Accounting for Nature

A scientific method for constructing environmental asset condition accounts

Wentworth Group of Concerned Scientists

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Sydney, Australia

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Accounting for Nature builds biophysical accounts using a common unit of measure (an *Econd)* that describes the condition of any environmental asset (native vegetation, soil, rivers, fauna, estuaries, etc), at any scale.

The common unit of measure enables scientific information to be placed into an accounting framework to link environmental management and economic decisions.

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"Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth." [1]

– Millennium Assessment, 2005

Why does the latest speculation on a 0.25 per cent change in interest rates receive lead coverage in our daily press, yet the most comprehensive assessment of the health of the world's ecosystems ever undertaken by science was largely ignored?[1]

Why was the Auditor General unable to make an informed judgment as to the progress towards either long-term or even intermediate outcomes on a $5 billion program attempting to redress the "*radically altered and degraded Australian landscape*"?[2]

In 1934 in the aftermath of the great depression, US economist Simon Kuznets developed a concept for measuring a nation's economy: the Gross Domestic Product (GDP). Initially used by nation states to inform policies and identify expenditure choices, GDP has evolved as a key measure of the performance of national economies worldwide.

Fast forward 80 years to a period where, according to the OECD, the massive increase in the consumption of materials and energy that has accompanied economic growth over the past century is now driving the depletion of the world's natural capital at scales that in many cases risk irreversible changes that could endanger two centuries of rising living standards.[3]

In a world with readily available market measures of things like jobs, exports, and income, the lack of an accepted measure of the condition of the nation's environmental assets has led to a significant imbalance in public policy.

If it is not measured, it cannot be managed.

This imbalance is highlighted in the Australian Treasury's Intergenerational Reports, which provide detailed information on trends in GDP, employment, population change, health, education and other economic and social statistics, yet have few comparable measures of the condition of environmental assets.

Central to the success of GDP is its ability to simplify complex economic information (things like consumption, investment, income, exports and imports) into a single metric. This metric can describe the economic health of any nation, large or small, and be used to track trends through time.

The production of GDP and other measures of economic performance is dependent on three things: a common unit of measure of economic activity (financial currencies), a system of accounts for recording economic transactions (the System of National Accounts), and the practical ability to collect this information across the economy.

In 2008, the Wentworth Group of Concerned Scientists and other experts in science, economics and statistics, applied an analogous conceptual framework to produce a practical and robust method to measure changes in the biophysical condition of environmental assets.[4]

Accounting for Nature uses the science of reference condition benchmarking to create a common unit of measure for building sets of biophysical accounts that are capable of describing the condition of any environmental asset (native vegetation, soil, rivers, fauna, estuaries, etc.), at any scale. The common measure, an *Econd,* is an index between 0 and 100, where 100 describes an environmental asset in an undegraded state.[5]

Over the past five years, Australia's Regional Natural Resource Management authorities, in cooperation with scientists, economists and statisticians in universities and Commonwealth and state government agencies, have conducted a continental scale trial to test the practical application of the *Accounting for Nature* model.[6]

This trial has made significant progress in demonstrating that it is now practical to establish a robust and on-going national program to measure the condition of Australia's environmental assets.[7]

The benefits of the *Accounting for Nature* model are:

1. The ability to measure success or otherwise of public investments (Commonwealth, state, territory, regional and local government) in natural resource management;
2. Increased efficiency of expenditures through better targeting of investments;
3. An increasingly informed community, leading to less conflict and enhanced community effort;
4. A cost effective pathway for industry, farmers and other land managers to demonstrate the sustainability of their business practices; and
5. The information that is needed for society to adapt as climate change imposes its footprint across the landscape.

This paper updates the 2008 *Accounting for Nature* model based on the practical experience of the Australian trial.

It describes the method for constructing an environmental asset condition account; demonstrates the opportunities for improving policy and investment decisions; and suggests institutional arrangements for a long-term program to construct annual, regional scale, national environmental accounts.

In the long run, a prosperous society depends on a healthy environment.

Every good business keeps track of its assets. Natural capital is a core asset on the balance sheet. It is true for an individual business. It is also true for the nation.[8]

The value of natural capital

"The first step towards the integration of sustainability into economic development is the... measurement of the crucial role of the environment as a source of natural capital and as a sink for by-products generated during the production of man-made capital and other human activities." [9]

– Rio Earth Summit, 1992

The natural environment matters because it affects the wellbeing of people directly, and because it underpins other things that people value.

Economists define wellbeing in terms of the total stock of capital – human, physical, social and natural – that is maintained or enhanced for current and future generations. It relates to all aspects of life, and encompasses much more than simple measures of economic activity.[10]

Economic growth over the past century has led to unprecedented advances in human, physical and social capital, for many people and for many nations.

The massive increase in the consumption of materials and energy that has accompanied this growth is also driving the depletion of the world's natural capital; polluting the atmosphere and degrading land, water and biodiversity assets, at scales that in many cases risk irreversible changes that could endanger two centuries of rising living standards (Figure 1).[3]

In the 2016 World Economic Forum's Global Risk Survey the top four long-term global risks of highest concern to business were environment related. They rated biodiversity loss and ecosystem collapse, water and food crises, extreme weather events, and a failure of climate change adaptation and mitigation, as major risks facing the world.[11]

Natural capital is the stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.[12]

Natural capital is degraded when these environmental assets lose their capacity to provide ecosystem services, now and in the future.

A sustainable society can create wealth without degrading its natural capital by using energy and materials more efficiently, and by ensuring that environmental assets maintain or enhance their capacity to provide these goods and services into the future.

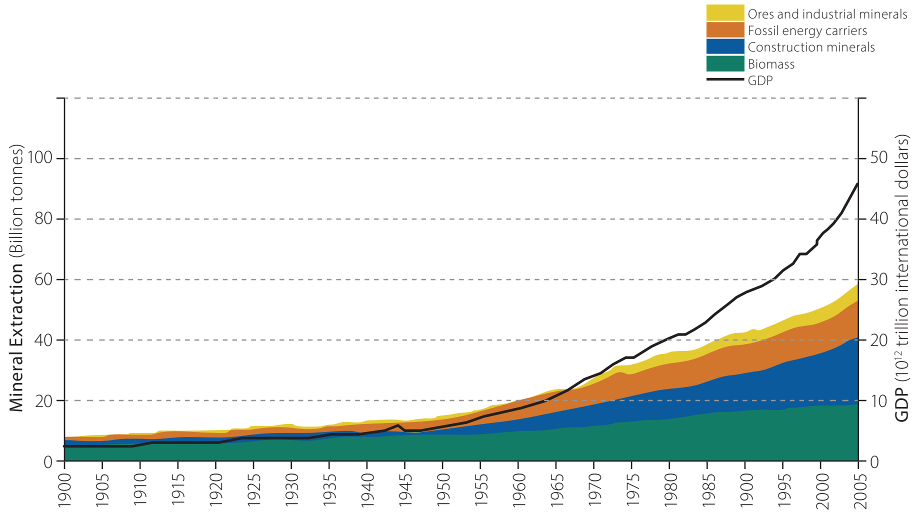


Figure 1: Global GDP and Global Material Extraction, 1900–2005.[13]

Managing a sustainable economy requires an ability to measure the quantity of natural resources to understand how efficiently these resources are being used, and how economic activity affects the stocks of those assets.

It also requires an ability to measure the impact human activity is having on the biophysical condition of those environmental assets from which these resources are extracted and wastes are deposited (Figure 2).

The Twin Pillars of Sustainable Development

A sustainable society creates wealth without degrading its natural capital, by:

1. Using energy and materials more efficiently; and
2. Ensuring that environmental assets maintain or enhance their capacity to provide goods and services that are valued by people today, and into the future.

Figure 2: The twin pillars of sustainable development.

In 1992, the United Nations Conference on Environment and Development (the Rio Earth Summit) took a major step forward in grappling with the challenges of sustainable development.

One outcome was an agreement that "the first step towards the integration of sustainability into economic management is the establishment of better measurement of the crucial role of the environment as a source of natural capital and as a sink for by-products generated during the production of man-made capital and other human activities."[9]

The United Nations Statistical Commission has taken up this challenge, and in 2012 formally adopted the international *System of Environmental Economic Accounting* (SEEA).[15, 16] Its purpose is to provide an agreed conceptual framework for understanding the interactions between the economy and the environment, and for describing stocks and changes in stocks of environmental assets (Figure 3).

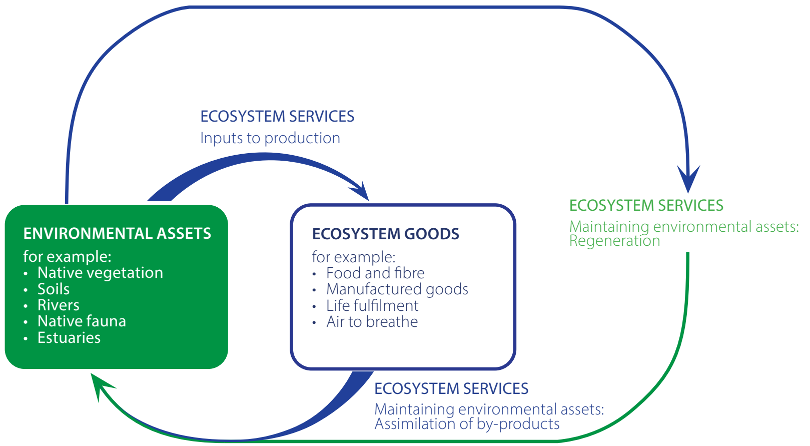


Figure 3: Environmental assets comprise ecosystems and other natural resources which provide goods and ecosystem services (adapted from CSIRO).[14]

The SEEA Central Framework employs the same accounting concepts and account structures as the *System of National Accounts* (SNA), with modifications to enable the quantity of stocks and flows of environmental assets (soil, vegetation, rivers, fauna, etc) to be presented in physical as well as financial units.[15]

The first pillar of sustainable development is for people to create greater value using less materials, less energy and with less impact on the environment.[10]

In 2016 the Australian Bureau of Statistics used this international standard to publish environmental-economic accounts that show changes in the efficiency in the use of some of Australia's natural resources. For example, Figure 4 shows decoupling of economic growth from greenhouse gas emissions, water and energy consumption between 1996-97 and 2013-14, while waste generation was closely coupled to economic growth.[17]

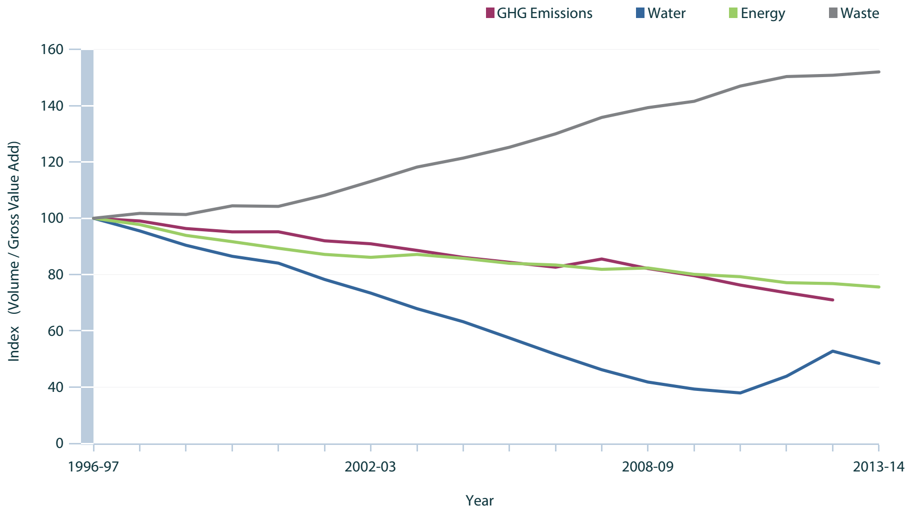


Figure 4: Change in the volume of greenhouse emissions, water and energy use and waste management per unit of Gross Value Add (GVA; used as a measure of economic growth) in Australia from 2013–14, relative to 1996–97 levels.[17]

The second pillar of sustainable development is to ensure that the stock of natural capital maintains or enhances its capacity to provide goods and services that are of value to society, now and into the future.

One aspect of the SEEA that has remained unresolved is the measurement of environmental degradation.[18] Degradation occurs when economic or other human activity inhibits the capacity of an environmental asset to generate the same range, quantity or quality of ecosystem services on an ongoing basis.[19]

The science to produce such information exists. What is missing is a practical, affordable and scientifically robust way of measuring the biophysical condition of environmental assets that underpin this natural capital at scales that can inform economic decisions.

Accounting for the condition of environmental assets

The role of science is not to determine which risks are worth taking, or deciding what choices we should take, but science must be involved in indicating what the choices, constraints and possibilities are.

– Adapted from Lord Robert May, Australian Scientist, former President of the Royal Society

The placement of scientific information into a common accounting framework represents a transformative shift in the business of environmental management, because it links environmental management and economic decisions:

- It simplifies complex scientific information to enable policy makers and the community to make more informed choices.
- It also enables the same information to be used to identify pressures driving change, to evaluate cost effective actions to manage those pressures, and then monitor the success of those investments over time.

Unlike the System of National Accounts which measures stocks and flows in monetary units, there is no agreed standardised unit for describing the biophysical condition of environmental assets.

Environmental assets are naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, that provide benefits to humanity.[20]

An environmental asset can be an ecosystem such as a forest, a river, or an estuary; a natural resource that contributes directly to economic activities such as a fish stock, agricultural soil, or a groundwater resource; it can be an individual species; or any other feature in nature.

Condition is a scientific measure of both the quantity and quality of an environmental asset (for example, the area of a forest and the diversity of plant and animal species that inhabit that forest).[21]

Accounting for Nature

In 2008, the Wentworth Group of Concerned Scientists and other experts sought to address this issue by developing the *Accounting for Nature* model which creates a common unit of measure (an *Econd)*, that can describe the condition of any environmental asset at any scale, and aggregate this information at different scales and for different assets.[4]

Accounting for the condition of environmental assets must address a number of challenges: no two environmental assets are the same; no single indicator can provide a complete picture of ecosystem health; often different indicators are needed to describe the same asset in different locations; and the cost of data collection creates variation in the quality of information collected.[5]

Accounting for Nature addresses these challenges by combining the science of reference condition benchmarking with a range of scientifically accredited sampling methods to create a common unit of measure. The common unit of measure is called an *Econd* – environmental condition index.

An *Econd* describes the condition of any environmental asset (river, soil, vegetation, fauna, estuary, etc.), at any scale, as an index between 0 and 100, where 100 is a measure of an asset in an undegraded state.

Key features of *Accounting for Nature*

1. Constructs an index to describe the condition of any environmental asset (an *Econd)*, using the science of reference benchmarking.
2. An *Econd* can be applied at any scale.
3. Tracks change in the condition of assets over time.
4. Uses an accounting framework to link the environment and the economy.
5. Indicators are accredited against national scientific and statistical standards.

Figure 5: Key features of the *Accounting for Nature* model.

Reference condition benchmarks provide the foundation for the common unit of measure. Reference condition is used extensively in the scientific literature to describe both terrestrial[22] and marine ecosystems.[23]

The benefit to environmental accounting is that reference condition benchmarking provides a common base from which to measure change, it can be applied across different assets and different landscapes, and it provides an historical context for interpreting the magnitude and direction of change.[24] It also allows for the use of different indicators to measure condition of the same asset in different ecological systems.

Reference condition is an estimate of an environmental asset in its undegraded (natural, pre-industrial or potential) state. It can be a measure at sites that are known to be in a natural condition (such as a river in the upper reaches of a catchment),[25] or a scientific estimate of an asset at a fixed point in time (for example, prior to industrial development).[26]

Each *Econd* is constructed by combining (where appropriate) scientifically accredited indicators (*Indicator Condition Scores*), which together provide a cost effective way of measuring the condition of an environmental asset.

National environmental accounting standards provide the scientific framework for the selection and combination of such indicators for each asset to best describe the characteristics of particular assets in particular locations. *Econds* are constructed using a seven step method (pages 9 to 12).

An *Econd* can be applied at any scale, and is therefore able to inform and monitor policy investment decisions at property, catchment and regional scales, and by all levels of government.

An *Econd* does not imply a monetary value, it does not describe a desired state, nor does it assess ecosystem services. What it does provide is biophysical information that is essential to interpreting the capacity of an environmental asset to provide those services.

For example, a coastal river might be capable of providing these services with an *Econd* of less than 100, if the water is safe to drink, it is safe for people to swim, it contains sufficient habitat for native species, and it does not pollute the estuary downstream.

The Australian regional trial

NRM Regions Australia (which represent Australia's 56 regional Natural Resource Management authorities), in cooperation with scientists, economists and statisticians in universities, Commonwealth and state government agencies, have conducted a continental wide trial to test the practical application of the *Accounting for Nature* model at a regional scale.

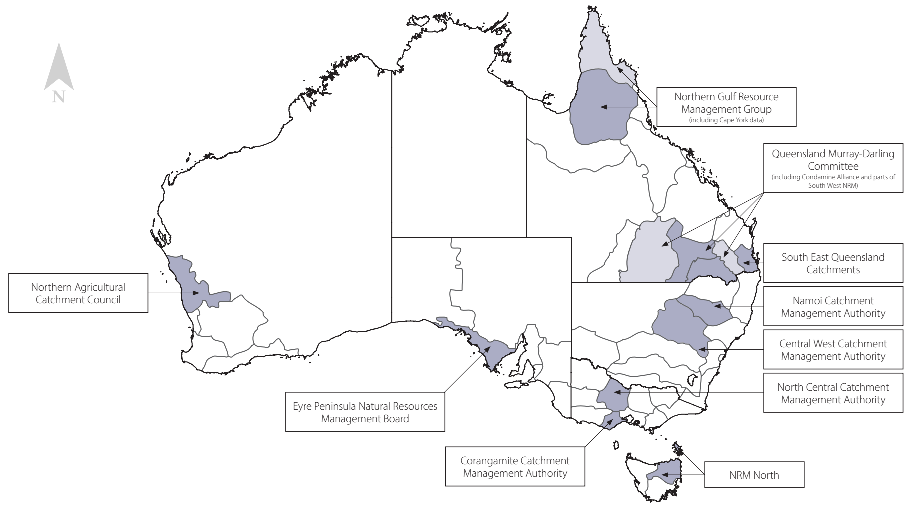


Figure 6: Ten regions participated in the Australian trial.

The trial was conducted over 5 years across ten geographically diverse regions, between 2011 and 2015 (Figure 6).[6] These regions reflect different landscapes (forests, savannahs, woodlands, urban), they are subject to different environmental pressures, and have different levels of resourcing and access to information.

NRM Regions Australia has identified approximately 35 environmental assets that are valued by regional communities.[27] Five assets are common to most regions: native vegetation in 80% of regions, rivers and wetlands in 70%, native fauna in 70%, soil in 50%, and estuaries in 90% of regions along the coast.

The trial produced examples of environmental asset condition accounts for each of these five assets.[6] One asset common to all regions (native vegetation) was chosen to determine whether different indicators can be used to describe the condition of the same asset in different regions, to enable regional scale information to be aggregated to create national accounts.

Asset condition accounting standards

Accounting for Nature requires an environmental asset condition account to be accredited by an appropriate scientific body against a set of agreed national environmental asset condition accounting standards.

The purpose of national standards is to ensure that the choice of indicators, the method of combining indicators, the frequency of data collection, and the selection of reference benchmarks, results in a measure of condition for each asset of sufficient quality to inform policy and investment decisions.

National standards are essential so that the community and policy makers have confidence that data contained in an account is relevant and sufficiently accurate to inform decisions. They are also essential to driving cost efficiencies in data collection so that information compiled at a property, local or regional scale can also be used to create state, territory and national accounts.

The creation of nationally compatible *Econds* will first require national standards for each environmental asset that set out the criteria for developing a consistent set of indicator themes, the methods for developing indicators that are sensitive to regional issues within those themes, and integrating and aggregating indicators.

National standards should be set out in *National Protocols* for each environmental asset. An example draft 'National Protocol for Constructing a Native Vegetation Asset Condition Account' was developed for the Australian regional trial.[28] It describes three components for measuring the condition of a native vegetation asset: the extent (the proportion the original vegetation that remains), the composition (the structural integrity of the vegetation, such as species richness or weediness), and the configuration (how the remaining vegetation is distributed across the landscape).

Data quality is likely to vary for different assets and in different locations. The national standards therefore assign a quality assurance rating for each asset to indicate how well data meet the standard (Figure 7). Ratings range between 0 and 5. A minimum rating of 1 is considered necessary for informing policy and investment decisions at the scale of the account (Figure 8).

An *Information Statement* is also required to accompany each account. The purpose of an *Information Statement* is to document the rationale behind selection of assets, choice of indicators, the origins of the data, the analysis and treatment of data, and the method of construction of the *Econds*.[29]

CRITERION 1: CLASSIFICATION OF ENVIRONMENTAL ASSETS
1.1. Does the account contain assets within the land/freshwater/marine asset class?
1.2. Do the selected assets meet the definition of an environmental asset?
1.3. Is the selected set of assets relevant for that region?
(a) Has the set of assets been determined in consultation with stakeholders and the community, and does it incorporate assets of state and national significance?
(b) Has the NRM governing body endorsed the set of assets as being consistent with the region's vision, goals and NRM priorities? (required at a minimum)
Overall measure: Extent to which the set of assets in the account is appropriate for that region.
CRITERION 2: SELECTION OF INDICATORS
2.1. Does the choice of indicators adequately satisfy the indicator principles? (Relevant, Simple, Sensitive, Measurable, Timely, Aggregative)
2.2. Does the set of indicators adequately describe the condition of the relevant asset?
Overall measure: Extent to which the selected indicators are suitable measures of environmental assets in the region.
CRITERION 3: ESTIMATING REFERENCE CONDITION
3.1 Do the methods for determining reference condition benchmarks comply with one of the standard methods, and are they the most appropriate methods?
Overall measure: Extent to which Reference Condition Benchmarks are correctly determined.

Figure 7: Sample of criteria for accrediting regional scale environmental asset condition accounts.

Indicators used for evaluating the condition of each asset and the frequency of data collection may vary from region to region and from indicator to indicator, provided they satisfy these nationally accredited accounting standards. This means that even where indicators are not identical, ensuring they satisfy appropriate scientific standards, there is a high level of confidence that the condition of assets can be compared between regions.[30]

The national standards can also be used to underpin environmental accounts constructed at property, catchment and conservation estate scales.

QUALITY ASSURANCE RATING	
5	Comprehensive
4	Substantial
3	Good
2	Reasonable
1	Acceptable
0	Not Accredited

Figure 8: Quality assurance ratings for environmental asset condition accounts.[6]

National Environmental Accounts

The purpose of the *System of Environmental Economic Accounts* (SEEA) is to present information to inform economic and policy decisions that result in the more efficient use of natural resources and the conservation of natural capital.[15]

The *Accounting for Nature* model is specifically aimed at producing a practical, affordable and scientifically robust way of measuring the biophysical condition of environmental assets (soil, native vegetation, rivers, fauna, estuaries) across a continent, and at scales that can inform such decisions.

National environmental asset condition accounts need to be assembled at a regional (landscape) scale, and be capable of being aggregated to create national environmental asset condition accounts. Regional (landscape) scale accounting is necessary to reflect the unique characteristics of different landscapes. It is also the scale to best inform policy and investment decisions. They also need to be produced annually to show trend.

Regional environmental accounts would describe the condition of environmental assets in five asset classes:

- Land (e.g.: native vegetation, soil, native fauna)
- Water (e.g.: rivers, groundwater, wetlands)
- Coasts (e.g.: estuaries, beaches)
- Marine (e.g.: fisheries, seagrass, reefs, marine fauna)
- Atmosphere (e.g.: air quality, greenhouse gas emissions)

The Australian Bureau of Statistics (ABS) is the official statistical agency of Commonwealth, state and territory governments. It is responsible for the nation's economic accounts. It should also manage the national environmental accounts. These annual accounts would also provide the information to contribute to the five yearly Intergenerational Reports (Figure 9).

The regional Australian trial was a pilot project to investigate the feasibility of developing a national system. It demonstrated potential for developing such a system. It also showed that more work is required to test the efficacy of scaling from regional to create state and national accounts.

The first step is the adoption of national asset condition accounting standards. It will also require a reallocation of existing research and monitoring programs to the collection of data to assess change in the asset condition between reporting periods.

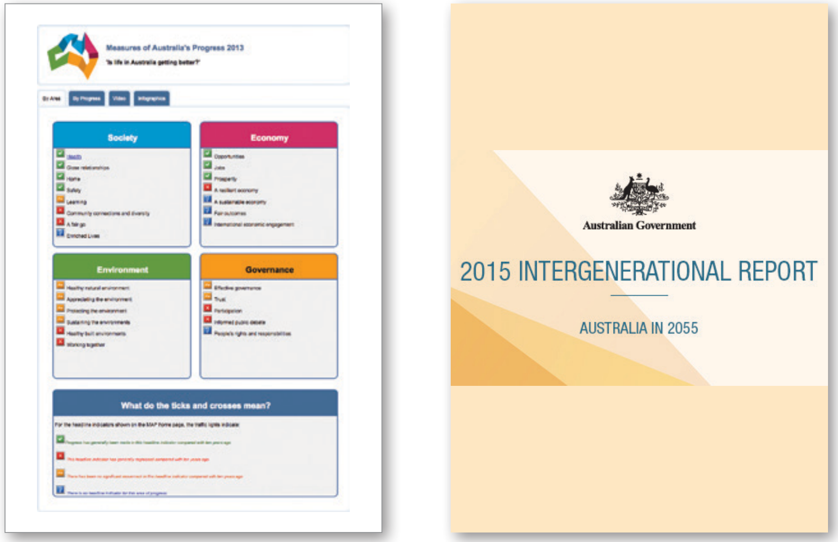


Figure 9: National Environmental Accounts can contribute to whole-of-government reporting processes.

A National Scientific Standards Council is required to advise the ABS on these scientific standards that will underpin environmental asset condition accounts. This body would also be responsible for recommending scientific accreditation of both national and regional environmental accounts.

The Commonwealth government can facilitate the creation of the *National Environmental Accounts of Australia* by overseeing the establishment of national environmental accounting standards, accrediting and auditing the reporting of information, and supporting regional natural resource management bodies to coordinate the assembly of regional accounts.

State and territory governments will be major beneficiaries of a system of national environmental accounts and can contribute by providing technical and institutional support for regional authorities to undertake data gathering and reporting programs, and assist with regional accreditation.

Structure of an environmental asset condition account

"…there is considerable value in starting with a set of national environmental accounts that provides a clear picture of the physical state, or 'condition', of the environment, recording changes in various environmental resources, and an indication of proximity to dangerous levels of environmental damage." [31]

– Dr Ken Henry, Australian Treasury Secretary, 2012

Environmental asset condition accounts contain four levels of information:

- Summary tables – which show the *Econd* scores for all assets in each year;
- Asset tables – which show the indicators used to construct the *Econds*;
- Data tables – which store the data used to calculate the indicators; and
- Balance sheets – which describe change between reporting periods.

Summary tables

The South East Queensland region provides an example of these four levels. The summary table (Figure 10) shows the regional *Econds* for each asset in each year. It shows for example, the condition of estuaries has declined from an *Econd* of 55 in 2006 (purple cell) to an *Econd* of 41 in 2011 (yellow cell).

REGIONAL ENVIRONMENTAL ASSET ACCOUNT – SEQ CATCHMENTS, QUEENSLAND											
Class	Asset	*Econd* & ICS	2003	2004	2005	2006	2007	2008	2009	2010	2011
LAND	Native Vegetation	*Econd*				29					
		Extent				53					
		Composition				53					
		Configuration									
FRESHWATER	Rivers	*Econd*	74				70	76	78	79	81
		Physical/chemical index	82				77	84	85	86	91
		Nutrient cycling index	64				60	75	70	73	61
		Macroinvertebrates index	76				69	74	79	82	88
		Fish index	62				68	65	69	71	76
COASTAL	Estuaries	*Econd*		57		55	42	44	39	41	41
		Physical/chemical index	51	57		57	39	40	34	36	37
		Biological Health Rating		58		51	50	53	51	53	49
		Foreshore/riparian habitat extent					48	51	51	51	51
	Moreton Bay	*Econd*		87	83	82	81	81	68	75	75
		Physical/chemical index		90	85	84	83	82	69	78	77
		Biological Health Rating		73	74	74	74	75	64	64	66
MARINE	Dugongs	*Econd*			11						
		Dugong Populaton			11						

Figure 10: Summary table showing *Econd* scores for assets in South East Queensland.

Indicator Condition Scores for each indicator (or combination of indicators) are also shown in the summary table. For example, estuary condition is measured using three components: a physical/chemical index, a biological health rating, and foreshore/riparian habitat extent. These three components are then combined using a scientifically accredited process to calculate the overall *Econd* to describe the condition of estuaries in the region.

Asset tables

An asset table (Figure 11) describes the condition of each asset within a region (e.g. the condition of the Albert River estuary in 2011 is 20). These can be compared with the overall condition of the asset in the region (41, yellow cell).

ESTUARIES ASSET TABLE – SEQ CATCHMENTS, QUEENSLAND										
Class/Indicator (unit)	Reference Benchmark	2009			2010			2011		
		Measure	ICS	*Econd*	Measure	ICS	*Econd*	Measure	ICS	*Econd*
TOTAL				39			41			41
Albert River estuary				22			18			20
Physical/chemical index	100	15.2	15		9.2	9		12.4	12	
Biological Health Rating	100	29.2	29		29.2	29		29.2	29	
Foreshore/riparian habitat	32.2	15.5	48		15.5	48		15.5	48	
Bremer River estuary				22			21			22
Physical/chemical index	100	15.2	15		13.0	13		14.2	14	
Biological Health Rating	100	33.3	33		33.3	33		33.3	33	
Foreshore/riparian habitat	34.8	15.3	44		15.3	44		15.3	44	
Brisbane River estuary				30			31			32
Physical/chemical index	100	26.2	26		24.8	25		29.4	29	
Biological Health Rating	100	47.2	47		55.6	56		47.2	47	
Foreshore/riparian habitat	160.6	51.4	32		51.4	32		51.4	32	
Cabbage Tree Creek estuary				22			27			36
Physical/chemical index	100	10.6	11		17.8	18		28.0	28	
Biological Health Rating	100	36.1	36		36.1	36		50.0	50	
Foreshore/riparian habitat	12.5	7.4	59		7.4	59		7.4	59	

Figure 11: Asset table showing indicator themes for individual estuaries.

Econds and *Indicator Condition Scores* are reported in the asset table for each individual asset, along with the reference benchmarks and observed measures for each accounting period. For example, the physical/chemical *Indicator Condition Score* for the Albert River in 2011 is 12 (green cell).

Data tables

The third level of information is the data table which shows the specific indicators used to construct the *Indicator Condition Scores* for each asset.

Figure 12 is an example of the Albert River estuary for the 2010–2011 accounting period. It shows the indicators for each component group, reference benchmarks, and the actual measure for each indicator which when combined, make up the *Indicator Condition Score* for this asset.

ESTUARIES DATA TABLE – SEQ CATCHMENTS, QUEENSLAND			
Albert River estuary	Reference Benchmark	2010–2011	
		Measure	ICS
Physical/chemical index	**100**	**12.4**	**12**
Chlorophyll-a	100	2	2
Disolved Oxygen	100	46	46
Total Nitrogen	100	14	14
Total Phosphorus	100	0	0
Turbidity	100	0	0
Biological Health Rating	**100.0**	**29.2**	**29**
Mixing Plots	3	1	33
δ15N	4	1	25
Foreshore/riparian habitat extent	**32.3**	**15.5**	**48**
Total Foreshore/riparian habitat extent	32.29	15.50	48

Figure 12: Data table, Albert River Estuary, South East Queensland, 2010–2011.

The summary, asset and data tables are linked, providing a consistent and transparent description of all the scientific information that is used to create the asset condition account. For example, the *Indicator Condition Score* for the physical/chemical index of 12 shown in the data table (green cell in Figure 12) also appears in the asset table (Figure 11). The overall *Econd* of all estuaries (*Econd* 41 yellow cell in Figure 11) also appears in the summary table (Figure 10 yellow cell).

Balance sheets

A balance sheet provides a point in time measure of the stock of an asset, presented in a manner where changes can be readily observed. Information in the balance sheet is drawn from the asset tables to describe changes in the biophysical condition of the stock of each asset between accounting periods.[15]

Figure 13 is an example of the changes in the condition of river assets in the SEQ region between 2010 and 2011. It shows for example that the condition of the Noosa River has improved by 5 *Econds* (blue cell) over this reporting period, whereas the Brisbane River has declined by 9 *Econds* (red cell) over the same period.

The balance sheet also shows which indicators most contribute to the change. For example, the largest improvement in the Noosa River was from a 7 per cent improvement in ecosystem processes, whereas the decline in the ecosystem processes of 19 per cent was the major cause in the overall decline in the condition of the Brisbane River. Ecosystem process indicators describe the growth rate of algae, primary production by plants through photosynthesis, and respiration of algae, bacteria and other organisms.

RIVERS BALANCE SHEET – SEQ CATCHMENTS, QUEENSLAND						
Class/Indicator (unit)	ICS1	ICS2	ICS3	ICS4	ICS5	*Econd*
	Physical	Nutrients	Eco Process	Insects	Fish	
All Rivers in SEQ						
Opening stock (2010)	86	73	81	82	71	**79**
Closing stock (2011)	91	61	89	88	76	**81**
Net Change	+5	-12	+8	-6	+5	+2
Noosa River						
Opening stock (2010)	94	96	88	86	81	**89**
Closing stock (2011)	97	100	95	92	86	**94**
Net Change	+3	+4	+7	+6	+5	**+5**
Brisbane River						
Opening stock (2010)	95	29	91	93	100	**81**
Closing stock (2011)	96	20	72	77	95	**72**
Net Change	+1	-9	-19	-16	-5	**-9**

Figure 13: Balance sheet for river assets in the South East Queensland region, 2010–11.

Method for constructing asset condition accounts

"Everything should be as simple as possible, but no simpler."

– Albert Einstein

In order to describe the complexity of an environmental asset in biophysical (non-monetary) values, several indicators may often need to be integrated to generate a single measure that best describes the condition of that asset in a particular location.

A seven step method for constructing environmental asset condition accounts was developed using the practical experience from the Australian trial to produce such measures (Figure 14).[32] The method can also be applied to create asset condition accounts at other scales: an individual property, a catchment, a local government area, a national park, or a private conservation reserve.

The seven-step process sets out an orderly and efficient method for assembling environmental information in a form that will satisfy the national scientific and accounting standards.

Step 1: Document the environmental assets

Step 2: Select environmental indicators

Step 3: Determine reference benchmarks

Step 4: Collect data

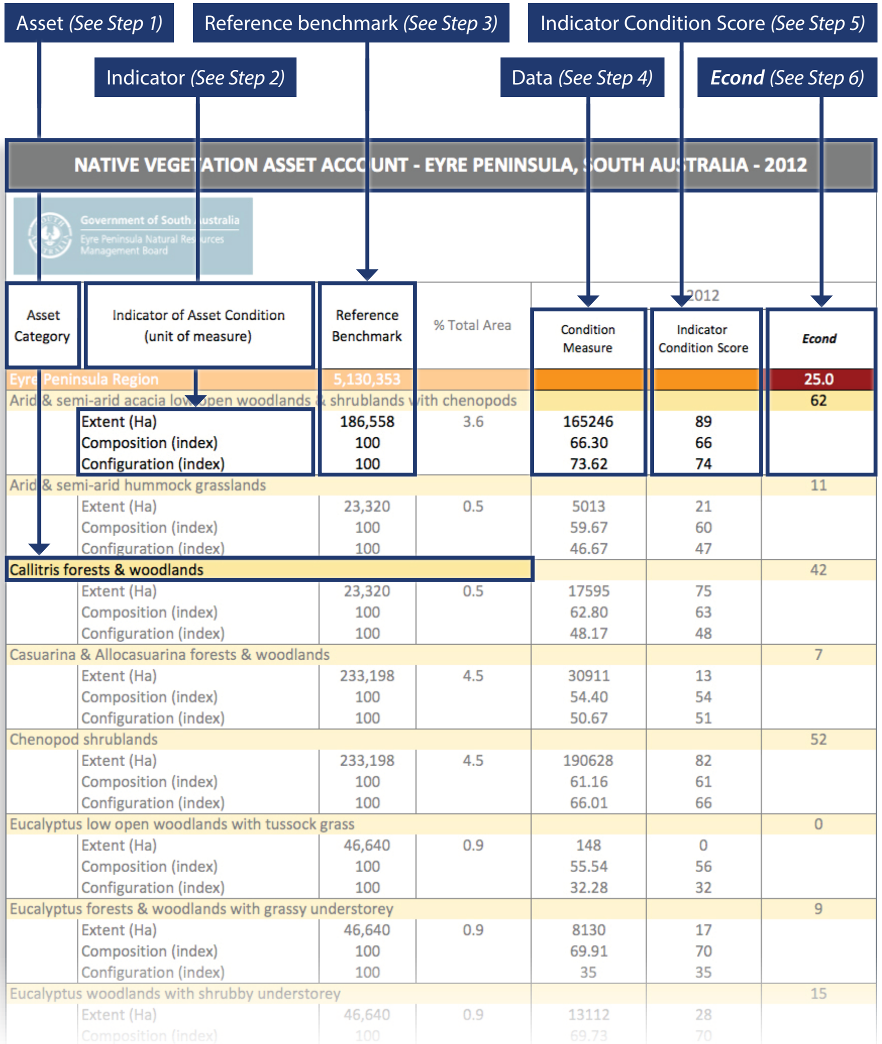
Step 5: Calculate *Indicator Condition Scores*

Step 6: Calculate *Econds*

Step 7: Submit for accreditation

Figure 14: Seven steps for constructing environmental asset condition accounts.

Figure 15 is an example of how six of these steps contribute to the assembly of a native vegetation asset condition account for the Eyre Peninsula region in South Australia. Step seven is the subsequent process of accreditation.



NATIVE VEGETATION ASSET ACCOUNT - EYRE PENINSULA, SOUTH AUSTRALIA - 2012

Asset Category	Indicator of Asset Condition (unit of measure)	Reference Benchmark	% Total Area	2012 Condition Measure	2012 Indicator Condition Score	2012 *Econd*
Eyre Peninsula Region		5,130,353				25.0
Arid & semi-arid acacia low open woodlands & shrublands with chenopods						62
	Extent (Ha)	186,558	3.6	165246	89	
	Composition (index)	100		66.30	66	
	Configuration (index)	100		73.62	74	
Arid & semi-arid hummock grasslands						11
	Extent (Ha)	23,320	0.5	5013	21	
	Composition (index)	100		59.67	60	
	Configuration (index)	100		46.67	47	
Callitris forests & woodlands						42
	Extent (Ha)	23,320	0.5	17595	75	
	Composition (index)	100		62.80	63	
	Configuration (index)	100		48.17	48	
Casuarina & Allocasuarina forests & woodlands						7
	Extent (Ha)	233,198	4.5	30911	13	
	Composition (index)	100		54.40	54	
	Configuration (index)	100		50.67	51	
Chenopod shrublands						52
	Extent (Ha)	233,198	4.5	190628	82	
	Composition (index)	100		61.16	61	
	Configuration (index)	100		66.01	66	
Eucalyptus low open woodlands with tussock grass						0
	Extent (Ha)	46,640	0.9	148	0	
	Composition (index)	100		55.54	56	
	Configuration (index)	100		32.28	32	
Eucalyptus forests & woodlands with grassy understorey						9
	Extent (Ha)	46,640	0.9	8130	17	
	Composition (index)	100		69.91	70	
	Configuration (index)	100		35	35	
Eucalyptus woodlands with shrubby understorey						15
	Extent (Ha)	46,640	0.9	13112	28	
	Composition (index)	100		69.73	70	

Figure 15: Features of an environmental asset condition account.[33]

Step 1: Document assets

The first step in constructing an environmental asset condition account is to document the environmental assets that represent significant ecological, economic or social value to people within the account boundaries.[34]

An environmental asset is defined as any naturally occurring living and non-living component of Earth that provide benefits to humanity.[20]

An environmental asset may comprise natural resources that contribute directly to economic activities such as a fish stock, agricultural soil, or a groundwater resource;[35] an ecosystem such as a forest, a river, or an estuary; an individual species of mammal or bird; or any other feature in nature.[36]

The assets in an environmental account are determined by the community, through an appropriate authority. A regional account for example, would incorporate assets that are valued by their local community, as well as assets of state, national and international significance, such as wetlands listed under the Ramsar Convention.

Environmental assets can be categorised into one of five asset classes:

- **Land** (e.g.: native vegetation, soil, native fauna);
- **Freshwater** (e.g.: rivers, groundwater, wetlands);
- **Coasts** (e.g.: estuaries, beaches);
- **Marine** (e.g.: fisheries, seagrass, reefs, marine fauna);
- **Atmosphere** (e.g.: air quality, greenhouse emissions).[37]

Step 2: Select indicators

Indicators are selected on their ability to measure the condition of the asset and changes in its condition over time. Sampling design must be based on establishing a level of confidence sufficient to describe the magnitude and direction of change that can inform a decision.

The condition of an environmental asset is assessed through indicators that describe an asset's vigour (level of biological productivity), organisation (its structure and interactions) and resilience (ability to rebound from shocks).[38]

For example, indicators of native vegetation would describe the extent of vegetation (the proportion remaining in the landscape), its composition (such as species richness and density of weeds), and its configuration (how the vegetation is configured across the landscape).

Indicators may incorporate measures of condition that are specifically appropriate to an asset in a particular landscape, provided they accord with a national standard.

State and territory assessment programs, such as the *Bushland Condition Monitoring Manual* developed in South Australia, the *Habitat Hectares* methodology in Victoria, and the *Biometric tool* in NSW employ different indicators to measure condition of native vegetation within their jurisdictions.[39, 40, 41] The use of a standard and accreditation process ensures consistency of the *Econds* generated from different assessment programs.

A scientific accreditation process (step 7) assesses the indicators against six indicator selection principles (Figure 16) in the context of the national standard.

Indicator Selection Principles

1. **Relevant** – the indicator is a measure or surrogate of the condition of an environmental asset appropriate to the account boundary.
2. **Simple** – the indicator is easily interpreted, monitored and appropriate for its intended use.
3. **Sensitive** – the indicator is able to detect change in the condition of the environmental asset and represent different aspects of the asset.
4. **Measurable** – the indicator is statistically valid and can be reproduced.
5. **Timely** – the indicator shows trends over time, provides early warning of potential problems and highlights future needs or issues.
6. **Aggregative** – the indicator is amenable to combination with other indicators to produce more general information about environmental conditions.

Figure 16: Indicator selection principles for environmental asset condition accounts.[42]

Step 3: Determine reference benchmarks

The conversion of scientific information into a common accounting framework is made possible through the use of reference condition benchmarks. Reference benchmarks provide a common baseline (or reference point), to compare both past and future changes, at any scale, and across time and space.

A reference benchmark is a scientific estimate of an environmental asset in its undegraded (natural, pre-industrial or potential) state. While reference benchmarks must meet this definition, the way in which the benchmark is determined may differ across landscapes and between assets.

For example, a reference benchmark can be measured at sites that are known to be in a natural condition (such as a river in the upper reaches of a catchment),[25] or an estimate of its condition at fixed point in time (for example, the condition of an asset prior to industrial development). Australia often uses a 'pre-European settlement' date of 1750, North America uses a 'pre-Columbian' benchmark, and Europe uses a 'pre-intensive agriculture' date.[26]

Reference condition accounting allows different indicators to be used to measure the same asset in different landscapes when they satisfy appropriate scientific standards. It also enables all the relevant information to be compiled into a single accounting framework (Figures 10, 11, 12 and 13).

A reference condition benchmark needs to be determined for each indicator that is used to measure the condition of an environmental asset, so they can then be combined in a meaningful way to construct *Indicator Condition Scores* and *Econds* for each asset (steps 5 and 6).

Step 4: Collect data

Data used in an environmental account need to be of sufficient precision to reliably inform policy and investment decisions at the scale for which an account is being constructed. Using the best available data maximises the reliability of the decisions based on that information.

All data will need to satisfy four data quality standards (Figure 17) to ensure the fit for the intended use. Where existing data are insufficient to meet the national standards, new data will need to be collected, and/or supplemented by expert opinion. This will involve consulting scientific literature for appropriate methodologies and sampling design.

Data Quality Standards

1. Data collected should be based on sampling programs that: are fit for the issue, question or hypothesis of interest; are of an acceptable spatial and temporal resolution; can be repeated; and can detect change.
2. Data sets should be suitably accurate and precise, statistically valid and reproducible.
3. Data sets should be treated and analysed to accepted standards.
4. Data sets should be managed so that they are retrievable and accessible.

Figure 17: Data quality standards for environmental asset condition accounts.[43]

Step 5: Calculate *Indicator Condition Scores*

Indicator Condition Scores document the state of each indicator at a particular point in time. *Indicator Condition Scores* reflect aspects of the asset's condition that provide a means of determining causes of environmental change. For example, a relatively low score for organic carbon compared to higher scores for pH, water erosion or salinity would suggest that the loss of soil carbon is the factor which limits soil condition in that location (Figure 18).

The national standards describe the process for determining which of several possible methods for calculating the *Indicator Condition Score* are appropriate for each asset in specific locations. Provided the method of combining individual indicators meet these national standards, the actual method used may vary depending on the specific nature of the indicator, the method of sampling, and/or the advice of experts.

Once reference benchmarks have been established for all indicators (step 3), standard accounting practices then convert the observed measure for each indicator into an *Indicator Condition Score*, on a scale of 0 to 100.

An *Indicator Condition Score* is a standardised raw value of an indicator measure against the reference benchmark. In some cases, the *Indicator Condition Score* may also act as an intermediate index comprising multiple indicators of a similar type (e.g. water quality indicators combined to form a water quality index). In each index, 100 represents the reference benchmark for each indicator and 0 indicates system function is absent.

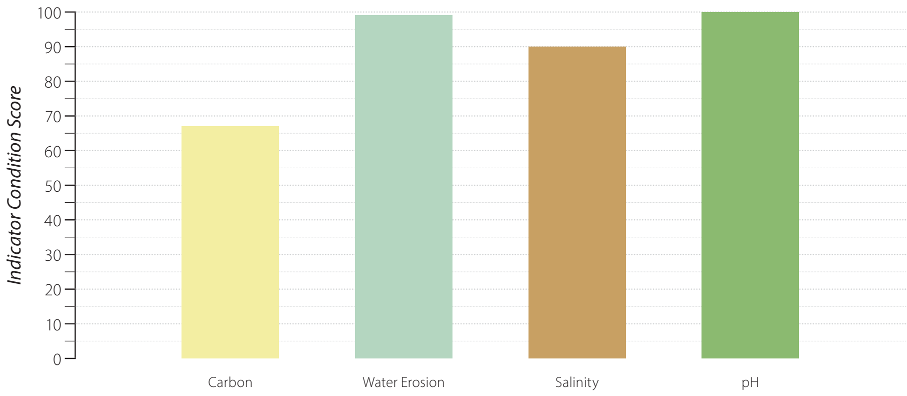


Figure 18: Individual *Indicator Condition Scores* for dermosol soils of the Brigalow Plains of the Queensland Murray–Darling Basin.

Step 6: Calculate an *Econd*

An *Econd* is a scientific measure, metric or model, accredited against agreed standards, that describes the current biophysical condition of an environmental asset as an index between 0 and 100, where 100 is a measure of the asset in its undegraded (reference) state.[44]

Each *Econd* is constructed by combining (where appropriate) a set of scientifically accredited *Indicator Condition Scores*, which together provide a cost effective way of measuring the condition of an environmental asset.

The process for determining the method is set out in a national standard for each asset. National environmental accounting standards provide the scientific framework for the selection and combination of such indicators for each asset in a particular location.

An *Econd* is calculated for individual components in each asset (for example sub-catchments of river assets, individual soil classes or specific types of native vegetation). These components are then combined to generate an overall *Econd* for each asset for a particular location appropriate to the scale of the account (property, local, catchment, regional, state or national).

There are several methods that might be suitable for calculating an *Econd:* taking a mean (e.g. native vegetation);[28] or the lowest performing *Indicator Condition Score* (e.g. soil);[6] or using expert rules where scientific literature and/or experts have developed processes for combining indicators (or indicator groups) into an overall index (e.g. Sustainable Rivers Audit for the Murray–Darling Basin);[45] or combining scientifically accredited weighted indicators[46, 47] (e.g. Index of Wetland Condition in the state of Victoria).[48]

The methodology used to combine the *Indicator Condition Scores* to create the *Econd* must comply with national standards for that asset. These methods should be documented in the *Information Statement* which accompanies each account.

Overall *Econds* for each asset are calculated by spatially weighting scores for individual *Econds* in proportion to the total area of the asset in its reference condition.

Step 7: Submit for accreditation

Once the information is assembled, the environmental account is then submitted for accreditation by an appropriate scientific body against national environmental accounting and data quality standards.

As part of this accreditation process, each asset receives a quality grading to provide confidence to the community and policy makers that data contained within the account is sufficiently precise to inform decisions.[21, 49]

The *Information Statements* which accompany each account are used to inform this accreditation process.

Applications for policy and investments

"If you don't measure it, you can't manage it."

The value proposition of a series of accounting tables all based on a common accounting framework is that it enables detailed, complex scientific information to be presented in a simple and clear way.

The benefit of simplifying complexity is that it enables experts and non-experts to better understand the capacity of environmental assets to provide on-going benefits to society. It also makes it easier for managers to identify the specific pressures that are driving change and the location of those pressures, to use this knowledge to set priorities, estimate cost effective actions to meet those priorities, and also monitor the results.

Simplifying complexity

The Australian Treasury has adopted a framework to underpin its analysis of public policy issues from a whole-of-economy, whole-of-society perspective, within its overall objective to improve the wellbeing of the Australian people.

The *Treasury Wellbeing Framework* describes five dimensions that directly or indirectly affect the wellbeing of people.[50] One dimension is whether the productive base needed to generate opportunities (the total stock of capital, including human, physical, social and natural assets) is maintained or enhanced for current and future generations.[51]

Another dimension is the cost of dealing with unwanted complexity. When information is too complex, it places significant restrictions on the ability of government, businesses, individuals and the community to make informed choices and tradeoffs that better match their preferences. People are then forced to rely on opinion, and this often leads to mistakes.

History suggests that with environmental policy, while mistakes are not always accidental, on many occasions they occur simply because people don't realise they are being made, or don't realise quickly enough.

The most common explanation for environmental degradation centres on the 'free-rider' problem, which occurs when someone who benefits from the use of a public good such as a natural resource, does not pay the full cost, and their use results in the loss of these services to other people, and/or future generations.

This market failure is often described as the 'tragedy of the commons'. It explains why public environmental goods often end up being degraded.[52]

In more recent times, an additional explanation for environmental degradation has emerged in the field of economic and behavioural psychology which points to deeply engrained hard-wired biases in people's decision making, particularly in our interaction with the environment.[31]

This bias is described as a 'neglect of scope' and it arises from the psychological inability of people to appreciate the scale of a decision (Figure 19).[53] It comes from the recognition that because the human mind has great difficulty imagining 'millions', 'thousands' or even 'hundreds' of things, it often substitutes a mental image of an individual. That image then tricks us into thinking that the issue at hand, whatever it is, affects just one individual.

Neglect of scope might explain for example, why broadscale land clearing is permitted when it causes long-term economic damage to topsoil and the health of river systems, or why species have to be on the edge of extinction before action is taken. It might explain for example, why a century ago people were paid a bounty of £1 a head to exterminate the Tasmanian Tiger, and yet some people are now prepared to spend a million dollars to bring one back from extinction.

The fact that society is prone to making such mistakes does not mean that they are unavoidable. If we can create the conditions by presenting complex information in a manner that enables people to act more rationally and less intuitively, we stand a better chance of securing better environmental outcomes.

The first step in promoting more rational behaviour is to present data in a way that enables governments, communities, businesses, and individuals to better understand the consequences of their decisions.

The benefit of the *Econd* is its ability to assemble, store and present information at a scale and in ways that enable people to better understand the meaning of complex scientific information.

Most people do not know, and should not need to know, the meaning of electrical conductivity of salts or mg/L of phosphorus for example, in order to understand whether a decision will maintain, enhance or degrade a river system.

The *Econd* presents an opportunity to fundamentally change people's understanding of how natural systems function and the impact our decisions are likely to have over time, because it simplifies complexity without reducing scientific rigour.

Neglect of Scope

One explanation for environmental degradation has emerged in the field of behavioural psychology, which describes the deeply ingrained psychological inability of people to appreciate the scale of a decision.

In one study, three groups of people were asked how much they personally would be prepared to pay to prevent a certain number of migratory birds from drowning in an oil slick.

The first group was asked how much they would pay to prevent 2,000 birds from drowning. The second group was asked how much they would pay to prevent 20,000 birds from drowning, and the third group was asked how much they would pay to save 200,000 birds from drowning.

The amounts were: $80 to save 2,000 birds; $78 to save 20,000 birds; and $88 to save 200,000 birds.

The explanation for this absurd result appears to arise from the emotion associated with the image of a single bird drowning in oil, or perhaps with the image of a single bird being saved from drowning.[54]

Figure 19: Neglect of scope – the inability of people to appreciate scale of a decision.

Describing condition

The following examples from the Australian trial show how the *Accounting for Nature* method enables complex scientific information to better describe the condition of environmental assets, understand changes in their condition over time, and in doing so better inform landscape, catchment, and even property scale investment decisions.

Native Vegetation

Reference condition accounting enables broad comparison of the difference in condition between regions across Australia, using where appropriate different indicators in different types of landscape (refer to the national asset condition accounting standards on page 5). Higher scores indicate better condition.

Figure 20 shows that the condition of native vegetation in the Northern Gulf and Cape York region of Queensland is 65 whereas the condition of vegetation the production landscape of the North Central region of Victoria is 14.

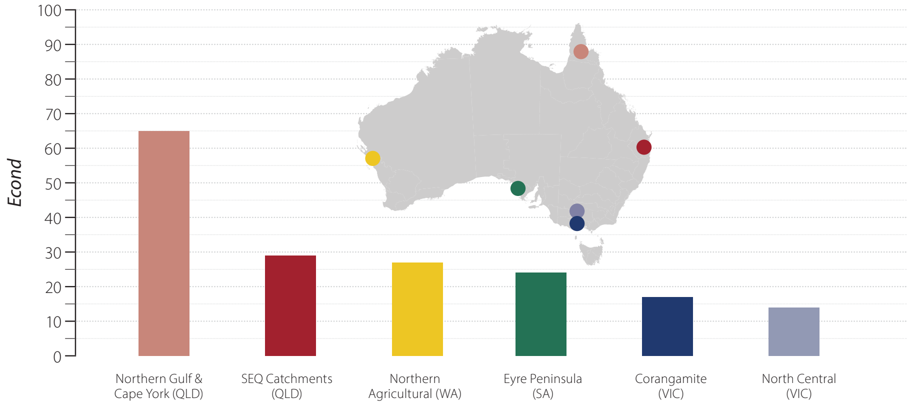


Figure 20: Condition of native vegetation assets in different regions across Australia.

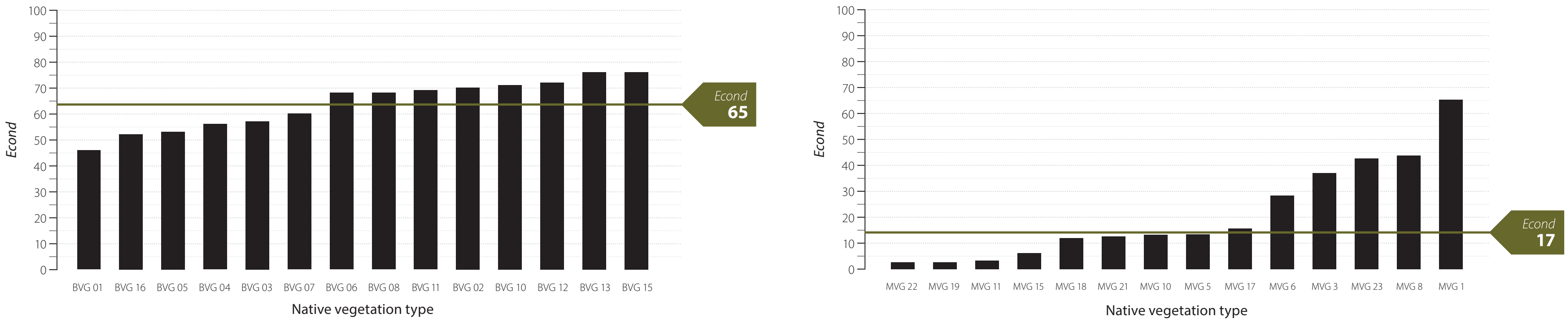


Figure 21: Native vegetation condition in the Northern Gulf (left) and Cape York (right) regions of Queensland and a production landscape in the Corangamite region in Victoria.

Another strength of a comprehensive, national set of accounts is it allows comparisons across assets and across regions to identify priority areas for investment. This is shown in Figure 21.

Figure 21 shows an example of the variation in the condition of native vegetation assets within and between two distinctly different landscapes: the relatively intact landscape of the Northern Gulf and Cape York regions in Queensland, and a production landscape in the Corangamite region in Victoria.

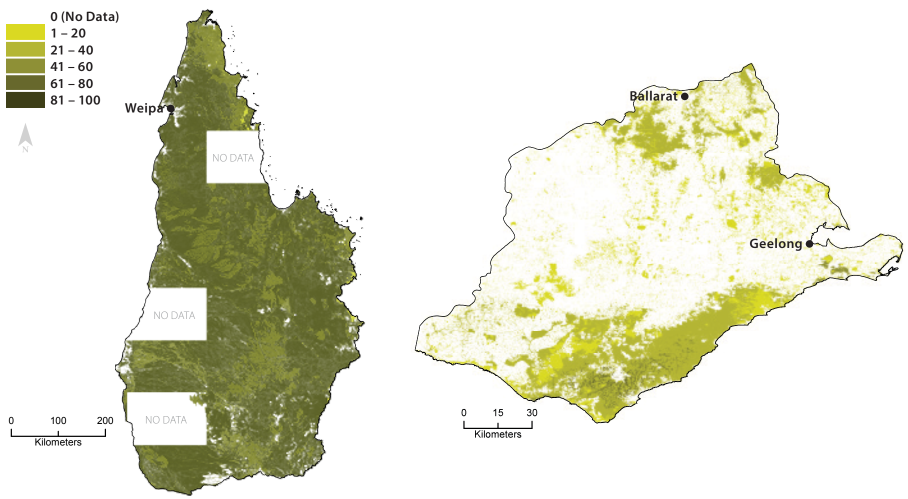


Figure 22: Condition of native vegetation condition across the Northern Gulf and Cape York regions of Queensland and Corangamite in Victoria.

Data in an environmental asset condition account can also be spatially referenced. Figure 22 shows the spatial distribution of the condition of the remaining native vegetation across these two landscapes.

Figure 23 is an example from the North Central region in Victoria that highlights the importance of understanding the quality as well as the quantity of an environmental asset in making policy and investment decisions.

It shows significant variation in the quantity (extent) of the 12 vegetation types in this landscape (light grey). It also shows that other factors (such as weeds, pests or overgrazing) can have a substantial impact on the condition of vegetation that remains (black bars).

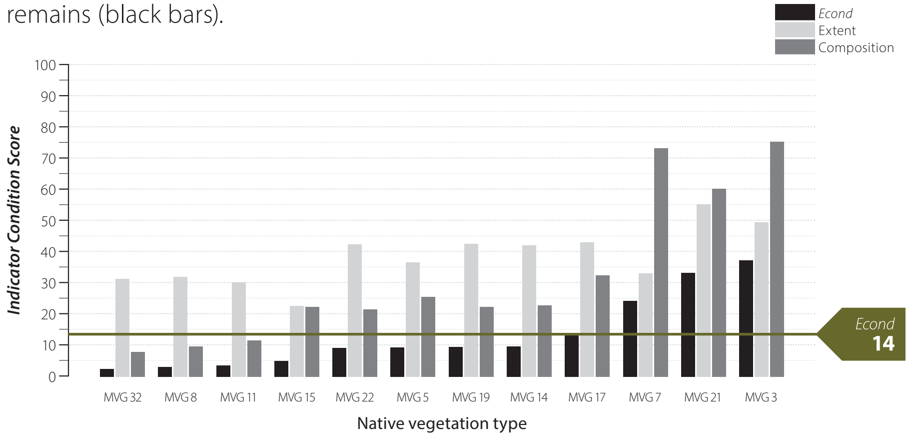


Figure 23: Impact of weeds and other disturbances on the condition of remaining native vegetation in the North Central region of Victoria.

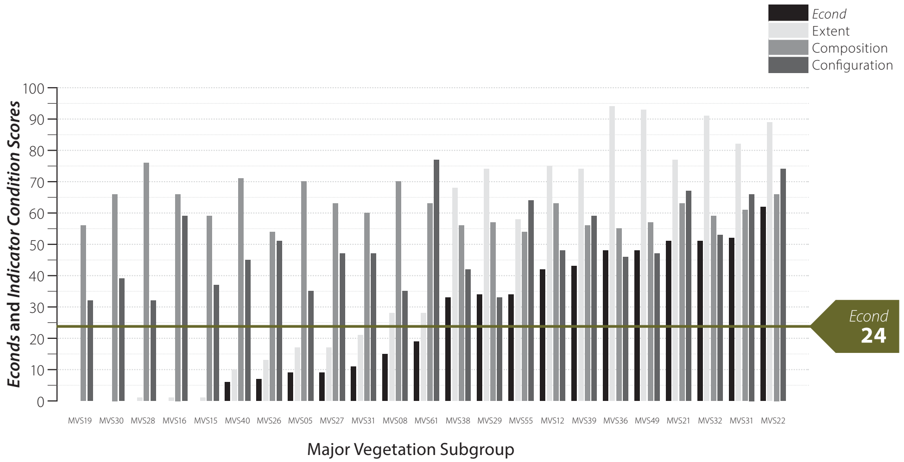


Figure 24: Extent (light grey), composition (mid grey), configuration (dark grey), and the overall condition (black) of 23 vegetation types in the Eyre Peninsula region, South Australia.

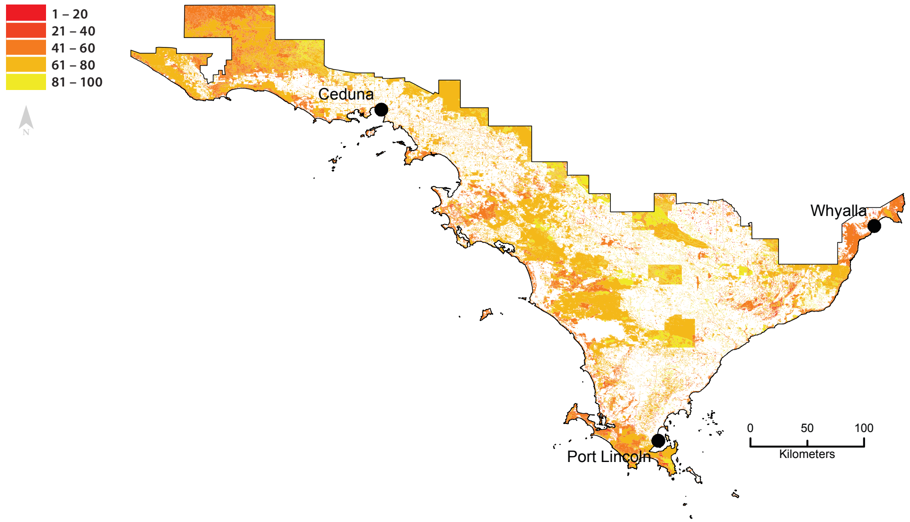


Figure 25: Impact of weeds on the condition of remaining native vegetation in the Eyre Peninsula region of South Australia (the darker the colour, the greater the impact).

Figure 24 shows a further level of detail. It describes the condition of each of the 23 vegetation types across the Eyre Peninsula region in South Australia (black bars). It also shows which of the three indicator themes (extent, composition or configuration) most influence the overall condition of each vegetation type.

The left hand side shows that five vegetation types have an *Econd* of less than 1 (black) and that the primary cause is that the native vegetation has been reduced to less than 1 per cent of its original extent (light grey bars). By comparison, the extent of the Temperate Tussock Grasslands (fifth from the right) has a score of 93, but its overall *Econd* is still less than 50, because weeds and other pressures are affecting its composition (mid grey bars).

One of the indicators that measure the composition of the native vegetation in the Eyre Peninsula is weeds. Figure 25 uses data in the accounts to show where in the landscape weeds are having the greatest impact on native vegetation (the darker the colour, the greater the impact of weeds).

If weeds are an indicator of native vegetation condition in all regions, as is likely, it would be possible to map the scale of impact of weeds on native vegetation across the entire continent.

Soil

The conservation of soil is the foundation of sustainable agricultural production. The process of producing food and fibre potentially degrades soil assets by removing nutrients and increasing acidity, while loss of surface cover and removal of crop residue makes soil vulnerable to erosion.

These and other changes to soil condition not only affect production. They can also affect the wider environment. For example, erosion can also affect the condition of rivers downstream.

Soil experts consider that four indicators (carbon, erosion, salinity and acidity) are sufficient to give a reliable measure of soil condition.[6] Figure 26 shows how these four indicators can be combined to describe the overall condition of soil across the Queensland Murray–Darling Basin region. High scores (dark colours) show soils in better condition than low scores (lighter colours).

Figure 27 describes the impact of one *Indicator Condition Score* (erosion) on the condition of soils across this region. It shows significant levels of soil erosion in the uplands of the region (light colour) and little or no erosion, and in some cases deposition, across the floodplains (dark colour).

Figure 28 shows how the soil account can be used to interpret which of the four indicators is having the greatest impact across the landscape. It shows erosion is the main driver of soil degradation in the upper catchments, and the loss of soil carbon is affecting soil condition in the central cropping areas. This information can be used by regional bodies, government agencies, and individual landholders to target management to protect the soil asset.

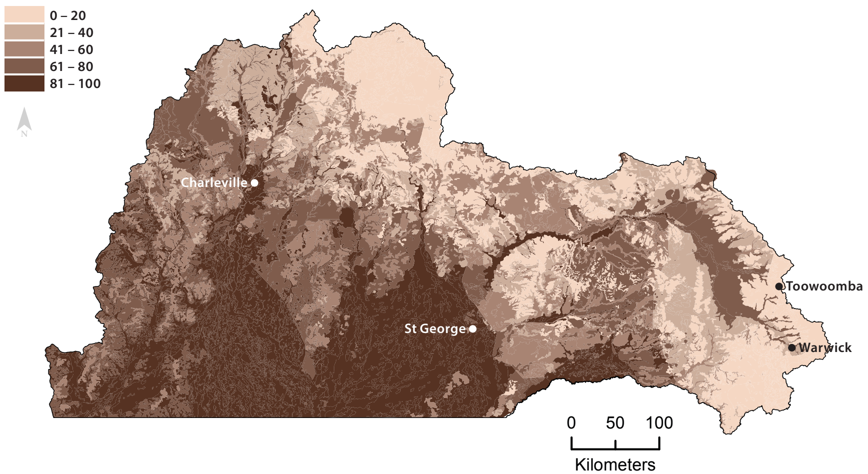


Figure 26: Overall condition of soil across the Queensland Murray–Darling Basin.

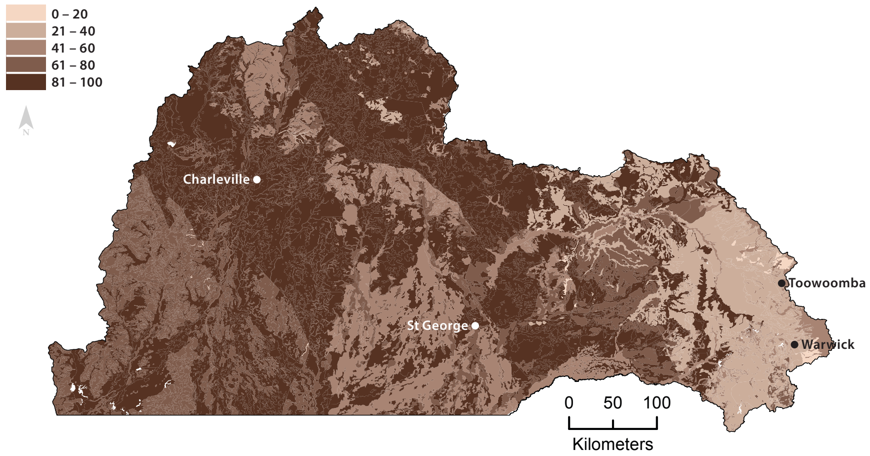


Figure 27: Impact of erosion on soils across the Queensland Murray–Darling Basin.

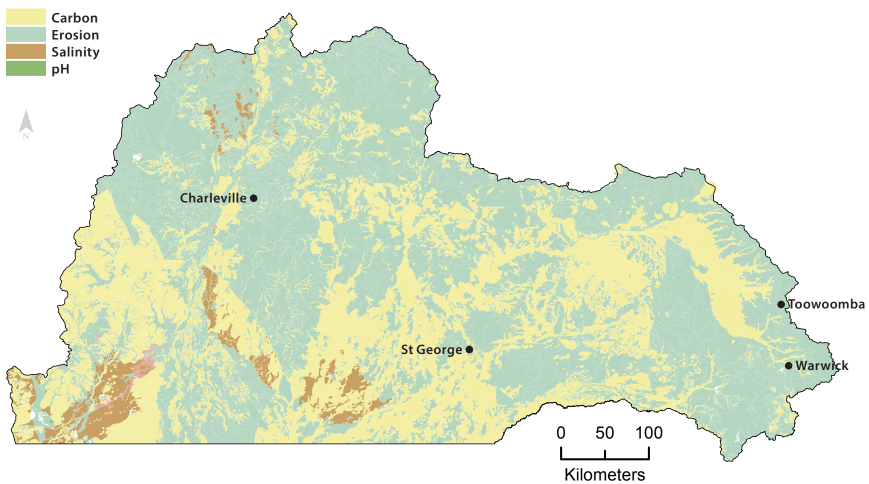


Figure 28: Limiting soil indicator score, Queensland Murray–Darling Basin region.

Native Fauna

Even when existing data is relatively scarce, such as population statistics for native species, reference condition accounting is still able to provide a greater understanding of the condition of particular environmental assets.

Figure 29 shows how regional expert interpretation of a national threatened species database can give a greater understanding of the condition of native fauna in a region in western NSW. It shows that reptiles and amphibians are in a better condition across the region than are mammals, birds or fish species.

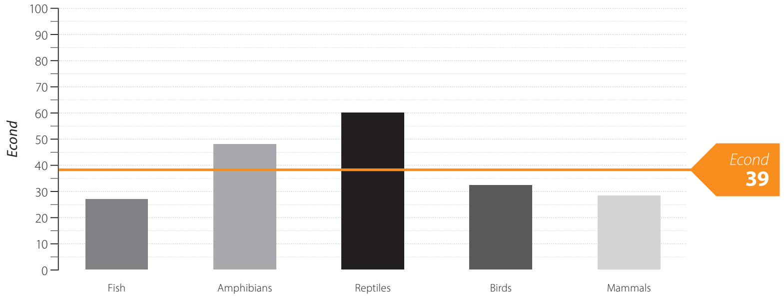


Figure 29: Condition of native fauna in the Central West region of NSW.

Figure 30 shows how expert analysis can highlight the significant variation in the condition of native bird species across two different landscapes: a rangeland in Western Australia and a production landscape in western New South Wales.

At a further level of detail, Figure 31 from the Northern Agricultural region of Western Australia shows the significant variation in condition of species within a region.

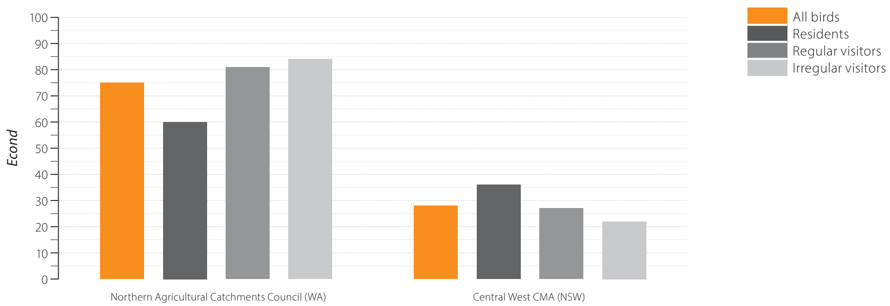


Figure 30: Condition of native bird species in the Northern Agricultural region of WA, and the Central West region of NSW.

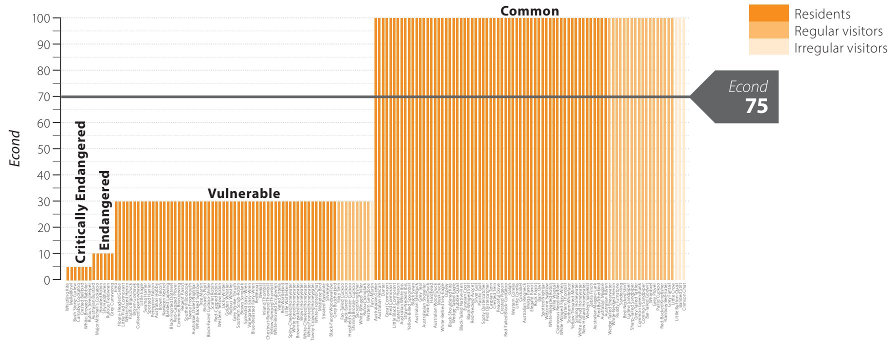


Figure 31: Condition of the 167 native bird species in the Northern Agricultural region of WA.

It shows that a high regional *Econd* for native bird species of 75 was produced because of the high abundance of half the species that inhabit this region.

It also shows that half the species in the region score an *Econd* of 30 or below, and of these, 8 per cent of species are endangered or critically endangered (with *Econds* of 10 and 5 respectively).

Comparing different assets

A common unit of measure that is based on national accounting standards using reference condition benchmarks, also makes it possible to understand the relative condition of different assets in different locations and across different landscapes.

Figure 32 provides an example of how the *Econd* enables information to be presented for a range of assets within a region. It displays the condition of six distinctly different environmental assets in the South East Queensland region.

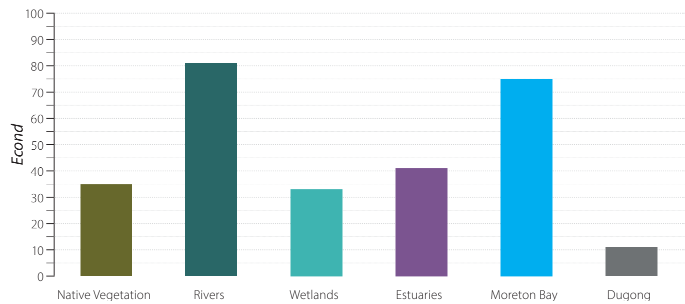


Figure 32: Condition of different assets across South East Queensland region.

Monitoring trend

The purpose of environmental accounting is to inform polices and guide investments to maintain or enhance natural capital. This requires an understanding not only of the biophysical state of an environmental asset, but also of the direction and magnitude of change over time. People want to know whether their actions are enhancing or degrading their assets.

Understanding trend requires the systematic collection of data over time, particularly in landscapes with high climate variability such as Australia. Quite often however, it is possible to use existing data that has been collected, in some cases, over many decades.

The Australian trial found that many regions were able to discover or compile time series data for many assets, including water quality records for rivers and estuaries, satellite data of native vegetation extent and land use change, and by combining historic information with scientific records to measure changes in soils.

Estuaries

South East Queensland's environmental account (Figure 33) shows time series data on the condition of the 18 estuaries along the Brisbane coast.

REGIONAL ESTUARY ACCOUNT – SEQ CATCHMENTS, QUEENSLAND							
Class	2004	2006	2007	2008	2009	2010	2011
Total *Econd*	57	55	42	44	39	41	41
Albert River estuary	32	24	17	19	22	18	20
Bremer River estuary	31	19	28	23	22	21	22
Brisbane River estuary	43	42	34	33	30	31	32
Cabbage Tree Creek estuary	43	42	23	29	22	27	36
Caboolture River estuary	65	57	29	23	26	30	38
Coomera River estuary	90	91	66	71	59	50	67
Currumbin Creek estuary	89	86	55	69	57	43	59
Eprapah Creek estuary	0	64	33	42	42	38	42
Logan River estuary	52	38	23	25	21	17	20
Maroochy River estuary	50	61	36	40	30	45	36
Mooloolah River estuary	83	82	71	77	70	76	56
Nerang River estuary	84	82	65	65	65	59	55
Noosa River estuary	91	87	93	90	87	88	82
North Pine River estuary	58	52	38	48	34	42	45
Oxley Creek estuary	27	25	23	30	22	20	22
Pimpama River estuary	71	69	53	52	46	49	39
Tallebudgera Creek estuary	91	85	60	66	60	67	70
Tingalpa Creek estuary	47	58	35	44	39	51	45

Figure 33: Coastal Estuaries Asset Account, South East Queensland, 2004–2011.

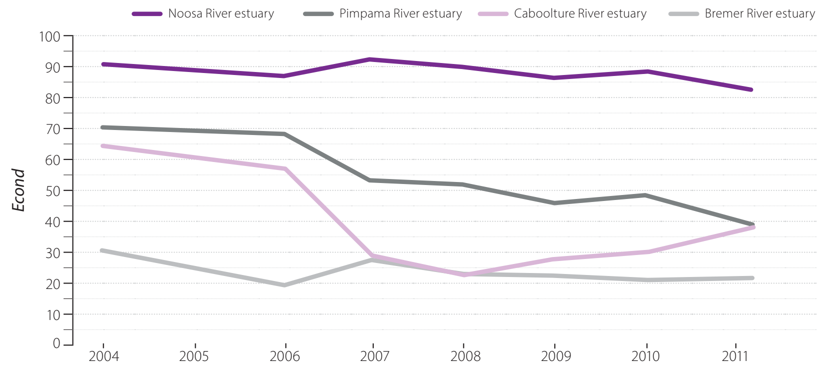


Figure 34: Change in condition of 4 estuaries in South East Queensland, 2004–2011.

Figure 34 shows the changes in four of these estuaries between 2004 and 2011. It shows that while the condition of the Noosa estuary (purple) is high, with *Econds* above 80, its condition has declined by 11 per cent from 93 in 2007 to 82 in 2011. In contrast the condition of the Caboolture estuary (pink) is significantly lower, but has improved by 9 per cent over the same period, from 29 in 2007 to 38 in 2011.

Another example of trend is provided by two surveys of the Tamar River estuary in Tasmania in 2010 and 2011 (Figure 35). It describes changes along the length of the estuary that resulted from higher rainfall and subsequent flooding in the catchment during the second measurement period.[55]

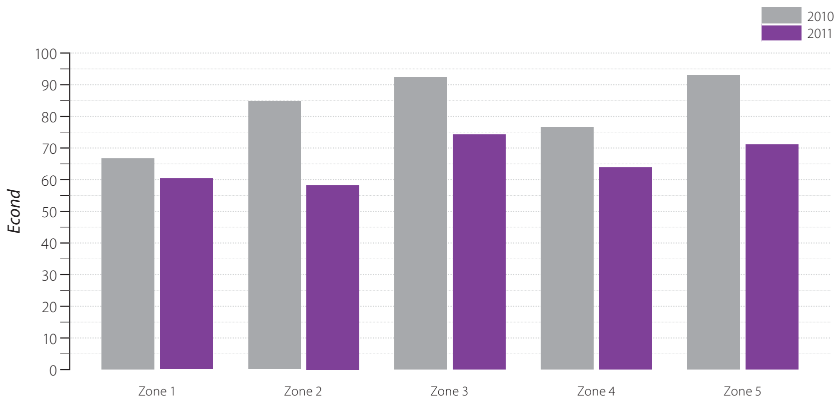


Figure 35: Change in condition along the Tamar River estuary, Tasmania, 2010–2011. Zone 1 is upstream and zone 5 is downstream at the estuary mouth.

Native Vegetation

Change in the extent of native vegetation assets can be observed with the aid of remote sensing. The Central West region of NSW utilised Landsat satellite data from Australia's *National Carbon Account* dating back to the 1970s, to show the change in woody vegetation across the region (Figure 36).

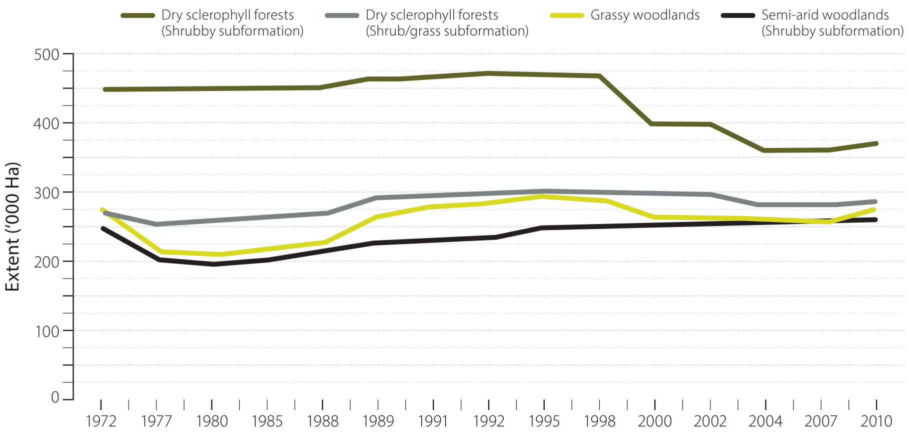


Figure 36: Change in woody vegetation 1972–2010, Central West region of NSW.

Asset condition accounting can also be facilitated by combining oral history, local knowledge, expert opinion and survey data, to give an understanding of long-term changes in the condition of environmental assets.

Figure 37 shows changes in the condition of native vegetation of what is now a nature reserve in north Queensland. It describes the rapid decline in the condition between the 1920s and 1940s as land was cleared for farming, and its steady recovery since dairy farming was abandoned in the 1940s.[28]

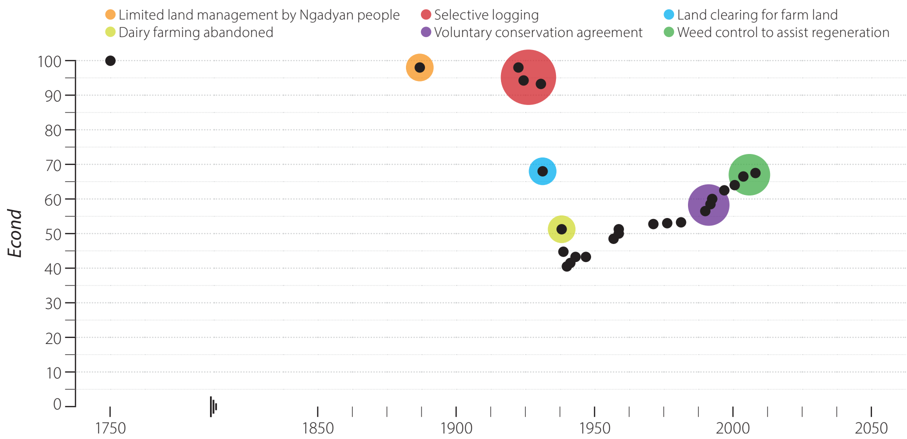


Figure 37: Changes in the Wooroonooran Nature Reserve, Queensland, 1750–2010.[56]

Soil

Knowledge of the rate of soil loss by erosion is fundamental to maintaining soil assets to meet the increasing demands for food and fibre for a growing population, as well as contribute to the condition of other environmental assets including river systems and estuaries.

Figure 38 demonstrates that even with limited regional scale data, through the combination of historical information, decades of remote sensing and scientific knowledge embedded in modeling, scientists are able to estimate the rate of soil erosion since European settlement in four major soil types across the Queensland Murray–Darling region. The nature of the soil and landscape, the time of clearing and farm management practices are the key drivers.

Figure 38 shows that between the 1920s and 2000, the Eastern Walloon Sandstone (brown line) and the Basaltic Uplands soil units (grey line) have lost over half their topsoil. It also shows how changes in pasture management and tillage practices have significantly slowed soil loss over the past 15 years. By comparison, the Brigalow plains have experienced almost no soil erosion since European settlement because these are mostly flat soils and many areas were cleared when improved practices became the norm.

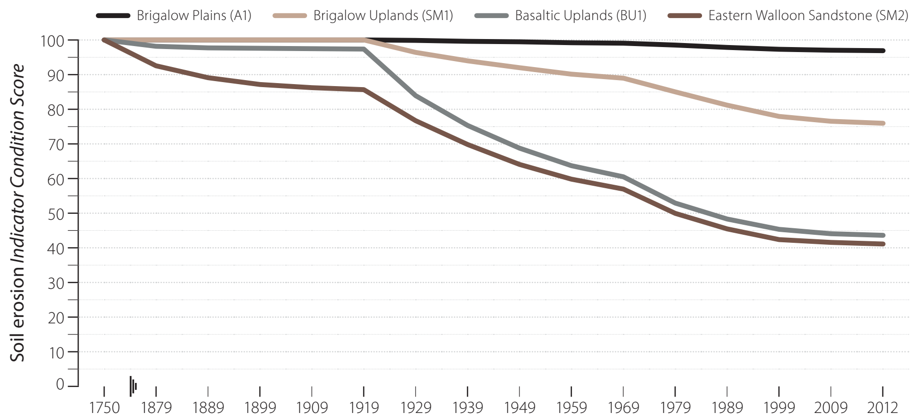


Figure 38: Trend in soil erosion, four soil units, Queensland Murray–Darling Basin (1750–2012).

Threatened Species

The regional Australian trial also demonstrated how existing data and historic information can be combined to describe long-term changes in the condition of individual populations of threatened species.

Two marine species accounts were prepared using survey data of Dugongs (a species of marine mammal) in Morton Bay, Queensland, and Southern Right Whales in the Great Australian Bight in South Australia.

It is possible to compare the condition of the populations of these two species because they both used scientifically valid methods for estimating population size, and both applied a reference condition.

Figure 39 shows the change in the Dugong population in Morton Bay from the mid-1970s to the mid-2000s (yellow line). This population was highly depleted in the early 1970s (an *Econd* less than 10), it partially recovered between 1985 and 1995 (when the *Econd* reached 25), and declined again to an *Econd* of 11 in 2005.

In contrast, while Southern Right Whales in the Great Australian Bight show significant annual variation, the population is steadily improving.

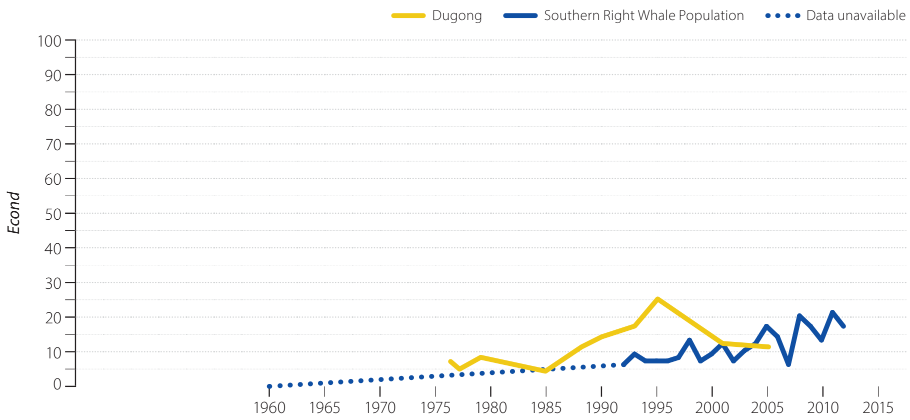


Figure 39: Condition of Dugongs in Moreton Bay, Queensland (1976–2005) and Southern Right Whales in the Great Australian Bight, South Australia (1992–2012).

Figure 40 presents the same information for the Southern Right Whales in a longer time series to highlight the magnitude of changes since European settlement.

The *Econd* of 100 in 1788 is established by the definition of the reference benchmark, and the *Econd* of 0 in the 1960s is known from historical accounts when whaling caused the local extinction of the species in the Bight.

The trend line from 1788 is speculative (hence dotted). It is likely the depletion was much more rapid around the turn of the 20th century, followed by a long period of very low abundance.

The benefit of this long-term historic time series information is that it shows in one graph, the variation in numbers from year to year, the scale of recovery since whaling was banned, time it has taken the population to recover to current levels, as well as the long-term potential for its recovery should the current policy to maintain the ban on whaling remains in place.

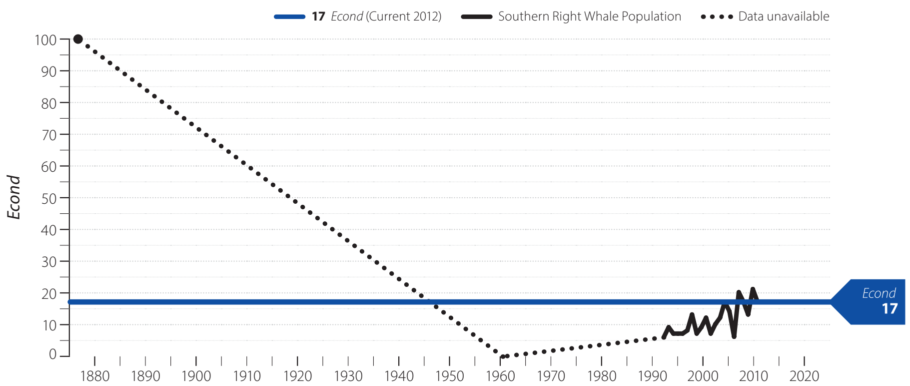


Figure 40: Trend in Southern Right Whale population, Eyre Peninsula, 1788–2012.

Guiding policy and investment decisions

In recent decades government (Commonwealth, state/territory and local), land managers and other private investors, have invested billions of dollars through Landcare and other programs to restore degraded landscapes. The Commonwealth government alone has spent over $3 billion on biodiversity conservation in the past 7 years (Figure 41).[57]

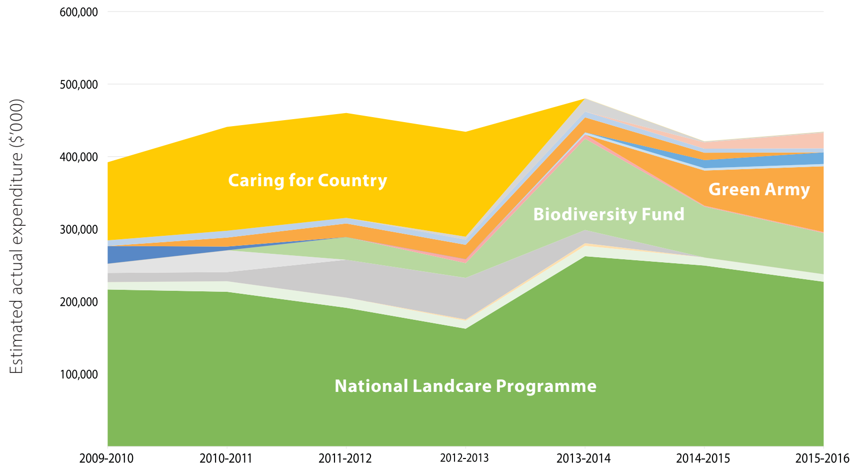


Figure 41: Commonwealth government expenditure in biodiversity conservation in Australia, 2009–10 to 2015–16.[58]

Governments have made these investments because a healthy environment provides a range of benefits to people and the economy.

For example, landholders derive direct benefits from healthy landscapes through increased farm values (Figure 42),[59] from carbon farming investments[60] and improved levels of production.[61]

Healthy landscapes improve agricultural production, enhance international competitiveness, and support long-term sustainability by protecting land and water resources from degradation. Healthy landscapes also improve the health of people, and are increasingly valued for tourism. They also store vast quantities of carbon in soil and vegetation.

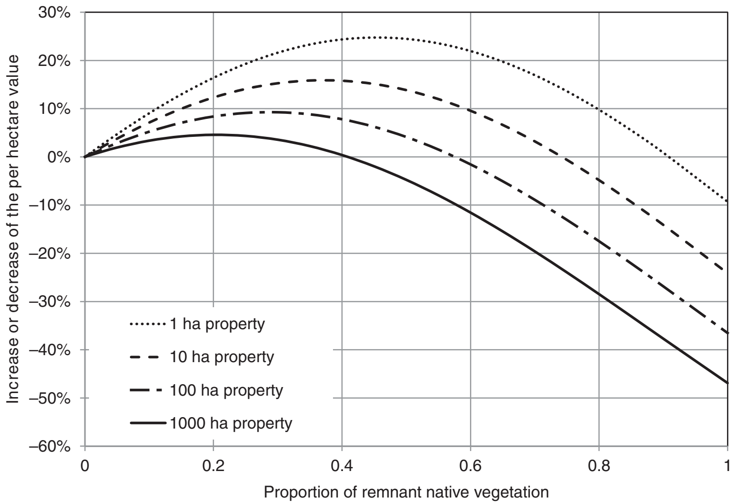


Figure 42: Change in land value with changes in native vegetation. Land values are optimised when 20–50% of native vegetation is retained on properties in the North Central region of Victoria.[59]

Environmental accounts that describe changes in the condition of environmental assets can be used by experts and non-experts to inform policy and management targets and guide investment decisions.

Reference condition accounting allows data to be easily interrogated to identify the specific pressures that are driving change, the location of those pressures and then use this knowledge to evaluate cost effective actions to meet those targets and monitor the results.

SEQ Catchments, the natural resources management body for south east Queensland, provides an example of how environmental accounts can inform the management of freshwater resources in a rapidly growing city on the east coast of Australia.

By 2041 south east Queensland is estimated to grow by an extra two million people, making it home to 5.35 million people. The Queensland government and local councils have set a goal to achieve this growth without degrading the health of its waterways.[62]

The SEQ Environmental Account shows changes in the condition of each of the 13 river systems across the region (Figure 43). This data monitors whether this policy goal is being achieved.

REGIONAL RIVER ACCOUNT – SEQ CATCHMENTS, QUEENSLAND						
Class	2003	2007	2008	2009	2010	2011
Regional *Econd*	74	70	76	78	79	81
Bremer River catchment waterways	69	71	71	75	76	80
Gold Coast catchment waterways	84	87	91	89	90	91
Lockyer Creek catchment waterways	69	65	69	73	74	76
Logan-Albert catchment waterways	75	75	76	78	79	81
Lower Brisbane River catchment waterways	63	65	66	64	66	69
Maroochy-Mooloolah Rivers catchment waterways	72	74	85	81	83	88
Mid-Brisbane catchment waterways	71	76	89	84	81	72
Noosa River catchment waterways	94	72	89	90	89	94
Pine River catchment waterways	74	72	76	79	82	86
Pumicestone-Caboolture River catchment waterways	76	75	86	81	81	86
Redland catchment waterways	70	62	63	66	65	69
Stanley River catchment waterways	81	77	90	88	86	88
Upper Brisbane River catchment waterways	74	63	72	75	78	79

Figure 43: Freshwater Asset Account for SEQ Catchments region.

Each year the region releases an annual SEQ Healthy Waterways Report Card (Figure 44).[63] This report card converts the scientific information contained in the freshwater asset condition account into 'ecosystem health' grades of A, B, C, D and F to describe the level to which each of the 13 river catchments in the region is meeting the region's water quality objectives.

'Ecosystem health' is a term used to describe the level of condition that enables an environmental asset to provide a specific range of goods and services over time (Figure 45).

A river receives an ecosystem health 'A' rating when it has an *Econd* over 90 because that means that the water is safe to drink, for people to swim, it provides habitat for native species, and is not polluting to the downstream estuary (see Figure 44).

A 'B' rating, which equates to an *Econd* between 55 and 90, means that guidelines have been met for most of the reporting area, with most key processes slightly impacted and most critical habitats intact. An 'F' rating, where an *Econd* is below 25, indicates the river is failing minimum standards.[63]

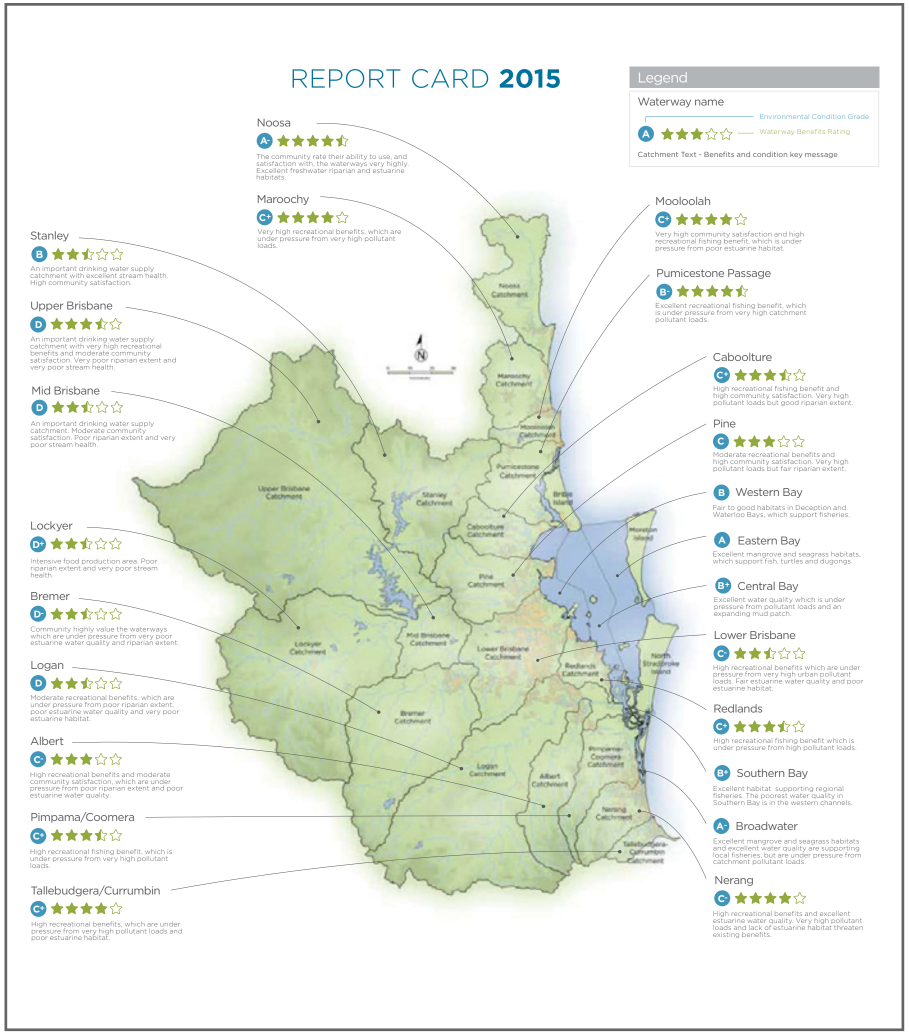


Figure 44: SEQ Healthy Waterways Report Card, 2015.

Environmental Condition and Ecosystem Health

Condition is a biophysical measure of the capacity of an environmental asset to provide a range of benefits to society, now and into the future.

Ecosystem health describes the level of condition that enables an environmental asset to provide a specific range of goods and services over time.

A river in a national park might be described as healthy when it is in a near pristine condition (*Econd* = 100), whereas a river in an urban catchment might be described as healthy at a lower level of condition (*Econd* = 55), if it maintains its capacity to provide safe drinking water, is safe for people to swim, provides habitat for native species, and is not polluting to the estuary downstream.

Figure 45: The difference between environmental 'condition' and ecosystem 'health'.

SEQ Catchments places this long-term trend data into qualitative models to estimate the likely pollution loads from increased urbanisation on these assets in the future (Figure 46).[64]

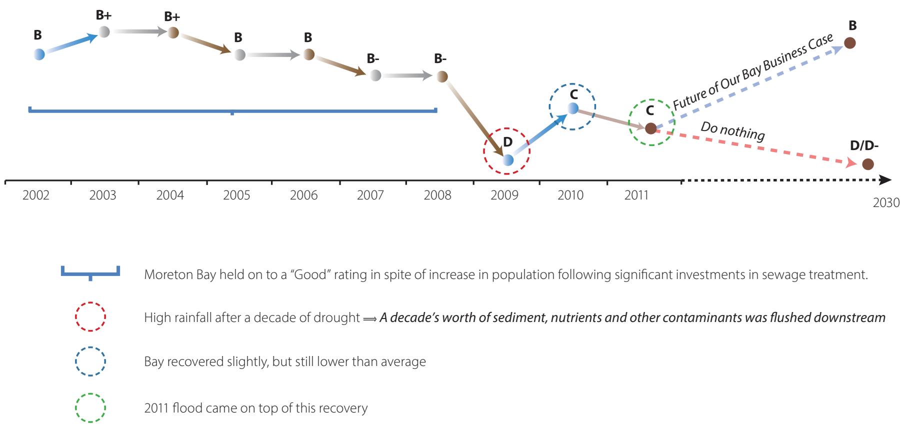


Figure 46: Long-term trends combined with qualitative interpretive information on events in the region, to inform future management options.[64]

The analysis found that increased nitrogen, phosphorus and sediment are likely to be the primary contributors to a decline in the condition of the region's freshwater assets in the future (Figure 47).

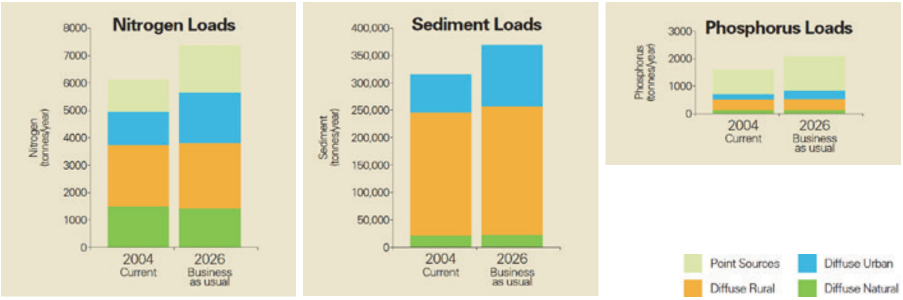


Figure 47: Primary indicators impacting on the condition of river assets in SEQ.

A regional green infrastructure investment plan was then produced which evaluated the overall level of investment required and the most cost-effective actions to achieve the region's goal of maintaining the condition of these river assets (Figure 48).[64, 65]

ACTIONS (INCLUDING LOW AND HIGH COST ESTIMATES WHERE AVAILABLE)	AMOUNT OF ACTION (Ha unless otherwise stated)	CUMULATIVE LOAD (tonnes/year)	CUMULATIVE COST ($/PA)
Gully treatment (low)	800 km	100,000	$5,000,000
Filter strips or buffer zones (low)	60,000	126,460	$6,991,115
Diversion banks (low)	20,000	135,770	$8,192,105
Diversion banks (high)	5,000	138,098	$8,842,641
Minimum tillage (low)	5,000	140,499	$9,849,261
Road runoff management (high)	2,000	140,989	$10,065,228
Livestock exclusion (low)	5,000	143,194	$12,245,973
Riparian projection or revegetation (low)	12,000	148,956	$18,564,445
Filter strips or buffer zones (high)	5,000	151,161	$21,124,450
Minimum tillage (high)	2,500	152,361	$22,621,473
Bioretention basins (detached house developments)	All greenfield development	154,246	$25,128,523
Bioretention basins (attached house developments)	All greenfield development	154,355	$25,325,813
Livestock exclusion (high)	1,000	154,796	$26,164,926

Figure 48: Long-term marginal abatement costs to maintain SEQ waterways.

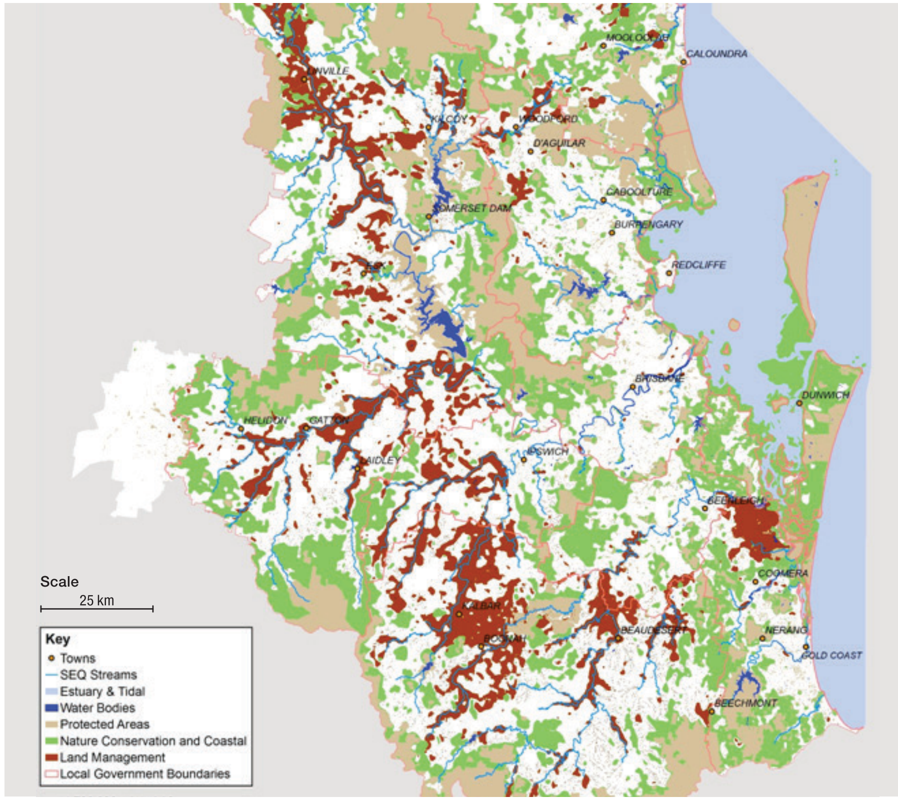


Figure 49: Map of land use across South East Queensland. Priority areas for investment in land management are shown in red.

Figure 49 shows how this information is combined with geospatial information to identify locations across the catchment where investments can be directed to achieve these outcomes (marked in red).

This analysis shows that investments such as restoring native vegetation along riparian (river) corridors can achieve the government's policy to maintain the Moreton Bay estuary at a target condition of "*B*" (*Econd* over 55), for a total annual cost of $26 million—less than $10 a year per ratepayer.

A $26 million investment equates to less than one per cent of the total public infrastructure budget (roads, power, waste management) to accommodate growth in the region.[65]

A legacy for future generations

"Of all the questions which can come before this nation, short of the actual preservation of its existence in a great war, there is none which compares in importance with the great central task of leaving this land even a better land for our descendants than it is for us."

– US President Theodore Roosevelt, 1912

If the legacy of our generation is to leave our world in a better condition than the one we have inherited, we need to create a sustainable economy—one that creates wealth without degrading its natural capital.

When we enhance natural capital we create opportunity. When we degrade natural capital we forego opportunity.[66] To create this opportunity we need an accounting framework that measures the condition of natural capital with the same diligence that we manage financial capital.

Accounting for Nature helps create this opportunity:

- It brings meaning to complex information by presenting scientific data in a simple and clear way to enable people to better understand the capacity of environmental assets to provide benefits to people and the economy.
- The data that underpin the accounts can also be used to identify the pressures driving change, the location of those pressures across the landscape, cost effective actions directed at addressing them, as well as monitoring and evaluating their progress.
- It also creates a cost effective pathway for industry, primary producers and other landholders to benefit from the sustainability of their business activities.

In the long run, a prosperous society depends on a healthy environment.

Every good business keeps track of its assets. Natural capital is a core asset on the balance sheet. It is true for an individual business. It is also true for the nation.[8]

Glossary

Asset – an item of value to society.[67]

Capacity – the ability of an environment asset to generate a set of ecosystem services in a sustainable way into the future.[68]

Common unit of measure – a method for converting an array of different indicators that describe the condition of environmental assets into a standardised index, based on a common reference condition benchmark.

Condition – a scientific description of the ecological 'state' of an environmental asset, measured through indicators that describe an asset's vigour (level of productivity), organisation (structure and interactions) and resilience (ability to rebound from a shock).[38]

Degradation – the loss in the capacity of an environmental asset to provide a range of ecosystem goods and services now and into the future.[20]

***Econd* –** a scientific measure, metric or model, accredited against agreed standards, that describes the current biophysical condition of an environmental asset as an index between 0 and 100, where 100 is a measure of the asset in its natural (reference) state.

Ecosystem – a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.[1, 21]

Ecosystem health – the level of condition that enables an environmental asset to provide a specific range of goods and services to people over time. Environmental assets are healthy when their capacity to provide food and materials, filter the air, absorb wastes, provide habitat for humans and other species, and give people the opportunity to enjoy the benefits of nature, can be sustained into the future.

Ecosystem service – a benefit people obtain from environmental assets (including ecosystems), comprising supporting services, provisioning services, regulating services and cultural services.[1, 21, 69]

Environmental asset – naturally occurring living and non-living components of Earth that provide benefits to humanity.[21] An environmental asset can be any biophysical feature in nature that provides benefits to society. It can be an ecosystem such as a forest, a river or an estuary; a natural resource that contributes directly to economic activities such as a fish stock, agricultural soil, or a groundwater resource; it can be an individual species of mammal or bird; or it can be any other feature in nature.

***Indicator Condition Score* –** a standardised raw value of an indicator measure against the reference benchmark. In some cases, the *Indicator Condition Score* may also act as an intermediate index comprising multiple indicators (indicator themes) of a similar type (e.g. water quality indicators combined to form a water quality index). In each index, 100 represents the reference benchmark for each indicator and 0 indicates system function is absent.[5]

Indicator theme – an overarching description of a group of indicators that, together, provide a measure of an aspect of an asset's condition. For example, indicators of pH, turbidity, dissolved oxygen and salinity may comprise a water quality indicator theme for rivers assets.

Natural capital – the stock of renewable and nonrenewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.[12]

Natural resource – natural biological assets that provide resources for use in economic activity, such as mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources and water resources.[70] In Australia, the term natural resources is often used to refer to all environmental assets, regardless of their use in economic activities.

Quality – the standard of something as measured against other things of a similar kind; the degree of excellence of something.[71]

Quantity – an amount of something.[72]

Reference condition benchmark – a scientific estimate of an environmental asset in its undegraded 'natural' (or potential) state. It can be a measure at sites that are known to be in an undegraded condition (such as a river in the upper reaches of a catchment),[25] or an estimate of its condition at fixed point in time (for example, the biophysical condition of an asset prior to industrial development).

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