An ecosystem services approach to choosing environmental indicators for state of environment reports

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State of environment (SOE) reports aim to give people a summary of the environment through indicators. When an SOE report is associated with specific environmental goals, it is straightforward to develop indicators from the goals. However, it is difficult when there are no specific goals. We explore the use of an ecosystem services framework to develop a general set of indicators for the land/water environment by considering a full range of benefits humans gain from the environment. This analysis shows that the national SOE report, Environment Aotearoa, is missing many indicators required for a broader picture. Many of the missing impact indicators relate to human health and are highly relevant. Our sparse networks of data collection reflect the low population of New Zealand and the limited resources that can be reasonably applied to data collection. An encouraging area of improvement is the use of more targeted indicators developed from the ground up in collaboration with stakeholders. While the analysis presented here is focussed on New Zealand, other countries are also data-sparse and face similar issues, and would benefit from a gap analysis of environmental indicators based on ecosystem services.

Introduction

State of environment (SOE) reports aim to give people an objective summary of their environment. It is implicit that there will be a response to SOE reports if a negative trend or a poor condition is reported. If not, then the reports would have no purpose. Therefore, SOE reports are effectively part of an adaptive management cycle (Environment Foundation 2019), where environmental goals are monitored through the report, and management is adapted to ensure progress towards the goals (Fig 1). (Adaptive management is defined in the EEZ act.) For example, in the New Zealand Resource Management Act 1991 (section 35), local authorities are legally required to monitor the state of their environment in order to carry out effectively their functions of sustainably managing natural resources, which is the environmental goal.

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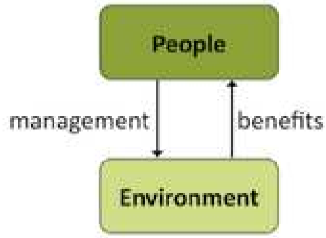
Figure 1. State of environment reporting helps people manage the environment to maintain or enhance its benefits.



State of environment reports usually have indicators, or measures, of important aspects of the environment. When an SOE report is associated with specific environmental goals, the important aspects may be inferred directly from the goals and it is straightforward to develop indicators. However, when there are no specific goals, it is more difficult to develop indicators (Garrett *et al.* 2016). So how does one go about designing a general set of indicators for an SOE report? An anthropocentric view, as in Fig 1, suggests there should be indicators of those environmental aspects that relate to human benefits. In other words, the indicators should follow the benefits or those aspects of the environment that closely relate to or control the benefits. A list of the benefits would therefore suggest a list of indicators.

The New Zealand national SOE report, Environment Aotearoa (Ministry for the Environment and Statistics New Zealand 2015), recognised this partly in the pressure-state-impact (PSI) framework prescribed by the Environmental Reporting Act (2015). Since Environment Aotearoa 2015, individual domain reports have been produced for marine, atmosphere and climate, freshwater, and land (Ministry for the Environment and Statistics New Zealand 2016, 2017a, 2017b, 2018)), and an air domain

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report was produced prior to Environment Aotearoa 2015 (Ministry for the Environment and Statistics New Zealand 2014). Environment Aotearoa 2019 has just been released (Ministry for the Environment and Statistics New Zealand 2019). Pressures explain the human activities and natural factors that influence the environment. State indicators describe the biophysical condition of the environment. The impact indicators measure the impact that state indicators have on environmental benefits to people. In this way, relative importance can be attached to trends detected in the state indicators, and more appropriate and prioritised responses made. Categories of impacts are listed at a high level in the Act: public health, economy, culture and recreation, te ao Māori, and ecological integrity. However, it is not clear which specific indicators would satisfy the need to monitor those impact categories. Currently a technical advisory group recommends indicators to the Government Statistician who assesses them for use on the basis of six criteria (Ministry for the Environment 2016b), however there are no explicit criteria for guiding choice of indicators by the technical advisory group.

Rather than listing specific indicators in the Act, a process for defining topics is described. The Minister of the Environment and the Minister of Statistics set the topics through regulation after consultation with the Government Statistician, the Parliamentary Commissioner for the Environment, the public, iwi authorities, and local authorities. These topics need to satisfy several requirements, including affecting significant areas, resources or numbers of people, and are measurable. This process, while increasing buy-in from the community, through consultation, may be susceptible to disputes among pressure groups with different values.

Is there an objective way to develop a list of indicators that cover all aspects of the environment and closely relate to the benefits that the environment provides for people? Certainly there are explicit frameworks of benefits or services. The ecosystem services approach makes explicit the link between environment and human well-being (Millennium Ecosystem Assessment 2005). It has a detailed breakdown of benefits into categories of "ecosystem services" from each ecosystem in the area of interest. The services form a hierarchy, with provisioning, regulating, cultural, and supporting services at the top level, and increasing detail at the lower level. Dymond *et al.* (2015) presented a synopsis of New Zealand ecosystem services with analysis of their conditions and trends based on an extensive review from more than 100 New Zealand scientists (Dymond 2013), while Harmsworth and Awatere (2013) adapted the ecosystem services principles into a Māori framework.

The more recent Intergovernmental Platform on Biodiversity and Ecosystem Services (Diaz *et al.* 2015), initiated in 2012 to enhance global science policy, set a broader conceptual framework built on ecosystem services principles within diverse cultures. The conceptual framework included elements of PSI with drivers (such as population and land use), nature's contributions to people, and good quality of life. Thematic assessments for pollination, land degradation and restoration have been produced for four global regions (https://www.ipbes.net/document-library-categories/assessment-reports-and-outputs). These are all broad scale assessments, although some relevant information for New Zealand is included in the Asia-Pacific regional assessment (IPBES, 2018).

In this paper, we explore the use of the ecosystem services framework to develop objectively environmental indicators for the land domain of a national SOE report. For each broad ecosystem, the major ecosystem services are considered, and a set of pressures, states, and impacts derived. From these, explicit indicators are derived and then compared with those reported in Environment Aotearoa and subsequent domain reports. We discuss the difference between the two, and the implied requisite enhancements to Environment Aotearoa, from a science perspective (Petrie (2018) took a policy perspective). We also discuss implications of this approach to other environmental reporting systems in New Zealand.

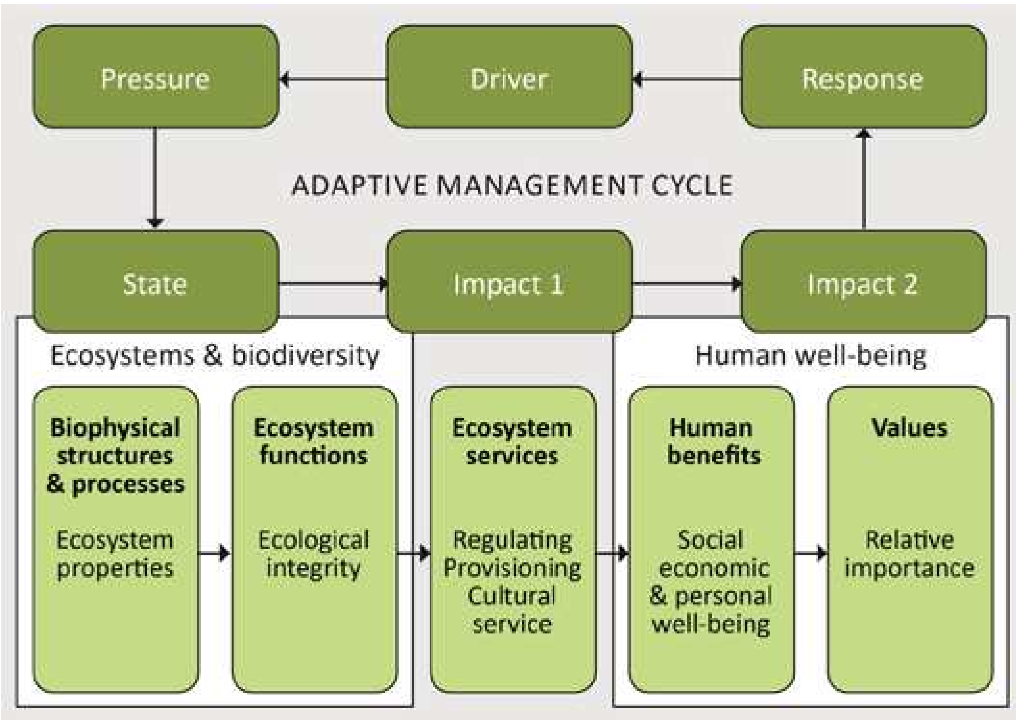

Figure 2. Relationship between pressure-state-impact and ecosystem services framework (Muller & Burkhard 2012).

Indicators of pressures, states, and impacts in ecosystems

The Driver-Pressure-State-Impact-Response (DPSIR) framework has been used for environmental reporting to describe causal links between elements of the broad environmental system (Müller & Burkhard 2012). The ecosystem services approach can easily fit into the DPSIR framework (see Fig 2). Pressure represents the elements (either anthropogenic or natural) that are affecting the state of ecosystems and can be either positive or negative (Ministry for the Environment 2014). State represents the natural capital stocks of ecosystems and biodiversity, characterised by their area and condition. Impacts are then two-fold: on ecosystem services (regulating, provisioning and cultural), and on human well-being (social, economic, personal).

The methodology we used separates major ecosystems into broad categories: including urban, pasture, cropping, orchard, exotic forest, indigenous forest, shrublands, grassland, alpine shrublands, rare ecosystems and wetlands (Harmsworth and Awatere 2013). The Ministry for the Environment (MfE) adopted the pressure-state-impact (PSI) framework, omitting drivers (D) and responses (R) on purpose to maintain political neutrality.

Table 1 tabulates the major pressures, states, and impacts for each ecosystem as essentially described in a national assessment of ecosystem services (Dymond 2013). The ecosystem classification follows that of Harmsworth and Awatere (2013). Table 2 tabulates quantitative measures of the pressures, states, and impacts that could be used as indicators. The solid colour in Table 2 identifies where the indicator has actually been used in Environment Aotearoa reporting, or is readily available in a nationally based dataset.

Immediately obvious is the sparse population of Table 2 by indicators in Environment Aotearoa. There are a number of reasons behind the sparseness of Table 2 beyond the control of officials in Ministry for the Environment and Statistics New Zealand. The Environmental Reporting Act in section 14 stipulates that the Government Statistician must follow best practice principles and protocols and be satisfied that the statistics accurately represent the topic they purport to measure. This required statistical rigor has meant that some indicators have not come up to expectations in the eyes of the Government Statistician. For example, in the SOE report, Environment New Zealand 2007 (Ministry for the Environment, 2007), the number of contaminated sites (land) was previously reported by region, but is not reported in Environment Aotearoa, even though an updated national dataset existed. This was due to the lack of consistency of reporting between regions as required by the high statistical rigor.

High statistical rigour gives more surety about trends, and should reduce arguments over whether trends show improvements or not (Radio New Zealand 2014). However, it also means that much information pertinent to understanding the full state of the environment is not considered. The Parliamentary Commissioner for the Environment (PCE 2016), in exercising her discretion under section 18 of the Environmental Reporting Act, reviewed Environment Aotearoa 2015 and commented that a national SOE report should be a set of coherent "stories" about different issues. Stories, of course, require complete narratives, and the concept flies in the face of the requirement for statistical rigor which rejects parts of the story. Following Environment Aotearoa 2015 and the PCE commentary, MfE has included more storylines in subsequent domain reports, by using body of evidence and case study information from scientific literature, and by establishing Technical Advisory Groups to inform MfE of recent research findings. In doing so, the Land domain report 2018 (Ministry for the Environment, 2018) highlighted the significant data gaps impeding reporting. These included gaps in scientific knowledge (understanding of processes and causal links between pressure and state), gaps in spatial coverage and trends over time (e.g. land use, soil health), and gaps on impacts on social, cultural and economic wellbeing.

Table 2 is sparse also because of the great effort required in gathering data. Section 11 of the Environmental Reporting Act relieves the Secretary for the Environment and Government Statistician of having to collect data where it cannot be obtained by using reasonable efforts. Unfortunately, much of the data required to populate Table 2 would require extraordinary efforts. For example, the pressure indicator "Area of cultivated land" in the cropping ecosystem is currently determined by the Agricultural Production Survey that is non-spatial and constrained to commercial-scale farms. Some spatial information is available but requires licensing, which is against the principles of publicly publishing any reporting data. Another method for determining cultivated land from publicly available data sources could be from sequential satellite imagery (North *et al.* 2015). However, the effort required setting up new systems to automatically identify the cultivated land and report at appropriate time and space scales is significant and currently well beyond that judged reasonable.

Many of the missing desired impact indicators relate to human health and are highly relevant. For example, in the urban ecosystem it would be desirable to know how many illnesses relate to freshwater contaminated by untreated sewerage. To capture a fuller understanding of the issue it would also be desirable to measure the annual volume of contaminated water in the district and also the toxicity of the receiving water. These indicators are missing because data collection is absent. Our sparse networks of science data collection reflect the low population of New Zealand and the resources that can be reasonably applied to data collection.

Discussion

Is it likely that the missing indicators in Table 2 will be included in future SOE reports? Even though data for many indicators already existed elsewhere in national databases, the cost of re-analysis and representation is high to meet statistical robustness and suitability for public consumption. The exact cost is difficult to estimate, but is likely to be tens of millions of dollars and may be stretching the taxpayer's perspective of reasonable effort. It looks unlikely, therefore, that many more of the missing indicators will appear in the near future, as it would take years to fill the gaps. What does that mean in the short to medium term if we are unable to get a comprehensive look at our environment and adapt our management for our own benefit?

Let us not allow to pass unchallenged the contention that Environment Aotearoa is the sole reliable source of environmental data. Indeed, there is much environmental monitoring in the land/water space at local scales (Garrett *et al.* 2016). There are many successful local projects where communities are involved with setting goals and indicators. In the Canterbury region, water zone committees, comprising sector representatives, local body representatives, and technical staff from the regional

Table 1. Pressures, states, and impacts in the major land ecosystems in New Zealand.

Ecosystem	*Pressure_1*	*Pressure_2*	*State*	*Impact*
Urban	Waste treatment		Contaminated land	Human health risk, loss of land utility
	Waste production		Land fill	Human health risk, loss of land utility
	Air pollution		Particulates in air	Low air quality
	Sewerage treatment		Contaminated discharge	Low water quality
	Urban runoff		Contaminated discharge	Low water quality
	Urbanisation		Productive land	Loss of utility value
	Weeds/pests		Weed spread, pest invasion	Habitat loss, reduced productivity
Pasture	Animal grazing	Nitrate leaching	Nitrate in waterways	Low water quality
		Fertiliser loss	Dissolved N and P in waterways	Low water quality
		Egestion	E. coli in waterways	Low water quality
		Soil treading	Soil compaction	Reduced productivity
		Treading of riverbanks	Soil erosion	Low water quality, sedimentation of waterways
	Land use change	Forest clearance	Soil erosion	Low water quality, reduced productivity, sedimentation
	Waste treatment		Contaminated land	Human health risk, loss of land utility
	Weeds/pests		Weed spread, pest invasion	Habitat loss, reduced productivity
Cropping	Cropping	Fertiliser loss	Dissolved N and P in waterways	Low water quality
		Cultivation/harvesting	Soil compaction, disturbance, and erosion	Reduced productivity
		Weed control	Herbicides in environment	Lower human health
		Pest control	Pesticides in environment	Lower human health
	Weeds/pests		Weed spread, pest invasion	Habitat loss, reduced productivity
Orchard	Horticulture	Fertiliser loss	Dissolved N and P in waterways	Low water quality
		Weed control	Herbicides in environment	Lower human health
		Pest control	Pesticides in environment	Lower human health
	Weeds/pests		Weed spread, pest invasion	Habitat loss, reduced productivity
Exotic forest	Forestry	Harvesting	Soil compaction, disturbance and erosion.	Reduced productivity
		Weed control	Herbicides in environment	Lower human health
		Pest control	Pesticides in environment	Lower human health
	Land use change	Forest clearance	Soil erosion	Low water quality, reduced productivity, sedimentation
	Waste treatment		Contaminated land	Human health risk, loss of land utility
	Weeds/pests		Weed spread, pest invasion	Habitat loss, reduced productivity

Table 1. Pressures, states, and impacts in the major land ecosystems in New Zealand (*continued*).

Indig. forest	Deforestation	Habitat loss	Reduced biodiversity
		Soil erosion, carbon loss.	Low water quality, climate change
	Mineral extraction	Land disturbance	Reduced biodiversity, low water quality
	Gas extraction	Land disturbance	Reduced biodiversity, low water quality
	Weeds/pests	Degraded habitat	Reduced biodiversity, reduced amenity value
	Tourism	Degraded habitat	Reduced biodiversity, reduced amenity value
Shrublands	Clearance	Habitat loss	Reduced biodiversity
		Soil erosion, carbon loss.	Low water quality, climate change
	Mineral extraction	Land disturbance	Reduced biodiversity, low water quality
	Gas extraction	Land disturbance	Reduced biodiversity, low water quality
	Weeds/pests	Degraded habitat	Reduced biodiversity, reduced amenity value
	Tourism	Degraded habitat	Reduced biodiversity, reduced amenity value
	Excess honey collection	Reduced nectar supply	Reduced biodiversity
Grassland	Conversion to pasture	Habitat loss	Reduced biodiversity, reduced amenity value
	Mineral extraction	Land disturbance	Reduced biodiversity, low water quality
	Gas extraction	Land disturbance	Reduced biodiversity, low water quality
	Weeds/pests	Degraded habitat	Reduced biodiversity, reduced amenity value
	Tourism	Degraded habitat	Reduced biodiversity, reduced amenity value
	Excess animal grazing	Land degradation	Reduced productivity, biodiversity, amentiy value
Alpine shrubland	Weeds/pests	Degraded habitat	Reduced biodiversity, reduced amenity value
	Tourism	Degraded habitat	Reduced biodiversity, reduced amenity value
Rare ecosystems	Land use	Habitat loss	Reduced biodiversity
	Weeds/pests	Degraded habitat	Reduced biodiversity
Wetlands	Drainage	Habitat loss	Reduced biodiversity, water reg. ,wild food, amenity
	Nutrient /sediment runoff	Wetland degradation	Reduced biodiversity, wild food, amenity value
	Weeds/pests	Degraded habitat	Reduced biodiversity, amenity value

Table 2. Indicators of pressures, states, and impacts in the major land ecosystems in New Zealand.*

Ecosystem	*Desired pressure indicator*	*Desired state indicator*	*Desired impact indicator*
Urban	No. of contaminated sites in district	No. of unmanaged sites per district	No. of related illnesses per district
	Waste to landfills in district, population in district	% of waste effectively managed	No. of related illnesses per district, land area of un-utilisable land
	Annual burning pressure (t/yr) in district	Seasonal average particulate concentrations	No. of related illnesses per district
	Annual volume of untreated sewerage in district	Toxicity of water	No. of related illnesses per district
	Annual volume of contaminated discharge in district	Toxicity of water	No. of related illnesses per district
	Population in region	Area of utilisable high class land	% of high class land under lifestyle and urban
	List of noxious weeds/pests in district	Area of parks and gardens free of noxious weeds/pests	Cost of noxious weeds in district
Pasture	Animals in region	Annual nitrate load in region	Average nitrate concentration in water at selected sites
	Fertiliser use in region	Annual total P load in region	Average total-P concentration in water at selected sites
	Cattle in region with access to waterways	Annual total E. coli load in region	Median *E. coli* concentration in water at selected sites
	Cattle in region with access to waterways	Length of eroded riverbanks (region)	Sediment load to rivers from banks in region
	Cattle on soils at risk of compaction (per region)	Area of compacted soils, % of compacted soils	Gross regional agricultural production
	Forest clearance in region	Area of land at risk of erosion (region)	Sediment load to rivers in region, average soil erosion in region
	No. of contaminated sites in region	No. of unmanaged sites per region	No. of related illnesses per region
	List of noxious weeds/pests in region	Area of infestation per weed/pest (region)	Area free of weeds and pests (natural and managed)
Cropping	Fertiliser use in region	Contribution to annual total P load in region	Average total-P concentration in water at selected sites
	Area of land cultivated in region	Proportion of soils not meeting target	Gross output per hectare in region
	Mass of herbicide sprayed per year in region	Herbicide concentration in environment	No. of related illnesses per region
	Mass of pesticides sprayed per year in region	Pesticide concentration in environment	No. of related illnesses per region
	List of noxious weeds/pest for cropping in region	Area of infestation per weed/pest (region)	Proportion of cropping land free of weeds/pests
Orchard	Fertiliser use in region	Contribution to annual total P load in region	Average total-P concentration in water at selected sites
	Mass of herbicide sprayed per year in region	Herbicide concentration in environment	No. of related illnesses per region
	Mass of pesticides sprayed per year in region	Pesticide concentration in environment	No. of related illnesses per region
	List of noxious weed/pests for horticulture in region	Area of infestation per weed/pest (region)	Proportion of horticulture land free of weeds/pests in region
Exotic forest	Harvested area	Proportion of soils not meeting target, average soil erosion, carbon stocks	Gross output per hectare in region, contribution to sediment load
	Mass of herbicide sprayed per year in region	Herbicide concentration in environment	No. of related illnesses per region
	Mass of pesticides sprayed per year in region	Pesticide concentration in environment	No. of related illnesses per region
	Forest clearance in region	Area of land at risk of erosion (region)	Sediment load to rivers in region, average soil erosion in region
	Land area of waste treatment (district)	Area of ineffective waste treatment (district)	No. of related illnesses per district
	List of noxious weeds/pests for forestry in region	Area of infestation per weed/pest (region)	Proportion of forestry free of weeds/pests (region)

Table 2. Indicators of pressures, states, and impacts in the major land ecosystems in New Zealand (*continued*).

Indig. forest	Area of forest cleared	Number of threatened land environments	Conservation status of indigenous species
		Area of land at risk of erosion (region), carbon stocks	Sediment load to rivers in region, average soil erosion in region
	Area of mining activity	Area of disturbed land	No. of threatened rare environments
	Area of gas extraction	Area of disturbed land	No. of threatened rare environments
	List of noxious weeds/pests in region	Area of infestation per weed/pest (region)	Area free of weeds and pests
	Visitor numbers	Area impacted by visitors	Amenity value
Shrublands	Area of shrubland cleared	Number of threatened land environments	Conservation status of indigenous species
		Area of land at risk of erosion (region)	Sediment load to rivers in region, average soil erosion in region
	Area of mining activity	Area of disturbed land	No. of threatened rare environments
	Area of gas extraction	Area of disturbed land	No. of threatened rare environments
	List of noxious weeds/pests in region	Area of infestation per weed/pest (region)	Area free of weeds and pests
	Visitor numbers	Area impacted by visitors	Amenity value
	Honey bee hive numbers in shrublands	Floral resources available for indigenous species	Conservation status of indigenous species
Grassland	Area of tussock grassland converted	No. of threatened land environments	Conservation status of indigenous species
	Area of mining activity	Area of disturbed land	No. of threatened rare environments
	Area of gas extraction	Area of disturbed land	No. of threatened rare environments
	List of noxious weeds/pests in region	Area of infestation per weed/pest (region)	Area free of weeds and pests
	Visitor numbers	Area impacted by visitors	Amenity value
	Animal stocking rates	Area of degraded land	Productivity, amenity value
Alpine shrubland	List of noxious weeds/pests in region	Area of infestation per weed/pest (region)	Area free of weeds and pests
	Visitor numbers	Area impacted by visitors	Amenity value
Rare ecosystems	Area of land use intensification/change	No. of threatened rare environments	Conservation status of indigenous species
	List of noxious weeds/pests in rare environments	No. of threatened rare environments	Conservation status of indigenous species
Wetlands	Area of wetlands drained	Proportion of wetlands remaining	Cons. status of indigenous species, amenity value, wild food harvest
	Nutrient/sediment discharge to wetlands	Condition of wetlands	Cons. status of indigenous species, amenity value, wild food harvest
	List of noxious weeds/pests in wetlands	Condition of wetlands	Cons. status of indigenous species

*A solid colour identifies where the indicator has actually been used in Environment Aotearoa reporting, or is readily available in a nationally based dataset. No colour identifies indicators not used in Environment Aotearoa, because complete data is unavailable. Shaded cells have some body of evidence but no indicator.

council, have been set up to develop water management plans. This initiative has followed the recommendations of the Land and Water Forum (2015), which has promoted collaborative processes involving community and stakeholders for managing water, a bottom-up approach within nationally set frameworks. Such initiatives are supported by monitoring information presented by Land Air Water Aotearoa (2016), which is a web site, organised primarily by regional and district councils, for giving information on land, air, and water quality.

The New Zealand Sustainability Dashboard (http://www.nzdashboard.org.nz/) has developed processes for primary production sectors to assess sustainability. The process is driven by the producers/farmers to achieve sustainability goals both for individual producers and for sectors as a whole after upscaling to regional and national scales. Case studies involve wine, kiwifruit, forestry, and organic sectors. This is another example of a bottom-up approach to the national sector scale, which has strong buy-in from users because of collaborative processes with stakeholders. Another example is the Waikato River Report Card (Waikato River Authority 2016), which summarises progress towards goals of Ture Whaimana o Te Awa o Waikato. Development of the report card engaged local community and provides accountability for restorative actions in the Waikato catchment. It synthesises complex information at local scales into simple key messages for the whole catchment. Further notable projects include the Wheel of Water Project (2016) on balancing water quality and quantity and the Montreal Process for the development of indicators for sustainable forestry (Ministry for Primary Industries 2015).

There are many local body SOE reports: Environment Canterbury 2008; Greater Wellington Regional Council 2013; Waikato District Council 2013; Bay of Plenty Regional Council 2014; Horizons Regional Council 2013. These reports are comprehensive, covering land, water, air, biodiversity, pests, and hazards. Yet much of this data does not make its way up to the national scale because of inconsistencies between regions. This has been recognised, so the Environmental Monitoring and Reporting project (EMaR) has been set up to provide support to regional councils to standardise methods and sharing of data collection through initiatives such as the National Environmental Monitoring Standards (NEMS). The goal of EMaR is to ensure that the efforts in compiling regional data will inform national SOE reporting.

Much is indeed being done at the local scale, but not consistently throughout the country. This inconsistency creates difficulties for Environment Aotearoa with its emphasis on statistical robustness rather than storyline, causing it to miss many important indicators in Table 2. A reporting system that includes all the local stories rather than excluding them is necessary to ensure a link between bottom–up and top–down approaches. Some New Zealand studies have already done this. The Waikato River Report Card shows how a hierarchy of data can be integrated up to simple scores at the top reporting level. Where data are missing, expert judgement is used so that integration may proceed. While simple scores are presented at the top level, the full hierarchy of data is retained and may be interrogated at any level. A recent scoping study for MfE on Te Ao Māori environmental indicators suggested that case studies, narratives, and commentaries are an important part of environmental reporting (Scheele *et al*. 2016). This is also one of the recommendations coming from the research community. A think-piece commissioned by Our land and Water, the National Science Challenge, highlighted the benefits of co-innovation for development of land and water indicators (Garrett *et al*. 2016). It concluded that success of bottom–up approaches depend on collaboration and co-innovation. Our Land and Water has initiated a working group examining the development of indicators, considering the history of indicator frameworks already developed in New Zealand in order to produce a cohesive set of land and water indicators for multiple stakeholders.

Environment Aotearoa is constrained by the Environmental Reporting Act to ensure statistical robustness. As a result, many indicators are not being covered and complete stories are not being told. Even with more comprehensive coverage of pressure, state, and impact indicators in Table 2, the full story may still not be covered. Niemeijer and de Groot (2008) advocated the DPSIR framework to provide a better context in which to plan appropriate responses. So at the national scale it appears that we need more and more indicators, which come at a greater cost than that deemed "reasonable" by the Environmental Reporting Act. The solution is to build indicators from the ground up in collaboration with stakeholders to ensure buy-in at the start (Garrett *et al*. 2016). Dymond et al. (2001) called this strategic monitoring, whereby environmental goals are monitored. While National Science Challenges are working towards this goal, there is a long way to go before a comprehensive picture of our land and water environment can be drawn. While the analysis presented here has focussed on New Zealand, other countries are also data-sparse and face similar issues (Geijzendorffer *et al*. 2015; Heink *et al*. 2016), and would benefit from a gap analysis of environmental indicators based on ecosystem services.

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