
- Research design to navigate challenges posed by highly uncertain or changing problems.

Demand for multidisciplinary research to address complex societal challenges has necessitated the bringing together of a (comparatively) wide range of information and expertise to work in ways whose scale and complexity go against the grain of the science system structure. Such efforts – the National Science Challenges being a familiar example – have delivered research that is designed for and used by those for whom it was intended, indicating that the science system holds potential to work in ways outside the typical model when required.

The grand challenges of the future – e.g., climate change adaptation and natural hazards resilience – remain stubbornly unresolved. We must ask, therefore: is the science system capable of solving them?

A *grand* problem is one that is:

- Urgent (when it is experienced),
- High-stakes (in its outcomes),
- Broad in the range of factors and processes which define it,
- Large and complex in both what is needed to understand and effectively address it,
- Highly and unavoidably uncertain in many of its aspects (Fazey et al., 2020).

These are not simple scientific problems, not least because the expertise needed to address them effectively must come from both science and society (Funtowicz and Ravetz, 2020; Urai and Kelly, 2023). Solutions developed in isolation by science or soicety, risk not understanding the whole nature of these problems (what they are and how they are experienced) and what might work as their solutions (Funtowicz and Ravetz, 2020). We need only consider our familiar grand problems – climate change adaptation and natural hazard resilience – to grasp this.

We believe that effectively addressing grand problems requires more than just disciplines collaborating, placing people on secondments, or holding consultations with experts or impacted groups in society. To us what is needed are new ways of drawing together the many parts of society, and the science system and having them function effectively in ways which are inclusive, connected, and adaptive across both local and national scales. In other words, to solve

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grand problems we need to weave together the science system and society in an effort whose scale, complexity, diversity of expertise, and adaptability are equal to the properties of the problems themselves.

The Te Ara Paerangi (Ministry of Business, Innovation, and Employment, 2021, 2022) review of the Aotearoa – New Zealand science system, identified significant challenges including sufficient resourcing, suitable funding on different scales, support for innovative research with direct societal impact, and a need for a collaborative approach and focus for specific complex problems. Proposed solutions broadly constituted: creating national priorities of complex research challenges, enabling research pathways that are more inclusive of private innovation and industry organisations, and direct support for growing the proportion of under-represented groups in the science system.

However, this is not enough. As long as we are structurally inhibited from identifying valuable information, expertise, opportunities and solutions; as long as we are structurally inhibited from making pan-system connections and seizing pan-system opportunities; and as long as the science system structure itself excludes vital parts of our society from its work, we will struggle to do our part in solving grand problems.

Here we present three synergistic reforms, each of which aims at improving inclusion, connectivity, and adaptability within the existing science system. Rather than creating a new system, these reforms focus on how to enhance the system capability within the current design. Our argument extends from an understanding of the science system as both highly specialised and highly centralised in its working model. We begin by addressing and explaining this working model, its value, and its limitations. We then move on to our three reforms and how they would act to mitigate these limitations and improve the system capacity for grand problem-solving.

The Science System

The science system is made up of those who commission, produce, use and are impacted by science, whether organisations, communities, or individuals. The degree of involvement varies across all these parties with some – like research organisations – more closely integrated than others, e.g., members of the public. Here "science", defined broadly, is all knowledge generated by, and all applications of, the scientific method. While we acknowledge the significant value of other science systems, like mātauranga ā iwi, our discussion focuses on the science system defined by the western scientific method, as reflects our experience.

The working model of the science system is both highly specialised and highly centralised. Work is centralised in organisations, institutes, departments, teams and roles, which are in-turn specialised around that work – the silo concept (Fazey et al., 2020). This model can be credited with our advanced state of knowledge and is a preferred mode of working for many scientists (Törmä, 2019). However, the model's structure makes connecting between roles, working groups and organisations challenging and inhibits the development of knowledge about what information and expertise exists in the system.

Specialisation and Centralisation

The most familiar expression of the highly specialised and centralised working model of the science system are silos (isolation of scientists and areas of expertise). Silos are a frequently named barrier to interdisciplinary research (Aung et al., 2022; Crossley, 2015; Kimmerling, 2020; Ministry of Business, Innovation, and Employment, 2021) with the duration and competitive nature of funding labelled as a key contributing factor to their development and endurance. However, some see silos as necessary for growing expertise and tackling highly focused problems in a limited area of knowledge, suggesting silos need bridging - not breaking down (Törmä, 2019). While we agree funding mechanisms can and need to be improved, and that there are limitations due to the availability of funding, our issue is with the organisational role of silos, their effect on the science system, and how we can introduce institutions that enable more ready and efficient collaboration across silos when opportunities present themselves.

More broadly, we see centralisation and specialisation as the driving force behind the larger cloistered and hierarchical structure of the science system. At a societal scale, we see this structure as playing a significant role in the lack of diversity in the science system. We know we need diversity for better science (Editorial, 2018), we know that we are lacking in representation of indigenous people (nga iwi taketake) (Kukutai et al., 2021; McAllister et al., 2020) and we know that these people face disproportionately more harm from current research culture (Berhe et al., 2022). Correcting this underrepresentation needs to be a priority for Aotearoa - New Zealand, and we seek to address some of the barriers which we understand as having inhibited representation of society in the science system.

The level of centralisation and specialisation in a work system are driven by the nature of its work. If work can be completed more efficiently by having the same resources perform the same task over time, they can develop specialties in this work. If demand for this work is expected to continue indefinitely, departments (or other administrative units) can be established with responsibility over that work (centralising the work in those departments). Specialisation creates efficiency in work production, while centralisation creates efficiency in work organisation. This is true at all scales in a work system: roles, working groups, administrative units, organisations, and the system overall. In all cases, by centralising responsibilities, the work of organisation in the system becomes more specialised.

What is specialised work? A laboratory technician repeating a specific suite of analyses for different work items is a specialised role. A researcher studying a specific part of a larger problem is similarly specialised, as is the leader who repeats reporting functions. Specialisation occurs anywhere a role focuses on a smaller range of tasks or requires a narrower depth of expertise (skill, experience, knowledge) to perform its tasks. This reflects the increasingly specific nature of the work and what is required to perform it. Generally, as the expertise required to perform tasks increases, it becomes more difficult for workers to have the necessary expertise for the same range of tasks, and it becomes efficient for the work system to reduce the scope of a role's tasks, creating a greater degree of specialisation as a result.

The role of organisation becomes more difficult as the number of direct reports and the breadth and complexity of their work increases. At a certain point, it becomes efficient to either focus some of the roles sharing these responsibilities more wholly on organisation (e.g., creating a team leader) or divide organisational responsibilities (and reporting lines) across multiple roles each focused on a smaller range of the work or workers (e.g., creating multiple teams). This is centralisation: the focusing of responsibilities in a work system.

In this way, large, highly specialised work systems develop hierarchical organisational structures with specialised work units and centralised responsibilities.

In a work system, communication is guided by structure. Typically, communication occurs within working groups and along direct reporting lines. Consequently, as systems become increasingly centralised, communication becomes more insular and exposure to (and understanding of) the wider work system becomes reduced. While everyone has the agency to act against this influence, and it is possible to design institutions and foster cultures to do the same, this influence is nevertheless an essential part of highly centralised work systems. Outside of any mitigations, this influence leads to insularity in the work system, which drives the development and entrenchment of work unit cultures specific to their work and their nature of working.

Decision-Making and Bias

The information and expertise available in decision-making strongly determine the possible outcomes of a decision. If information or expertise that might have changed the outcome of a decision for the better is absent in decision-making, it can incur a great cost for the work system.

In highly centralised work systems decision-making is an exclusive responsibility. Decision-makers can choose to consult or otherwise include those without this responsibility in their deliberations. It is only efficient to do so in certain circumstances, as inclusion comes with cost as workers spend time on the decision-making process rather than their work. Inclusive decision-making, particularly if it requires establishing consultation groups, is also much slower than if decisions were simply made by those with the power to do so. Accordingly, the risk that delayed decisions will cost the work system is enhanced. Consequently, these are deterrents to inclusive decision-making, but they are not the only ones: work culture – particularly in highly insular work systems – can also act to inhibit the frequency and extensiveness of inclusive decision-making.

Bias is any influence which may skew the outcome of a decision away from its best possible outcome. These include societal, personal, conditional or structural factors, like culture, beliefs, habits, emotional state or accessibility to information. All bias increases the risk that decisions are sub-optimal for the purpose of their work system, and we are all biased in our own ways.

Up to now we have defined expertise in a strictly work-based sense (knowledge, skill, experience), but a full definition also includes one's perspective, or worldview. With such a definition, one's biases can be reflected in their expertise as both benefits and limitations, depending on the context, and the expertise of decision-making can be expanded by including those with different knowledge, skill, experience and perspective.

In this work we focus on a bias introduced by high degrees of specialisation and centralisation in a work system. We refer to this as 'knowledge bias', a cognitive bias representing the combined influence of the assumption that - as it relates to decision-making:

- We understand what information and expertise we bring;
- Others involved have the information and expertise we think they have;
- We are fully aware of what information and expertise is missing.

As centralisation and specialisation increase in a work system, this bias poses greater risks to decision-making. As we are driven to have and be familiar with only the information and expertise needed for our own work, we become less aware of what others may contribute, including what may be absent.

Within hierarchical organisation, knowledge bias can be mitigated by those in reporting lines having a sound knowledge of all aspects of the work system which reports to them. However, as scale and specialisation grow, the work of organisation becomes more demanding and this becomes increasingly difficult to achieve. A more robust approach is to consider how wider and more significant inclusion may be introduced to decision-making when knowledge bias is thought to pose a significant risk.

Yet this is not the only dimension of diversity which is suppressed by the current science system structure: non-academic pathways into the science system (as non-research staff) and the practice of including community perspective in the identification of problems and solutions is also poorly accommodated. In the science system, linear career pathways and limited avenues for entrance and contribution pose a significant challenge for mitigating bias. Many pathways in, out, and through the system would allow more diverse expertise (accounting for expertise formed by different life experiences and work in different system aspects) to be introduced and developed in the system which, if included in decision-making, could greatly reduce the risks of bias. To use Batchelor et al.'s (2021) metaphor, in lieu of fixing (or redesigning) the leaky, linear pipeline (the loss of under-represented peoples at different stages in the linear model of an academic career), a braided river is needed (Batchelor et al., 2021). Enabling and supporting non-linear pathways in science, mutually informing diverse

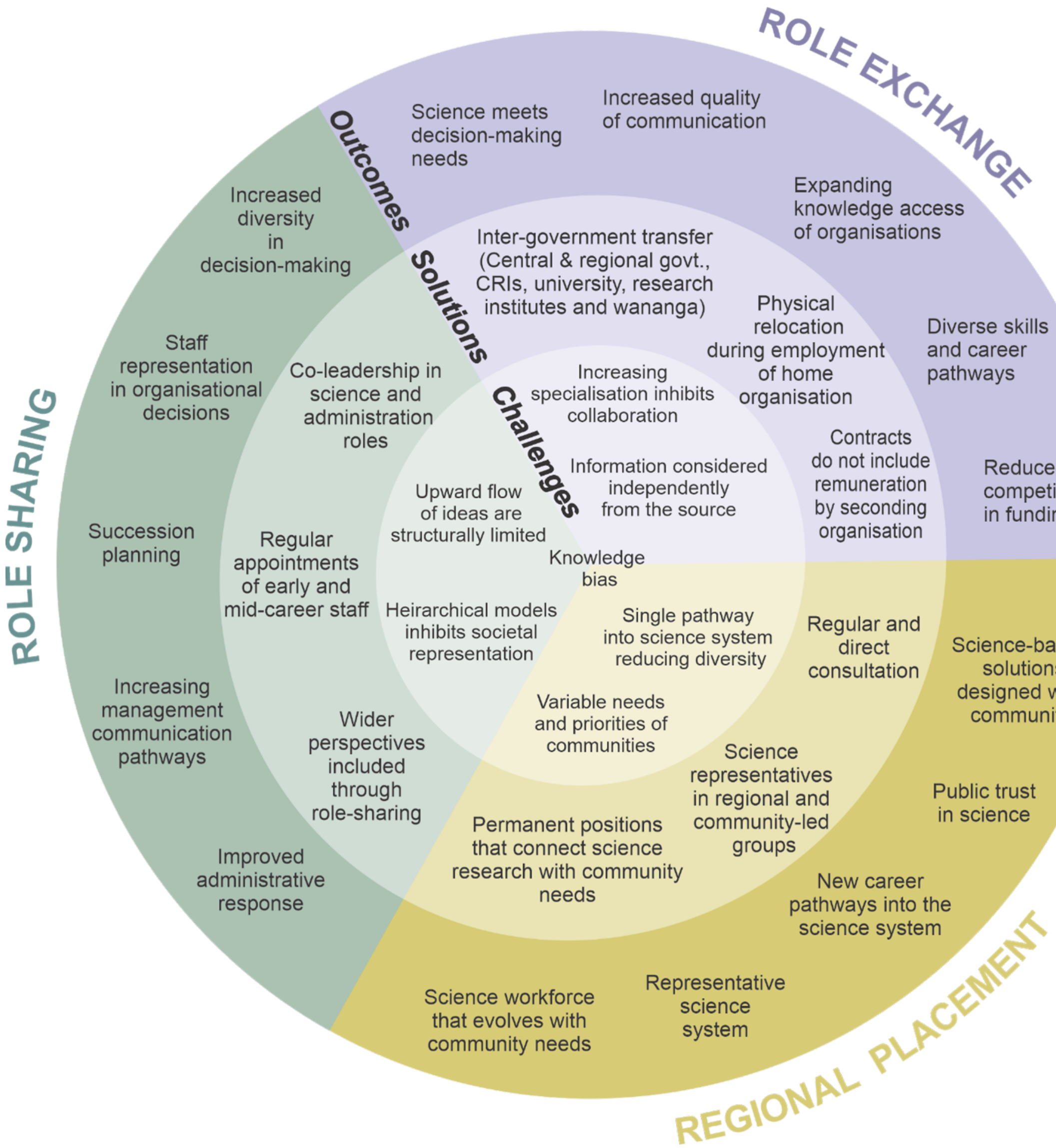

Figure 1: Descriptive diagram illustrating examples of challenges, solutions and outcomes of the three reforms proposed here – Role Sharing, Role Exchange, Regional Placement.

perspectives, life and professional experiences, can not only provide additional perspectives, but help overcome the detrimental effects on mental health associated with the research culture of linear academic progress (Limas et al., 2022).

Three reforms to improve science system capability

To enhance the current science system, we propose three reforms (Figure 1). These reforms aim to improve adaptability, connectivity and collaboration within and between organisations in the science system, and to improve the opportunities to include more diverse information and expertise in decision-making. In addition to these primary goals, each reform presents many additional benefits, particularly in the development of the people of the science system and in the inclusion of those traditionally on its margins or otherwise excluded from it.

The reforms are:

Role-sharing A model of shared leadership roles that introduces more diversity of expertise to decision-making, improves the upward integration of information in an organisation, facilitates succession planning, builds expertise in both established leaders and their deputies, and ultimately looks to share leadership responsibilities across a wider range of roles.

Role Exchange Regular exchange and capacity sharing between government and science organisations to diversify expertise and expand opportunities, facilitate understanding of different organisation's contexts and needs, and promote collaboration across organisations.

Regional Placement The permanent placement of Crown Research Institute (CRI) employees in regional hubs (e.g., council or iwi-led authorities) to act as representatives for CRI areas of expertise and advocate for community needs, provide a pathway for communities to be more included in and benefit more from the science system, and to enhance applied science impact.

Ultimately, the reforms, and the widening of personal expertise and system inclusion they support, grow the ease, readiness, and effectiveness with which the system can pivot from a siloed work model to a grand problem-solving model.

We consider each reform and its associated institution to be able to be implemented independently and within single organisations, although the benefits of each reform increase with the breadth of its and the other's institutions presence across the science system.

Role sharing

Two people, with different life experiences and worldviews, knowledge, skills, and bias, when presented with the same information will not always make the same decision. In any work system, what outcomes exist for one decision are constrained by what information has been reported to the decision-maker(s) and what expertise is available to them in their decision-making. In a hierarchical organisation structure, the possible decision outcomes are greatly reduced by the restricted information pathways of the hierarchy itself, as not all information can be passed on across each successive level.

We have experienced in our workplace how deputy or co-leadership (collectively termed here as role sharing) is effective at introducing diversity of perspective into project and people leadership roles, leveraging different skill sets, improving organisational understanding, representation, and communication, and making organisational workloads more manageable. To us it is sensible that any organisation - where knowledge bias and under-representation is high - might benefit from seeing such a reform employed more widely.

We propose a model where leaders are paired with deputies in a role-sharing arrangement. Here, pairings are designed around a mixture of expertise including perspective and capability: we envisage that by drawing together people with different expertise and perspectives to share decision-making, some of the risk around information availability and personal biases can be mitigated. Here, both diversity of role and of role-holder is desirable within the range of what is useful for the decisions made by leaders, i.e., it would be better to pair a low-level worker with a high-level leader when that leader's role has a scope that includes the work and expertise of the worker. With respect to diversity, we envisage gender, ethnicity, career stage, life experience, and distance in the organisational structure as possible dimensions, although we note that more exist and recommend a selection process that considers carefully which personal or role differences would most greatly increase the relevant diversity of perspective and expertise in the decision-making process.

In this model, a role is split into principal and deputy parts, with the principal leader holding formal accountability for the role and managing the sharing of responsibilities with the deputy leader. The division of responsibilities may be such that the deputy leader performs some of the administrative tasks of the role, attends meetings as a role representative, contributes perspective in decision-making, or any other arrangement the co-leaders agree, up to and including an equal sharing of the role. The idea is to divest some power to the deputy role to mitigate bias (plus the additional benefits) without overburdening them or placing unfair expectations on them – specifically we must avoid delegating all Māori-related responsibilities of a role to Māori staff, unless they are employed in that specific role.

This model of role-sharing invests more capability in leadership roles, brings more diversity to decision-making, shortcuts long chains of communication, nurtures leadership, and opens another channel for leaders to seek and receive information and build relationships throughout the organisation.

While this model directly mitigates a kind of knowledge bias as encountered in day-to-day work, in the longer-term, role sharing is a two-way street that influences those involved (and their work groups through them) to develop wider connections and understanding and diminish their bias through this development. Indeed, we envisage these placements to have higher turnover than regular leadership positions, increasing organisational understanding and better utilisation of early and mid-career staff.

Like the two reforms which follow, Role Sharing presents an uncharacteristic connection in the science system: one which reaches across structural divisions to enable communication and understanding to grow outside of the grand problem-solving efforts where it will be most needed. Similarly, it also offers a way to bring the braided river model of a science career to life, particularly for the deputy, as it offers a step away from their day-to-day and into the world of leadership beyond what they might otherwise be familiar with.

As a further development, the formation of steering groups to govern and guide leaders might be considered. By forming such groups with a mixture of expertise and entrusting them with the responsibilities of governance, the risks of bias and information availability can be reduced further than in the more specific co-leadership model we propose. In both cases, a selection and oversight role will be needed to ensure appropriate appointments, good function, and a safe means of mediation between those sharing the role.

Role Exchange

Solving grand problems will require collaboration across working groups in the science system at a scale and level of interconnectedness never experienced before. To address these problems effectively, we need to build systemic understanding and relationships across appropriate working groups and organisations, and leverage them towards adaptive, ready and capable collaboration.

We see the method of secondment as a relatively difficult and time-consuming process that aims to enable more cross-organisational work, but tends to be fixed-term and highly specific, with secondees placed in work groups similar to their previous position where they might use their specific expertise. This is a good model for some challenges but is insufficient for moving the science system towards what will be needed for grand problem-solving.

We propose role exchange as inter-organisational exchanges/placements in addition to the present system of secondment and cross-organisational work. In this model, working for and physically in other organisations will be a regular occurrence, even when there is no current or specific shared work being undertaken between the organisations' staff. In this way, staff on placement will continue to perform their substantive role while also being available to perform or facilitate additional work with the host organisation. Unlike traditional secondment, these roles would continue to be resourced by the home organisation, with associated administrative costs of physical placement supported by the hosting organisation. We propose this model to navigate different remuneration scales by the various institutes and as a reflection of the shared benefits of a more deeply partnered science system.

By co-locating people, specifically those with skills, character, and perspectives that lend themselves to exchange, a latent connective capacity can be developed between the organisations by way of the relationships, visibility, and understanding which naturally grows through co-location. If those placed on exchange also work with both organisations involved, they can deliver valuable work in addition to building and sustaining this connective capacity (the two are strongly related).

Specifically, we envisage the placement of scientists where science is used, with goal of fostering deeper understanding of the drivers, influences, and processes defining and constraining the production and use of science for both its producers and users. This development is particularly important for the role of science in response to grand problems: we will need systemic understanding like this to facilitate the work system adaptability, scale and complexity that these problems demand.

Regional Placement

While many societal challenges are similar across Aotearoa – New Zealand, appropriate solutions will differ regionally. This is because every community has different needs and priorities. While centralisation of research has the benefit of resources and coordination on a national scale, community access to this resource and knowledge has significant barriers including grant application processes and a general understanding of what support is available. Furthermore, large funding mechanisms encourage research based on focused areas of expertise lead by one or two institutes. While we are beginning to see more collaborative impact-led research as a standard practice, maintaining community partner relationships extends beyond funding timescales and often occurs in an ad hoc manner.

We know that grand problems – like climate change adaptation – will be experienced differently across the motu, with some areas more negatively affected than others. Science can provide a lot of the knowledge and understanding needed to face these problems, but we will also need to understand the barriers and unique challenges that define these problems where their impacts are felt. To achieve this, we propose regional placement: the permanent physical location of science organisation representatives within regional authorities. In effect, Regional Placement is another form of Role Exchange. The difference is that staff from central government organisations (e.g., ministries, agencies, entities) are distributed among region-specific organisations, like councils and iwi authorities, in permanent positions.

We see those on Regional Placement functioning to help **i)** identify and prioritise challenges for a community/region by/with the people of that region, **ii)** determine what science organisations are best placed to address each challenge, **iii)** work collaboratively as representatives of their organisations to develop solutions with direct community engagement/partnership, **iv)** provide and support the implementation of the science-based solutions, including access to the centralised resources and funding, and **v)** improve visibility and public trust of science capability. These benefits are in addition to those expressed more generally in Role Exchange.

We also see Regional Placement as a novel way to draw those traditionally outside the science system into its work, not only in its design, but also in its production and implementation through internships and joint positions. We seek to create opportunities for those who hold extensive knowledge and skill to participate in science-based solutions but who have previously been unaccommodated by the science system.

Regional Placement offers more than a practical way to increase diversity and ground science in societal needs: by drawing on the varied knowledge bases, ways of knowing, and problem-solving approaches in communities, we can include information and expertise that are not typically represented in the centralised model. This gives a greater potential for solving grand problems at local scales and for feeding insights back into central hubs to support other, similar problem-solving efforts elsewhere. We particularly hope that this would create more opportunities for Māori and for mātauranga ā iwi to take a more central role in the science system, although this requires adequate, independent support for Māori to do so (Kukutai et al., 2021; Ministry of Business, Innovation, and Employment, 2021, 2022).

Lastly, Regional Placement offers a new working model for staff who want to live regionally. Whether for young families to live near parents, Māori to live with their whanau or in their rohe, or simply to empower a less-urban life, opening up more remote working options will act to draw in, optimise the efficiency of, and retain staff with a wider diversity of needs and perspectives.

Together

These three reforms build upon the science system as it stands today. The result of these approaches together would be to nurture an alternative way of working in the science system, one which is more inclusive, connected, and adaptive, and one in which complex, large, uncertain, and high-stakes problems can be more effectively addressed.

While we acknowledge the wealth of expertise supported by a specialised and centralised science system, we equally acknowledge the challenges such a system creates. Particularly, those arising from linear career pathways and siloed organisation and the bias they introduce to decision making. Rather than rebuilding anew, we focus on what changes might develop connections between elements of the science system to leverage its capability in new directions and mitigate its structural challenges.

More than just a different way of working, these reforms present new pathways for the people of the science system. We know what the benefits of these might be – if only for the mental health and longevity of our staff – but we can also imagine the possibilities that come from enabling more diverse careers. Similarly, we can ask: what potential might we unlock by encouraging wider and more inclusive collaboration?

It is our hope that this work elicits interest in these questions and raises many more like them, that the ideas presented here provide a useful framework for understanding the science system as the reader has experienced it, and for imagining how it might be improved for the benefit of the society which upholds it.

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