The future of environmental reporting in Aotearoa

Secretary for the Environment's Science Advisory Panel

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About this report:

From the Ministry for the Environment:

The Ministry for the Environment commissioned the Secretary for the Environment's Science Advisory Panel (the Panel) to provide advice on deriving the best value from reporting under the proposed amendments to Environmental Reporting Act 2015 (ERA). The Panel's purpose is to provide independent strategic advice grounded in science and mātauranga Māori, raising awareness of any science trends, risks, and opportunities to the Ministry for the Environment (the Ministry).

This paper builds on previous strategic advice the Panel provided to inform the development of the proposed amendments to the ERA; the current proposals to amend the ERA; and the Parliamentary Commissioner for the Environment's (PCE) recommendations to transition to a comprehensive, nationally coordinated environmental monitoring system.

This advice is intended to inform both the Ministry and Stats NZ, as relevant to their roles under the future ERA. The advice focuses on reporting under the future ERA: understanding that the transition needs to be balanced with meeting the needs of the existing ERA, and that recommended changes will take time to get right. The paper sets out recommended principles to guide environmental reporting decision-making, and makes recommendations to transform the environment reporting system, including capability needs.

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Contents

Executive summary

1. Aotearoa New Zealand's Environmental Reporting Act (ERA) is currently being amended to require regular reports on New Zealand's environment that will inform New Zealanders on the health of the environment and enable decisions that lead to effective, enduring environmental stewardship and kaitiakitanga.
2. Our aim is to ensure that Aotearoa leverages opportunities provided by the ERA amendments by: (1) accessing the best underpinning evidence available; (2) utilising innovative new ways to analyse and interpret that evidence; and (3) refining a world-leading reporting framework aimed at clearly communicating the state of the environment and how and why it is changing.
3. Current national and international trends in environmental reporting (ER) include increasing Indigenous leadership and applications of whole system frameworks, as well as indicators of wellbeing, connecting people to the environment, using score cards, multi-scale reporting, accommodating uncertainty and variable data, and fair and equitable data access.
4. Environment Aotearoa 2022 (EA22) was novel and world leading with an Indigenous framing (Ministry for the Environment and Statistics New Zealand, 2022). We propose a set of design principles to ensure that the Ministry gives effect to Te Tiriti o Waitangi in future ER, and to provide a checklist for ongoing work informed by other global trends. Flexibility to shape and refine the ER programme over time is vital, but principles should underpin all ER decisions and guide implementation.
5. Foremost we propose that ER is designed to track progress towards clearly stated, visible national environmental outcomes, in order to make good environmental decisions.
6. Beyond these foundational building blocks, we also propose essential elements within a layered structure that need to be included in a fit-for-purpose reporting programme. Conceptually we depict this with the visual aid of a tree (rākau) informed by Te Rita Papesch's work on A Māori Model of Leadership (2021) (**Figure 1**):
    - The roots represent the knowledge layer (Ngā Pakiaka): data, indicators, and multiple knowledge systems (including mātauranga). The roots are enduring and need stable investment in perpetuity.
    - The trunk (Te Tumu) represents strength derived from analysis, synthesis and drawing together knowledge.
    - The crown (Ngā Peka) represents our narratives: the pūrākau (stories) we weave. Different pūrākau paint different pictures, but the underlying information remains the same.
    - Feedbacks and adaptative management, represented by falling leaves, are important in any reporting system.
7. Strengthening these essential elements to build an enduring reporting programme includes:
    - viewing reporting as a vital part of a 'system', with connections to local, regional and national environmental stewardship
    - ensuring design principles underpin all reporting decisions to support the purpose of the ERA
    - giving effect to Te Tiriti including championing Indigenous-led frameworks, building Māori capability internally, and sourcing and resourcing Māori knowledge externally
    - deriving more value from knowledge and monitoring data
    - creating compelling stories tailored for a range of audiences, whilst assuring readers that familiar aspects remain integral and science and mātauranga evidence underpin all reporting.

8. Finally, we collate recommendations made throughout the text to support the changes needed to transition over time to a more impactful ER programme.

Figure 1: A conceptual guide depicting the essential elements of a fit-for-purpose environmental reporting programme

PART 1: Putting environmental reporting in context

National context

9. Environmental reporting in Aotearoa is a statutory responsibility under the Environmental Reporting Act 2015 (ERA). As of 2022, amendments are being made to the ERA with the intention of strengthening the ER framework in Aotearoa. The amended purpose of ER will be to require regular reporting on New Zealand's environment that informs New Zealanders on the health of the environment and enables decisions that lead to effective, enduring environmental stewardship and kaitiakitanga by:
    - requiring regular, independent, evidence-based, trusted and reliable state of the environment (SOE) reporting
    - providing greater alignment with and requiring recognition of te ao Māori, including mātauranga Māori, and the values and aspirations of hapū, iwi, and Māori for the environment in environmental reporting
    - supporting flexibility in reporting formats.
10. In accordance with international SOE reporting, Aotearoa is currently legislated for the PSI parts of the drivers-pressures-state-impact-response (DPSIR) framework. The proposed amended ERA will fulfil a recommendation by the Parliamentary Commissioner for the Environment (PCE) to include drivers and outlooks in Aotearoa's reporting framework (PCE, 2019).

International trends

11. Aotearoa has not yet picked up two important international trends: (1) explicitly recognising uncertainty in underpinning data, identifying knowledge gaps, and integrating models that can accommodate variable data; and (2) linking ER to national outcomes (or goals) and targets, and quantifying progress towards these. Strengthening these elements of the ER framework was a recommendation made by the PCE in 2019, and we support that recommendation.
12. **E**nvironmental reporting has evolved internationally over the past 30-50 years from quantifying environmental subsidies and monitoring pollutants, to supporting trading in (or offsetting) environmental services. Aotearoa has largely kept pace with these trends.
13. In international jurisdictions, SOE reports display varying levels of detail and mix qualitative and quantitative information, often packaged differently for different audiences. However, a recent trend is towards whole-system frameworks that focus on national outcomes (or goals) and targets and quantify progress towards them. Information is often presented over longer timeframes.
14. Qualitative assessments, supported by underlying quantitative evidence, are a common approach used to aid communication. The European Environment Agency leads the way with reports focusing on three aspects: (1) current state of the environment; (2) whether things have improved since the last report (i.e. trends and impacts); and (3) prospects of achieving specified objectives (i.e. outlooks) (European Environment Agency, 2015; 2020). The 2017 and 2021 Australian SOE reports (Jackson et al, 2017; Australian Government, 2021) also compared new evidence with information from the previous report.
15. International jurisdictions are broadening reporting beyond environmental condition to include social and economic indicators and impacts of management. There is recognition that social and economic factors both drive and respond to environmental change, and link ER to wider decision

making. For example, in 2022 the UK Environment Agency explicitly linked nature and wellbeing for the first time (Environment Agency UK, 2022).

16. We are not aware of any international jurisdictions that have utilised an Indigenous framework in the way that Environment Aotearoa 2022 (EA22) utilised the whetū (stars) of Matariki (Ministry for the Environment and Statistics New Zealand, 2022). Indigenous framing by a government agency is novel and world-leading, and there are opportunities to build on it for future reports. To our knowledge, the 2021 Australian SOE report is the only example that came close to acknowledging Indigenous values, with a strong Indigenous narrative throughout (Australian Government, 2021).
17. Many overseas SOE reports emphasise integrity and consistency of information with a focus on data availability and provide interactive ways to work with data, which aids transparency. Much more attention is being paid to data acquisition across scales. This supports adaptive management (detection of, and responses to, environmental change), because information is gathered systematically with a clear role for Indigenous/local knowledge. SOE reports internationally are tending towards supporting open science frameworks, such as the FAIR (Findable, Accessible, Interoperable, Reusable) guiding principles for fair and equitable data access, and scientific data management and stewardship (Wilkinson et al, 2016).
18. However, international jurisdictions are also grappling with issues such as building feedbacks and interdependencies into reporting and ensuring targeted and purposeful collection of the 'right' information to inform management and policy decisions.
19. International trends to watch include reporting on 'just and equitable access' to nature. Environmental degradation is a pathway to intergenerational inequity and social injustice, so community wellbeing indicators are increasingly prevalent in reporting. This highlights connections between people and environment and outlines environmental responsibility. Environmental economics can thus provide additional subsets of evidence for decision-makers who must make trade-offs involving a nation's future. One example is the recent IPBES reports on nature's contributions to people (IPBES, 2016).

Linking environmental reporting to national goals or outcomes

20. **Why do we report on the state of the environment?** In our view it is imperative that ER is designed to track progress towards clearly stated, visible national environmental outcomes, in order to make good environmental decisions. Aotearoa currently has no comprehensive statement of enduring environmental outcomes that clearly outlines 'this is what we are aiming for, by [date]'. Without such high-level strategic goals, we cannot quantify progress towards them. ER could also demonstrate how Aotearoa is contributing to global goals (e.g. The Sustainable Development Goals, [United Nations, 2015]) if appropriate.
21. Tracking towards national goals would ensure that ER is not viewed as an isolated responsibility. Rather, ER should be seen as a vital part of a 'system', with connections across many local, regional and national entities responsible for environmental stewardship. A joined-up, whole-of-government vision ensures that everyone takes responsibility for their part of the system.

PART 2: Design principles to underpin environmental reporting

Design principles should support the purpose of the ERA

22. The aspirations or principles underlying environmental reporting programmes often remain unstated. Principles should ground us: they are the foundation for shaping a world-class ER system. Importantly, a principles-based approach to further development of the ER programme will ensure that the Ministry gives effect to Te Tiriti o Waitangi under the ERA. Whilst flexibility to shape and refine the ER programme over time is vital, principles should underpin all ER decisions and guide how the Act is implemented.

23. We recommend building on the principles in the Framework for Environmental Reporting in New Zealand document (Ministry for the Environment, 2014); and that they be refined, agreed and endorsed (e.g. through Cabinet) and upheld through independent governance of the ER system. In **Table 1** we link suggested principles to the purpose in the proposed ERA.

Table 1: Design principles for environmental reporting in Aotearoa

Purpose in proposed ERA amendments	Associated design principles (suggested by Panel): A fit-for-purpose ER system will enable us to…
1. To require regular reports on New Zealand's environment that will inform New Zealanders on the health of the environment and enable decisions that lead to effective, enduring environmental stewardship and kaitiakitanga by:	**Track progress** • Hold Aotearoa to account by tracking progress towards delivery of national and international goals or outcomes, independent of the government of the day • Enable meaningful interpretation: understand how and why the environment is changing so Aotearoa can respond **Support decision-making** • Inform budget decisions: drive investment through stronger narratives about the state of the environment • Leverage and trigger social attitude and policy change: link whole-of-government initiatives and ensure reporting is an anchor supporting system-wide needs • Support adaptive management: to rapidly detect and respond to environmental change, including quantifying and communicating uncertainty
a. requiring regular, independent, evidence-based, trusted and reliable state of the environment (SOE) reporting	**Promote systems thinking** • Quantify and report on systemic causalities, interdependencies, and feedbacks: to balance alternative courses of action – including explicit links between nature and human activities and wellbeing • Foresight emerging global trends and outlooks: to support planning for long-term environmental changes • Connect across multiple players in the system: including upholding rights and interests of tangata whenua in rangatiratanga and kaitiakitanga
b. providing greater alignment with and requiring recognition of te ao Māori, including mātauranga	**Give effect to Te Tiriti** • Champion an Indigenous/te ao Māori worldview: as a cornerstone of reporting

	Māori, and the values and aspirations of hapū, iwi, and Māori for the environment in environmental reporting	• Enable integration and linkages: across domains, sectors and scales, valuing local and place-based knowledge especially mātauranga Māori
c.	supporting flexibility in reporting formats.	**Add value** • Balance consistency and flexibility: secure core indicators over inter-generational timeframes but enhance flexibility to respond quickly to emerging drivers and pressures • Empower and support diverse narratives and communication: not 'one size fits all' but reflective of different audiences, localities and priorities for communities including hapū/iwi **Enhance data use** • Enhance data accessibility, credibility, and re-use: ensure reporting data are shared equitably and can be used for many purposes and interests, whilst respecting sovereignty • Prioritise targeted data collection: actively identify data gaps and collect the right data to inform interpretation • Support up-to-the-minute modelling, prediction and forecasting: including qualitative data and local and Indigenous knowledge

PART 3: Strengthening the environmental reporting programme

Building on the layers of an enduring reporting programme

24. The purpose and principles are foundational building blocks for any reporting system. Beyond these, there are several essential elements that we suggest need to be included in a fit-for-purpose ER programme. We conceptualise these elements in three layers: a knowledge layer (Ngā Pakiaka), an interpretive layer (Te Tumu), and narratives (Ngā Peka). Conceptually we use a tree (rākau) as a visual aid to depict these essential elements (Papesch, 2021) (Figure 1).

Ngā Pakiaka: knowledge systems, core indicators, and monitoring data

25. The roots of the rākau represent the knowledge layer (Ngā Pakiaka): the monitoring data, core indicators, and multiple knowledge systems (including mātauranga) that anchor the ER programme. The roots are the enduring part of the reporting system and need stable investment in perpetuity. The knowledge layer is critical to get right.

26. As the PCE (2019) noted, (1) Aotearoa has a passive monitoring system that makes use of what is available, rather than actively seeking the 'right' data; (2) there is inertia in the system because management actions are highly reliant on current monitoring; (3) critical data are not always accessible or used effectively; and (4) the system is based on what we are currently able to measure, rather than being driven by the outcomes we are aiming to achieve.

27. We think there are many opportunities to shape and re-design the knowledge layer to avoid unintended outcomes of the current ER system. Below we outline practical steps to derive more value from data inputs, mātauranga, and core indicators. Each would be feasible under the current ERA proposals.

28. **Continue to design a cohesive monitoring system:** Both in Aotearoa and internationally, there are new research advances in monitoring design to draw from (Garcia-Alaniz et al, 2017; Horowitz et al, 2001; Ogle et al, 2020; Rozemeijer et al, 2014). Researchers in Aotearoa have already used local and Indigenous data in a national monitoring framework (Lyver et al, 2017; O'Callaghan et al, 2019; van Dam-Bates et al, 2018) and have published on the assumptions and social processes behind indicator development (Reid and Rout, 2020). Incorporating such advances would better enable reporting against the purpose of the ERA.

29. **Build a case for significant new investment:** Aotearoa is falling far short of international standards when it comes to dedicated, long-term funding to support environmental monitoring (PCE, 2020). Lack of investment results in data gaps and puts Aotearoa at risk of being unable to identify, let alone mitigate or manage, significant environmental change (Etherington et al, 2022). Getting the fundamental aspects of ER right would support a business case for urgent and critical investment in monitoring infrastructure that has been eroded over decades.

30. **Make better use of time series and/or legacy data**: As noted by the PCE (2019), effective interpretation is almost always improved with longer environmental time series. The Tier 1 monitoring system is good for national-level data, but Aotearoa also holds several long time-series ecological datasets (Turnbull et al, 2011) and other legacy monitoring data (van Dam-Bates et al, 2018) which are not currently utilised. These could be incorporated into environmental reporting.

31. **Plug data gaps:** Beyond the immediate need to prioritise previously identified data gaps as recommended by the PCE, ongoing refinement will need to work out ways to cost-effectively fill gaps whilst systematically assessing the value of current monitoring activity (and being brave about terminating lower-priority data collection). An adaptive management approach can help identify new information needed and develop ways to lock this in through a continual cycle of learning and identifying new information needs. This facilitates purposeful targeting of the 'right' monitoring data without collection of new data becoming a burden (Ruhl and Craig, 2014). For example, adaptive planning is central to climate change adaptation processes, which are fundamentally reliant on long-term monitoring data. Yet there is a systemic lack of recognition of the value of monitoring to support that decision-making process in Aotearoa.

32. **Make use of a greater diversity of data:** What constitutes 'data and knowledge' is also becoming more nuanced. While core indicators need to retain consistency, tools in the interpretive layer need to look to wider data inputs – making use of data that may not previously have been considered as suitable for ER (van Dam-Bates et al, 2018). As a country we need to be more open to using a greater diversity of data sources in the knowledge layer. Doing so would help derive greater value through modelling and simulation, which is vital for integration across sectors, scales and disciplines.

33. **Invest in new technologies**: A vast number of new technologies for measuring and monitoring the environment are becoming available. These include detailed satellite imagery and LIDAR systems; environmental DNA (eDNA); Artificial Intelligence (AI) for detecting the presence of pests or rare species; novel scent technologies; sound measurement, and other environmental sensors to name just a few examples. The challenges of adopting new technologies include (1) integration with existing data streams and (2) initial investment may be prohibitive for some technologies. However, the benefits could be significant. For example, the use of novel technologies to measure environmental states at local, regional and national scales would help with data integration across scales. As a first step, an initial scan of emerging technologies, using pre-defined criteria to assess suitability for future use as part of ER would be informative.

34. **Ensure equitable data access**: Data availability, transparency and accessibility is another critical issue. Open data standards present challenges and opportunities for communities in terms of what gets collected, by whom, and for whom. In our view, equitable access to information is essential. One approach may be to draw on the work of the Mana Ōrite Work Programme between Stats NZ and the Data Iwi Leaders Group of the National Iwi Chairs Forum (New Zealand Government, 2021) who have co-designed a Māori data governance model that reflects Māori values, fair principles, and Māori needs and interests in data.

35. **Critically prioritise core indicators:** Finally, whilst core indicators were identified by the PCE (2019) as essential to shift from passive to active information gathering, we see it as vital that there is a robust process of identifying new core indicators through time, either in response to emerging global or national priorities or in response to measuring the results of management activities aimed at environmental restoration (adaptive management). Undoubtedly, ideas for new core indicators will emerge during development of theme reports. Experts can identify and refine such indicators, but a process is needed to ensure that indicator selection is systematic and not ad hoc. Applying the principles (Table 1) is a logical starting point.

Te Tumu: How we synthesise and interpret data and knowledge

36. The trunk of the rākau (Figure 1) represents strength derived from drawing together syntheses, analyses, and interpretation of knowledge, but there is also a degree of branching out into new methods and models. Several areas could be streamlined to improve the interpretive layer.

37. **Aim for better integration across both temporal and spatial scales**: There are several reasons why Aotearoa needs to improve multi-scale integration of reporting information:

    a. The environment responds to drivers and pressures at a range of temporal and spatial scales, from global (e.g. climate change) to very localized (e.g. nutrient runoff). Even for a given environmental driver, the environmental state can respond at a range of scales (Gornish and Tylianakis, 2013; Newbold et al, 2016), as can the entities who manage the environment (Landauer et al, 2019).

    b. A pertinent issue is how to aggregate often heterogenous local knowledge (Ban et al, 2017; Herse et al, 2020), including mātauranga Māori, into a national picture while retaining local context dependencies. Given that the Crown operates nationally whereas mana whenua status (and management practices such as kaitiakitanga and māhinga kai) operate locally, cross-scale integration is imperative to meaningfully give effect to Te Tiriti o Waitangi.

    c. Integrative measures are needed to help break down the silo mindset of domain-based reporting, because such measures strengthen cross-scale management actions.

38. Theme-based commentaries will be the first test of an ER system that has been designed to present multi-scale information. For example, a theme-based report on 'land use' will need to cover land, freshwater, marine and social indicators – using data from local, regional and national monitoring sites.

39. **Utilise available multi-scale knowledge**: Standardised sampling of core indicators nationally and longitudinally is 'gold standard'. However, resources will never be sufficient to carry out all necessary measurements to fully capture environmental state and trends. Thus, failure to use ('imperfect') available data carries a significant opportunity cost commensurate with the quantity of unused data (Allen et al, 2011). Further, some data sources are necessarily locally focused and/or nationally heterogeneous (e.g. mātauranga). Suggestions for making optimal use of multi-scale data include:

    a. Rather than filtering out data sources that do not meet certain standards, opportunity costs could be avoided and confidence in results upheld by building data scale and quality into analyses (e.g. through uncertainty or informing prior expectations) and inferring the state of the environment forensically, rather than solely with 'gold standard' data.

    b. Utilise existing data in different ways. For example, the Time-Evolving Data Science / Artificial Intelligence for Advanced Open Environmental Science (TAIAO) MBIE endeavour will use data collected by Metsevice for weather forecasting in new ways that will be widely beneficial.

    c. New technologies such as machine learning and AI may facilitate more efficient data collection and/or use of existing data in novel ways.

    d. A first step could be to complete a 'stocktake' both of potential data sources that are not currently utilised as well as options for automating data collection and/or scaling up and assess whether the resultant data would be fit for purpose, guided by pre-defined criteria and the design principles in Table 1.

40. **Decisively commission modelling expertise from the research sector:** Models can fill multiple roles in environmental reporting, for example (Baker, 2019):

    - forecasting and scenarios (e.g. to predict consequences of management activities)
    - combining data streams into system models, and potentially combining data from across domains (e.g. land use data to predict change in freshwater and coastal marine environments)
    - extrapolation of patchy or remotely-sensed data to national-scale coverage (Brown and Brabyn, 2012)

- identifying biophysical thresholds before a dangerous tipping point or degraded environmental state is reached. This is an essential ingredient in policy formation.

41. Aotearoa has not fully embraced the opportunity to utilise 'big data' and modelling approaches to overcome perceived shortcomings such as gaps in monitoring data, data with a high degree of uncertainty, and/or data of variable quality. There is an opportunity to utilise emerging new methods of modelling and synthesis of environmental data that would make inferences about environmental state and trends much more powerful and compelling. Expertise in constructing complex social-ecological 'system' models would need to be explicitly commissioned, with scope focused on delivery of outcomes.
42. **Report on how people are interacting with the environment (both for good and bad):** There is considerable evidence that people can be detached from a sense of shared ownership of environmental problems (Howell, 2013; Jasanoff, 2010). Choosing indicators that demonstrate how people engage with the environment can provide insights into future environmental states. This would give greater visibility to hundreds of volunteer efforts across the country and enormous iwi/hapū/whānau contributions to environmental stewardship, while making degradation more visible to New Zealanders (e.g. how land area under dairying is growing). Examples include:
    - number of community groups/hours involved in restoration planting, pest control, clean up days
    - how many environmental restoration initiatives are hapū-led
    - stocking rates or fertiliser use as examples of exploitation
    - social metrics alongside some of the above, such as reasons why people are involved in community conservation and restoration
    - number of people who spend time in nature each week, understanding the drivers and enablers of such engagement, and whether this improves wellbeing.
43. **Report on 'systems' measures:** Many environmental drivers and pressures have non-additive effects, such that in combination they can have greater or lesser impacts than the sum of their independent effects (Brook et al, 2008; Darling and Côté, 2008; Didham et al, 2007). This has already been observed in earth's climate systems. In addition, ecosystems and their connections to human systems (such as economies) can reach thresholds or tipping points beyond which even small increases in a stressor can produce large and potentially irreversible impacts (Scheffer et al, 2009; Scheffer et al, 2012; Steffen, 2018). These complexities and internal dynamics of ecosystems make it difficult to predict how a whole ecological or social-ecological system will change as a function of changes in single high-resolution parameters. In this sense, the emergent properties of ecosystems that should be prioritised (such as biodiversity or ability to sustain life and livelihoods) can be poorly captured by single biophysical measures and may require systems measurement. It is also system-level properties that are most likely to generate interest and support from the public, and whose degradation is most difficult to justify or ignore.

Ngā Peka: The stories we tell and the environmental narratives we weave

44. The crown of the rākau (Figure 1) represents our narratives: the pūrākau (stories) we weave based on synthesis and interpretation. Rather than presenting environmental information as a set of dry numbers and statistics, narratives help people feel a connection with the environment – a first step in environmental stewardship. Different pūrākau paint a picture for different communities of interest, but the underlying information remains the same. In any good reporting

system, there will be feedbacks. These are represented by falling leaves: a cycle of adaptive management and decision-making that supports environmental responsibility and stewardship.

45. On the face of it, narratives could be interpreted as moving away from simply presenting state and trend indicators and can attract criticism by being perceived to give greater weighting to qualitative metrics. We suggest new approaches to ensure engaging and informative narratives and we highlight areas where clearer linkages to original expectations (such as domain-based reporting of [primarily biophysical] measures) are needed to ensure that familiar aspects remain an integral part of ER, and that science and mātauranga evidence continues to underpin it.

46. **Package information for varied audiences:** Ideally, different narratives would be developed for varied audiences (e.g. public; policymakers; scientists; Ministers) and each audience is briefed appropriately prior to or during release of reports. Many international organisations release a 'summary for policymakers' or other companion document simultaneously with the main report. Examples include *The global assessment report on biodiversity and ecosystem services* (IPBES, 2019), and the Intergovernmental Panel on Climate Change's 2018 report.

47. **Deepen narratives around mātauranga Māori as essential evidence:** EA22 was a bold new approach for environmental reporting, founded upon a vision of dual knowledge systems working in partnership to evaluate environmental state in Aotearoa. Importantly, the framing for the assessment was drawn from te ao Māori conceptualisations of human relationships with te ao Tūroa and atua: metaphysical representations of the fundamental importance of natural resources for human wellbeing (Ministry for the Environment and Statistics New Zealand, 2022). Using the Matariki framework, EA22 was internationally innovative, and it drew out connections between humans and the environment in a manner that embraced whole-system methodologies. Some areas where this approach could be further strengthened are:

    a. **Be bold:** Efforts around more holistic framing are not out of step with international trends. What is world-leading is that EA22 was Indigenous-led, with the framing being guided by a panel of Māori experts. Identifying and pursuing opportunities to demonstrate the enormous value this brought to ER nationally and globally should not be underestimated. We strongly support working closely with tangata whenua and Māori science advisory groups to continue to champion Indigenous-led ER.

    b. **Resist institutionalisation:** Opportunities exist to ensure that mātauranga Māori has an independent voice and (in line with the principles) is empowered to tell its own stories. These narratives are likely to be powerful and compelling – as witnessed recently by the way in which the country embraced the Matariki public holiday.

    c. **Support collection of better-quality information and data**, in particular when it comes to mātauranga Māori: Expand provision of resources to support hapū and iwi to engage in environmental monitoring approaches, collect their own data framed from a te ao Māori perspective, and take a leadership role in data sovereignty (Mathias, 2022).

    d. **Build transdisciplinary understanding:** Having a team of empathetic officials open to te ao Māori framing and perspectives helped with successful implementation of EA22. Deepening the skills and expertise of Ministry officials, and having a level of comfort and expertise in interweaving knowledge systems in a transdisciplinary framework, will be vital to future reporting.

48. **Value a continuum of qualitative and quantitative measures:** Qualitative information can and should play a vital role in environmental reporting. Highlighting exemplars where qualitative information has been (or will be) used as evidence to inform decision-makers will help dispel the notion held by some that quantitative data should take primacy. Further, some social engagement measures are qualitative, thus lending themselves to a narrative approach. This is not to suggest that quantitative information is not important (it is); but rather to endorse a

current trajectory towards redressing the balance between qualitative and quantitative measures to inform reporting narratives.

49. **Expand narratives about non-biophysical and integrative indicators:** Integrative or 'systemic' indicators provide underpinning evidence about the state of the environment that lend themselves to narrative-style reporting. Again, this is not to diminish the value of traditional biophysical or core indicators, but rather to encourage expansion in line with a systems approach to reporting. The advantages of such integrative measures are:

    - they are typically most likely to engage the public as stakeholders
    - they are typically the end point for which biophysical indicators are measured
    - in situations where cause and effect are coupled through complex multivariate and/or non-linear pathways, simple biophysical indicators poorly capture acceptable limits (Gladstone-Gallagher et al, 2022).

    Examples of such measures include human wellbeing and connections to nature (e.g. 'satisfaction' surveys); mauri; social participation in environmental activities (e.g. restoration activities, funding spent, and community hours worked); and economic indicators (e.g. expenditure on water treatment).

50. **Ensure narratives support whole-of-government initiatives:** Reporting single environmental components or metrics without system context can alienate audiences, particularly non-specialists. Further, most people do not understand (or care about) which government agency is responsible for what. The PCE suggested clarifying the respective roles of the Government Statistician and the Secretary for the Environment, and we agree that identifying priority 'system' linkages and using narratives to clearly articulate these connections to a lay audience would be useful. Examples include wellbeing indicators (Treasury); biodiversity metrics (DOC), invasive species metrics (DOC and MPI) and climate change metrics (Climate Commission). Choosing to highlight these system connections would have the added advantage of clarifying the responsibilities of others in the system, for example Stats NZ's responsibility for handling, display and storage of raw data.

51. **Develop narratives across scales and disciplines:** There are many opportunities to better utilise a narrative-based reporting approach to explain and demonstrate how local information contributes to a national picture. For example, a 'mountains to sea' approach transcends previous discipline-focused silos and paints a picture of the scale of an environmental problem.

PART 4: Recommendations and next steps

52. **What does successful ER look like?** In our view, the PCE articulated this clearly in his 2019 review of ER – we need a system that is 'comprehensive, nationally-coordinated, and based on core indicators assembled from consistently and reliably collected data'. To that we would add that environmental reporting needs to track progress towards agreed national goals or outcomes; to clearly demonstrate the link between environmental change and human wellbeing; and to retain the flexibility to take advantage of emerging developments in science, technology and innovation.

53. **Work to the design principles**: We recommend refining and adopting the principles in Table 1, taking these through a Cabinet process if needed, developing a governance entity for ER, and ensuring that all key decisions for the ER programme are tested against the principles going forward.

54. **Orient ER towards national and global goals**: As we have noted elsewhere, ER should be set up to help track progress towards national (and international) goals or outcomes. We recommend consulting with the PCE on a process to develop such goals, and in the first instance ensure that development of core indicators can demonstrate clear line of sight to national goals.

55. **Centre Te Tiriti**: Environmental reporting in Aotearoa is aided by the reassertion of te ao Māori values and perspectives, most notably acknowledging a growing role for mātauranga Māori, which increasingly informs monitoring, management, and protection of iwi and hapū lands and waters. Te ao Māori conceptually straddles previous domain-structured interpretations of the environment. Governance and leadership by Māori must continue as an enduring part of environmental reporting given that the proposed amendments to the ERA intend to explicitly recognise the Crown's Treaty of Waitangi responsibilities. We further recommend specific provision of resources and support for hapū/iwi to develop approaches based on hapūtanga, which will build regional capability and capacity.

56. **Build capability and capacity to deliver an impactful ER programme**: In future, new capability and capacity will be needed to better bring together local and national agencies, iwi/hapū, and the research sector. This will need a clear plan the prioritises these areas and builds on existing capabilities:

    a. **Knowledge layer**: There are two key needs around mātauranga expertise: (a) expertise sourced outside of research institutions and (b) capability within the Ministry to champion mātauranga Māori, understand alternative world views and knowledge systems, and how mātauranga and science interconnect. Other knowledge layer expert needs include skills to identify and/or develop inter- and trans-disciplinary core indicators and system measures; and people that can find data, assess whether it is fit for purpose, and identify data gaps and shortfalls.

    b. **Interpretive layer:** Experts who can model complex social-ecological systems and handle large data sets; kaumātua and tohunga who draw from mātauranga in their rohe; experts who can ensure equitable access to data whilst navigating the balance between open data needs cf. expectations around data sovereignty; people with a wide strategic view of relevant scientific expertise across Aotearoa and experience drawing information from a breadth of disciplines and knowledge systems.

    c. **Narrative layer:** Strategic communications skills with the ability to package relevant information for a range of audiences; storytellers who can weave narratives from a te ao Māori perspective (e.g. Matariki for EA22); people with experience summarising complex scientific information for policymakers, decision-makers, and politicians.

d. **Trans-disciplinary skills**: A broader mix of skill sets will be required in future to deliver a fit-for-purpose ER programme. People with single-discipline expertise will always be required. Increasingly however, more cross-cutting, big data, and inter- or trans-disciplinary skills will be needed to support ER. People that can visualise system connections, communicate complexity, and quantify social-ecological feedbacks will also be needed. We note opportunities for building relationships with the research sector afforded currently in development of the Environment and Climate Research Strategy, and that such skills have been grown and developed in the National Science Challenges (NSCs) over the past decade. Cessation of the NSCs in 2024 may offer opportunities to obtain trans-disciplinary capability.

57. **Strengthen knowledge systems, core indicators, and monitoring data**: In addition to building system-wide capability and capacity to deliver a more impactful ER, strengthening the knowledge layer should include:

    a. **Stocktake**: work with external parties to identify spatial and temporal datasets (biophysical; social; mātauranga) and ascertain their suitability for theme reports in the first instance. Once the stocktake has been completed, we suggest prioritising which data sets to include – determined by the scope of the first theme reports and by suitability for modelling and 'big data'-type analyses.

    b. **Environmental scan of emerging technologies**: We recommend holding a workshop or environmental scan of emerging technologies that may be fit for purpose for ER.

    c. **Development of 'systems' measures**: We recommend developing a process to choose 'systems' measures including wellbeing indicators specific to environmental reporting, and how people are interacting with the environment – both restorative and extractive. We further recommend that the Ministry clarifies that the intent behind reporting on wellbeing is to illustrate links between people and nature, and not duplicate efforts, for example by Treasury, to implement a wider wellbeing framework.

    d. **Development of new core indicators in future**: We recommend developing a robust process to systematically identify and prioritise emerging (new) core indicators as system feedbacks kick in.

58. **Strengthen how we synthesise and interpret the data**: This is an area where improvement is needed to tap into the significant national expertise in modelling and analysis of complex data. We recommend scanning the research sector and decisively commissioning the expertise required; a case study approach could trial the use of multi-scale data in reporting, including how such data are aggregated locally to nationally.

59. **Agree on audiences, narratives, and pūrākau**: Our recommendations here include deciding on priority audiences and beginning to focus different reporting documents accordingly. This will include identifying qualitative indicators and/or social measures to strengthen narratives that resonate with people; choosing 'case study' stories about the state of the environment that span scales and disciplines; and ensuring that some aspects of environmental reporting connect across government agencies and iwi/hapū. We further recommend undertaking a Māori-led exercise to deepen reporting narratives from a te ao Māori perspective.

60. **Clarify the nature and scope of theme-based commentaries:** The PCE recommended that the structure of the reporting system should not constrain its ability to effectively report on the issues that matter. These issues are cross-cutting and systemic in nature, not confined to a single domain – indeed, it was acknowledged that domain-based reporting gave an incomplete picture of environmental state. In our view it is vital that theme-based reporting does not fall into the same trap. One or two case studies could be used to test different approaches to theme-based commentaries, for example to compare a 'mountains to sea' or cross-agency approach to presenting the commentaries.

61. **Improve system connections and collaborate with partners to strengthen the impact of ER**: We advocate strongly for ER not to be viewed as an isolated statutory responsibility, but as a critical component of the wider system and a valuable way to build bridges with other agencies. Suggestions include:

    a. **Work with local government:** Local government are collectors of environmental data. A spatially scalable reporting framework would support consistency in regional reporting and provide relevant data for national reporting. To achieve this requires careful consultation with local government. Local government scientists can and have identified science needs to support environmental monitoring and reporting and also know what styles of reporting resonate with communities. Capacity and capability are likely to be lacking locally, however, when it comes to assessing social and cultural wellbeing, so strong guidance, leadership, and investment in these areas is needed. Through developing core indicators, the Ministry has an opportunity to work with local, including how to refocus monitoring investment into critical data gap areas.

    b. **Shape investment from the research community:** *Te Ara Paerangi Future Pathways Green Paper* (Ministry of Business, Innovation and Employment, 2021) provides one opportunity to target Ministry resources in such a way as to leverage investment from external research sources.

    c. **Better utilise data from diverse sources:** We recommend using criteria to identify existing data, and a system-wide scan of what is available as an initial step to future inclusion in environmental reporting.

62. **Build a case for better resourcing:** A comprehensive assessment of information available from a range of sources may help build a case for eventual new investment in environmental reporting. Our recommendations to undertake a stocktake of relevant monitoring data sets would help guide targeted resourcing to fill gaps and our suggestion to work more closely with the research sector would build cross-agency support for research that is vital to ER but currently precariously funded. We emphasised the value of pūrākau/narratives in Part 3 because making stories and narratives about the state of the environment more appealing and understandable to a wide range of audiences will ultimately serve to garner public support for investment.

References

Allen CR, Fontaine JJ, Pope KL, Garmestani AS. 2011. Adaptive management for a turbulent future. *Journal of Environmental Management* 92: 1339-1345.

Australian Government. 2021. *Australia State of the Environment 2021.* Retrieved from https://soe.dcceew.gov.au/ (6 October 2022).

Baker M. 2019*. Te Kete Tua-ātea, Māori modelling of the future and the kaitiakitanga of water*. PhD Thesis, Massey University, Manawatū. Retrieved from https://mro.massey.ac.nz/handle/10179/15367 (6 October 2022).

Ban NC, Eckert L, McGreer M, Frid A. 2017. Indigenous knowledge as data for modern fishery management: A case study of Dungeness crab in Pacific Canada. *Ecosystem Health and Sustainability* 3: 1379887.

Brook BW, Sodhi NS, Bradshaw CJ. 2008. Synergies among extinction drivers under global change. *Trends in Ecology and Evolution* 23(8): 453-460.

Brown G, Brabyn L. 2012. The extrapolation of social landscape values to a national level in New Zealand using landscape character classification. *Applied Geography* 35: 84-94.

Darling ES, Côté IM. 2008. Quantifying the evidence for ecological synergies. *Ecology Letters* 11: 1278-1286.

Didham RK, Tylianakis JM, Gemmell NJ, Rand TA, Ewers RM. 2007. Interactive effects of habitat modification and species invasion on native species decline. *Trends in Ecology and Evolution* 22(9): 489-496.

Environment Agency UK, Chief Scientist's Group. 2022. *Working with nature.* Bristol: Environment Agency. Retrieved from https://www.gov.uk/government/publications/working-with-nature (6 October 2022).

European Environment Agency. 2020. *The European Environment — State and Outlook 2020: Knowledge for Transition to a Sustainable Europe*. Copenhagen: European Environment Agency. Retrieved from https://www.eea.europa.eu/soer/publications/soer-2020 (6 October 2022).

European Environment Agency. 2015. *The European Environment — State and Outlook 2015: Synthesis Report*. Copenhagen: European Environment Agency. Retrieved from https://www.eea.europa.eu/soer/2015 (6 October 2022).

Etherington TR, Perry GLW, Wilmshurst JM. 2022. HOTRUNZ: an open-access 1 km resolution monthly 1910–2019 time series of interpolated temperature and rainfall grids with associated uncertainty for New Zealand. *Earth System Science Data* 14: 2817-2832.

Garcia-Alaniz N, Equihua M, Pérez-Maqueo O, Benítez JE, Maeda P, Urrutia FP, Martínez JJF, Gaytán SAV, Schmidt M. 2017. The Mexican national biodiversity and ecosystem degradation monitoring system. *Current Opinion in Environmental Sustainability* 26: 62-68.

Gladstone-Gallagher RV, Tylianakis JM, Yletyinen J, Dakos V, Douglas EJ, Greenhalgh S, Hewitt JE, Hikuroa D, Lade SJ, Le Heron R, Norkko A, Perry GLW, Pilditch CA, Schiel D, Siwicka E, Warburton H, Thrush SF. 2022. Social-ecological connections across land, water, and sea demand a reprioritization of environmental management. *Elementa: Science of the Anthropocene* 10(1): 00075.

Gornish ES, Tylianakis JM. 2013. Community shifts under climate change: Mechanisms at multiple scales. *American Journal of Botany* 100(7): 1422–1434.

Herse MR, Lyver PO, Scott N, McIntosh AR, Coats SC, Gormley AM, Tylianakis JM. 2020. Engaging indigenous peoples and local communities in environmental management could alleviate scale mismatches in social–ecological systems. *BioScience* 70: 699-707.

Horowitz AJ, Elrick KA, Smith JJ. 2001. Estimating suspended sediment and trace element fluxes in large river basins: Methodological considerations as applied to the NASQAN programme. *Hydrological Processes* 15: 1107-1132.

Howell RA. 2013. It's not (just) "the environment, stupid!" Values, motivations, and routes to engagement of people adopting lower-carbon lifestyles. *Global Environmental Change* 23: 281-290.

IPBES. 2016. *Values in contrast with the IPBES framework*. Retrieved from https://ipbes.net/values-contrast-ipbes-framework (6 October 2022).

IPBES. 2019. The global assessment report on biodiversity and ecosystem services. Bonn, Germany: IPBES secretariat. Retrieved from https://ipbes.net/global-assessment (6 October 2022).

IPCC. 2018. *Global warming of 1.5°C: Summary for policymakers.* Switzerland: IPCC. Retrieved from https://www.ipcc.ch/sr15/chapter/spm/ (6 October 2022).

Jackson WJ, Argent RM, Bax NJ, Clark GF, Coleman S, Cresswell ID, Emmerson KM, Evans K, Hibberd MF, Johnston EL, Keywood MD, Klekociuk A, Mackay R, Metcalfe D, Murphy H, Rankin A, Smith DC, Wienecke B. 2017. *Australia state of the environment 2016: Overview.* Independent report to the Australian Government Minister for the Environment and Energy. Canberra: Australian Government Department of the Environment and Energy.

Jasanoff S. 2010. A new climate for society. *Theory, Culture and Society* 27: 233-253.

Landauer M, Juhola S, Klein J. 2019. The role of scale in integrating climate change adaptation and mitigation in cities. *Journal of Environmental Planning and Management* 62: 741-765.

Lyver P, Timoti P, Jones CJ, Richardson SJ, Tahi BL, Greenhalgh S. 2017. An indigenous community-based monitoring system for assessing forest health in New Zealand. *Biodiversity and Conservation* 26: 3183-3212.

Mathias S. 2022. Inside the fight for Māori data sovereignty. *The Spinoff.* Retrieved from https://thespinoff.co.nz/internet/29-07-2022/indigenous-data-sovereignty-will-make-the-internet-a-better-place-for-maori (6 October 2022)

Ministry for the Environment. 2014. *A Framework for Environmental Reporting in New Zealand.* Wellington: Ministry for the Environment. Retrieved from https://environment.govt.nz/publications/a-framework-for-environmental-reporting-in-new-zealand (6 October 2022).

Ministry for the Environment, Statistics New Zealand. 2022. *Environment Aotearoa 2022: New Zealand's Environmental Reporting Series*. Wellington: Ministry for the Environment. Retrieved from https://environment.govt.nz/assets/publications/environment-aotearoa-2022.pdf (6 October 2022).

Ministry of Business, Innovation and Employment. 2021. *Te Ara Paerangi Future Pathways Green Paper.* Retrieved from https://www.mbie.govt.nz/dmsdocument/17637-future-pathways-green-paper (6 October 2022).

New Zealand Government. 2021. *Māori Data Governance: Co-designing Māori Data Governance.* Retrieved from https://data.govt.nz/toolkit/data-governance/maori/ (6 October 2022).

Newbold T, Hudson LN, Hill SLL, Contu S, Gray CL, Scharlemann JPW, Börger L, Phillips HRP, Sheil D, Lysenko I, Purvis A. 2016. Global patterns of terrestrial assemblage turnover within and among land uses. *Ecography* 39: 1151–1163.

O'Callaghan J, Stevens C, Roughan M, Cornelisen C, Sutton P, Garrett S, Giorli G, Smith RO, Currie KI, Suanda SH, Williams M, Bowen M, Fernandez D, Vennell R, Knight B, Barter P, Mccomb P, Oliver M, Livingston M, Macdonald H. 2019. Developing an integrated ocean observing system for New Zealand. *Frontiers in Marine Science* 6: 143.

Ogle SM, Butterbach-Bahl K, Cardenas L, Skiba U, Scheer C. 2020. From research to policy: optimizing the design of a national monitoring system to mitigate soil nitrous oxide emissions. *Current Opinion in Environmental Sustainability* 47: 28-36.

Papesch TR. 2021. A Māori model of leadership practice. *Te Kaharoa* 14(1).

Parliamentary Commissioner for the Environment (PCE). 2019. *Focusing Aotearoa New Zealand's Environmental Reporting System.* Wellington: Parliamentary Commissioner for the Environment. Retrieved from https://www.pce.parliament.nz/publications/focusing-aotearoa-new-zealand-s-environmental-reporting-system (6 October 2022).

Parliamentary Commissioner for the Environment (PCE). 2020. *A Review of the Funding and Prioritisation of Environmental Research in New Zealand.* Wellington: Parliamentary Commissioner for the Environment. Retrieved from https://www.pce.parliament.nz/publications/environmental-research-funding-review (6 October 2022).

Reid J, Rout M. 2020. Developing sustainability indicators – The need for radical transparency. *Ecological Indicators* 110(1): 105941.

Rozemeijer JC, Klein J, Broers HP, van Tol-Leenders TP, Van Der Grift B. 2014. Water quality status and trends in agriculture-dominated headwaters; a national monitoring network for assessing the effectiveness of national and European manure legislation in The Netherlands. *Environmental Monitoring and Assessment* 186: 8981-8995.

Ruhl JB, Craig R. 2014. Designing administrative law for adaptive management. *Vanderbilt Law Review* 67: 1.

Scheffer M, Bascompte J, Brock WA, Brovkin V, Carpenter SR, Dakos V, Held H, Van Nes EH, Rietkerk M, Sugihara G. 2009. Early-warning signals for critical transitions. *Nature* 461(7260): 53-59.

Scheffer M, Carpenter SR, Lenton TM, Bascompte J, Brock W, Dakos V, Van de Koppel J, Van de Leemput IA, Levin SA, Van Nes EH, Pascual M, 2012. Anticipating critical transitions. *Science* 338(6105): 344-348.

Steffen W, Rockström J, Richardson K, Lenton TM, Folke C, Liverman D, Summerhayes CP, Barnosky AD, Cornell SE, Crucifix M, Donges JF, Fetzer I, Lade SJ, Scheffer M, Winkelmann R, Schellnhuber JS. 2018. Trajectories of the Earth system in the Anthropocene. *Proceedings of the National Academy of Sciences* 115: 8252-8259.

Turnbull MH, Pharis RP, Kurepin LV, Sarfati M, Mander LN, Kelly D. 2011. Flowering in snow tussock (*Chionochloa* spp.) is influenced by temperature and hormonal cues. *Functional Plant Biology* 39(1): 38-50.

United Nations. 2015. *Sustainable Development Goals*. Retrieved from https://sdgs.un.org/goals (6 October 2022).

van Dam-Bates P, Gansell O, Robertson B. 2018. Using balanced acceptance sampling as a master sample for environmental surveys. *Methods in Ecology and Evolution* 9: 1718–1726.

Wilkinson MD, Dumontier M, Aalbersberg IJ, Appleton G, Axton M, Baak A, Blomberg N, Boiten JW, da Silva Santos LB, Bourne PE, Bouwman J, Brookes AJ, Clark T, Crosas M, Dillo I, Dumon O, Edmunds S, Evelo CT, Finkers R, Gonzalez-Beltran A, Gray AJ, Groth P, Goble C, Grethe JS, Heringa J, 't Hoen PA, Hooft R, Kuhn T, Kok R, Kok J, Lusher SJ, Martone ME, Mons A, Packer AL, Persson B, Rocca-Serra P, Roos M, van Schaik R, Sansone SA, Schultes E, Sengstag T, Slater T, Strawn G, Swertz MA, Thompson M, van der Lei J, van Mulligen E, Velterop J, Waagmeester A, Wittenburg P, Wolstencroft K, Zhao J, Mons B. 2016. The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data* 3: 160018. Erratum in: *Scientific Data* 2019 6:6.