Environmental-economic accounts: 2018 (corrected)

Data to 2016

Corrections were made to the February 2018 version of this report. See the footnotes on pages 14, 22, and 52 for details.

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Purpose and summary

Environmental-economic accounts: 2018 presents a summary of New Zealand's stocks and flows of natural capital (environmental assets) measured to date, the economic activities being undertaken to protect the environment, and other information that show the interactions between the environment and the economy.

This report includes accounts for:

- physical stocks of land cover, timber, and water
- monetary stocks of timber, fish, and renewable energy resources
- annual resource rents for fish, timber, minerals, and renewable energy
- physical flows of air emissions (greenhouse gases)
- environmental protection expenditure by central and local government, and environmental taxes.

We also include:

- physical estimates of carbon stored and sequestered by forests and a range of potential monetary values for carbon sequestration as an ecosystem service
- estimates of the marine economy in terms of GDP and jobs
- estimates of the renewable energy generation sector in terms of gross domestic product and jobs.

We compiled the information using the System of Environmental-Economic Accounting (SEEA) framework, which the United Nations adopted in 2012 as the international standard for measuring the interactions between the environment and the economy.

Further information on the definitions, concepts, sources, and methods we used to compile the accounts are available from Environmental-economic accounting: sources and methods.

The data in this report reflect the available information we have collected to date. There are numerous gaps in our data which we intend to fill over time. We encourage you to provide feedback to environmental.accounts@stats.govt.nz on the information contained in this report, and welcome suggestions for future developments.

Revisions to previously published accounts

To support Treasury's narrative on natural capital in their 2018 Investment Statement: Investing for wellbeing, we updated the forestry monetary and physical stocks accounts, the fish monetary stock account, and the water physical stock account on 28 August 2017. These accounts were provisional and the final estimates are in this report. There are minor revisions to the forestry accounts due to revised exotic plantation data from the Ministry for Primary Industries. Fish monetary stock revisions are more significant due to a change in the discount rate used. The water physical stock data is unchanged.

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Introduction to environmental accounting

Environmental accounting aims to show the interactions between the environment and the economy. It can be used to assess whether patterns of economic activity are depleting or degrading our resources, to show the value of natural resources, and to determine who benefits from natural resource use and what actions are being undertaken to protect the environment.

Our economy intrinsically operates within (and not separate from) the environment. Through environmental accounting we are able to show the impacts of economic activity on the environment and the dependency of the economy on natural resources. It also contributes to a broader understanding of our national wealth, and shows whether environmental assets are being left for future generations.

Industry contributions to gross domestic product

Primary industries (agriculture, forestry, fishing, and mining) accounted for 5.5 percent of gross domestic product (GDP) in 2016, amounting to $14.0 billion. This contribution has declined from 12.1 percent in 1972. In 2016, agriculture accounted for 3.1 percent of GDP; forestry and logging 0.6 percent; fishing, aquaculture and agriculture, forestry and fishing support services 0.9 percent; and mining 1.0 percent.

A range of other industries rely on natural resources either directly or indirectly. The electricity, gas, water and waste services industry accounted for 3.0 percent of GDP in 2016. Food, beverage and tobacco product manufacturing contributed a further 4.5 percent.

Thirteen of our top 20 export commodities, about 70 percent of New Zealand's export earnings, depend on natural resources. Total exports of goods and services accounted for $70.2 billion (27.6 percent) of GDP in 2016.

About the SEEA

The System of Environmental-Economic Accounting (SEEA) is an internationally accepted framework that specifies how environmental and economic information can be integrated coherently. It uses the concepts, definitions, and classifications consistent with those in the System of National Accounts (SNA), which is used by Stats NZ to produce economic statistics such as gross domestic product. The SEEA framework allows us to make direct comparisons between environmental and economic information, so that we have a clearer understanding of environmental-economic trade-offs and a more complete picture of our country's economic and environmental performance.

Scope of this report

All data in this report are at the national level, except for information on land cover and water physical stock, which are available by region. In time, as we develop the ecosystem accounts, we will aim to produce more information at a finer geographic level. We identify key gaps in our environmental accounts throughout this report.

This report includes accounts for:

- physical stocks of land cover, timber, and water

- monetary stocks of timber, fish, and renewable energy resources
- annual resource rents (income minus extraction costs) for fish, timber, minerals, and renewable energy
- physical flows of air emissions (greenhouse gases)
- environmental protection expenditure by central and local government, and environmental taxes.

We also include:

- physical estimates of carbon stored and sequestered by forests and a range of potential monetary values for carbon sequestration as an ecosystem service
- estimates of the marine economy in terms of GDP and jobs
- estimates of the renewable energy generation sector in terms of GDP and jobs.

Key findings

Environmental accounting aims to show the stocks of natural capital, whether or not they are available for economic use, the flow of resources from the environment to the economy, the flow of residuals (eg pollutants) from economic activity to the environment, and the economic activities being undertaken to protect the environment.

This report presents information on New Zealand's physical stocks of environmental assets (eg water, forests, and land), the value of some of our natural capital stocks, the flows of greenhouse gas emissions from economic activity, and the extent to which economic activity is being undertaken to protect the environment.

Natural capital in physical terms

Accounting for natural capital in physical terms, such as the number of hectares of land cover or the volume of water, provides the basis for understanding how much of our natural resources are available for economic production, private consumption, and future generations.

Land cover

The land cover account shows the extent to which land cover has changed across New Zealand.

- From 1996 to 2012 (latest data available), 2.3 percent of New Zealand's land cover changed classes. Tree-covered areas increased 199,547 hectares (2.2 percent), while grassland cover decreased 214,581 hectares (1.6 percent). Artificial surfaces increased 24,220 hectares (10.9 percent).

- The increase in tree-covered areas was driven by changes from grassland (82 percent of the change) while a further 20 percent was due to changes from shrub-covered areas.
- In 2012, grassland accounted for 49.1 percent of New Zealand's land cover and tree-covered areas 33.9 percent.

Timber

The timber account shows how the composition of New Zealand's timber resource has changed over time, and reasons for the changes.

- Between 1995 and 2016, total cultivated (exotic) timber resources increased 90 percent, driven by new planting in the 1980s and 1990s and natural growth.
- In 2016, total timber stocks fell slightly as cultivated timber planted in the 1990s started to reach harvesting age.
- The flow of carbon sequestration services is strongly and inversely related to the real GDP of the forestry and logging industry. As cultivated timber reaches maturity over the next decade, GDP for the forestry and logging industry is expected to rise while carbon sequestration services provided by forestry is expected to fall.
- Between 1995 and 2016, total natural (indigenous) timber resources decreased slightly by 0.2 percent (10,546 hectares or 3,802 thousand cubic meters).

Water

The water physical stock account records the inflows, outflows, and change in water storage across New Zealand.

- Between 1995 and 2014, the average annual volume of precipitation (includes rainfall, snow, sleet, and hail) that fell in New Zealand was 549,392 million cubic metres, enough to fill Lake Taupo over nine times.
- The West Coast had the largest rainfall volume over this period, although it has only the fifth-largest land area. Southland and Canterbury had the next largest amounts of annual precipitation. Otago, with its extensive dry areas, had only the fourth-largest precipitation volume, although it is the second-largest region.
- In 2014, abstraction for hydroelectricity generation was 153,989 million cubic metres. This amounts to an estimated 93 cubic metres per person per day.
- Changes in soil moisture and groundwater were the main source of increase in change in storage in 16 of the 20 years (eight each) measured.
- Changes in ice storage can affect renewable hydroelectricity resources and surrounding ecosystems. From 1996 to 2014, New Zealand's estimated glacier ice volume decreased 35 percent.

Natural capital in monetary terms

Measuring stocks in monetary terms focuses on the value of individual environmental assets and changes in those values over time. The valuation of assets under SEEA focuses on the benefits that accrue to economic owners of environmental assets, and assists in a broader understanding of national wealth. These valuations help us understand the economic benefits received from natural capital, and thus, how dependent economic outcomes are on natural capital. While stocks of environmental assets show the resources available for production and consumption, it is the flow of these assets that benefits economy and society.

- The value of fish, timber, and renewable energy stocks reached $38.9 billion in 2016, up 47 percent from 2007.
- Initial estimates of the resource rents (annual income generated from extracting the resources minus costs) for the forestry and logging, and electricity, gas, water, and waste services industries showed they accounted for 53 percent and 28 percent of their industries GDP in 2016, respectively.
- Timber had the highest resource rent in 2016, surpassing that for fish. Total resource rents for fish, minerals, renewable energy, and timber assets amounted to $2.0 billion in 2016, up 25 percent since 2007. Our estimates of natural capital in monetary terms are partial but so far have amounted to 0.8 percent of GDP in 2016.
- Electricity generated from renewables accounted for 82 percent of total electricity generation. Returns to electricity operators from the use of all renewables (resource rent) reached $818 million, $574 million of which was from hydroelectricity. In 2016 the resource rent from geothermal reached $173 million (up 9.5 percent a year from 2007); for wind it was $56 million.
- The value of New Zealand's commercial fish resource was $7.2 billion in 2016 (up 163 percent since 1996). Rock lobster, with an asset value of $2.4 billion, contributed 34

percent of the total value of New Zealand's fish resource. The total value of seafood exports increased 12 percent from September 2015 to $1.9 billion.

- The number of species included in the quota management system (QMS) increased from 26 in 1986 to 98 in 2016. This does affect the total allowable commercial catch, and catch and asset value of New Zealand's fish resources. The asset value for the original 26 QMS species increased 60 percent while the total allowable commercial catch (TACC) for these species reduced 29 percent.

Flows from the economy to the environment

The flows of residuals (eg pollutants) from economic activity back to the environment can be recorded in SEEA. It is important to capture these types of environment-economy interactions to show how economic activity affects the environment. At present, the only SEEA flow account we have is for greenhouse gas emissions. The air emissions account excludes emissions and removals from the greenhouse gas inventory land-use change and forestry sector.

- The air emissions account shows five industries recorded a decrease in emissions, three of which while increasing economic output: fishing; mining; and transport equipment, machinery and equipment manufacturing. Greenhouse gas intensity has decreased for these industries. Their economic activity has 'decoupled' from their air emissions (a breaking of the link between emissions and economic growth).
- Emissions increased at a faster rate than GDP for forestry; food, beverage, and tobacco product manufacturing; petroleum, chemical, polymer, and rubber product manufacturing; metal product manufacturing; and total manufacturing. Greenhouse gas intensity has increased for these industries.
- Agriculture, transport and storage, and electricity, gas, water, and waste services accounted for 76.5 percent of industry emissions in 2015. Emissions from all these industries increased but at a slower rate than their GDP, therefore showing relative decoupling. The agriculture industry's carbon dioxide equivalent emissions increased 0.6 percent a year, while it's GDP (in real terms) increased by 1.4 percent a year.
- Primary industries accounted for 57.1 percent of carbon dioxide equivalent emissions in 2015, goods-producing industries 24.8 percent, and service industries 11.1 percent. Households accounted for 6.9 percent.
- From 1990 to 2015, total economy real GDP increased at a rate of 3.1 percent a year while carbon dioxide equivalent emissions increased 0.9 percent a year, driving a decline in greenhouse gas intensity. Emissions growth was 0.5 percent a year for primary industries, 1.2 percent for goods-producing industries, and 2.2 percent a year for service industries.

Environmental activity accounts

To understand the interactions between the environment and economy, it is important to consider the monetary transactions within the economy that are undertaken to preserve and protect the environment. These transactions, including taxes and subsidies, reflect government efforts to influence the behaviour of producers and consumers with respect to the environment.

- The environmental protection expenditure account shows that general (central and local) government final consumption expenditure on environmental protection reached $2.1 billion in 2016, up 17 percent from 2009.

- Wastewater management accounted for 56 percent ($586 million) of local government environmental protection final consumption expenditure in 2016, while pest management accounted for 3 percent ($33 million).
- General government investment in environmental protection amounted to $970 million. Environmental protection investment to total investment declined from 14.8 percent to 9.7 percent from 2009 to 2016.
- The environmental tax account shows that the share of environmental taxes paid by households has increased relative to industry. In 2016, households paid 13 percent of environmental taxes, up from 7 percent in 1999. The average household paid $380 in environmental taxes in 2016.
- Over the same period, industries' contribution to environmental taxes dropped from 93 percent to 87 percent.
- In 2016, the total amount of environmental taxes (energy, transport, resource (including harvesting of biological resources and extraction of raw materials), and pollution taxes) was $4.9 billion, nearly three times that for 1999 ($1.6 billion). This was 6.2 percent of all tax received by general government, up from 4.8 percent in 1999.
- Resources taxes declined from 8 percent of total environmental taxes in 1999 to 1 percent in 2016. In 2016, most environmental taxes were energy taxes (51 percent) and transport taxes (47 percent). Combined pollution and resources taxes made up only 2 percent of the total.

Natural capital: physical estimates

Accounting for natural capital in physical terms, such as the number of hectares of tree-covered areas or the volume of water, provides the basis for understanding the amount of natural resources available for economic production, for private consumption, and for future generations. Natural capital stocks generate the ecosystem services that contribute to our well-being. They can also inform on whether economic growth is sustainable in a strong sense – strong sustainability requires that natural wealth is non-declining.

In physical terms, the conceptual scope for an individual environmental asset or ecosystem is broad and includes all the resources that may provide benefits to humanity, so there may be some stocks with zero economic value. For example, we can analyse all land within the country, but in monetary terms some land may have zero value. Recording these assets in physical terms is still essential for recognising the (non-monetary) values they provide.

This section presents accounts in physical terms of some of New Zealand's main natural resources: land, water, and timber.

Land cover

Land is the base of operations for New Zealand's economy and society. SEEA defines land cover as "the observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces" (United Nations, 2014a).

Although land commonly refers to terrestrial areas, the land cover account includes inland water resources and coastal margins. It shows the amount (in hectares) of land cover types, and how they are changing over time. The objective of land accounts in physical terms is to describe the area of land and changes in the area of land over an accounting period (UN, 2014a, para 5.263). The land cover account is experimental as the SEEA land cover classification is still subject to further research and testing (UN, 2014, p177).

Key facts

In 2012:

- Grassland accounted for 49.1 percent of New Zealand's land cover and tree-covered areas a further 33.9 percent.
- Shrub-covered areas accounted for 8 percent, and artificial surfaces a further 1 percent.

From 1996 to 2012:

- 2.3 percent of New Zealand's land cover changed classes.
- Tree-covered areas increased 199,547 hectares (2.2 percent). There were additions of 304,775 hectares of tree-covered areas but 105, 228 hectares of reductions.

- Of the net change in tree-covered areas, 163,150[1] (or 82 percent) were classed as grassland in 1996 while a further 39,153[2] (20 percent) hectares were classed as shrub-covered areas.
- Grassland cover fell 214,581 hectares (1.6 percent).
- Artificial surfaces increased 24,220 hectares (10.9 percent).

Changes in New Zealand's land cover

As a stock account, the land cover account presents the opening stock, additions and reductions to stock, and closing stock. Stocks for land cover are measured in hectares. The accounting framework allows the net change to be decomposed into additions and reductions to stock: this can be insightful when net change is close to zero at the total level but significant changes occur at a localised level (Office for National Statistics (ONS), 2015b).

Table 1 shows the provisional land cover account using the SEEA classification.

Table 1

Land cover, New Zealand, 1996–2012

Land cover	Opening area (1996)	Additions	Reductions	Net change	Closing area (2012)
			Hectares		
Artificial surfaces	221,419	25,078	858	24,220	245,640
Coastal water bodies and intertidal areas	94,271	79	59	20	94,291
Grassland	13,405,584	161,095	375,676	-214,581	13,191,003
Herbaceous crops	363,635	14,488	8,374	6,115	369,749
Inland water bodies	439,765	2,804	251	2,554	442,319
Mangroves	28,056	43	2	41	28,097
Permanent snow and glaciers	111,040	…	…	…	111,040
Shrub-covered areas	2,095,201	57,788	107,994	-50,206	2,044,995
Shrubs and/or herbaceous vegetation, aquatic or regularly flooded	166,600	221	1,705	-1,483	165,117
Terrestrial barren land	941,750	2,239	3,861	-1,622	940,128
Tree-covered areas	8,906,877	304,775	105,228	199,547	9,106,424
Woody crops	68,203	42,274	6,878	35,395	103,599
Total	26,842,401	610,885	610,885	0	26,842,401

Note: The SEEA land cover classification includes classes for 'multiple or layered crops' and 'sparsely natural vegetated areas'. These are, however, not relevant in New Zealand.

Symbol: … not available. Permanent snow and glaciers was measured in 1996 but has not been updated since.

Source: Stats NZ using data from Landcare Research

[1] The previous version incorrectly stated this number as 162,968.

[2] The previous version incorrectly stated this number as 38,901.

Of New Zealand's 26.8 million hectares, grassland accounted for 49.1 percent of New Zealand's land cover, and tree-covered areas a further 33.9 percent in 2012. Shrub-covered areas accounted for 8 percent, and artificial surfaces areas a further 1 percent.

From 1996 to 2012, 2.3 percent of New Zealand's land cover changed classes. Land cover increased for tree-covered areas (2.2 percent, 199,547 hectares), woody crops (51.9 percent, 35,395 hectares) and artificial surfaces (10.9 percent, 24,220 hectares). Land cover decreased for grassland (1.6 percent, 214,581 hectares), and shrubland (2.4 percent, 50,206 hectares).

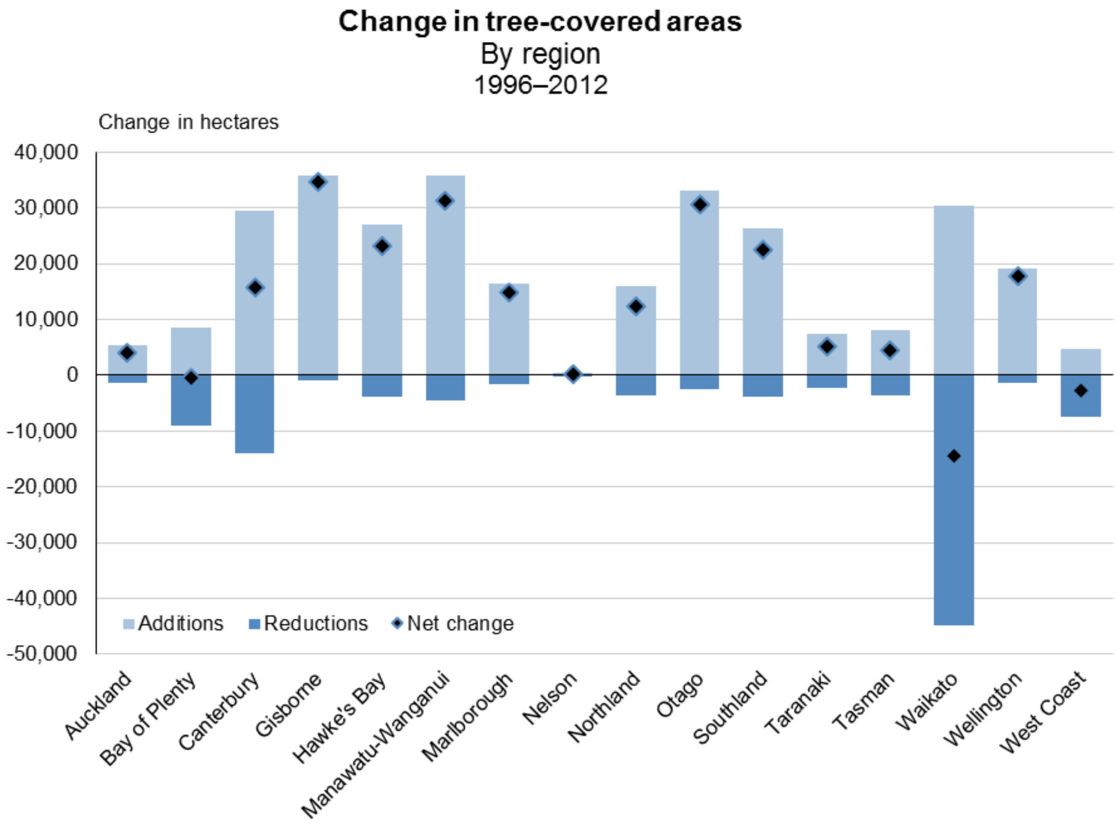
Changes in land cover of permanent snow and glaciers in hectares are not available as these areas have not been measured since 1996. Glacier ice volumes (in cubic metres from the water physical stock account) fell 35 percent from 1996-2014 indicating that the number of hectares covered by permanent snow and glaciers has also decreased over time.

Additions of 161, 095 hectares of grassland were outstripped by the 375,676 hectares of reductions leading to an overall net reduction. For tree-covered areas, there were 304,775 hectares of additional stock while 105, 228 hectares of tree-covered areas changed class so that the net change amounted to 199,547 hectares.

The change in tree-covered areas was driven by changes from grassland to trees. Of the net 199,547 hectares that changed to tree-covered areas, 163,150 (or 82 percent) were classed as grassland in 1996 while a further 39,153 (20 percent) hectares were classed as shrub-covered areas.

Most regions recorded an increase in land covered by tree-covered areas, except for Bay of Plenty, Waikato, and the West Coast. Net change in tree-covered areas was greatest for Gisborne, followed by Manawatu-Wanganui, and Otago (figure 1). Despite the net reduction for Waikato, the region had the fourth-highest increase in tree-covered areas from 1996 to 2012. Canterbury had the fifth-highest increase in tree-covered areas, but the second-largest reduction.

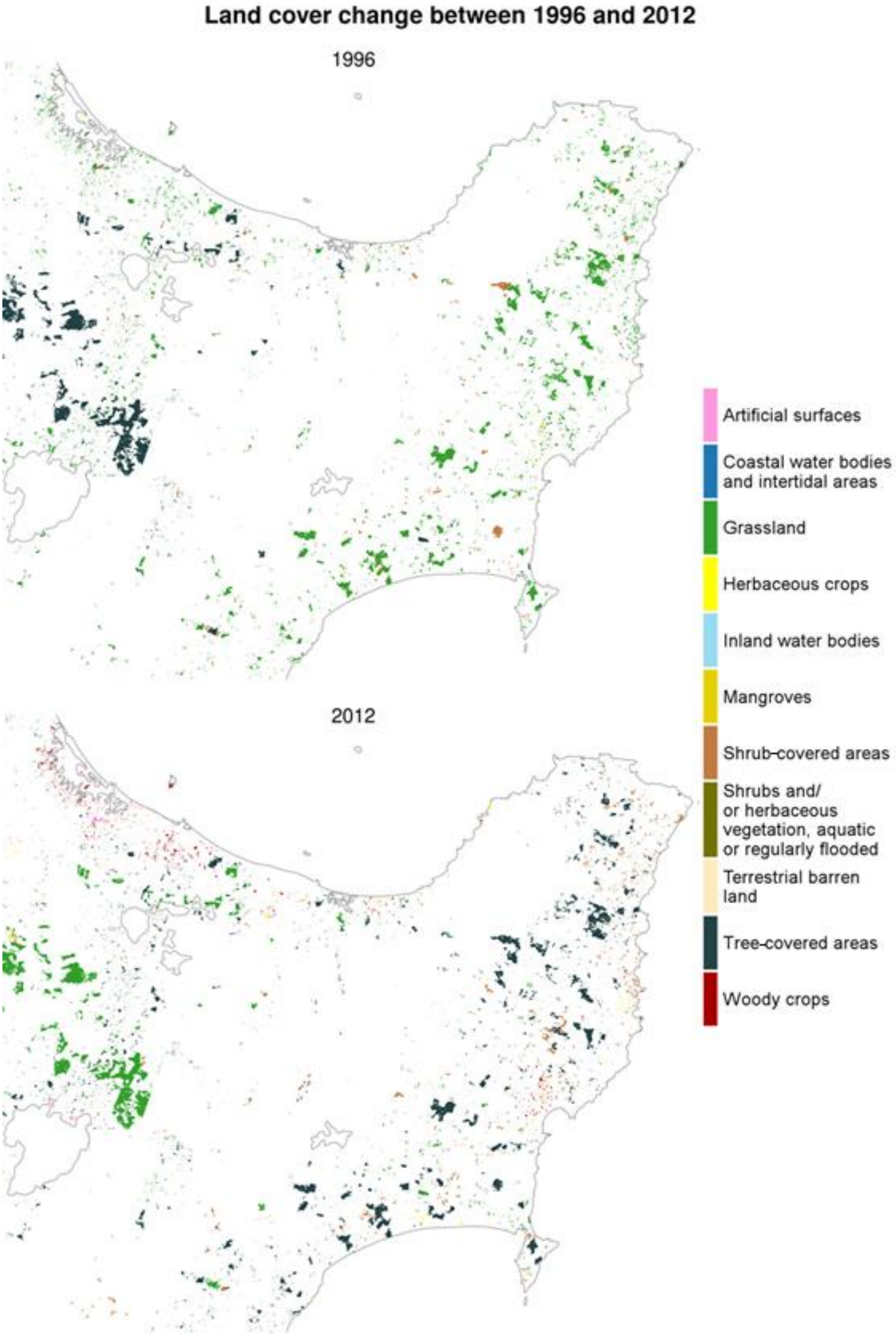
Figure 1



Source: Stats NZ using data from Landcare Research

Figure 2 shows the change in land cover in the middle of the North Island between 1996 and 2012. It only colours areas that changed within this period. The top map shows what the land cover that changed was in 1996, the bottom map shows what land cover that changed turned into by 2012. It illustrates the change from grassland to tree covered areas within the Gisborne region, and the change from tree covered areas to grassland near Taupo (Waikato).

Figure 2



Source: Stats NZ

The SEEA land cover account does not distinguish between natural and managed areas, that is, it does not provide information on how the land is used. Although natural changes in the environment and previous and current land use determine land cover, particularly in agricultural and forestry areas, characteristics of vegetation (eg whether it is natural or cultivated) are not inherent features of the land cover.

The future development of a land use account (both physical and monetary terms) using the SEEA framework will enable comparisons between land use and land cover. For example, this could show the amount of tree-covered areas in agricultural, forestry, and conservation land. Land cover accounts allow international comparisons and provide a basis for measuring ecosystem services.

See SEEA land cover account to access maps and more data on land cover change across New Zealand.

Timber

The timber stock account shows the composition of New Zealand's timber resource, how the resource changes annually, and the reasons for the changes. It presents the forest resource in terms of total cubic metres, but is also available in total hectares.

The timber stock account is an example of how the SEEA accounting structure can be used to distinguish between the use and non-use of natural resources, with estimates for timber that are either available or unavailable for supply. The timber stock account allows us to analyse how the resource is used compared with its economic output, enhancing our understanding of the relationships between the inputs into timber production and how this affects the environment.

Key facts

In 2016:

- Total timber stocks fell slightly, by 256 thousand cubic metres (0.0 percent) as cultivated timber planted in the 1980s and 1990s started to reach harvesting age.
- Land area harvested exceeded land area planted by 2,503 hectares.
- As cultivated timber reaches maturity over the next decade, GDP for the forestry and logging industry is expected to rise while carbon sequestration services provided by forestry is expected to fall.

From 1995 to 2016:

- Total natural timber resources decreased slightly by 0.2 percent (10,546 hectares or 3,802 thousand cubic meters).
- Total cultivated timber stocks increased 90 percent, driven by new planting in the 1980s and 1990s, and natural growth.
- Carbon stocks in cultivated forests increased 69 percent.
- Total timber available for wood supply stocks increased 25 percent, resulting primarily from growth of existing cultivated timber stocks.

Total timber resources

Forests covered 9.1 million hectares in 2012, or 34 percent of New Zealand's total land cover. Natural (indigenous) tree-covered areas accounted for 6.3 million hectares (23.5 percent) of New Zealand's land cover in 2012. This coverage, combined with data from the Ministry for Primary Industries for cultivated timber, provides a basis for New Zealand's timber resource accounts.

Wood unavailable for supply includes wood in areas which are geographically inaccessible, or where logging is prohibited, or where the wood is from a species that is not of commercial value. Wood available for supply includes trees of all ages, as most can be harvested at almost any age, even if the majority are harvested only when they reach maturity.

In 2016, 69 percent of New Zealand's timber resources were in the form of natural (indigenous) forests unavailable for wood supply. Cultivated (exotic) forest available for wood supply accounted for an additional 18 percent of New Zealand's timber resources.

Total hectares of timber resources increased from 1995 to reach a peak of 8.1 million hectares in 2003. In 2016 the total area decreased slightly to 8.0 million hectares. Total timber resources increased 234,052 cubic meters between 1995 and 2016, declining slightly for the first time in 2016.

Differences between land cover account and timber account

The number of hectares covered by trees in the land cover account differ from those in the timber physical stock account.

- For natural (indigenous) forests, the timber account uses the indigenous forest class from the land cover database. The land cover account includes additional classes as tree-covered areas, including broadleaved indigenous hardwood and deciduous hardwood.
- For cultivated (exotic) forests, the timber account uses Ministry for Primary Industries data. In 2012 the land cover database estimates exotic forest land cover is 5 percent higher than MPI estimates of exotic planted forests available for wood supply. This difference is an area for future investigation.

Cultivated (exotic) forests have been planted in New Zealand since the early 20th century and are found throughout the country. About one-third are located in the central North Island, with other major forest-growing areas including Northland, East Coast, Hawke's Bay, Nelson, Marlborough, Otago, and Southland.

The dominant species in cultivated forests is radiata pine, which made up 94 percent of total exotic forests in 2016. Douglas fir made up 3 percent, eucalyptus 1 percent, and the remainder a variety of special-purpose species such as black walnut and Corsican pine. These proportions have not changed significantly over time.

In 1995 the total volume of natural (indigenous) timber resources available for wood supply was larger than that for cultivated (exotic) timber. However, this reversed over the following 15 years. Total hectares of cultivated forest increased 15 percent between 1995 and 2016, while cultivated timber available for wood supply increased 90 percent. This reflects both new plantations and growth of the volume of wood in existing plantations.

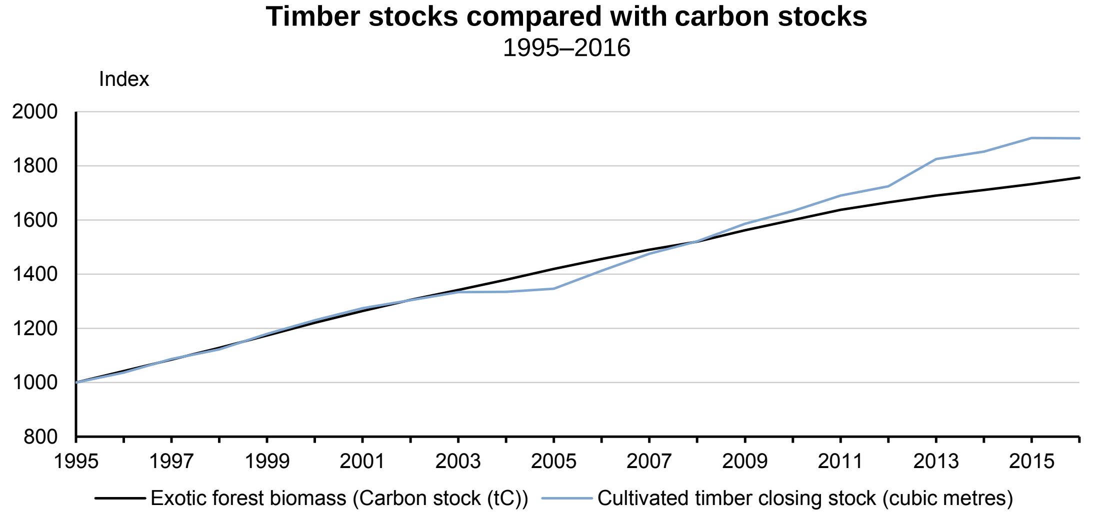
Estimates of the value of the timber stock are presented in Natural capital: monetary estimates.

Carbon stocks

Trees provide an important regulating ecosystem service in sequestering and storing carbon. When timber stocks increase, so do the stocks of carbon. As the forests planted in the 1980s and 1990s are harvested, cultivated timber stocks are expected to decrease along with carbon stocks.

Estimates of carbon stocks are closely correlated to total timber stocks (figure 3).

Figure 3



Note: Stock data is year ended 1 April, and carbon stock data is year ended December.
The carbon stock data has been converted to the closest possible March year i.e. December 2010 becomes March 2011.

Source: Stats NZ

In terms of ecosystem services, storage of carbon (a stock measure) should be distinguished from carbon sequestration (a flow measure). The SEEA notes that “a high carbon stock may mean that sequestration is limited because the vegetation is close to its maximum biomass under the ecological conditions pertaining in the particular area. A low carbon stock may mean that there is scope for additional sequestration (eg, in a recently felled forest with intact soil fertility)” (UN, 2014b).

This implies that the carbon sequestration service provided by cultivated forests is likely to be inversely related to removals, and GDP growth, when new planting and natural growth are insufficient to offset harvesting. This is explored further in the next section.

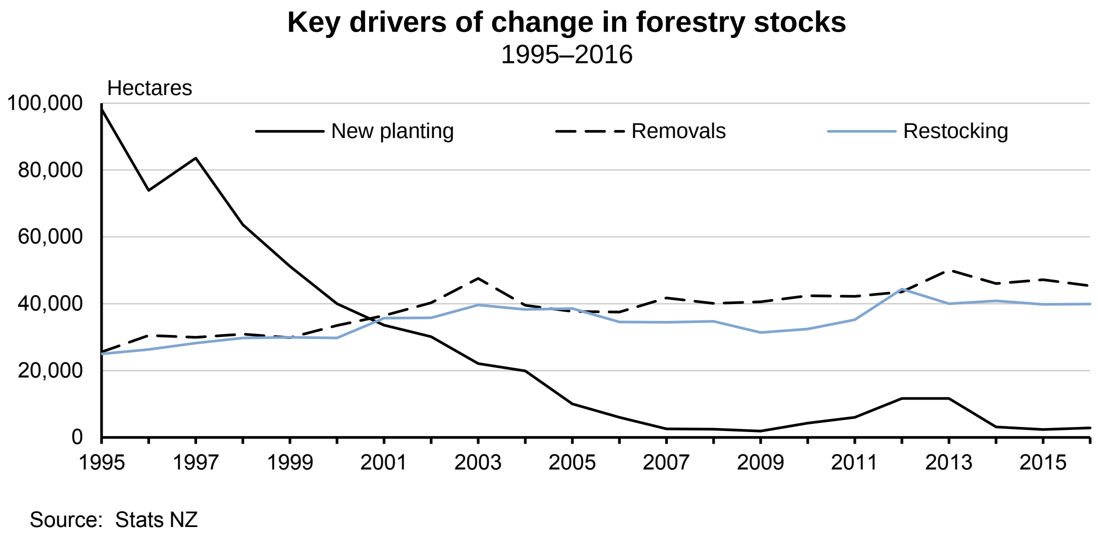
Further work will be undertaken to understand the differences between timber stock and carbon sequestration growth and incorporate carbon sequestration into future environmental accounts.

Drivers of change in timber stocks

Natural growth and harvesting are identified in the timber stock account as major components of change in commercial forests. New planting is not included in the timber stock account as planting itself does not increase the timber stock, but natural growth does so after planting has occurred. However, new planting data is included in the downloadable Excel tables accompanying this report.

After significant new planting of 98,000 hectares of timber in 1995, new planting continued but at a decreasing rate (figure 4).

Figure 4



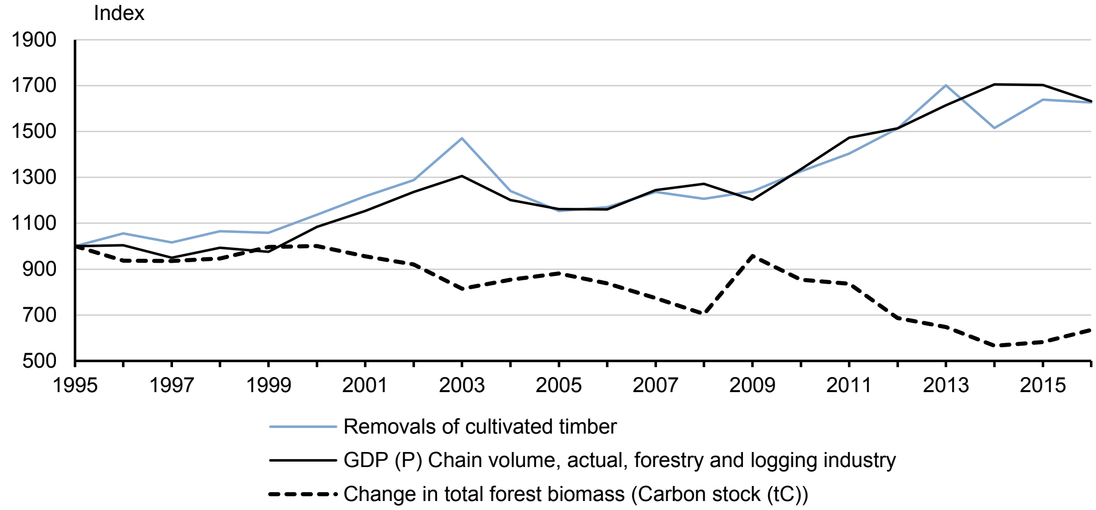
New planting (planting of trees on land that has not previously been used for growing production forests), and restocking (replanting planted production forest that has been harvested) combined was larger than removals until 2007. Hectares of cultivated timber available for wood supply peaked in 2003, and then generally declined over the next 10 years as planting and restocking no longer exceeded removals. The value of timber stocks in cubic metres continued to increase as the existing forests planted continued to grow and increase the value of timber (per hectare of forest) as they matured.

Radiata pine takes about 26–32 years to grow to maturity. This presents unique problems in presenting a full picture of the industry as activity decades ago is only starting to flow through from original investment to harvest, with subsequent impact on GDP and carbon sequestration. The forest planted in 1995 is only now beginning to reach maturity. The beginning of the harvest of the forest planted at this time, or a bit before, can be seen in the 2016 closing stock estimates. In 2016, closing stocks in cubic metres fell for the first time since at least 1995, when data is first available.

Total removals of cultivated timber and GDP in real terms (which has the effects of price change removed) for the forestry and logging industry are closely related (figure 5). Therefore, future removal rates are expected to be closely linked to future GDP. As forestry plantations cultivated in the 1980s and 1990s mature and are removed, it is reasonable to expect GDP for the forestry and logging industry to increase substantially. This increase will include flow-on effects to industries providing services to the forestry and logging industry, and with positive impacts on other measures of welfare, such as employment in the forestry and logging industry. Carbon sequestration, however, is expected to decrease as the harvested forests will no longer provide the service.

Figure 5

Timber removals, gross domestic product, and carbon sequestration
1995–2016



Note: Removals data is year ended 1 April, GDP data is year ended March, and carbon stock data is year ended December. The carbon stock data has been converted to the closest possible March year i.e. December 2010 becomes March 2011. GDP is provisional (P)

Source: Stats NZ

Forests in New Zealand are subject to natural losses, although only losses due to fire are currently captured in the timber accounts. In particular, losses from pests and disease are an area for future development. All major cultivated forests are inspected for pests and disease once a year. The economic losses from insects and disease in cultivated forests was estimated at $83 million in 2013 (Ministry for Primary Industries, 2015)

Natural forests

Natural (indigenous) forests occur in most parts of New Zealand, but are dominant on the mountain slopes of the West Coast and Fiordland areas of the South Island. The major indigenous species include beech, kauri, rimu, taraire, and tawa. About 78 percent of New Zealand's indigenous forests are Crown-owned, of which the vast majority is set aside for conservation, heritage, and recreation uses. A small percentage of the Crown-owned forests was set aside for future sustainable harvesting. The remaining indigenous forests are privately owned, but most are not available for timber production. New Zealand law requires that privately owned indigenous forests be managed in a way that they can provide products and amenity value for future generations.

Between 1995 and 2016, total hectares of natural forest decreased only 0.2 percent (10,546[3] hectares or 3,802 cubic metres).

[3] The previous version of this report incorrectly stated this as 10,456 hectares.

Future development of natural forest estimates

Estimates of total hectares of natural forest before 2012 are reliable, which was when the most recent land cover database was available. However, estimates of cubic metres of stock in natural forests are currently based on a fixed conversion factor. Improving this conversion factor, or finding alternative stock estimates in cubic metres for natural forests, is an area for future development.

Data on natural forests available for supply and those unavailable for supply are less reliable and is an area for future development.

Water

In 2012, inland water bodies accounted for 442,319 hectares (1.6 percent) of land cover and permanent snow and glaciers a further 111,040 hectares (0.4 percent), providing the basis for New Zealand’s water stocks.

The water physical stock account describes how stocks of fresh water are affected by water flows within the hydrological system during accounting periods. This account describes a system of stock or asset accounts, with opening and closing stocks of water resources and the flows that affect these stocks.

In the New Zealand water physical stock account, total opening and closing stocks are not quantified. Instead, the account is presented in terms of inflows, outflows, and changes in storage levels.

The water physical stock account deals with the inland water components of the hydrological system. The scope is broad and includes all fresh water (as opposed to seawater) resources whether above, on, or below ground that provide both direct-use and non-use benefits. Direct-use benefits include water that can be extracted in the current period and water that may be used in the future. Non-economic-use benefits (such as those for recreational benefit) arise simply by having the resource in existence.

The water physical stock account measures, where possible, interactions between the hydrological cycle and the economy. The exchange of water between the environment and the economy is partly represented by information on water abstraction and discharges: water use for livestock drinking and dairy-shed requirements; and abstraction and discharge for hydroelectricity generation.

The stock classification for freshwater resources reflects the components of the hydrological system that are available for water abstraction and that provide direct inputs into the economy. Soil moisture, glaciers, and permanent snow are not specifically classified as a ‘stock’ as water is not abstracted directly from these sources. However, they are important components of the hydrological system and are included in this account.

Key facts

In the year ended June 2014:

- The West Coast region received the highest precipitation.
- Abstraction for hydroelectricity generation amounted to an estimated 94 cubic metres per person per day, roughly equivalent to 627 full baths of water per person each day.

In the year ended June, 1995–2014:

- The average volume of precipitation was enough to fill Lake Taupo just over nine times each year.
- The total volume of groundwater varied by less than 1 percent.

Between the years ended April, 1995-2014:

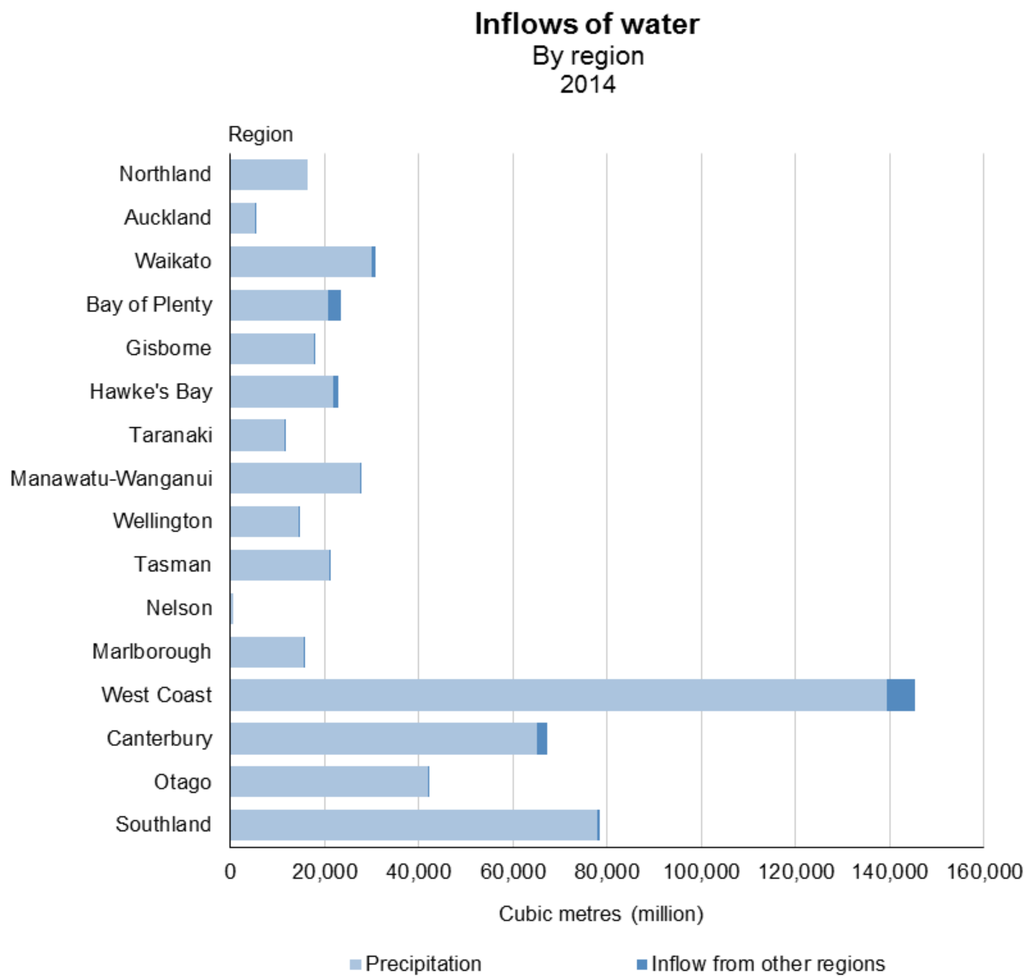
- New Zealand's estimated ice volume decreased by 35 percent.

Inflows

As an island nation, inflows of water in New Zealand are dominated by precipitation. Between 1995 and 2014, the average annual volume of precipitation (includes rainfall, snow, sleet, and hail) that fell in New Zealand was 549,392 million cubic metres, enough to fill Lake Taupo over nine times. Annual precipitation was highest in 1996 at 636,120 million cubic metres, and lowest in 2012 at 473,474 million cubic metres. In 2014, precipitation was 526,936 million cubic metres. From 1995 to 2014, the West Coast had the largest rainfall volume (figure 6) although it has only the fifth-largest land area. Southland and Canterbury had the next largest amounts of annual precipitation. Otago, with its extensive dry areas, had only the fourth-largest precipitation volume, although it is the second-largest region.

The lower-than-average national values for precipitation and outflow to sea in some years (1997, 2001, 2003, 2005-08, and 2012–14) are mainly caused by low precipitation in the South Island and Taranaki or central North Island. Consistent effects of El Niño-Southern Oscillation (ENSO) events on precipitation are not visible at the national scale, because ENSO effects vary by region (Gordon, 1986; Salinger & Mullan, 1999). A severe El Niño event occurred in 1997–98, with weak events in some periods (2002–03, 2004–05, 2006–07, and 2009-10). A severe La Niña event occurred in 2010–11, with weak conditions in some periods (1998–2000, 2007–08, 2008–09, and 2013). The tendency for lower-than-average national precipitation values since 2000 (nine of 15 years) may also reflect a change in the phase of the Interdecadal Pacific Oscillation (IPO) since that time.

Figure 6



Source: Stats NZ using data from NIWA and GNS

In general, regions in New Zealand are bounded by catchment boundaries. Most rivers do not flow from one region to another so inflows from other regions account for a small component of total inflows. However, there are some exceptions, for example, the Buller river which flows between Tasman and the West Coast.

Outflows

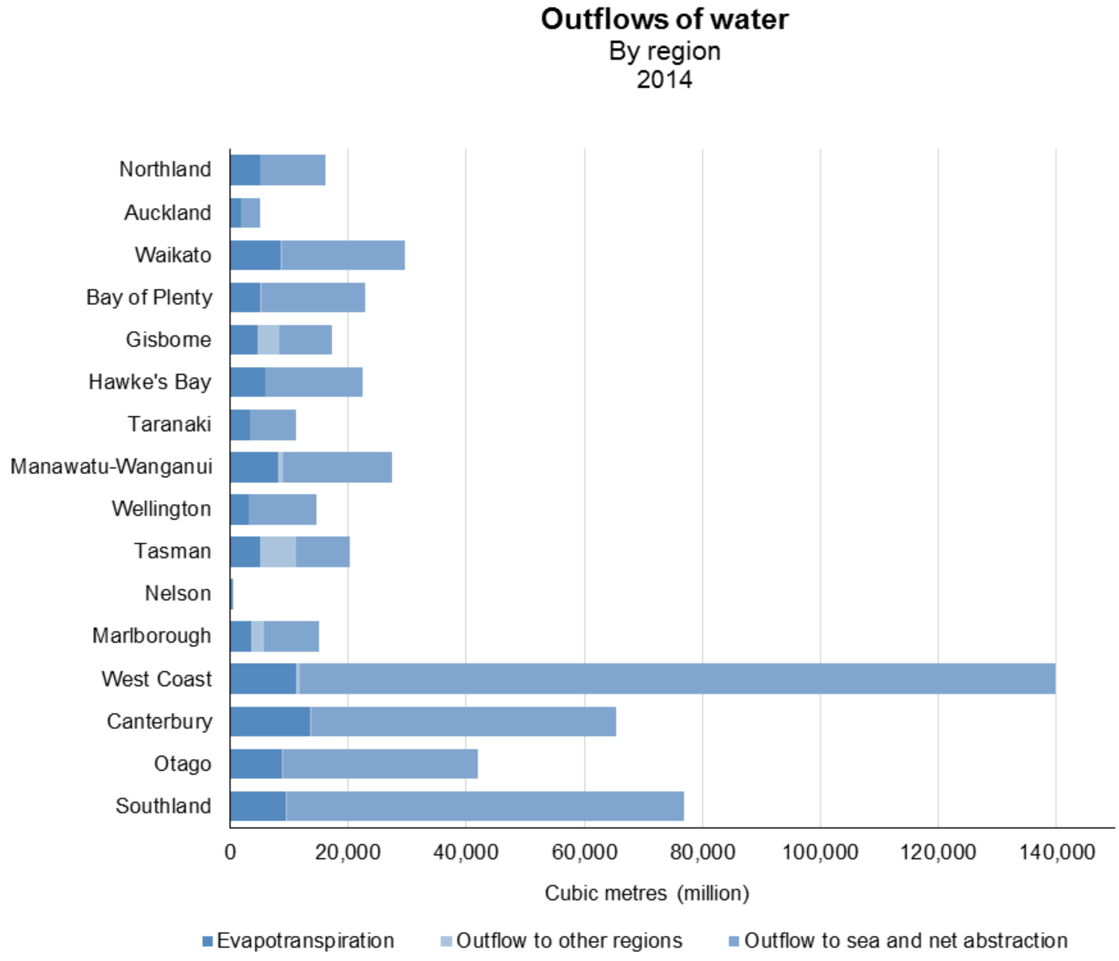
Between 1995 and 2014, the average annual total outflow, being the sum of evapotranspiration, outflow to other regions, and outflow to sea and net abstraction, was 555,881 million cubic metres, enough to fill Lake Taupo over nine times. Annual total outflow fluctuated over the period, with a high of 646,037 million cubic metres in 1996, and a low of 474,174 million cubic metres in 2012. In 2014, total outflow was 526,518 million cubic metres.

In 2014, outflows to sea and net abstraction (abstraction less discharges) were the greatest source of outflows for all regions, except for Nelson. Between 1995 and 2014, the average annual outflow to sea and net abstraction was 438,780 million cubic metres. This value fluctuated over the period, with a high of 519,876 million cubic metres in 1996, and a low of 357,197 million cubic metres in

2012. In 2014, outflows to sea and net abstraction was 414,567 million cubic metres. This volume accounted for 81 percent of total outflows for the year, with evapotranspiration accounting for the remaining 19 percent. (Evapotranspiration is the loss of water by evaporation from the soil and transpiration from plants.) Net abstraction totals are unavailable, and are therefore included with outflows to sea as a residual volume.

Evapotranspiration accounted for a significant component of outflows in all regions (figure 7). Between 1995 and 2014, the average annual evapotranspiration was 102,458 million cubic metres. Annual evapotranspiration fluctuated over the period, with a high of 109,724 million cubic metres in 2002, and a low of 95,064 million cubic metres in 2013. In 2014, evapotranspiration was 97,672 million cubic metres.

Figure 7



Source: Stats NZ using data from NIWA and GNS

Abstraction and discharges for hydroelectricity generation

Use of water for hydroelectricity generation is treated as non-consumptive use of water, as the water used is returned to the hydrological system. Volumes of water discharged match those abstracted, meaning that the net abstraction at the national level is zero.

Between 1995 and 2014, the average annual abstraction for hydroelectricity generation (total volume of water abstracted from surface water by hydro-generation companies), was 158,739 million cubic metres. Over the period there was a high of 184,698 million cubic metres in 1996 and a low of 142,635 million cubic metres in 2002. In 2014, abstraction for hydroelectricity generation was 153,989 million cubic metres. This amounts to an estimated 93 cubic metres per person per day.

The volume of water abstracted for hydroelectricity generation averaged 37 percent of the volume of outflows to seas and net abstraction, but includes water that was abstracted several times (because power stations are often built in chains along rivers).

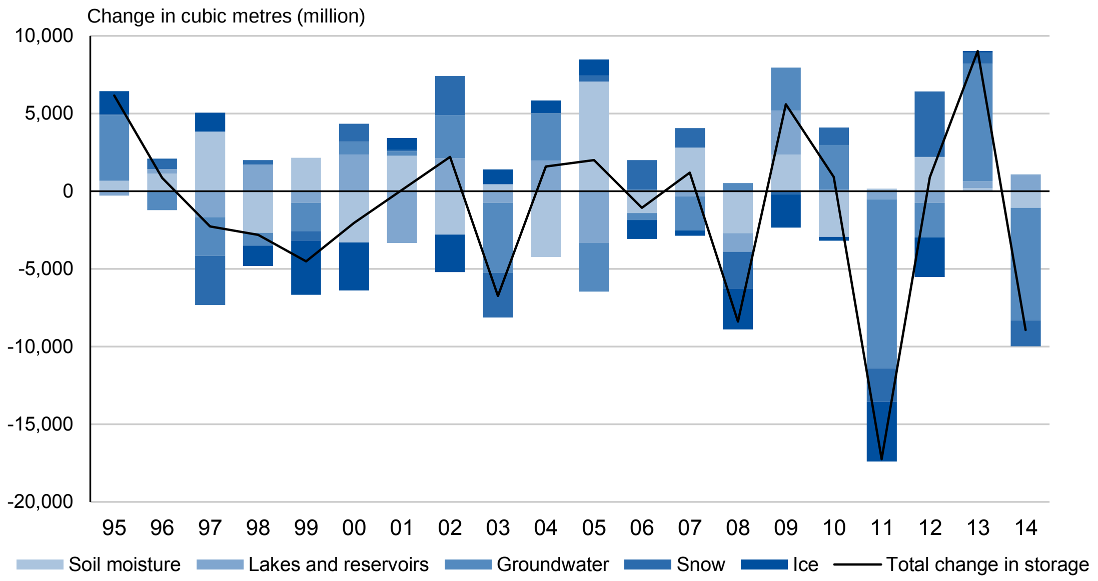
Estimates of the monetary value of the water used for hydroelectricity generation are available in Natural capital: monetary estimates.

Change in storage

Between 1995 and 2014, the largest annual decrease in the total change in water storage occurred in 2011 (figure 8). The largest annual increase was in 2013. In 2014, changes in the volume of stored water amounted to less than 2 percent of the volume of precipitation falling in New Zealand during the year.

Figure 8

Change in water storage
1995–2014



Source: Stats NZ using data from NIWA and GNS

Change in soil moisture was the main source of increase in change in storage in eight of the 20 years measured. Between 1995 and 2014, the largest annual decrease in soil moisture occurred in 2004, while the largest annual increase occurred in 2005. The amount of soil moisture varies according to rainfall, evapotranspiration, and land use.

Change in groundwater was the main source of increase in change in storage in a further eight of the 20 years measured. Between 1995 and 2014, the largest annual decrease in groundwater occurred in 2011, while the largest increase occurred in 2013. The variation of total groundwater volume over 2010–14 was less than 1 percent (Moreau & Bekele, 2017). The estimated groundwater volume in New Zealand aquifers in 2014 was 604,780 million cubic metres.

Changes in ice storage can affect renewable hydroelectricity resources and surrounding ecosystems, and can also affect ecosystem services such as recreational use and tourism. From 1996 to 2014, New Zealand's estimated ice volume decreased 35 percent, decreasing further from 2014 to 2016 (MfE and Stats NZ, 2017). This figure is greater than that in MfE and Stats NZ (2017), which used a longer and more recent set of measurements. The data used in this report are consistent with that in *Environment Aotearoa 2015* (MfE and Statistics New Zealand, 2015) so that we can provide a regional breakdown and maintain consistency at the national level.

Canterbury is the region with the largest groundwater storage, estimated to be 520,830 million cubic metres and approximately 70 percent of New Zealand's groundwater. Waikato has the second-largest groundwater storage, with approximately 34,010 million cubic metres of water, closely followed by Bay of Plenty with 31,450 million cubic metres of water (Moreau & Bekele, 2017). Previous studies found that the variability in groundwater volume on a national basis only broadly related to national rainfall variability (White & Reeves, 2002).

See SEEA water physical stock account to access maps and more data on water stocks across New Zealand.

Natural capital: monetary estimates

The measurement of stocks in monetary terms focuses on the economic value of individual environmental assets and changes in those values over time. The valuation of assets under SEEA focuses on the benefits that accrue to economic owners of environmental assets, and assist in a broader understanding of national wealth. These valuations assist in understanding the economic benefits received from natural capital, and thus how dependent economic outcomes are on natural capital.

The use of natural resources provides a monetary return to producers in the form of resource rents. These arise when the value obtained from the resource exceeds the cost of its extraction. Our initial estimates of resource rents show they accounted for 53 percent of forestry and logging GDP and 28 percent of electricity, gas, water, and waste, services GDP in 2016.

In some cases, particularly for petroleum, the rents provide an income source for government. In 2017, rents from natural resources paid to government from extracting petroleum (and to a much lesser extent, minerals, coal, and ironsands) amounted to $248 million (Stats NZ, 2017).

This approach to measuring stocks of environmental assets in monetary terms aligns with the measurement of economic assets in the national accounts. Further social benefits that may accrue to current and future generations are not incorporated here, but may be developed over time as we develop ecosystem accounts.

For comparability with the national accounts, the preferred approach to the valuation of assets is the use of market values. Valuation uses the net present value approach, which uses estimates of the expected economic benefits that can be attributed to an environmental asset, for example, profits from the sale of resources – and then converts the expected economic benefits by giving them a value in the current period using discounting. The resulting value is referred to as the asset value. The resource rent is the income received net of extraction costs just in the current period.

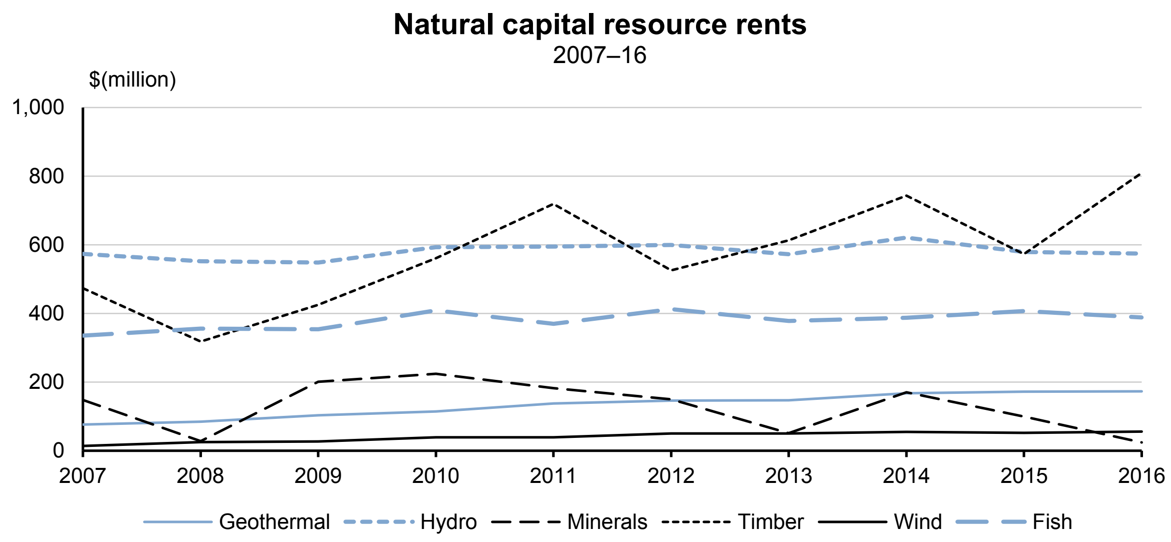
This section presents the monetary estimates of some of New Zealand’s main natural resources: renewable energy, fish, and timber. The estimates are also called ‘provisioning ecosystem services’, or the material benefits people obtain from ecosystems, and can be valued in monetary terms where price information is available.

Value of natural capital

Our estimates of natural capital in monetary terms are partial as we have not measured the value of all environmental assets. Timber had the highest annual resource rent in 2016, surpassing that for hydro. Total resource rents for fish, hydro, geothermal, metallic and non-metallic minerals, timber, and wind amounted to $2 billion (0.8 percent of GDP) in 2016, up 25 percent since 2007 (figure 9).

For some environmental assets, we calculated the asset value of the resource. The value of fish, timber, and renewable energy stocks reached $38.9 billion in 2016, up 47 percent from 2007. Stock values for timber were consistently the highest of all measured assets from 2007 to 2016, and also showed the greatest absolute change (figure 10).

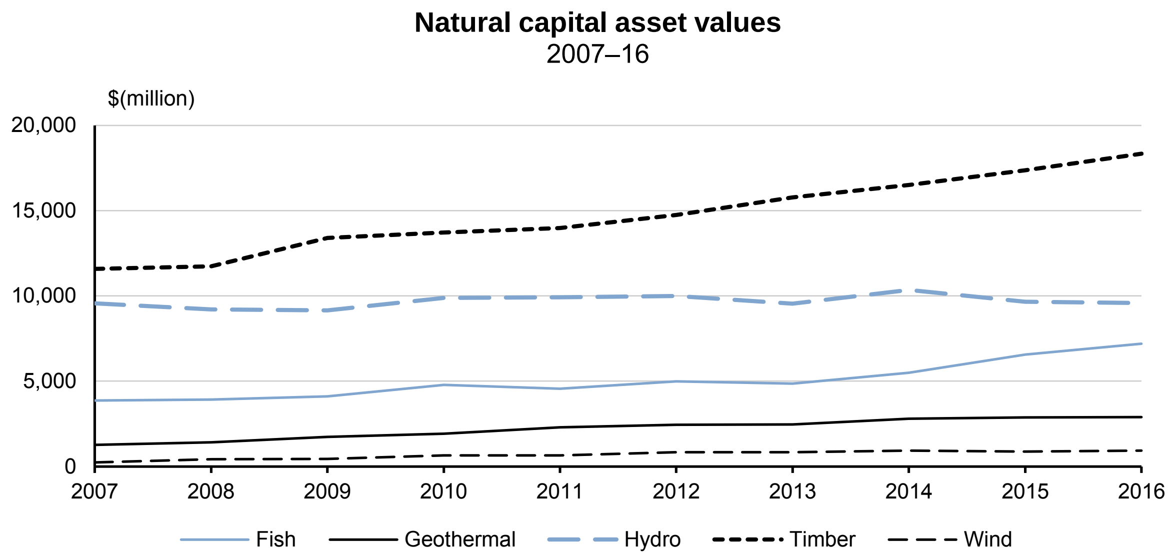
Figure 9



Source: Stats NZ

Differences between the value of the stock and resource rent come from differences in discount rates between assets. The declining discount rate for fish stocks in recent years has been a key factor in understanding why the value of the fish stock is approaching that of hydroelectricity resources. The changing discount rate for fish stocks has been significant in determining its asset value and is discussed later in this chapter.

Figure 10



Source: Stats NZ

Renewable energy

The entire electricity and gas supply industry accounted for $6.7 billion, or 2.7 percent, of GDP in 2016. There were 6,800 filled jobs in the electricity supply industry, 2,330 in electricity generation and transmission, and 4,470 in electricity distribution and on-selling and electricity market operation.

New Zealand's use of renewable energy sources is high when compared internationally. Renewable energy resources are key contributors to the GDP of the electricity industry and a source of national natural wealth.

Environmental accounting can show the economic value of the resources used in production. The renewable energy account presents the estimated asset values of water and other renewable resources in New Zealand that are used to generate electricity. An asset value is the market price of an asset if it was sold. A renewable resource, or renewable, is a resource that after being used, can return to previous stock levels by natural processes.

Developing renewable energy resources often involves trading off one aspect (or opportunity) for another. For example, hydroelectricity generation does not directly result in carbon dioxide emissions; it is also a means of transitioning towards a low-carbon economy. On the other hand, damming river systems can result in the loss of wildlife habitat and natural character, which compromises ecological function and amenity values (Parliamentary Commissioner for the Environment, 2012).

Similar trade-offs also apply when other renewable energy resources are developed. For example, a common barrier to wind farms is the perception that turbines are incompatible with the amenity and landscape values of the surrounding area (Parliamentary Commissioner for the Environment, 2006). When considering trade-offs, decisions must balance the values from undeveloped rivers and landscapes against the benefits provided by renewable energy. Asset values provide a starting point to understand the scope of these benefits.

Key facts

In 2016:

- Returns to electricity operators from the use of all renewables (resource rent) was $818 million, $574 million of which was from hydroelectricity.
- Electricity generated from renewables accounted for 82 percent of total electricity generation.

From 2007 to 2016 (March year):

- The proportion of resource rent generated from renewables compared with total resource rent generated from electricity production increased steadily from 68 percent in 2007 to 82 percent in 2016.
- The resource rent from geothermal increased from $76 million in 2007 to $173 million in 2016 – a growth rate of 9.5 percent a year.
- The resource rent from wind was $14 million in 2007, up to $56 million (6.8 percent of resource rent from renewables) in 2016.

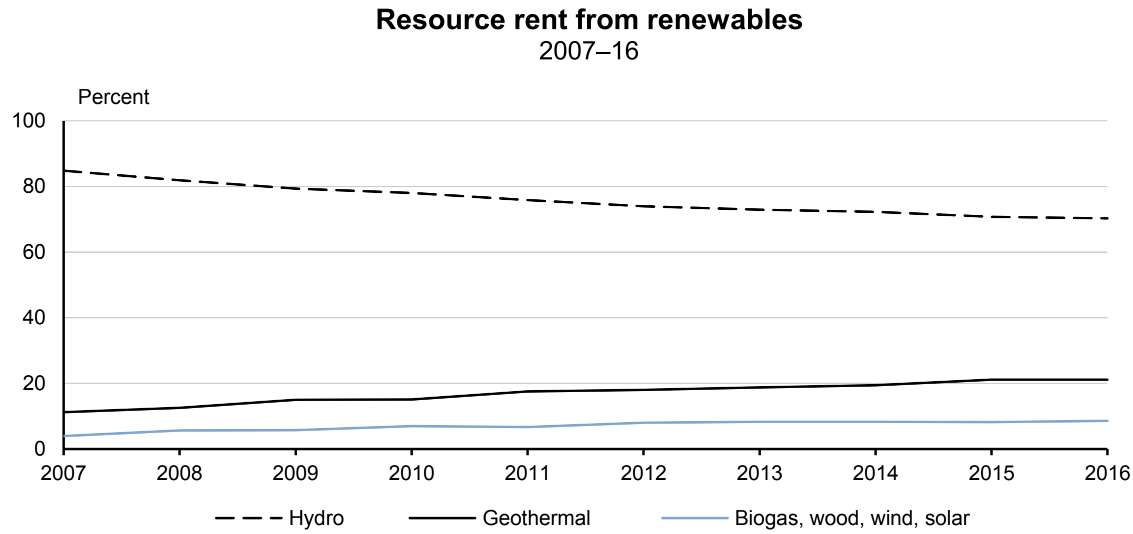
Hydropower

Hydropower generates energy from turbines being spun from the force of water moving downstream. The potential energy created is captured by damming rivers and diverting the flows through pipes and turbines, which extract kinetic energy.

In 2016, 39 hydro-generation plants had an operating capacity of 10 megawatts or greater, with these stations accounting for over 95 percent of operating capacity. Of these, 22 were in the North Island, seven of which were in the Waikato region. In the South Island, generation plants were concentrated in the Canterbury, Otago, and Southland regions.

The resource rent from hydroelectricity generation was estimated at $574 million in 2016, the same as that in 2007. The rent from hydroelectricity generation accounted for over half the total resource rent from electricity generation (which includes non-renewables), which was estimated at $995 million in 2016 (figure 11).

Figure 11



Source: Stats NZ using data from Ministry of Business, Innovation and Employment

The asset value of water for electricity generation was estimated at $9.6 billion in 2016, equal to the value in 2007. The asset value and resource rent fluctuated over this period. The asset value fell to a low of about $9.2 billion in 2008 and 2009, but peaked in 2014 at $10.4 billion. Resource rents showed the same variation, with a low of $549 million in 2009 and a high of $621 million in 2014.

Hydroelectric generation accounted for 58 percent of electricity generated (24,851 of 43,053 gigawatt hours) in the year ended March 2016. From 2007 to 2016, resource rent fluctuated due to the variability in total hydroelectricity production, which peaked at 24,934 gigawatt hours in 2011.

Geothermal

New Zealand's geothermal resources are derived from groundwater heated naturally within Earth's crust. Groundwater heats when water seeps into the crust and comes into contact with a hot body of rock. Most geothermal-generating capacity is in the Taupo Volcanic Zone.

The resource rent from geothermal electricity generation was estimated at $173 million in 2016, up from $76 million in 2007. The latest figure accounted for 21 percent of the total resource rent from electricity generation from renewables, which was estimated to be $818 million in 2016.

The asset value of steam used in geothermal generation was an estimated $2.9 billion in 2016, up from $1.3 billion in 2007. The higher asset value (and resource rent) in 2016 reflects the increased share of geothermal electricity generation. Over the period, the resource rent and asset value increased steadily in line with the increase in both the amount of geothermal electricity generated and its share of all electricity generation.

Geothermal generation accounted for 17 percent of electricity generated (7,484 of 43,053 gigawatt hours) in the year ended March 2016. From 2007 to 2016, the geothermal resource rent increased steadily in line with total geothermal electricity production, which peaked at 7,484 gigawatt hours in 2016.

The increase in electricity generation from geothermal energy between 2007 and 2016 was a result of reliable, secure, and cost-effective source of renewable energy. Concern over the dependence on hydro resources and the Maui gas field in the early 2000s prompted additional geothermal development (De Vos et al, 2010). Since 2007, eight geothermal schemes with a generating capacity of 10 megawatts or greater were commissioned (these were new schemes or upgrades to existing generating capacity) (MBIE, 2016).

Wind

In the decade to 2016, wind power emerged as a significant environmental asset. Wind energy is the process of exploiting the kinetic energy of wind. Wind turbines convert this kinetic energy into mechanical power, which can be used to generate electricity. New Zealand has a relatively abundant supply of wind – its physical geography means the country is exposed to strong, consistent westerly winds. In 2016, eight wind farms (mostly in the North Island) had a generating capacity of 10 megawatts or greater.

The resource rent from wind generation was an estimated $56 million in 2016, up from $14 million in 2007. The asset value of wind was estimated at $926 million in 2016, up from $238 million in 2007. The increase in asset value between 2007 and 2016 was a result of the growing contribution of electricity from wind generation.

Wind generation supplied 5.6 percent of New Zealand's electricity (2,404 of 43,053 gigawatt hours) in the year ended March 2016. From 2007 to 2016, the resource rent fluctuated with the variability in total wind generation, which peaked at 2,404 gigawatt hours in 2016.

Non-renewables energy

Estimates for the asset value of non-renewable forms of electricity generation (oil, coal, and gas) are not presented in this report. This is because we lack information on the lifespan of these assets, which we require to calculate their values. Estimates of the resource rent for total electricity generation including from non-renewables, however, are included.

Fish

In 2016, the fishing and aquaculture industry contributed $459 million (0.18 percent) to GDP, and the seafood processing industry contributed a further $512 million (0.20 percent). In 2016, there were 43,640 filled jobs in the combined fishing and aquaculture and seafood processing industries. In 2016, seafood exports contributed $1.9 billion in export earnings to the New Zealand economy, a 43 percent increase from $1.4 billion in 2003. The total value of seafood exports increased by 12 percent from September 2015 to $1.9 billion.

The fish monetary stock account presents a time series of the asset value of New Zealand's commercial fish resource, based on quota values. Asset values in this report are derived from the quota and annual catch entitlement (ACE) values of the resource as managed under [the quota management system](#) (QMS). The time series shows trends in the total asset value of New Zealand's commercial fish resource and includes a breakdown of individual species.

The asset value of New Zealand's commercial fish resource reflects changes in both supply and demand. The supply of fish, from New Zealand fisheries, is affected primarily by the total allowable commercial catch, but also by the abundance and location of fish, environmental conditions, and economic factors affecting the fishing industry such as the cost of fuel, labour, and equipment. Total allowable commercial catch is set by MPI, (formerly by the Ministry of Fisheries) and is largely fixed unless adjusted downwards due to concerns about stock levels or alternatively upwards due to stock recovery. On the demand side, an increasing global population and subsequent demand for food, changing consumer preferences, and recognition by nutritionists of the health benefits of fish and seafood, all have an effect.

We present asset values for the 98 species (or species groups) managed under 642 separate fish stocks in New Zealand's QMS. Except for eels, freshwater species are not managed by the QMS and are therefore not included in this report.

Note that the number of species included in the QMS increased from the original 26 species included in 1986 (32 were included in 1996) to 98 in 2016. This does affect the total allowable commercial catch, and catch and asset value of New Zealand's fish resources.

Key facts

In the September 2016 year, under the QMS:

- The calculated asset value of New Zealand's commercial fish resource was $7.2 billion.
- The top 20 species of fish contributed 91 percent of the value of New Zealand's commercial fish resource.
- Rock lobster, with an asset value of $2.4 billion, contributed 34 percent of the total value of New Zealand's fish commercial resource.
- Hoki followed rock lobster, contributing $1.0 billion, or 14 percent of the total value.

Between the 1996 and 2016 September years:

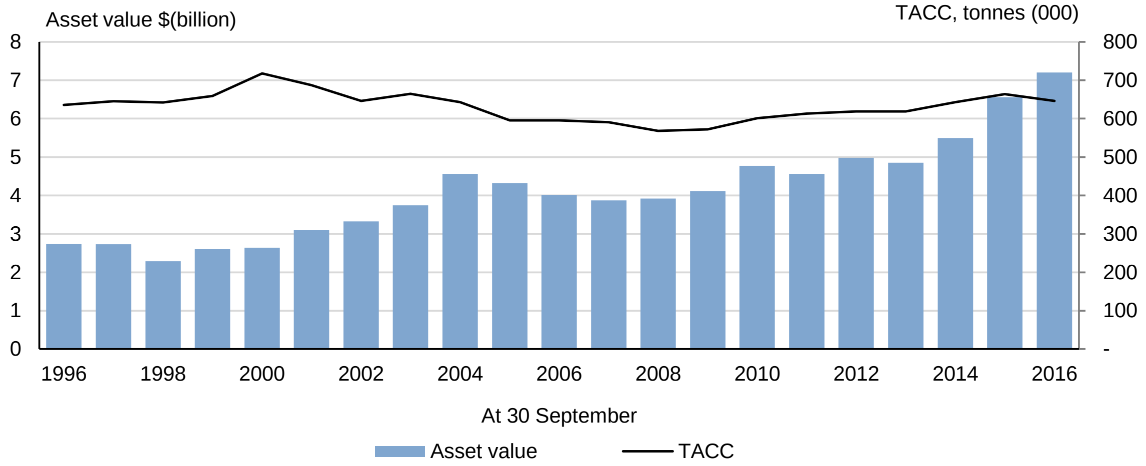
- The asset value of the commercial fish resource increased $4.5 billion, from $2.7 billion to $7.2 billion. This was an annual average growth rate of 5 percent per year.
- The asset value for the original 26 QMS species increased 60 percent while the total allowable commercial catch for these species decreased 29 percent.
- Hoki had the highest asset value in almost every year until 2009; rock lobster had the highest asset value in 1998, 2008, and after 2010. These two species combined accounted for 37 percent of the total asset value in 1996, which increased to 48 percent in 2016.

Value of fish stock in monetary terms

In the year ended September 2016, the total asset value of New Zealand's commercial fish resource under the QMS was $7.2 billion, a 10 percent increase from the 2015 value of $6.6 billion (figure 12). The total asset value has been increasing steadily since 2013, driven by increases in the value of rock lobster and, to a lesser degree, hoki. The total asset value has now increased 163 percent in the 20 years from 1996 to 2016, or at an annual average growth rate of 5 percent per year. Most fish stocks have a 1 October to 30 September fishing year but some have a year ending in February or April. All fish stocks with a year ending in any given calendar year are counted towards that year's total.

Figure 12

Total asset value and total allowable commercial catch
New Zealand's commercial fish resource
1996–2016



Source: Stats NZ using data from Fishserve

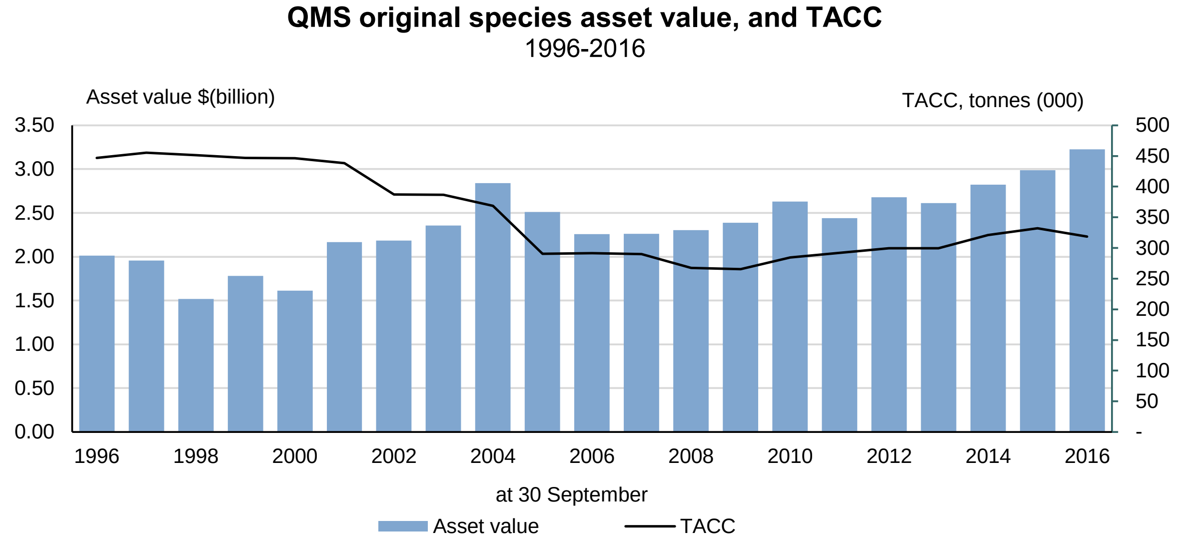
The increase in the value of the fish stock is driven by increasing prices and the declining discount rate (see how the discount rate influences the asset value for future generations) as the total allowable commercial catch has remained relatively constant. The increase in prices may be driven by increased demand. Although most of the commercial catch is exported, prices paid at home will reflect global demand. In the year to September 2016, the food price index (FPI) recorded a 2.3 percent increase in fish and seafood prices, while the export revenue for all seafood was at its highest value since 2003. From 1996-2016, the FPI recorded a 58 percent increase in prices of fish and seafood (Stats NZ, 2016).

Asset value of the original QMS species

The theoretical benefits of individual-transferable-quota-based management systems, such as New Zealand's QMS, include sustainable use of the resource and increased economic efficiency (Lock & Leslie, 2007). With that aim in mind it is interesting to note the time series for the initial 26 species introduced into the QMS on 1 October 1986 (figure 13). The asset value for the original 26 QMS species has increased by 60 percent to $3.2 billion over the period 1996–2016 while the total allowable commercial catch for these species reduced 29 percent over the same time period. Total TACC for these 26 species reduced from 446,998 tonnes to 318,375 tonnes with most (70 percent) of the reduction being the 90,000 tonne reduction in hoki. The initial QMS species are alfonsino and long-finned beryx, barracouta, blue cod, blue moki, blue warehou, bluenose, elephant fish, flats, gemfish, grey mullet, gurnard, hake, hapuku and bass, hoki, john dory, ling, orange roughy, oreo, red cod, rig, school shark, silver warehou, snapper, stargazer, tarakihi, and trevally.

The 26 QMS species made up 45 percent of the total asset value of the commercial fish resource in 2016, compared with 73 percent in 1996. This ratio has been steadily decreasing due to the addition into the QMS of valuable species such as rock lobster (1990), scampi (2004), paua (1987), and southern blue whiting (1996).

Figure 13



Note: QMS – Quota Management System; TACC – total allowable commercial catch

Source: Stats NZ using data from Fishserve

How the discount rate influences the asset value for future generations

SEEA states that where realistic market values are available, an asset value for fish stocks can be produced through the value of licences and quotas. Where these quotas are valid in perpetuity, the value of all quotas, at the market price, should be equal to the value of the use of the fish stock. The asset value based on quota valuations methodology is equal to the average value of the traded quota ($/tonne) multiplied by the total allowable commercial catch.

If the quotas are valid for one year only, the total should approximate the resource rent for that year and a net present value approach is taken to value the fish stocks.

The net present value approach uses the value of annual catch entitlement (ACE) transfers as an approximation for the resource rent for the asset in that year, and discounts the sum of the future net income stream (or rent) in order to express its value at the present time. This approach requires assumptions to be made, including the choice of discount rate. The value of the quota represents the net present value of the owner's expected income using the quota over its period of validity.

Asset values, which reflect the present value of the income stream of the asset, are dependent on discount rates. By discounting future income so that it is expressed in terms of income earned today, an asset's value, based on future income, can be estimated. A discount rate is a time preference for money, reflecting the fact that income received in the future is not as valuable as income received today.

Higher discount rates suggest that current consumption is preferred. This has the effect of lowering the asset value by using more of the resource 'now'. Conversely, lower discount rates reflect a preference for future consumption and lead to higher asset values.

Our estimates of the value of the fish stock captures changes in the discount rate over time. From 2002 to 2011, the discount rate varied between 7–9 percent but declined to 5 percent in 2016. This decline suggests commercial fishers are placing a higher value on future consumption. As a result, the value of the fish stock, which reflects the future income streams from using the fish resource, is increasing.

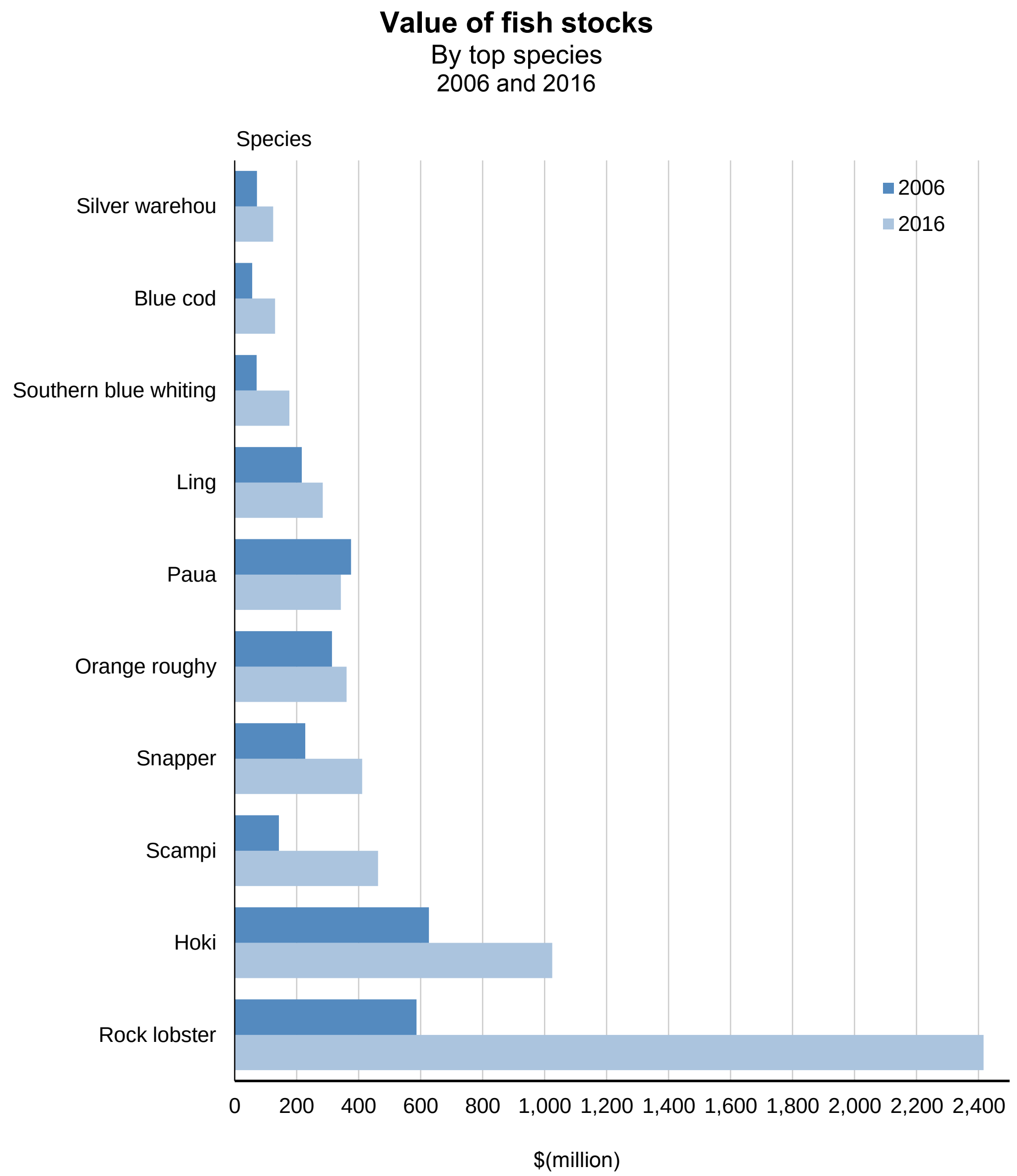
For more information on the methodology used in this account please see Environmental-economic accounting: sources and methods.

Species valuations

For the September 2016 year, 20 species contributed 91 percent of the total value of New Zealand's commercial fish resource as managed under the QMS. Of these 20 species, 10 contributed 80 percent: blue cod, hoki, ling, orange roughy, pāua, rock lobster, scampi, silver warehou, snapper, and southern blue whiting.

Figure 14 shows the values of the top 10 species (by asset value at 30 September 2016) compared with their values in 2006.

Figure 14



Source: Stats NZ using data from Fishserve

In 2016, rock lobster had the highest asset value of all fish species ($2.4 billion), followed by hoki ($1.0 billion), and scampi ($463 million). The three species made up 54 percent of the total value of New Zealand's commercial fish resource. All other species (other than the top 10) had a total asset value of $1.5 billion. Over 1996–2016, hoki had the highest asset value in almost every year until 2009, while rock lobster had the highest in 1998, 2008, and after 2010. The two species combined accounted for 37 percent of the total asset value in 1996, which increased to 48 percent in 2016.

Hoki is the largest fishery with a catch of over 136,000 tonnes in 2016. This was 34 percent of the total catch in 2016. From 1996 to 2016 the value of hoki increased 60 percent, but its value as a percentage of the total commercial fisheries' asset value decreased from 23 percent to 14 percent.

From 2015 to 2016, the asset value of rock lobster rose for the third consecutive year, by 17 percent. In 2016 it contributed 34 percent to the total commercial fisheries asset value, compared with 13 percent in 1996. Because of this strong increase, we looked at the data to assess confidence in these figures. There was little change in the total allowable commercial catch over

1996–2016 and catch figures (only available from 2002) showed commercial fishers consistently caught about 95 percent of the total allowable commercial catch, indicating some certainty around allocation. In addition, rock lobster exports increased from $116 million in 2003 to $318 million in 2016, or at a similar annual average growth rate (8 percent) as the rock lobster asset value (10 percent).

Valuing QMS stocks with quota trades rather than ACE transfers gives us more confidence in the results as we do not have to rely on a discount rate and the assumptions around that rate. The rock lobster species group has 11 quota management areas, and four of these accounted for just over 70 percent of the average asset value from 1996 to 2016. For these 11 quota areas we were able to use available quota trade information in most years and all of them in 2016. Perhaps because of rock lobster's inshore status, and hence lower capital costs, the data supplier FishServe records a lot of quota trade and ACE transfer information, more than for many other species. This enables us to use a preferred quota trade methodology with ACE values where quota is absent, and also to directly compare the two main methods, that is, to estimate the asset of rock lobster entirely through quota trades or through ACE transfers.

For a list of all the species in the QMS, their quota management areas and the year they were brought into the QMS please see the fish monetary stock account Excel tables that accompany this report.

Other species highlights

- From 2005 to 2016 the value of scampi increased 213 percent (scampi was introduced into the QMS on 1 October 2004).
- From 1996 to 2016 the value of snapper increased 42 percent while its total allowable commercial catch decreased 8 percent.
- Total allowable commercial catch for orange roughy decreased by 59 percent from 1996 to 2016. Over the same period the value increased 55 percent.
- Pāua is the only species in the top 10 at September 2016 to have decreased in value from 2006 (down 8 percent). However, pāua's value in 2016 is still 140 percent greater than its 1996 value.

Future developments

The fish monetary stock account does not include recreational fishing. Recreational catch is the catching of fish for non-commercial and non-customary purposes. It is an important aspect of New Zealand fisheries, which is recognised in the government's setting of allowable catch levels. The total allowable catch takes into account recreational and customary fishing needs, as well as commercial requirements.

We do not have enough information to produce an asset valuation for recreational fisheries. However, we acknowledge that the recreation catch for some fish stocks is a large proportion of the total catch. Development of ecosystem service accounts may provide new measures of the services from recreational fishing.

Timber

The timber monetary stock account provides information on the monetary stock of commercial forestry resources in New Zealand and the changes in these stock levels over time. The account is important because timber has value as a harvested resource, with subsequent impact on New Zealand's GDP. Timber stores carbon for a long time to mitigate or defer climate change, and reduces soil erosion. The forestry and logging industry contributed $1.5 billion (or 0.6 percent) to GDP in 2016.

Key facts

In 2016:

- The value of cultivated (exotic and commercially viable) timber stocks reached $18.3 billion. Timber stocks increased 6 percent or $961 million on the 2015 value.
- A decrease in timber stock volumes of 0.05 percent was offset by a 6 percent increase in price.

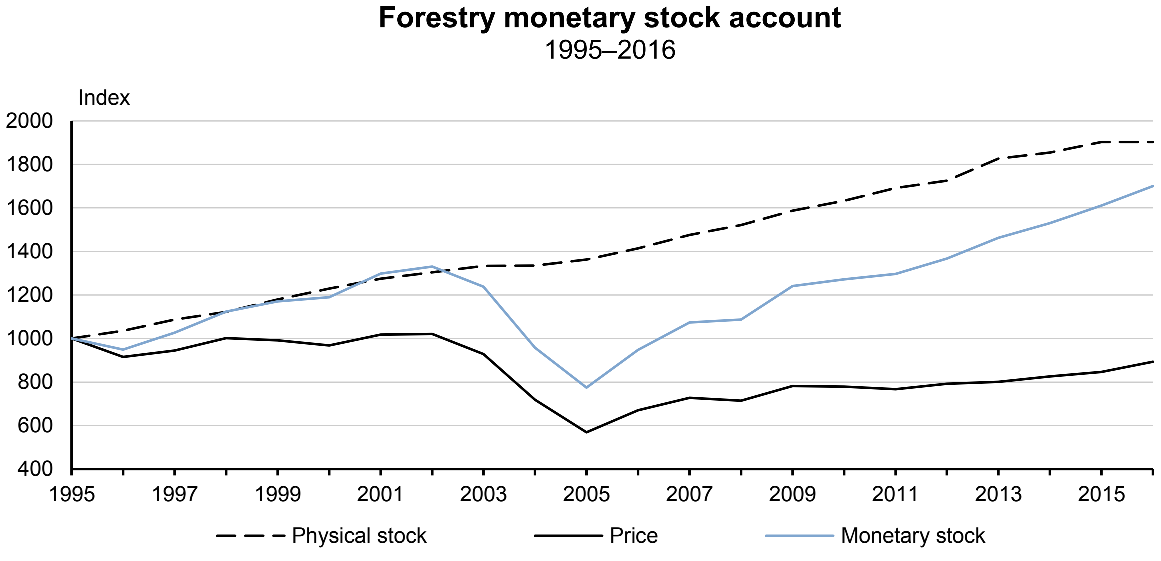
From 1995 to 2016:

- Timber monetary stocks increased 70.0 percent, or $7.5 billion, driven by an increase in cultivated timber stock volumes.

Value of timber stocks

The value of cultivated (exotic and commercially viable) timber stocks reached $18.3 billion in 2016, up 70.0 percent from $10.8 billion in 1995 (figure 15). This was driven by an increase of 90 percent in stock volumes, which was offset by an 11 percent decrease in the price of timber per cubic metre.

Figure 15



Source: Stats NZ. Ministry of Primary Industries

Resource rent measures the return from use of a resource after all other costs are taken into account. Timber resource rents accounted for between 35.3 and 53.5 percent of forestry and logging GDP from 2007 to 2016.

In addition to resource rents, forests provide numerous regulating and cultural services known as ecosystem services.

As discussed in Natural capital: physical estimates, forests and their soils store and capture a significant amount of carbon and so provide an essential regulating ecosystem service in the form of carbon sequestration. The economic value of carbon sequestration depends on both the carbon price (in New Zealand this is determined by the Emissions Trading Scheme) and the amount of carbon sequestered. In 2016, carbon price averaged $15.39 a tonne, up from $6.66 in 2015, and reached $21.30 in February 2018. Exotic forests sequestered 5.3 million tonnes of carbon in 2015, suggesting an annual value of $35.3 million for this regulating service from exotic forest ecosystems alone.

Further research is required to determine the value of carbon sequestration provided by New Zealand's ecosystems. The estimated value of carbon sequestration in the United Kingdom provided by grassland and forest land (which include exotic and indigenous forests) was £1.6 billion (around $3 billion) in 2015 (Office for National Statistics (ONS), 2018). This significantly higher value than that for New Zealand reflects a much broader scope of ecosystem assets as well as a much higher carbon price (the UK's carbon price was around £60–61 GBP from 1997 to 2015, or around $115). The application of carbon prices to the different ecosystems is a key issue for research (Smith et al, 2017).

Additional ecosystem services provided by forests include air pollution removal, and area for recreational activities. The New Zealand Institute of Economic Research (2017) discusses the range of ecosystem services from forests in New Zealand and estimates of their significance.

Future developments of monetary accounts

New Zealand's estimated natural capital in monetary terms so far only covers renewable energy, fish, and timber. We have yet to measure the value of land, minerals (as a stock), water in any other capacity than hydroelectricity resources, and non-renewable energy sources on a SEEA basis.

We have also yet to measure other ecosystem services in monetary terms. The estimates presented above reflect the 'provisioning' services but we have not yet measured 'regulating' or 'cultural' services in either physical or monetary terms, which would give an indication of the range of services received from a particular ecosystem (eg tree-covered areas). The Office for National Statistics (2018) has shown that these services can be significant. This is because 58 percent of the measured asset value of UK's natural capital was attributable to cultural and regulating services (recreation, pollution removal, and carbon sequestration) in 2015.

Flows from the economy to the environment

Stocks of environmental assets show the available resources for production and consumption, but it is the flow of these assets that provides benefits to the economy and society.

The flows of residuals (eg pollutants) from economic activity back to the environment can also be recorded in SEEA. These residual flows will also have impacts on the economy and society. These types of environment-economy interactions are important to capture to show the dependencies and impacts of the economy on the environment.

Flow accounts show the supply of resources from the environment to the economy, and the use of resources within the economy. Flow accounts, therefore, provide inputs to production and consumption, and outputs, including disposal of solid waste and other residuals (such as to air or water) from the economy back to the environment.

Flow accounts have a number of purposes, including:

- revealing the economic flows generated by harvesting or extraction of the resource
- identifying potential threats to the environment as a result of residual flows and the economic source
- providing information needed to construct environmental performance indicators that help analyse further the environmental impacts of particular economic and social activities (eg decoupling indicators).

Note that the 'non-use' of environmental assets may also provide benefits to society, and be assigned a bequest value (the value placed on preserving the resource for future generations). As SEEA focuses on the transactions between the environment and economy, these effects are not captured here, but are likely significant.

At present, the only SEEA residual flow account we have developed is for greenhouse gas emissions. We have yet to develop residual flow accounts for other residual effects of the economy on the environment (eg waste) or flow accounts that show the use of natural resource inputs within the economy (eg timber, water).

Greenhouse gas emissions by industry and households

Background to the air emissions account

Climate change is one of the most important environmental challenges globally (Intergovernmental Panel on Climate Change (IPCC), 2013). Sufficient evidence shows climate change has been caused by the emission of greenhouse gases from human activities (IPCC, 2013). Robust data to track how the sources have changed is essential as countries seek to reduce greenhouse gases in response to the Paris agreement of December 2015. New Zealand's national targets are:

- an unconditional target to reduce emissions by 5 percent on 1990 levels by 2020
- to reduce greenhouse gas emissions by 30 percent below 2005 levels by 2030
- a long-term target to reduce emissions by 50 percent by 2050.

The air emissions account presents estimates of greenhouse gas emissions by industry and households using data from MfE's Greenhouse Gas Inventory, which is published every year. Using the United Nations Framework Convention on Climate Change guidelines, the inventory presents information for carbon dioxide; methane; nitrous oxide; and other pollutants for the agriculture, industrial processes and product use, waste, energy, and land use, land-use change and forestry sectors on a territorial basis.

The air emissions account and the inventory are both compiled under standard international frameworks but for different purposes. The inventory, the source information for understanding New Zealand's position under the Kyoto protocol and for achieving national and international targets, is New Zealand's official measure of greenhouse gas emissions. The air emissions account provides supporting information for understanding the economic context of greenhouse gas emissions and for showing how they are changing in relation to economic activity. The air emissions account currently includes carbon dioxide, methane, and nitrous oxide emissions but can be extended to cover ambient air pollution and other greenhouse gas pollutants. As the purposes differ, estimates from the inventory and air emissions account naturally differ.

The air emissions account converts sector-based emissions from the inventory to industry-based emissions. In most cases, the inventory categories are directly allocated to an industry. In some cases, because the inventory is based on methods that seek to measure emission by source of process rather than industry, additional information is used to compile the air emissions account (see box below, 'From the Inventory to industry: How the allocation of emissions works'). In using the same industrial classification as that underlying GDP, changes in greenhouse gases can be compared with GDP for a range of industries. This enables us to assess:

- how emissions have changed in relation to economic growth
- whether structural change in the economy has affected our emissions profile
- where there are opportunities for targeted emissions-reduction policies while maintaining economic growth

The two key principles of the air emissions account are:

- production boundary – only emissions relating to New Zealand's GDP should be included, for example, emissions by tourists are excluded; this approach differs from the 'territorial' approach used in the inventory
- consistent industrial classification – a classification system should be used that groups firms by the similarity of the goods and services they produce; this differs from the process-based sectors in the inventory.

Estimates of greenhouse gases compiled under the SEEA framework will differ, in theory and in practice, from those in the inventory due to the use of these principles and different methodological approaches to data processing. In this release we applied a consistent industrial classification. In future releases, we will adjust for the production boundary (eg non-resident emissions, and emissions by New Zealand residents overseas), and will present a bridging table to show how the inventory and air emissions account compare.

From the inventory to industry: How the allocation of emissions works

Estimates of greenhouse gases from the inventory are allocated to industries in one of two ways. In most cases, the emissions in the inventory can be allocated directly (and uniquely) to an industry. For example, emissions from the digestive processes of livestock are allocated to the agriculture industry. In some cases, notably for road transport, emissions in the inventory are allocated to multiple industries. This is done using additional data sources to give the process-based data an industry dimension.

An industry's emissions can arise from multiple processes. For example, emissions from the agriculture industry consist of those from enteric fermentation and fertiliser use, as well as fuel combustion emissions from both stationary and mobile sources and from unmanaged waste disposal sites. While both the inventory and air emissions account include categories such as 'agriculture', 'waste', and 'transport', these mean different things in the context of each publication.

The air emissions account used data from the 2017 inventory submission, which contains data to 2015. Inventory data to 2016 will be available in April 2018. The air emissions account estimates presented here will not be comparable to the 2018 (or subsequent) inventory release.

Future development of the air emissions account

This release contains estimates of greenhouse gases on a territorial (ie geographic) basis. Future releases will account for the emissions of economic residents overseas, and adjust for non-economic resident emissions over New Zealand's territory. At present, it is difficult to assess the significance of these adjustments. Revisions to service industries, particularly transport and storage (eg when we account for international air travel), and households (eg when we adjust for tourist emissions) are expected.

Key facts

In 2015:

- Primary industries (excluding emissions and removals from land-use change and forestry sector) accounted for 57.1 percent of carbon dioxide equivalent emissions in 2015, goods-producing industries 24.8 percent, and service industries 11.1 percent. Households accounted for 6.9 percent.
- Agriculture, transport and storage, and electricity, gas, water, and waste services accounted for 76.5 percent of industry emissions carbon dioxide equivalent emissions in 2015.

From 1990 to 2015:

- Total economy real GDP increased at a rate of 3.1 percent a year while carbon dioxide equivalent emissions increased 0.9 percent a year, driving a decline in greenhouse gas intensity in the economy.
- Emissions growth was 0.5 percent a year for primary industries, 1.2 percent for goods-producing industries, and 2.2 percent a year for service industries.

- Emissions from agriculture, transport and storage, and electricity, gas, water, and waste services all increased but at a slower rate than their GDP, therefore showing relative decoupling.
- The agriculture industry's carbon dioxide equivalent emissions increased 0.6 percent a year, while its GDP increased by 1.4 percent a year.
- Five industries recorded a decrease in emissions, three of which managed to do this while increasing economic output: fishing; mining; and transport equipment, machinery and equipment manufacturing.
- Emissions increased at a faster rate than GDP for forestry (processing and transportation of forestry products within New Zealand); food, beverage, and tobacco product manufacturing; petroleum, chemical, polymer, and rubber product manufacturing; metal product manufacturing, and total manufacturing.

Greenhouse gas emissions by broad industry group

In this section, we present estimates of carbon dioxide equivalents, carbon dioxide, methane, and nitrous oxide by broad industry group. Primary industries include agriculture, forest, fishing, and mining. Excluded are emissions and removals from the land-use change and forestry sector within the Greenhouse Gas Inventory. Goods-producing industries include manufacturing, construction, and utilities. Service industries include multiple industries ranging from wholesale and retail trade, to communications and finance, to government, and transport and storage, among others.

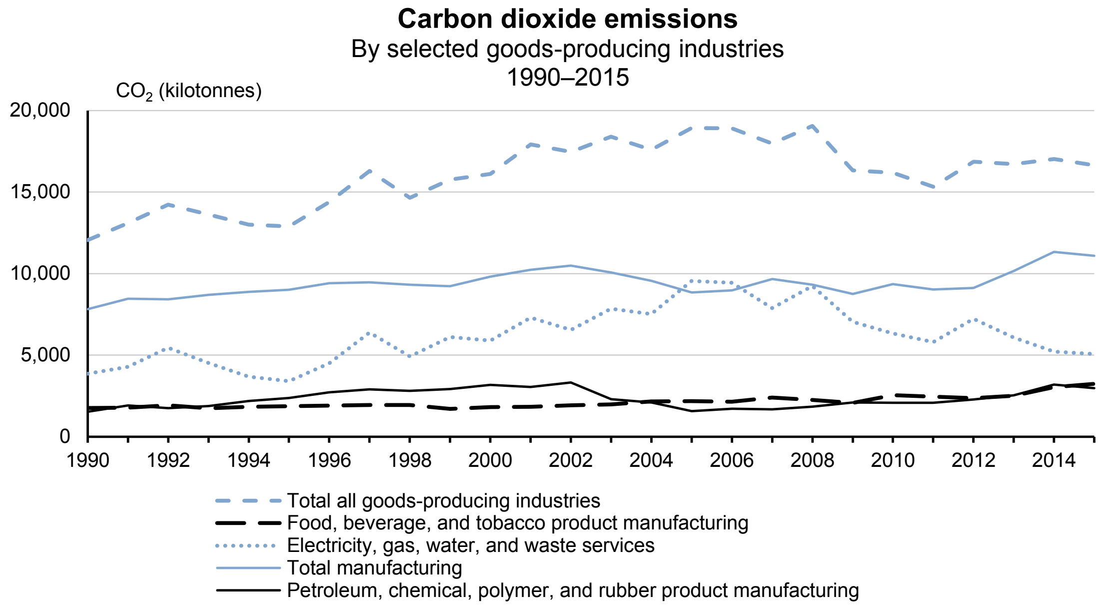
Carbon dioxide equivalent emissions

Different greenhouse gases have different effects on warming Earth, through how long they stay in the atmosphere (their 'lifetime') and their ability to absorb energy or trap heat. Carbon dioxide equivalent is a measure used to compare the emissions from various greenhouse gases based upon their global warming potential. Carbon dioxide equivalent emissions from primary industries accounted for 57.1 percent of emissions in 2015, down from 62.0 percent in 1990. Goods-producing industries accounted for 24.8 percent, and service industries 11.1 percent. The service industries contribution, up from 8.1 percent in 1990, reflects the stronger growth in emissions (up 2.2 percent a year) compared with those from primary and goods-producing industries (up 0.5 percent and 1.2 a year, respectively). Households accounted for 6.9 percent of total emissions in 2015, increasing at a rate of 1.1 percent a year from 1990 to 2015.

Carbon dioxide

Carbon dioxide can stay in the atmosphere for up to thousands of years (its 'lifetime'), in comparison to methane and nitrous oxide which are both much shorter lived. Emissions from primary industries accounted for 14.5 percent of carbon dioxide emissions, goods-producing industries 46.4 percent, and service industries 24.6 percent in 2015. The service industries accounted for 19.9 percent of based carbon dioxide emissions in 1990, while primary industries accounted for 16.9 percent. Households accounted for 14.5 percent of total emissions, increasing at a rate of 1.1 percent a year from 1990 to 2015. Figure 16 shows the goods-producing industries that recorded the highest carbon dioxide emissions in 2015.

Figure 16



Source: Stats NZ using data from: Ministry for the Environment; Ministry for Business, Innovation and Employment

New Zealand's share of goods-producing and service industries emissions to total industry emissions is lower than the average of countries reported in the Organisation for Economic Co-operation and Development (OECD) air emissions accounts database. This, in part, reflects the relatively large primary sector in New Zealand. OECD data, for which estimates of carbon dioxide emissions by industry are available for 24 countries, show that the average share of goods-producing industry emissions to total industry emissions is 66 percent (ranging from 29 percent to 89 percent in 2014). The average share for service industries is 28 percent (ranging from 9 percent to 64 percent). Households account for 20 percent of total emissions in the 24 OECD countries reported, ranging from 4 percent to 41 percent. These comparisons, however, should be treated with caution as the New Zealand data is not adjusted for economic residency. It is not yet possible to state whether residency adjustments will lead to upwards or downwards revisions as both New Zealand residents overseas and non-residents in New Zealand are to be accounted for.

Methane and nitrous oxide

Although methane and nitrous oxide have much shorter lifetimes than carbon dioxide (lifetimes of 12 and 121 years, respectively), they are more potent greenhouse gases, trapping more heat than the equivalent amount of carbon dioxide. However, the shorter lifetimes and higher potency of methane and nitrous oxide means that reducing their emissions will decrease their concentrations in the atmosphere more quickly. In contrast, today's global carbon dioxide emissions will continue to influence atmospheric carbon dioxide concentrations for a very long time. In 2015, emissions from primary industries accounted for 89.3 percent of methane emissions, the majority of which came from the agriculture industry. Goods-producing industries accounted for a further 10.0 percent. Households accounted for 0.6 percent of total methane emissions. The distribution of nitrous oxide emissions by broad industry group is similar to that for methane.

Emissions and GDP

Comparing emissions growth to that of GDP, in real terms, can show whether industries have been able to reduce emissions with or without a loss in economic production or whether industries have not yet been able to decouple emissions and economic growth. Care is required in interpreting emissions in comparison to GDP: in some cases, emissions are an intrinsic part of the production process, in others (particularly where emissions are sourced from general energy use and not dependent on the type of product produced) emissions may be small and such comparisons may not be as insightful.

What is decoupling?

Decoupling refers to the link between 'economic goods' and 'environmental bads'. This link needs to be tracked over time due to the role of:

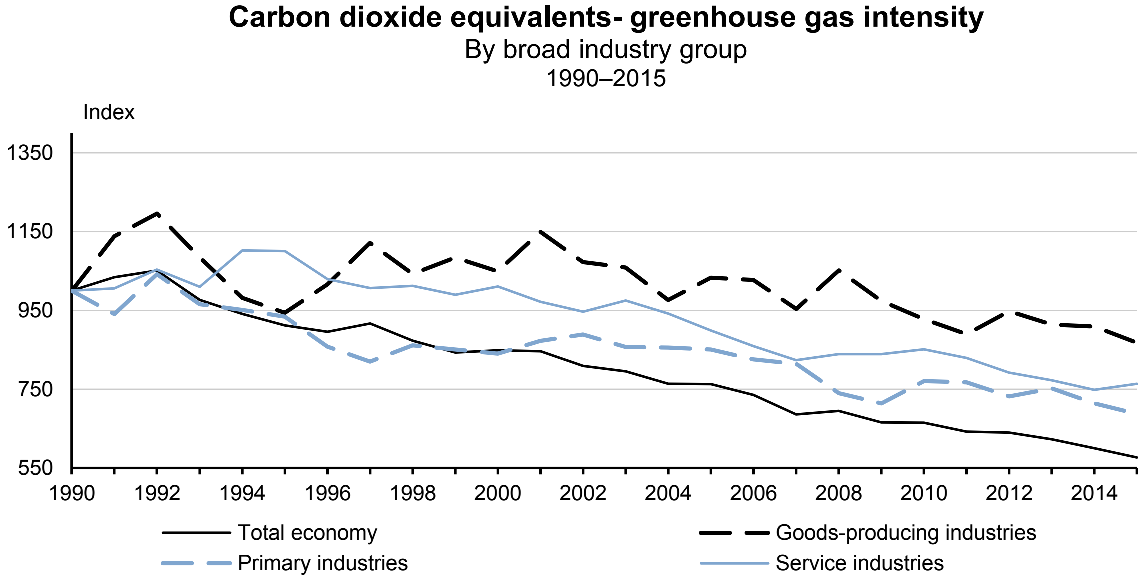
- structural change (eg growth of lower-emitting service industries relative to higher-emitting primary and goods-producing industries)
- adoption of technological innovations by businesses.

Absolute decoupling occurs when the environmentally relevant variable is stable or decreasing while the economic driving force is growing. Relative decoupling occurs when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable.

From 1990 to 2015, total economy real GDP increased at a rate of 3.1 percent a year while carbon dioxide equivalent emissions increased 0.9 percent a year, driving a decline in greenhouse gas intensity in the economy (figure 17). By 2015, all three industry groups (primary, goods-producing, and service industries) had shown relative decoupling as economic output increased at a faster rate than emissions. However, carbon dioxide equivalent emissions had increased in all three economic sectors. Emissions growth was 0.5 percent a year for primary industries, 1.2 percent for goods-producing industries, and 2.2 percent a year for service industries.

Emissions intensity in level terms varies significantly across the three broad industry groups. In 2015, the service sector accounted for 69.1 percent of economic activity (as measured by GDP in current prices), but only 11.9 percent of industry emissions, implying a low amount of emissions per unit of GDP. The primary sector accounted for only 7.4 percent of economic activity, but 61.4 percent of industry emissions which was mainly due to agricultural methane emissions. This shows a much higher amount of emissions per unit of GDP. The contribution of the goods-producing sector to the economy was broadly similar to its contribution to emissions, accounting for 23.5 percent of economic activity and 26.7 percent of industry emissions.

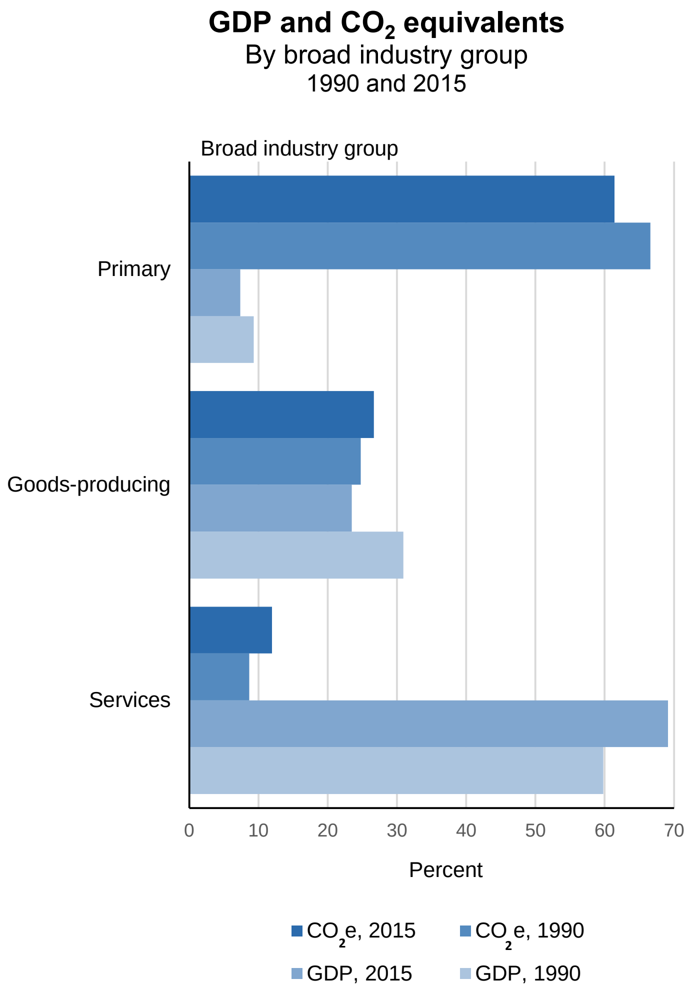
Figure 17



Source: Stats NZ using data from: Ministry for the Environment; Ministry for Business, Innovation and Employment

Since 1990, the contribution of service industries to the economy increased from 59.8 percent to 69.1 percent while its contribution to emissions increased less proportionately, from 8.7 percent to 11.9 percent (figure 18). The contribution of the goods-producing sector to the economy decreased from 30.9 percent to 23.5 percent, but its contribution to emissions increased slightly from 24.8 percent to 26.7 percent.

Figure 18



Source: Stats NZ using data from Ministry for the Environment and Ministry for Business, Innovation and Employment

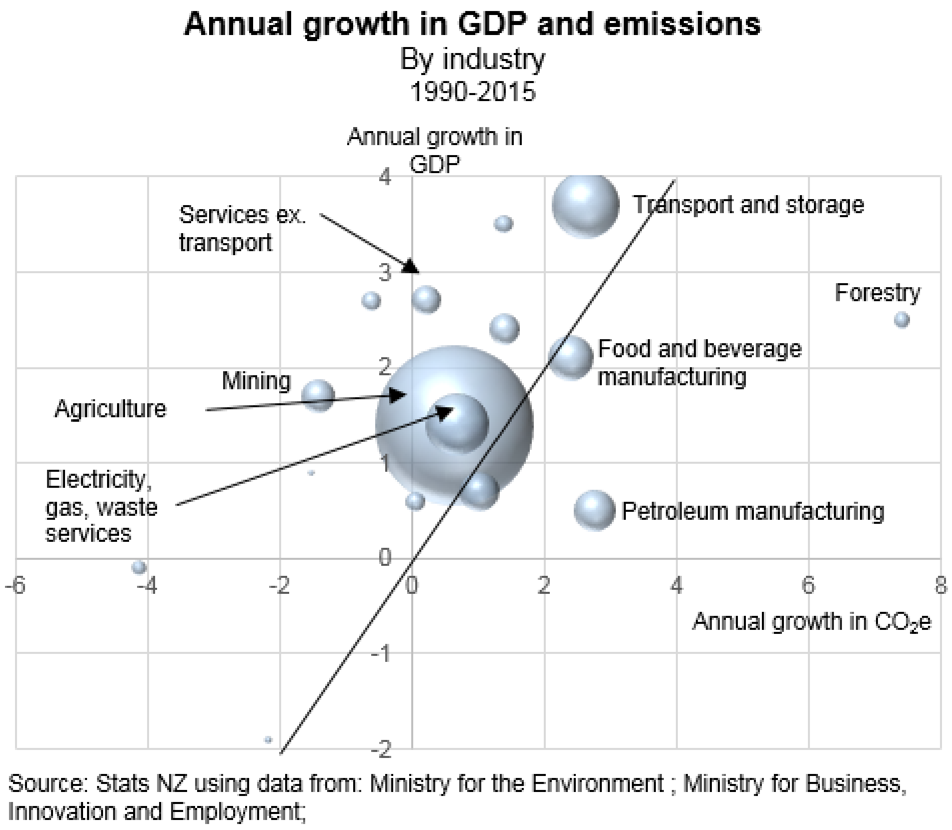
Figure 19 shows the annual changes in GDP and emissions by industry. The size of the bubble reflects the industry's proportion of total economy emissions in 2015. Industries whose centre is to the left of the 45-degree line increased their GDP faster than emissions (ie relative or absolute decoupling), while those to the right increased their GDP but emissions increased at a faster rate (ie greenhouse gas intensity increased).

From 1990 to 2015, five industries recorded a decrease in emissions, three of which did so while increasing economic output, thus showing absolute decoupling: fishing; mining; and transport equipment, machinery and equipment manufacturing. However, the emissions of these industries are relatively small. The industry emissions profile is dominated by agriculture, transport and storage, and electricity, gas, water, and waste services which accounted for 76.5 percent of industry emissions in 2015. Emissions increased in all of these industries from 1990 to 2015, at a slower rate than their GDP, therefore showing relative decoupling. The agriculture industry's carbon dioxide equivalent emissions increased 0.6 percent a year, while its GDP increased by 1.4 percent a year.

Emissions increased at a faster rate than GDP for forestry; food, beverage, and tobacco product manufacturing; petroleum, chemical, polymer, and rubber product manufacturing; metal product manufacturing, and total manufacturing.

The growth in emissions from the forestry industry reflects only energy and road transport emissions as air emissions accounts exclude emissions and removals from the land use and forestry sector including tree planting, harvesting, and land conversion (Eurostat, 2015). Under SEEA, carbon sequestration is recorded in ecosystem service accounts, and discussed in the timber section of this report, but not in the air emissions account which measures the flow of emissions from the economy to the environment not net emissions.

Figure 19



See [SEEA air emissions account]() to access more data on greenhouse gas emissions by industry and households.

Future development of flow accounts

We have yet to produce any flow accounts showing the flows of resources from the environment to the economy. Water and timber flow accounts are likely to be developed first. The accounts will show which industries are using these natural resources. Further flow accounts, for both resources and residuals, may be developed depending on customer demand.

Environmental activity accounts

To understand the interactions between the environment and economy, it is important to consider the monetary transactions within the economy that are undertaken to preserve and protect the environment. Taxes and subsidies also reflect efforts by governments, on behalf of society, to influence producer and consumer behaviour with respect to the environment.

Combined with information on the changing pressures on the environment, information on these transactions helps us assess whether fiscal policy and economic resources are being used effectively to reduce pressures on the environment. The information may also be used to assess whether investments in natural capital are maintaining or increasing the flow of ecosystem services.

This section presents information on central and local government expenditure on environmental protection and environmental taxes compiled using the SEEA framework. We also include estimates of New Zealand's marine economy, and the renewable energy generation economy.

Environmental protection expenditure

The environmental protection expenditure account provides information that assists in understanding society's response to the challenge of environmental degradation and depletion of natural resources, and the potential for economic activity to be based on environmentally friendly and more resource-efficient activities. Environmental protection activities are those activities whose primary purpose is the prevention, reduction, and elimination of pollution and other forms of degradation of the environment. Resource management activities are those activities whose primary purpose is preserving and maintaining the stock of natural resources and hence safeguarding against depletion.

While a full environmental protection expenditure account has yet to be developed, data on general (central and local) government final consumption expenditure and investment expenditure are included in this report.

- Government final consumption expenditure represents government expenditure on goods and services that are used for the direct satisfaction of individuals and communities.
- Investment expenditure is the net increase in physical assets (acquisitions less disposals).

The relative importance of environmental protection final consumption expenditure and investment is expressed relative to the total expenditure and investment by each sector.

Data are available from 2009. Local government data by type of environmental protection expenditure are available from this year. Central government data are only currently available from 2009 due to a significant change to the structure of Crown Financial Information System data for 2007–08.

Key facts

- Final consumption expenditure on environmental protection by general government reached $2.1 billion in 2016, amounting to 4.5 percent[4] of total government final consumption expenditure.
- Local government environmental protection final consumption expenditure reached $1.1 billion in 2016, up 17 percent from $901 million in 2009.
- Wastewater management accounted for 56 percent ($586 million) of local government environmental protection final consumption expenditure, while pest management account for 3 percent ($33 million) in 2016.
- Central government final consumption expenditure on environmental protection increased 18 percent from 2009 to 2016, reaching $1.0 billion in 2016.
- General government investment in environmental protection amounted to $970 million in 2016, with $880 million from local government and $91 million from central government.
- General government environmental protection investment to total investment declined from 14.8 percent in 2009 to 9.7 percent in 2016.

Expenditure on environmental protection

Final consumption expenditure on environmental protection by general government reached $2.1 billion in 2016, amounting to 4.5 percent[4] of total government final consumption expenditure. This share was down from 4.8 percent in 2009.[5] General government final consumption expenditure on environmental protection[6] increased at a rate of 2.3 percent a year from 2009 to 2016. Final consumption expenditure includes intermediate consumption, salaries and wages (and other associated payments to employees), indirect taxes, and depreciation.

Central government final consumption expenditure on environmental protection increased 18 percent (or 2.4 percent a year) from 2009 to 2016 reaching $1.0 billion in 2016 (figure 20).

Local government environmental protection final consumption expenditure on air and water quality, wastewater, pest management, solid waste and refuse, and flood, river, land, and soil management reached $1.1 billion in 2016 (figure 21), up 17 percent from $901 million in 2009 (a rate of 2.2 percent a year). Wastewater management accounted for 56 percent ($586 million) of local government environmental protection final consumption expenditure, while pest management accounted for 3 percent ($33 million) in 2016.

The share of final consumption expenditure for both central and local government remained relatively constant, with environmental protection expenditure accounting for around 19–21 percent of total final consumption expenditure for local government and 2–3 percent for central government.

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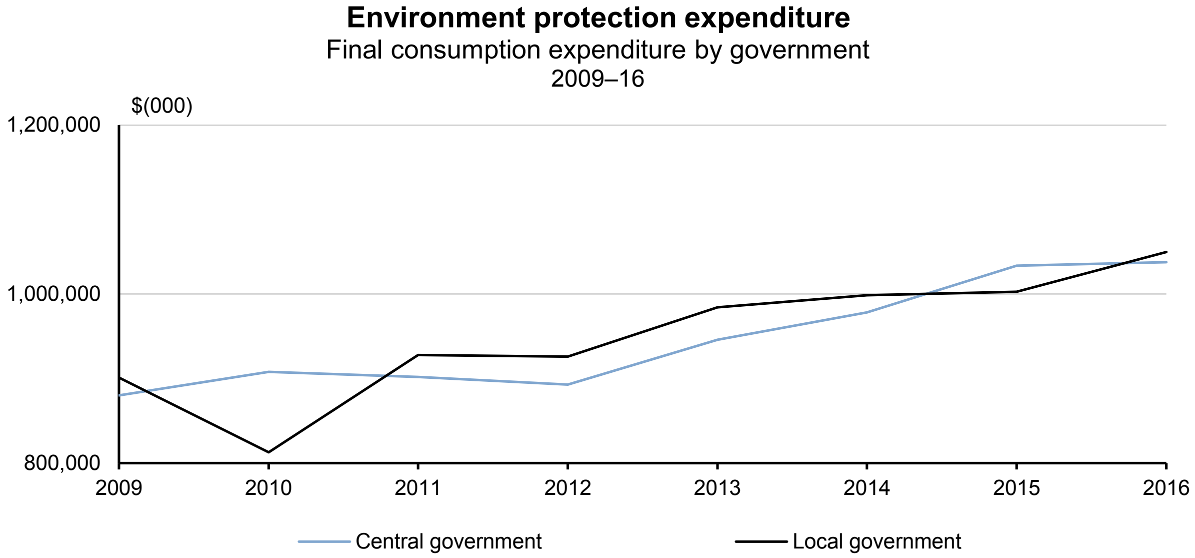
[4] The previous version of this report incorrectly said that final consumption expenditure on environmental protection by general government amounted to 22.5 percent of total government final consumption expenditure.

[5] The previous version of this report incorrectly said that this share was up from 20.9 percent in 2009.

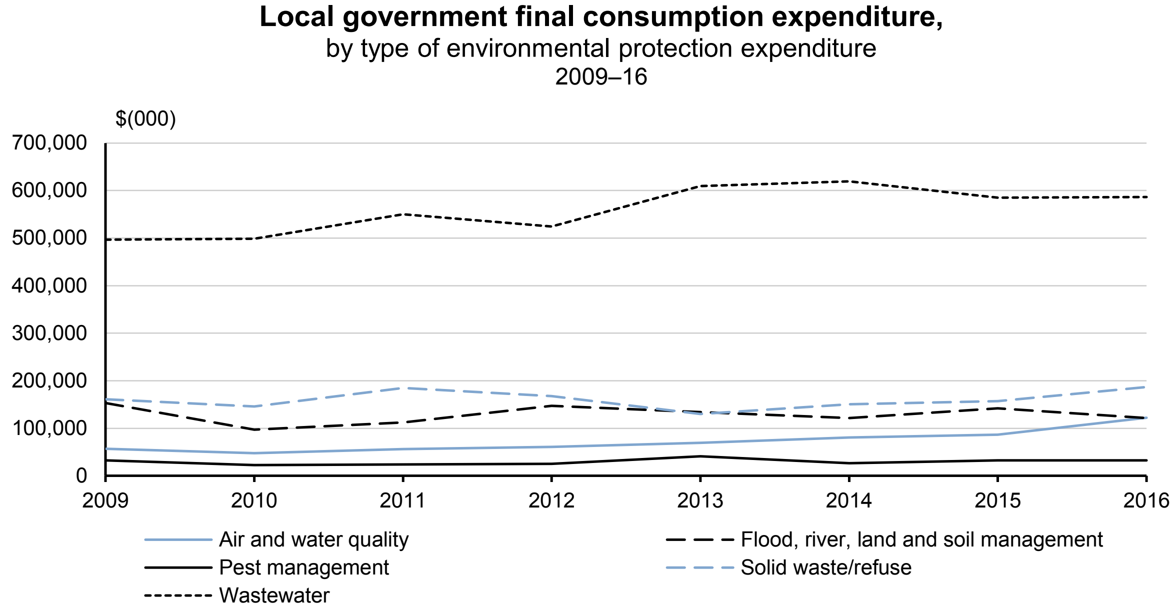
[6] The previous version of this report incorrectly said final consumption expenditure increased at a rate of 2.3 percent a year from 2009 to 2016. We corrected this to general government final consumption expenditure on environmental protection.

Figure 20



Source: Stats NZ

Figure 21



Source: Stats NZ

Functions of central and local governments

Central government

Central government spending on environmental protection generally consists of departmental output classes, non-departmental output classes, and other expenses to be incurred by the Crown. Departmental output classes are costs incurred by government departments and offices of parliament for the provision of environmental goods and services. Included are Department of Conservation, Ministry for the Environment, Ministry for Primary Industries, and the Office of the Parliamentary Commissioner for the Environment.

Non-departmental output classes are costs incurred by the Crown when purchasing goods and services from Crown entities, state-owned enterprises, or other third parties. Crown entities include the Energy Efficiency and Conservation Authority (set up by the government under the Energy Efficiency and Conservation Act 2000), and Environmental Risk Management Authority.

Local government

Local government consists of four types of councils – city, district, regional, and unitary. Each fulfils different roles and all are engaged to some degree in activities aimed at protecting the environment and promoting the sustainable use of resources.

City councils provide the essential utilities and infrastructure that enable cities to function. Utilities that fall under the environmental protection expenditure are waste management, sewage, and stormwater.

District councils provide the same key environmental protection expenditure functions as city councils: waste management, sewage, stormwater, resource consents, district plans, and parks and reserves. They also have district-specific areas of environmental protection expenditure similar to city councils, for example restoring landfill sites and protecting the coastal environment.

Regional councils have a strategic planning and monitoring role, with a focus on protecting the natural environment and regional transportation, including harbours. They are also more involved with promoting sustainable land use than city or district councils. Regional councils do not provide essential utilities, such as refuse collection and sewage disposal.

Unitary councils fulfil the functions of both a district and regional councils, spending on both the provision of essential utilities as well as activities normally looked after by regional councils, such as pest control and inland-water management.

Investment in environmental protection

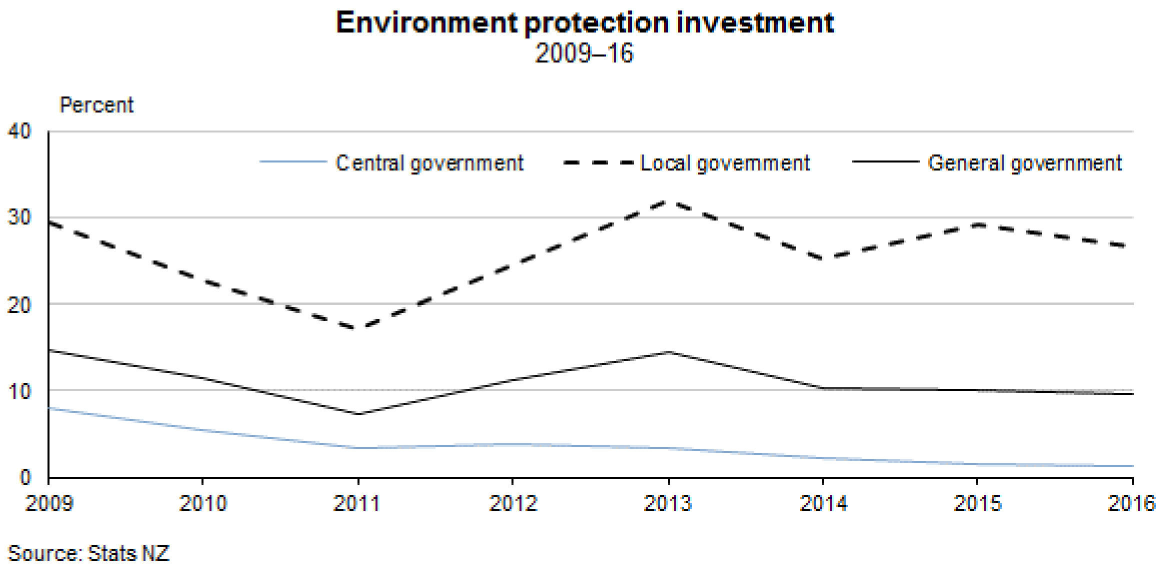
Environmental protection investment is the additions less disposals of fixed assets (gross fixed capital formation) for those departments whose primary purpose is to provide environmental protection. It includes, among other items, furniture, computer software and hardware, land improvements, transport equipment, non-residential buildings, other construction, and plant, machinery and equipment.

Investment in environmental protection amounted to $970 million in 2016, with $880 million from local government and $91 million by central government. Wastewater accounted for 81 percent of local government environmental protection investment, while flood, river, land, and soil management accounted for a further 15 percent.

Combined, environmental protection investment to total investment declined from 14.8 percent in 2009 to 9.7 percent in 2016. Declines in the importance of environmental protection investment have been observed in Europe where this proportion declined from 6.3 percent in 2006 to 5.9 percent in 2015 for European Union (EU)-28 countries (Eurostat, 2017).

From 2009 to 2016, the share of central government's environmental protection investment to total investment fell from 7.9 percent to 1.4 percent (figure 22). For local government, this share was 26.7 percent in 2016, varying between 17.2 percent and 32.1 percent from 2009 to 2016.

Figure 22



Environmental protection research and development

Information on expenditure on research and development for environmental benefit is available from Stats NZ's research and development (R&D) survey. In 2016, R&D expenditure for environmental purposes amounted to $315 million, or 10 percent of total R&D expenditure. Government sector expenditure accounted for 70.8 percent ($223 million), with higher education accounting for a further 22.9 percent ($72 million) and business the remaining 6.0 percent ($19 million).

Included in these estimates are research and development expenditures related to (among other things) air, climate, control of pests, diseases and exotic species, ecosystem assessment, water quality, and soils. Also included are a number of expenditures related to natural resource management. Under the SEEA framework these expenditures are to be excluded from the estimate of research and development for environmental protection but are presented here to give an indication of the extent of activity being undertaken.

Gaps in the environmental protection expenditure account

Our current estimates of environmental protection expenditure and investment do not include those by households or market enterprises. In EU-28 countries, household environmental protection expenditure exceeded general government expenditure in 2015: 41 percent was undertaken by central government compared with 59 percent by households (Eurostat, 2017).

It is unclear whether household environmental protection expenditure will be as significant in New Zealand. Unlike many European countries, households in New Zealand do not consume the environmental goods and services, rather, local governments buy these for the community (Stats NZ, nd, p7).

Investment by private companies is likely to be significant. In 2015, 2.0 percent of total investment by corporations in EU-28 countries related to environmental protection (Eurostat, 2017). Further work is required to fill these data gaps and determine the significance of these sectors to environmental protection expenditure in New Zealand.

Environmental taxes

Environmental taxes reflect efforts by governments, on behalf of society, to influence the behaviour of producers and consumers with respect to the environment. There is considerable interest in the use and effectiveness of these taxes as they show a direct response of countries to manage environmental change through economic instruments, meeting dual targets of environmental and economic management. Environmental taxes is one of six SEEA accounts that European Union countries are required to produce under legislation (see section 'European environmental accounts' in Environmental accounts – establishing the links between the environment and the economy).

Environmental taxes are taxes with a base that is a physical unit (or a proxy of a physical unit) of something that has a proven, specific negative impact on the environment. These include:

- energy taxes on energy production and on energy products used for both transport and stationary purposes (eg taxes on petrol or diesel, electricity consumption and production, and emissions of greenhouse gases – including proceeds from emission permits recorded as taxes in the national accounts)
- transport taxes related to the ownership and use of motor vehicles, although taxes on other transport and related transport services are also included (eg motor vehicle import or sales, registration of motor vehicles, flights and flight tickets)
- pollution taxes on the management of waste (including measured or estimated emissions to air excluding carbon dioxide, measured or estimated effluents to water, and waste collection treatment and disposal)
- resource taxes on raw materials, such as water abstraction, harvesting of biological resources, or extraction of minerals, oil, and gas.

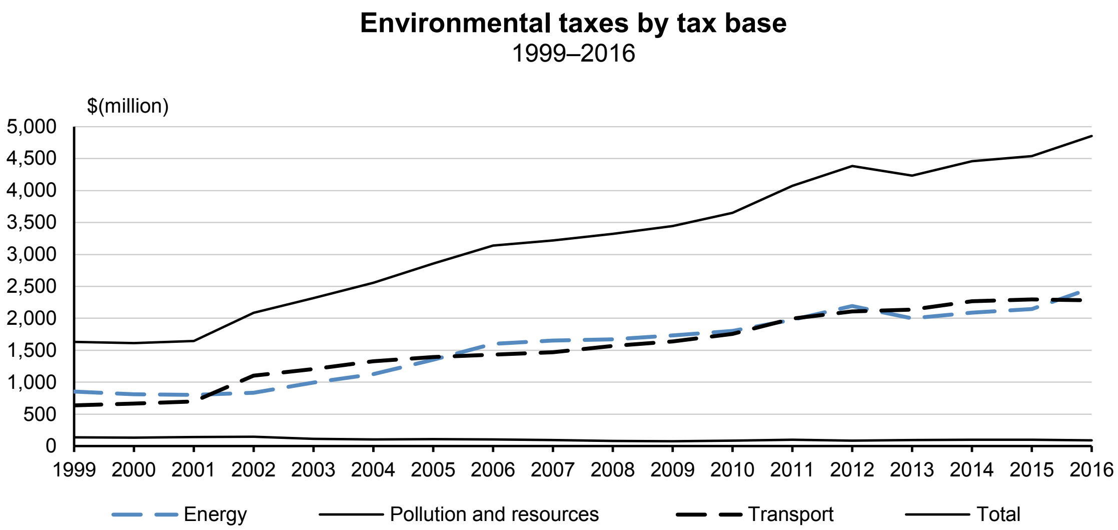
Key facts

- In 2016 the total amount of environmental taxes was $4.9 billion, an increase of $3.2 billion from $1.6 billion in 1999.
- This was 6.2 percent of all taxation received by general government (central and local) up from 4.8 percent in 1999.
- In 2016, most environment taxes were energy (51 percent) and transport (47 percent) taxes. Combined pollution and resources taxes made up only 2 percent of the total.
- This is reflected in the breakdown of taxes by industry with most taxes paid by the petroleum, chemical, polymer, and rubber product manufacturing industries (27 percent) and the transport and storage industries (20 percent).
- Resources taxes declined from $138 million (8 percent) in 1999 to $60 million (1 percent) in 2016.
- The average household paid $380 in environmental taxes in 2016. The share of environment taxes paid by households increased relative to industry. In 2016, households paid 13 percent of environment taxes, up from 7 percent in 1999. Over the same period industry contribution dropped from 93 percent to 87 percent.
- Almost all environment taxes paid by households are transport environment taxes.

Environmental tax type

New Zealand's environmental taxes are made up mainly of energy and transport taxes. Over the period 1999–2016, energy taxes increased from $856 million to $2.5 billion, while transport taxes increased from $637 million to $2.3 billion (figure 23). Movements were volatile over the period 2002–05, but generally each of these two tax types made up on average 48 percent of the total over the time period.

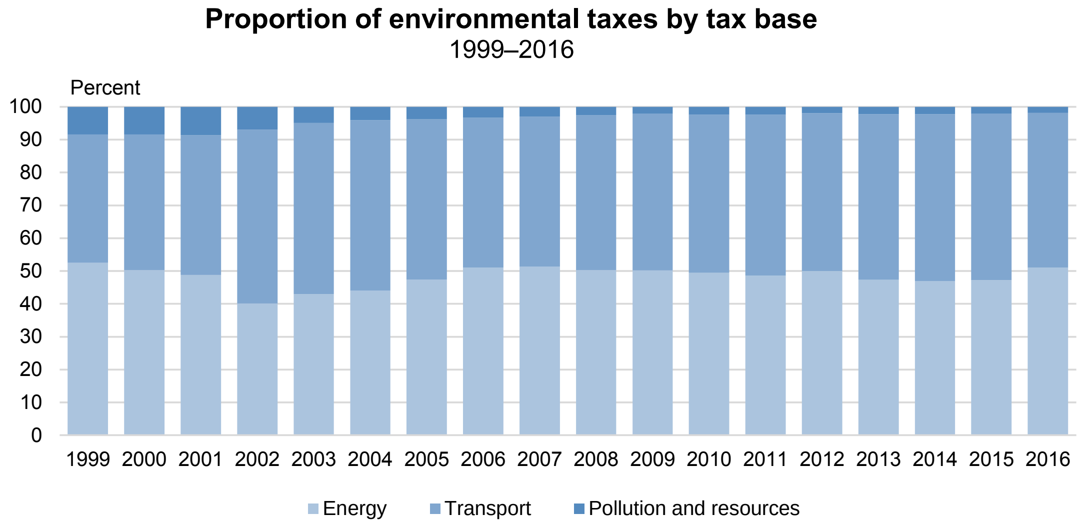
Figure 23



Source: Stats NZ

The share of pollution and resource taxes declined over the period 1999–2016 (figure 24). In 1999 these taxes made up 8 percent of total environmental taxes, but dropped to 2 percent in 2016. Unlike energy and transport taxes, the total amount of pollution and resource taxes also declined, from $138 million in 1999 to $93 million in 2016.

Figure 24



Source: Stats NZ

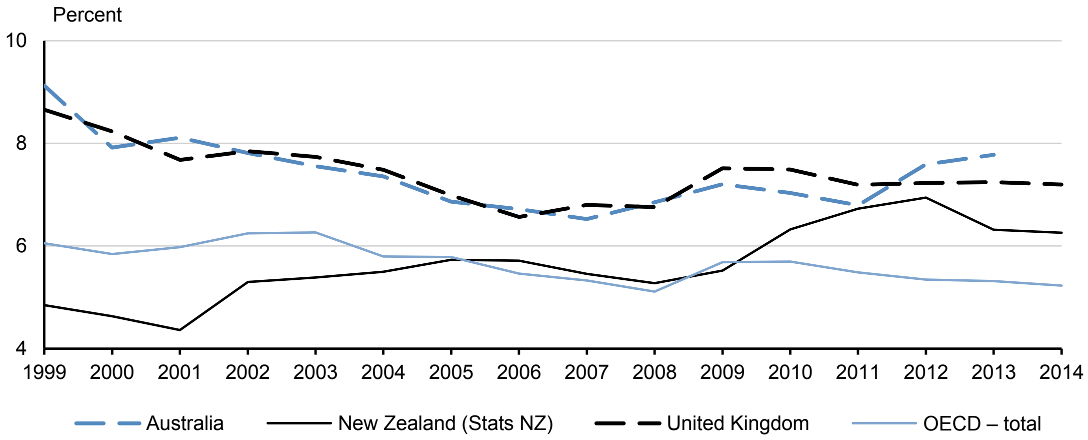
International comparisons

The OECD has produced estimates of environmental taxes for member economies. In 2014 across the OECD, environmental taxes made up 5.2 percent of total tax revenue (OECD, nd). The OECD's estimates of 4.2 percent in 2014 for New Zealand are lower than Stats NZ's estimates. The Stats NZ estimates are based on more recent and complete data. In all OECD countries, the share of environmental taxes to total taxes declined slightly over the 1999-2014 period (figure 25). This is attributed in part to rising fuel costs triggering substitution away from motor vehicle fuels (OECD, 2016).

In OECD countries in 2013, the make-up of environmentally related taxes was similar to that for New Zealand. Revenue was dominated by taxes on energy products, which included motor vehicle fuels (69 percent), and motor vehicles and transport (28 percent). Other environmental taxes, such as those on resources and pollution, made up 3 percent; unlike New Zealand, the share of these taxes across the OECD is growing.

Figure 25

Environmentally related tax revenue as a proportion of total tax revenue
1995–2014



Note: Australia data for 2014 is not available. Estimates for New Zealand are provided by Stats NZ, other estimates are from the Organisation for Economic Co-operation and Development (OECD).

Source: OECD; Stats NZ

In the UK, environmental taxes raised £44.6 billion in 2014 (around $85 billion), providing 7.5 percent of all revenue from taxes and social contributions (ONS, 2015a). In the UK the percentage of taxes paid by households is much higher than in New Zealand. In 2012, just under half (49 percent) of all environmental taxes in the UK were paid by households compared with 16 percent in New Zealand. The main reason for this difference is due to a differing treatment of energy taxes. Two-thirds (66 percent) of all environmental taxes paid by UK households were energy taxes, which were made up of taxes on transport fuels. In New Zealand fuel excise taxes are paid directly to the government by the petroleum and coal product manufacturing industry, a subgroup of petroleum, chemical, polymer, and rubber product manufacturing. This industry then passes on the taxes to households and other industries through fuel pump levies.

About the estimates

National totals for taxes are provided through the Treasury's Crown Financial Information System (CFISnet), a secure website that collects actual and forecast information from government departments, Crown entities, and state-owned enterprises.

CFISnet is detailed enough for us to be confident in the total amount of environmental taxes and the totals by environmental tax type. Where information is not available to allocate a specific large tax directly to an industry or group of industries, we allocate taxes on a proportional basis to industries. The proportions used are derived mainly from taxes and subsidies data collected though the annual enterprise survey (AES). However, AES is not used as the data source for the contribution to GDP by agriculture industries, so the proportions are not available. For agriculture industries, we had to assume the allocation based on the ratio of environmental taxes to total taxes in other industries. This is an area for future improvement in the taxes account.

Marine economy

The marine economy provides information about the economic activities that took place in, or used, the marine environment, or that produced goods and services necessary for those activities, and made a direct contribution to the national economy.

Our marine environment is intricately linked to our society and economy. Almost all our imports and exports, both by value and volume, pass through the marine environment; most of our oil and gas reserves are located offshore; and our fishing industry is significant. Yet there is limited understanding of how much these and other activities together contribute to New Zealand's economy.

The marine economy attempts to fill this information gap by using a methodology consistent and comparable with other economies. It aims to improve our understanding of how New Zealand's marine environment is used to generate economic activity (measured as its contribution to GDP). Information about the contribution our marine environment makes to the national economy is useful for policy development relating to ocean (marine) management and for informing public debate.

Key facts

- In 2016, New Zealand's marine economy contributed $3.6 billion (1.4 percent) to the national economy as measured by GDP ($254.7 billion).
- A further $3.1 billion was generated indirectly, bringing the total marine economy value added to $6.8 billion in 2016, or 2.7 percent of GDP.
- From 2008 to 2015, offshore minerals was the largest contributor to the marine economy but was surpassed by shipping in 2016, which accounted for 33.6 percent of marine economy GDP.
- Contributions to the marine economy by fisheries and aquaculture increased from 26.3 percent in 2007 to 31.3 percent in 2016.
- In 2016, 29,986 wage or salary earners worked in the marine economy. These people held 101,860 filled jobs with total earnings of $1.7 billion.
- Over 2007–16, total earnings increased 27 percent ($365 million) while the number of filled jobs decreased 13 percent (15,040 jobs).

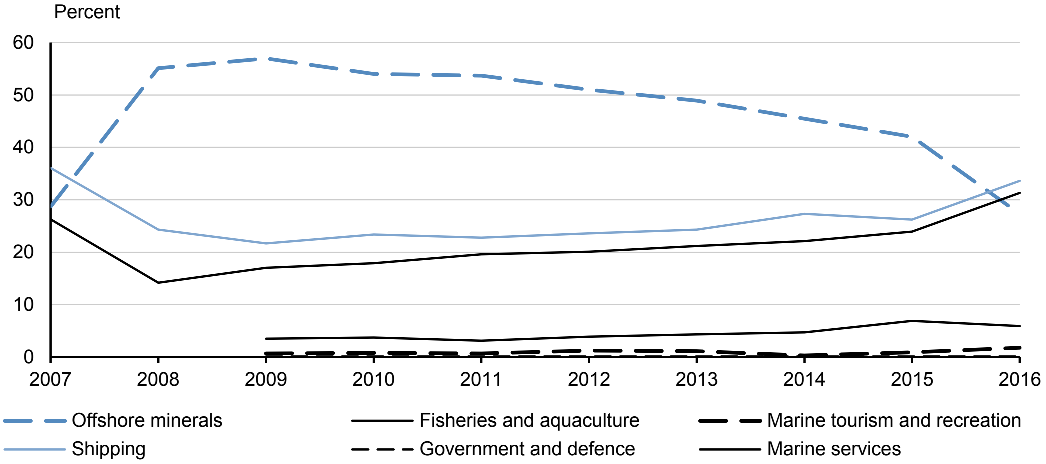
Contribution of the marine economy to GDP

In 2016, New Zealand's marine economy contributed $3.6 billion (1.4 percent) to the national economy as measured by GDP ($255 billion). While this value represents an increase of nearly 33 percent in GDP over the period 2007–16, the proportion of GDP remained steady at about 2 percent, with a small decrease in recent years.

The marine economy grew strongly in 2007–08 mainly due to increased value added from offshore minerals (figure 26). In 2007, offshore minerals contributed $782 million, rising to almost $2.2 billion in 2008, mainly due to increased production. Falls in oil prices contributed to the decline in the contribution of offshore minerals to the marine economy in 2016.

Figure 26

Proportion of New Zealand's marine economy
By activity category
2007–16



Note: Data not available for marine tourism and recreation, marine services, and government and defence for 2007 and 2008 due to a change in survey design.

Source: Stats NZ

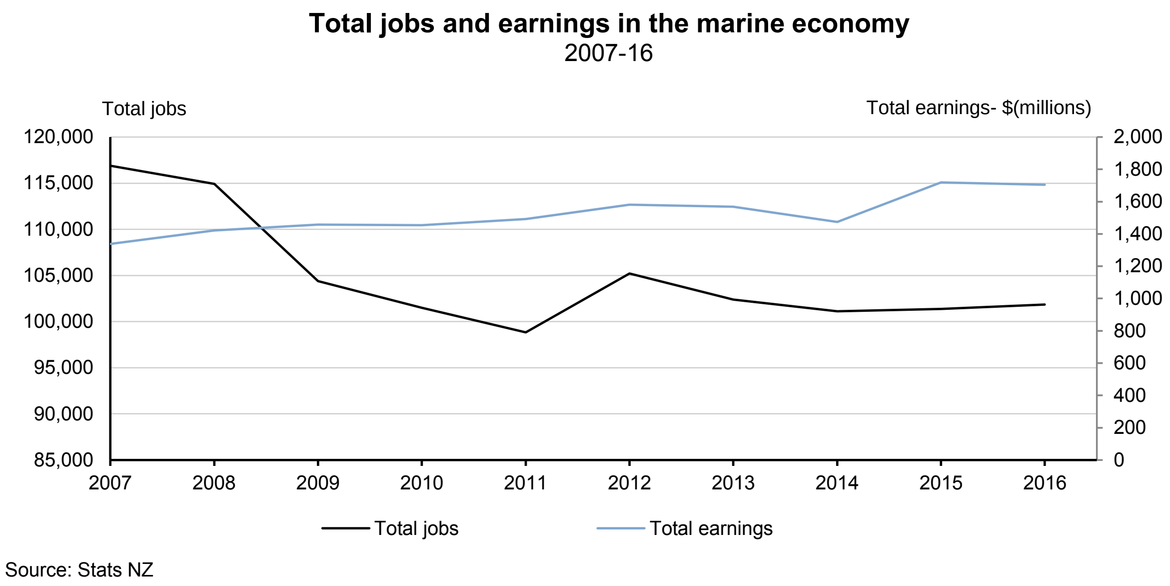
From 2008 to 2015, offshore minerals was the largest contributor to the marine economy. In 2016, offshore minerals decreased to being the third-largest contributor, from 42 percent in 2015 to 27.3 percent in 2016. Shipping was the highest contributor in 2016, with 33.6 percent.

Contributions to the marine economy by fisheries and aquaculture increased from 26.3 percent in 2007 to 31.3 percent in 2016. Fisheries and aquaculture was the second-highest contributor in 2016, contributing $1.1 billion to the marine economy.

We included estimates of government and defence (local government marine safety) activities in the marine economy. This added $4.5 million to the marine economy in 2016, and was the lowest contributor to the marine economy, contributing a steady 0.1 percent from 2009 to 2016.

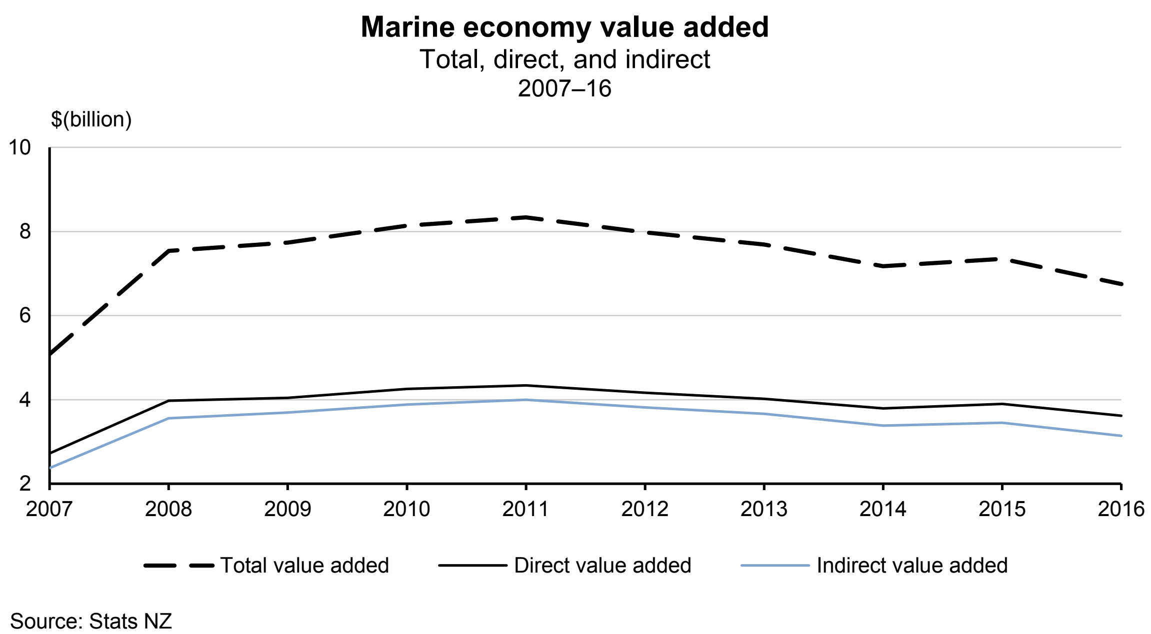
In 2016, 29,986 wage or salary earners worked in the marine economy. These people held 101,860 filled jobs with total earnings of $1.7 billion (figure 27). Over 2007–16, total earnings increased 27 percent ($365 million) while the number of filled jobs decreased 13 percent (15,040 jobs). Of the 29,986 wage or salary earners, 84 percent had another job in the same industry.

Figure 27



Activity in the marine economy leads to further economic activity in non-marine industries. For any given output of goods and services, other industries within and outside the marine economy supplied intermediate inputs used in the production of those goods and services. Measuring these indirect effects, therefore, gives an indication of the broader economic significance of the marine economy. Total marine economy value added was estimated at $6.8 billion in 2016, or 2.7 percent of GDP. The indirect component accounted for $3.1 billion of this value, or 46.5 percent of total marine economy value added (figure 28).

Figure 28



Renewable energy economy

Renewable energy, such as hydro, geothermal, wind and solar, is the main source of New Zealand's energy supply. Comparatively, New Zealand has one of the highest proportions of renewable energy to total energy supply.

The renewable energy economy consists of those activities engaged in hydro, geothermal, solar, tidal, wind, biomass and other renewable electricity generation.

In 2016, the value added of the generation of renewable energy was $1.5 billion, up from $1.2 billion in 2012. A total of 2,100 jobs were in renewable energy generation in 2016, up from 1930 in 2012.

Future developments

There are many gaps in our available data for our environmental-economic accounts, both in terms of the completeness of existing gaps, and the measurement of stocks and flows of particular assets.

We will continue to consult with key parties to fill these gaps and develop and improve the environmental accounts.

In the short term, we will prioritise the following developments.

- Environmental-economic accounts for understanding the transition to a low-emissions economy. This includes further refining the air emissions account (in particular, adjusting for economic residency) and developing other accounts that will be of value to this topic.
- Ecosystem condition, extent, and services accounts. The most significant gap in our environmental accounts relates to ecosystem services and will be a priority for development.
- Flow accounts for natural resources. We do not have timely accounts on the flow of natural resources within the economy. We intend to develop the timber and water flow accounts in the next 12 months. Further flow accounts for residuals may be developed depending on customer demand.

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