Chapter 17:
Impacts on environment, ecology, and the ability to adapt to climate change

Contents

Chapter 17: Impacts on environment, ecology, and the ability to adapt to climate change 1

17.1 The physical impacts of climate change 3

17.2 The mitigation-adaptation link 4

17.2.1 The link between policies to reduce energy emissions and adaptation 4

17.2.2 The link between policies to reduce land emissions and adaptation 5

17.3 Environmental and ecological impacts of actions to reduce emissions 6

17.4 Environment and ecological impacts of actions to reduce emissions from transport and energy, industry and power sector 6

17.4.1 Total environmental impacts from moving to electric vehicles (EVs) 7

17.4.2 Air quality benefits from moving to electric vehicles and improved fuel efficiency 7

17.4.3 Mining, recycling and disposal of minerals and metals for low-emissions technologies 8

17.4.4 Land and water implications from low-carbon fuels 9

17.4.5 Environmental impacts from replacing fossil fuel boilers 10

17.4.6 Ecological consequences of new renewable electricity sources 10

17.5 Environmental and ecological impacts of actions to reduce land emissions 11

17.5.1 On-farm practice change impact on water quality and soil health 11

17.5.2 Biodiversity and water quality benefits from afforestation 11

17.5.3 Water quality impacts from land-use change to horticulture 14

17.5.4 Policy synergies 14

17.6 Environmental and ecological impacts from actions to reduce emissions from waste 14

17.7 References 16

We can already see the physical impacts of climate change in Aotearoa today, and these changes are expected to continue. On a global scale, acting earlier to tackle climate change will reduce total emissions and help to reduce the severity of impacts that we experience. The difference in impacts between a global temperature rise of 1.5˚C and 2˚C is large and serious. Therefore, it is important that Aotearoa is aware of the impact that contributing to global action to reduce emissions could have on our country's ability to adapt.

The climate transition could bring positive and negative environmental and ecological impacts. In addition to reducing our emissions, using low-carbon technologies and changing land practices could have broader environmental impacts, including on biodiversity, water quality and air quality.

This chapter looks at the environmental and ecological impacts from reducing emissions in the transport, energy, industry, buildings and land sectors, as well as the mitigation and adaptation link.

17.1 The physical impacts of climate change

The physical impacts of climate change are being observed in Aotearoa today; with increasing temperatures, changes in the frequency and severity of droughts, more extreme rainfall patterns, increasing fire risk, rising seas and shrinking glaciers.[1] With ongoing climate change, these changes are expected to continue and in some cases accelerate.

Far more than the current generation, future generations would bear the brunt of these impacts of climate change – both from the physical impacts that are locked in from historic emissions and from any current and future emissions.

Climate risks are particularly relevant to Māori as kaitiaki of the whenua. These risks include the impact on Māori interests, traditions and wellbeing. It is therefore essential that mātauranga Māori is used to better understand climate risks and develop future climate adaptation plans and policies.[2]

Globally, acting earlier to address climate change reduces cumulative emissions and avoids more severe physical impacts of climate change. The Intergovernmental Panel on Climate Change's *Special Report on Global Warming of 1.5°C* concludes that climate risks would be significantly lower if warming is limited to 1.5°C rather than 2°C. In a 2°C world, sea levels are projected to rise more, there would be more species loss and almost all of the world's coral reefs would be destroyed. Earlier global action enhances the ability for society and natural systems to adapt to these physical impacts, reduces the impact on indigenous culture and reduces the number of people exposed to climate-related risks, including risks to health, water supply, food security and economic growth.[3]

Extreme weather events, such as storms and flooding and rising sea levels pose a number of risks to households, businesses and communities. These risks are not just physical; they include the risks to human health, wellbeing and the financial system. For example, increased flooding from storm surges and higher sea levels pose a risk to low-lying homes, the banks that provide mortgages and those who insure them. An assessment of our country's exposure to rising sea levels suggests that there are 140,244 buildings within 1.2 metres of the spring high tide mark, with a replacement value of $43.78 billion in 2016 dollars.[4]

[1] (Ministry for the Environment & Statistics NZ, 2020)
[2] (Ministry for the Environment, 2020)
[3] (IPCC, 2018)
[4] (Paulik et al., 2019, p. 12)

Sea level rise is also a risk to ancestral land, coastal marae, papakainga, wāhi tapu and urupa and could displace the haukāinga who uphold tikanga.

Warmer temperatures, drought and the introduction of new pests and diseases could, for example, impact rural livelihoods and the wider food and fibre industry. They could also impact indigenous biodiversity and disrupt mahinga kai, rongoā and other practices that enable members of whānau, hapū and Iwi to apply and retain their tikanga and mātauranga.[5]

Analysis by Aotearoa scientists suggests that droughts alone cost Aotearoa $800 million between 2007 and 2017.[6]

While there are estimates of the damages from more severe climate change, there is a growing body of research showing that these estimates significantly underestimate the true cost.[7] This is because it is challenging to quantify many of the most serious consequences of climate change as they lie outside of human experience. The most serious consequences include destabilisation of the Greenland and Antarctic ice sheets, disruption to ocean and atmospheric circulation, biodiversity loss and the collapse of ecosystems. These risks provide a compelling reason for the globe to work together to reduce emissions.

While Aotearoa acting alone to reduce emissions would not reduce these impacts, by playing its part as a responsible global citizen, Aotearoa would contribute to the global action necessary to reduce the severity of these impacts.

17.2 The mitigation-adaptation link

Some of the physical impacts of climate change could affect the country's ability to reduce emissions. At the same time, the actions Aotearoa takes to reduce emissions could impact on the ability to adapt to these physical impacts.

17.2.1 The link between policies to reduce energy emissions and adaptation

On the energy side, Aotearoa is expected to become increasingly reliant on renewable energy that can also be affected as the climate changes. Wind, solar and hydro electricity generation depend on the weather. Shifts in rainfall, wind, temperature and the occurrence of storms could affect the availability of these energy resources. This would have broader impacts on the security of electricity supply.

Electricity infrastructure would be impacted by warmer temperatures and extreme weather events. This is because the carrying capacity of electric power cables decreases as temperatures rise. Transmission and distribution networks are vulnerable to increased risks of flooding, landslides and other natural hazards. This effect may further impact the capacity of electricity systems, as increased demand for electricity puts pressure on the transmission and distribution network, thereby reducing their capacity.[8]

[5] (Ministry for the Environment & Statistics NZ, 2020)
[6] (Frame et al., 2020)
[7] (DeFries et al., 2019)
[8] (Yalew et al., 2020)

Electricity infrastructure could also be impacted if storms were to become more frequent and more severe. Power outages due to storms would be particularly problematic for charging electric vehicles (EVs). This infrastructure would need to be more resilient, particularly as our dependence on electricity increases with use of electricity for EVs and process heat. Warmer temperatures would also mean demand for electricity would increase in summer due to increased air conditioning.

Seasonal rainfall and dry years already have a significant impact on our country's electricity generation, prices and use of coal and gas. A recent modelling assessment projects that climate change would have a beneficial impact on inflows into hydro lakes due to increases in winter precipitation in major hydropower basins and a shift in the dry season towards summer. By 2050 the South Island is expected to experience statistically significant increases in hydropower generation with little change in the North Island. By late-century, however, hydropower generation is expected to increase throughout all of Aotearoa. This is especially the case for the South Island.[9] Modelling also suggests that wind generation would not be significantly impacted as windspeeds are projected to only change moderately.[10]

In some cases, the actions Aotearoa takes to reduce emissions can complement its strategies to adapt to climate change. For example, decentralised and local renewable energy generation supports climate resilience by reducing the risk of widespread power outages from extreme weather events or peak power loads,[11] as well as providing energy sovereignty for Iwi/Māori and remote or rural communities.

However, the actions we take to reduce energy emissions could also negatively affect our ability to adapt to climate change. For example, while building more dense cities can reduce the distance that people need to travel and could reduce transport emissions, densifying in low-lying areas could increase the country's exposure to climate change. This is relevant to Aotearoa as many central cities are located in low-lying areas close to the sea.[12] It is therefore critical that both local and central government make plans for future sea-level rise and the risk of coastal erosion, such as by developing flexible adaptation plans, undertaking coastal hazard assessments, restricting development in coastal erosion areas and planning for managed retreat.[13] This then needs to be factored into decision making on mitigating climate change.

17.2.2 The link between policies to reduce land emissions and adaptation

Our forests may also become more exposed to wind damage, wildfire and pest incursion as a result of climate change. Global climate modelling suggests that the risk of fire would increase in many parts of Aotearoa due to increased temperature and wind speed and reduced rainfall and humidity.[14] This could have impacts on the supply of biomass for biomass industry and the ability to reduce emissions from higher temperature process heat. See *Chapter 9: Removing carbon from our atmosphere* for more information on the risks to forestry from climate change.

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[9] (Collins et al., 2020)
[10] (Meridian Energy, 2019)
[11] (Hamin & Gurran, 2009)
[12] (Ministry for the Environment, 2017)
[13] (Ministry for the Environment, 2017)
[14] (Pearce et al., 2011)

Animals will require more shade and shelter as rising temperatures increase the risk of heat stress.[15] Trees on farms whether native or exotic can help to provide this shade. Native forests can also be used in green firebreaks to protect from the increased risk of fires due to climate change.[16]

On the other hand, some land-use changes may reduce emissions but require more water that may be less available due to climate change. Exotic afforestation can also decrease water yield by 30-50%.[17] This could be a particular issue in areas that experience water shortages or where there is demand for irrigation, such as the eastern foothills of the Southern Alps and the tussock grasslands in the South Island.[18]

Nitrate leaching from pastures could also increase and become more variable with climate change due to extreme rainfall events and changing rainfall patterns.[19] Practices that optimise fertiliser application to different types of soils as a mitigation measure could prepare for adapting to future climate variabilities.

17.3 Environmental and ecological impacts of actions to reduce emissions

There could be positive and negative environmental and ecological impacts of the climate transition for Aotearoa.

The next sections look at the environmental and ecological impacts of the climate transition. In addition to reducing our country's emissions, using low-carbon technologies and changing land-use practices would have broader environmental impacts, such as effects on biodiversity and water quality as well as on the atmosphere. These sections specifically look at the environmental and ecological impacts from reducing emissions in transport, energy and industry, waste and the land sector.

17.4 Environment and ecological impacts of actions to reduce emissions from transport and energy, industry and power sector

This section looks at the environmental and ecological impacts from reducing emissions in transport, energy and industry sector.

More specifically, it looks at the impacts from reducing emissions through electrification, such as moving to EVs and switching to low-carbon fuels, such as biomass. Although building new hydroelectric dams or expanding existing hydroelectric assets is not explicitly included in our pathways, we have considered their environmental effects given their scale and significance.

[15] (Ausseil et al., 2019)
[16] (Curran et al., 2018)
[17] (Dymond et al., 2012)
[18] (Dymond et al., 2012)
[19] (Ausseil et al., 2019)

17.4.1 Total environmental impacts from moving to electric vehicles (EVs)

Many submitters raised concerns about the total impact of EVs on the environment. Although EVs are low emissions, they are not zero emissions. The EV total supply chain (from cradle to grave) is extensive and it includes the extraction of raw materials, the battery manufacture, vehicle manufacture and shipping. Each of these activities has associated emissions.

Evidence shows that the life cycle cost of an EV on the environment in comparison to an internal combustion engine vehicle (ICE) is significantly reduced. This can range from 40% to 70% fewer emissions depending on a range of factors including the extraction and production methods, materials used and how the electricity used to fuel the vehicle is generated. The life cycle impact of an EV on the environment is expected to decrease further as countries move towards more renewable electricity generation, battery technology continues to improve and global efforts to reduce emissions from EV supply chains increase.[20]

Aotearoa has a highly renewable electricity system, which provides us with one of the better opportunities globally to reduce emissions from transport by adopting EVs. An EV used in Aotearoa would emit about 60% fewer emissions over its full life cycle than a petrol vehicle, even when you take into account raw material extraction, battery manufacture, vehicle manufacture and shipping. The total amount of energy used during the entire life cycle of the vehicle (cumulative energy demand) was around 40% less for the EV than for the petrol and diesel vehicles.[21] Both figures will improve as Aotearoa phases out the use of fossil fuels for electricity generation and global efforts to reduce emissions from EV supply chains increase.

There has been a mixture of academic research on the positive and negative impacts of EVs compared with ICE vehicles. Some studies have concluded that if resource use and other environmental impacts such as freshwater contamination are considered, some EVs perform worse than ICE vehicles from a life cycle perspective.[22] Other international studies have shown that a 30% decrease in grid carbon intensity could reduce emissions from the battery production chain by about 17%, in addition to even greater savings in the use phase.[23] Use of recycled materials and battery chemistries with lower carbon intensity could also reduce emissions in the manufacturing phase.

Furthermore, the establishment of a second-life battery market could allow for EV batteries to support the electric grid for years after their life in the vehicle, which would further reduce the environmental impact attributable to EVs (see section 18.3.4). Even as EVs use larger batteries to allow longer electric-range travel, these improvements will allow for lower lifecycle emissions and will further increase EVs life cycle advantage over ICE vehicles.

17.4.2 Air quality benefits from moving to electric vehicles and improved fuel efficiency

Vehicle exhaust is a significant source of air pollution in Aotearoa, particularly in heavy transport areas. Vehicle exhaust emits a range of pollutants, including nitrogen oxides and fine particulate matter that is less than 2.5 micrometres wide. Fine particulate matter has greater health impacts than coarser particulate matter as it can get deeper into the lungs and cause respiratory issues.[24]

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[20] (Transport & Environment, 2017)
[21] (EECA, 2015)
[22] (Dolganova et al., 2020; Puig-Samper Naranjo et al., 2021)
[23] (Hall & Lutsey, 2018)
[24] (Ministry for the Environment & Statistics NZ, 2018)

Moving to EVs from petrol and diesel vehicles would reduce air pollution and particulate matter that is less than 2.5 micrometres wide. EVs would continue to generate some air pollution as the weight of the vehicle wears down the road pavement, tyres and brake pads. However, these particulates tend to be coarser and have fewer health impacts.[25]

Measurements show that as vehicles have become more emissions- and fuel-efficient over time in Aotearoa, air pollutant concentrations have decreased.[26]

In addition, studies in Aotearoa and internationally on the life cycle assessment of EVs have found they produce significantly fewer emissions than conventional petrol or diesel vehicles.[27]

17.4.3 Mining, recycling and disposal of minerals and metals for low-emissions technologies

Many technologies that are expected to be important in the transition to a low-emissions economy – including wind turbines, solar panels and batteries – require mineral and metal inputs. How these minerals and metals are sourced, recycled and disposed of could have environmental impacts.

There are valid concerns surrounding the sustainability and the ethicality of the EV supply chain. Understanding where and how the raw materials used in the production of lithium ion batteries are sourced is important for many consumers.

Some methods of extracting lithium, for example, use significant amounts of water and can have a long-lasting impact on the surrounding environment and local communities. Extraction of cobalt is another example where there can be ethical concerns. Almost 70% of the world's cobalt is produced in the Democratic Republic of the Congo, and 15-30% of the Congolese cobalt is produced by artisanal and small-scale mining (ASM).[28] For years, human rights groups have documented severe human rights issues in ASM operations.

Improving the sustainable management of EV supply chains will be important for reducing the adverse social and environmental impacts.[29] Some car manufacturers are committed to full traceability of their source materials (i.e. understanding exactly where and how materials have been produced). Digital technologies that establish transparent and reliable shared data networks could be deployed to significantly boost the transparency of supply chains. For example, using blockchain so the information about the material's origin cannot be changed undetected.[30]

Studies have concluded that there are sufficient reserves of these critical metals to meet increased EV demand.[31] For example, worldwide lithium production in 2016 amounted to 35,000 tonnes. Data from the US Geological Survey estimates lithium resources worldwide at approximately 40 million tons.[32] According to Deutsche Bank and Bloomberg, these reserves could last for an estimated 185 years, even if the market triples.[33] It is expected that further innovations in battery technology

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25 (Ministry for the Environment & Statistics NZ, 2018)
26 (Bluett et al., 2016)
27 (Elkind et al., 2020; Life Cycle Strategies, 2015)
28 (World Economic Forum, 2020)
29 (Elkind et al., 2020)
30 (Volvo, 2019)
31 (Transport & Environment, 2017)
32 https://www.usgs.gov/centers/nmic/lithium-statistics-and-information
33 ('We're Going to Need More Lithium', 2017)

would also help to reduce the use of these metals. Sustainable management of supply chains is required to reduce the adverse social and environmental impacts.[34]

Many EV batteries globally are discarded at the end of their useful life. This is a significant sustainability issue that manufacturers, consumers and policy makers are increasingly aware of, and efforts are being made globally to avoid battery dumping and create a circular battery supply chain.

Repurposing or reusing batteries – either as storage or recycling materials – would also extend their life cycle. Work is underway in Aotearoa on reusing, recycling and disposing of EV batteries. A used battery still has value. It can be refurbished, repurposed or recycled – for example, a used EV battery can be repurposed as a grid battery to store electricity from solar photovoltaic panels, or materials can be reclaimed for reuse.[35,36] Through the Ministry for the Environment's Waste Minimisation Fund, the Battery Industry Group was set up in early 2020 to research and develop a co-designed framework for a circular product stewardship scheme for large batteries of all types used in Aotearoa.[37]

Disposing of the materials for renewable energy technologies, such as solar panels or wind panels, requires the necessary infrastructure and skills. For example, although the materials of solar panels are recyclable, Aotearoa does not currently have the capacity for recycling these.[38] Facilities for recycling and disposing of solar photovoltaics are expected to increase as recycling infrastructure grows in Aotearoa.

Although wind turbines produce energy without any emissions, the turbine blades can be difficult to recycle or dispose of when turbines are decommissioned. This is because turbine blades are made of composite materials and it is costly to separate the materials for recycling. Internationally, most wind turbine blade waste is currently sent to landfill. However, the wind energy industry is working to find new methods for recycling composite waste.[39]

17.4.4 Land and water implications from low-carbon fuels

There are environmental effects from using low-emissions fuels, such as biofuels or hydrogen, which would depend on how the fuels are supplied and distributed.

Although liquid biofuel use in Aotearoa is currently very small (an estimated 0.1% of total transport fuels), increased demand for biofuels would have implications for land use. For example, growing crops for biofuel feedstocks may compete with other land uses, such as food production. However, using land to grow feedstocks for biofuels may generate other environmental benefits, such as erosion control and reducing freshwater nutrient loads.[40] It is important that any biofuel production is economically and environmentally sustainable in order to maximise these benefits.

Green hydrogen produced from renewable electricity is a potential low-emissions option for transport or industry. Producing green hydrogen at scale can be extremely energy intensive and requires significant build out of new renewable electricity generation as well as hydrogen distribution infrastructure. The environmental implications of hydrogen production and use would

[34] (Elkind et al., 2020)
[35] (EECA, 2017)
[36] (Vector, 2019)
[37] (Battery Industry Group, 2019)
[38] (Ecotricity, 2020)
[39] (Cefic et al., 2020)
[40] (Suckling et al., 2018)

depend on whether it is produced via electrolysis (water) with renewable electricity (green hydrogen) or via fossil fuels with carbon capture and storage (blue hydrogen).

17.4.5 Environmental impacts from replacing fossil fuel boilers

The environmental impacts of replacing fossil fuel boilers would depend on what they are replaced with. Electrode boilers and heat pumps can be used for producing lower temperature heat, reducing greenhouse gas emissions and improving energy efficiency. These boilers and pumps also do not emit particulate matter and other pollutants that contribute to localised air pollution.

However, moving to biomass boilers – which can be used to produce low- to high-temperature heat – would be associated with emissions of some air pollutants. Canterbury District Health Board has replaced a coal fired boiler at Burwood Hospital with biomass and diesel fired boilers. In addition to reducing emissions, an assessment by BECA suggests this change would also reduce particulate matter and sulfur dioxide, but increase nitrogen dioxide. However, it found that concentrations of these air pollutants would still be below air quality limits.[41]

The ash or biochar produced by most biomass boilers can also be used by horticulturalists to lift the productivity of agriculture and as a bioremediation tool for contaminated soils.[42]

17.4.6 Ecological consequences of new renewable electricity sources

Building new hydroelectric dams or expanding existing assets could be part of our response to meet emissions budgets and targets, even though our modelling does not explicitly include new hydroelectric assets. In addition, a pumped hydro scheme, such as that proposed on Lake Onslow, could help to reduce electricity emissions while providing flexible capacity to meet daily peaks in electricity demand as well as demand in dry years where hydro lake levels are low.

However, such schemes can have substantial impacts on the landscape and carry ecological consequences. Hydro schemes require a large area of land to be flooded for water storage and can impact water flows downriver of the scheme, to the detriment of nationally significant wetlands, habitats for endemic bird and fish species and in some cases endangered or threatened species.

Hydro dams can also obstruct native freshwater fish from migrating up and down rivers. More than half of our native freshwater fish migrate up rivers from the sea to suitable habitats and food sources and return to the sea at the end of their life.[43]

Any proposed scheme would need to assess the environmental and ecological impacts, in particular on our endangered or threatened species and be consented under the resource management framework. In addition, given the freshwater implications, attention would also need to be paid to the commitments within the Treaty of Waitangi Act and other forms of statutory obligations or non-statutory agreements with Iwi/Māori that relate to freshwater management.

[41] (BECA, 2015)
[42] (Biochar Network New Zealand, 2019)
[43] (Ministry for the Environment & Stats NZ, 2017)

17.5 Environmental and ecological impacts of actions to reduce land emissions

The actions Aotearoa takes to reduce emissions from land could bring positive or negative environmental and ecological impacts.

This section looks more closely at the environmental and ecological impacts of reducing emissions through on-farm practice change or new technologies, afforestation and land-use change to horticulture.

17.5.1 On-farm practice change impact on water quality and soil health

Changing farm practices to reduce emissions can also bring environmental and financial co-benefits, however the extent of these co-benefits would depend on the farm, the farm's specific climate and soil conditions, the current management system and the advice and skills farm businesses can draw on.

Making practice changes on farms can reduce emissions and improve water quality and soil health. This is particularly the case for practice changes that reduce nitrous oxide emissions, as nitrogen in the soil reacts to produce both nitrous oxide and nitrate that runs off into waterways.

Careful balancing of stocking rates, pasture management and supplementary feed can lead to a farm system where production, profit, emissions and other environmental outcomes are optimised. What an optimal system looks like would vary considerably between farms, and what any given farm can achieve would depend on how that farm is managed overall. For example, for some farmers applying nitrogen fertiliser more precisely – by using less and/or adjusting the rate and timing of applications – would reduce nitrous oxide emissions and nitrogen leaching and runoff. However, this must be carefully managed because if reductions in fertiliser result in lower pasture growth, but stocking rates are maintained by using high-nitrogen supplementary feed, the reductions of nitrous oxide may be minimal.[44]

Regenerative agriculture is an approach to farming that focusses on regenerating soil, improving water quality, enhancing ecosystem services, improving biodiversity and promoting livestock welfare.[45] Many farmers in Aotearoa already implement practices in line with these principles, such as cover cropping and mixed grass species in pastures that help to fix nitrogen and promote soil microbial diversity.[46] However, there is scope for further actions on our farms, for example by reducing synthetic fertiliser use, reverting land to native forests and planting more trees.

Improving the drainage of soils that are not draining well or avoiding soil compaction could improve soil structure and therefore soil health,[47] and reduce nitrous oxide emissions.[48]

17.5.2 Biodiversity and water quality benefits from afforestation

The environmental and ecological impacts of land-use change to forests depends on the desired objectives, the type of forest, where it is being planted and how it is managed.

[44] See, for example (C. de Klein et al., 2016)
[45] (Lal, 2020; Newton et al., 2020; Siegfried, 2020)
[46] (Vukicevich et al., 2016)
[47] (Kibblewhite et al., 2008)
[48] (C. A. M. de Klein & Ledgard, 2005)

Trees sequester carbon dioxide no matter where they are planted – albeit at a faster rate for exotics compared to natives.[49] However, other environmental impacts are location and management-specific. For example, planting trees on steep slopes and gullies can help reduce erosion and sediment runoff if the trees are selected and managed for that purpose.[50]

If the right type of tree is planted in the right place at the right time, it can have water quality, soil health, erosion and biodiversity co-benefits in addition to sequestering carbon dioxide. Aotearoa research suggests that planting trees on agricultural land can improve water quality and stream health within four to six years, including reducing stream temperatures and reducing nitrogen and phosphorous runoff to water. While exotic forests provide many of the same benefits as native forests over much of the forest growing cycle, there are negative impacts on waterways when exotic production forests are harvested through clear-fell.[51]

About one third of the original soil protection plantations in Aotearoa are now production forests that are being clear-felled. After clear-felling, the risk of landslides in exotic production forests – particularly those on steep slopes – increases and may cause debris to flow downstream affecting houses, roads and bridges. This can be reduced by changing forest management practices to harvesting over longer rotations, small-coupe clear-felling, continuous cover forests[52] or retiring the forests from production.[53]

The type of tree that is planted is important in determining the biodiversity co-benefits. Exotic forests provide some habitat for some native species, such as robins, fantails, kiwi and native falcons;[54] they host more native species than pasture. However, the biodiversity benefit of exotic forests is small in comparison to native forests, which host numerous threatened and non-threatened species.[55]

Synergies can occur between carbon sequestration efforts and biodiversity protection for native forests. When carbon gain is prioritised for natural regeneration in Aotearoa, biodiversity suffers a larger trade-off than carbon sequestration when biodiversity is prioritised. If both carbon and biodiversity are prioritised, then the average gains in carbon and biodiversity could be 10-20% more than if either carbon or biodiversity is prioritised independently.[56]

Controlling herbivores and predators may enhance carbon stocks and biodiversity in native forests in the long term. Deer, wild pigs, wild cats, goats, possums and livestock can have negative impacts on native forests. These animals change both the composition of plant species and the animal communities that depend on them. In Aotearoa possums are the major cause of the decline of native trees such as pōhutukawa, rewarewa, kāmahi, māhoe, tawa and rātā.[57] Ungulates such as goats and deer have increased significantly over the last decade.[58]

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[49] Sequestration rates vary depending on tree species and site conditions (e.g. temperature, soil, slope) where trees are planted. Planted pines in Aotearoa sequester carbon dioxide about five times more quickly than native forests (Ministry for Primary Industries, Unpublished)
[50] (Bloomberg et al., 2019; Satchell, 2018)
[51] (Baillie & Neary, 2015)
[52] (Amishev et al., 2014)
[53] (Phillips et al., 2015)
[54] (MacLeod et al., 2008)
[55] (Brockerhoff et al., 2008)
[56] (Carswell et al., 2015)
[57] (Nugent et al., 2010)
[58] Based on data from public conservation lands (Department of Conservation, 2021)

Carrying out more predator control, fencing out grazing and browsing animals and preventing fires in our regenerating and native forests can result in more native birds, more tree growth and can prevent forest decline in the long term.[59] However, removing grazers and browsers is no easy task. Studies have shown that it is difficult to sufficiently suppress these species over large enough areas and for long enough to see a response.[60] Active control of browsers was found to be more beneficial in young forests that were still establishing.[61]

Woody and riparian vegetation in production landscapes increases biodiversity values, improves water quality and reduces erosion. Increasing the amount and diversity of vegetation within production landscapes can have a range of environmental and ecological benefits, even without large-scale changes to forests. Woody patches, hedgerows and shelterbelts, riparian planting and wetlands can all increase the range of plants and animals found on farms and improve both the amount of carbon storage and biodiversity.[62]

On-farm native vegetation expands over 1.5 million hectares of sheep and beef land.[63] Much of this vegetation is on lowland ecosystems and is critical for biodiversity conservation as part of a larger network of sites that can improve connectivity in the landscape and serve as stepping stones for birds that disperse tree seeds.[64] Revegetation and fencing of farm gullies have co-benefits for erosion and biodiversity.

Planting trees and shrubs along gullies and stream banks can reduce soil erosion and the amounts of phosphorus getting into waterways by up to 60%.[65] A recent review of over 300 international studies found that the presence of these sorts of 'non-productive' vegetation resulted in positive improvements of ecological processes in most cases.[66]

In Aotearoa, rare and unique native birds are of interest to many people and several studies have looked at native birds in production landscapes. For example, open farmland can provide important habitats for species like the South Island pied oystercatcher and the world's rarest gull, the black billed gull.[67]

The diversity within an individual farm can also affect the birds that are found there. A study of South Island sheep and beef farms found that the number of species present was strongly influenced by habitat composition, extent and diversity, with the most diverse farms having the greatest number of bird species and native birds.[68]

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[59] (Carswell et al., 2015)
[60] (Nugent et al., 2010)
[61] (Carswell et al., 2015)
[62] (Burrows et al., 2018)
[63] This comprises 8.2% indigenous forest (0.81 million ha), 5.5% mānuka/kānuka (0.56 million ha), 1.7% indigenous scrub and shrubland (0.17 million ha) ((2020)).
[64] (Norton et al., 2018; Norton & Pannell, 2018)
[65] (Parliamentary Commissioner for the Environment, 2012)
[66] (Case et al., 2020)
[67] (Parliamentary Commissioner for the Environment, 2017)
[68] (Blackwell et al., 2005; MacLeod et al., 2008)

17.5.3 Water quality impacts from land-use change to horticulture

Land-use change from dairy to horticulture on flatter and more productive land could reduce biogenic emissions per hectare[69] however, this could also cause water quality to deteriorate due to the increased use of fertiliser and consequential nitrogen and phosphorus losses. Nutrient losses would vary depending on the crop, the site, weather conditions, the soil's physical and chemical properties and how the land is managed.[70]

Increasing the area of horticulture would increase water demand in Aotearoa. Climate change modelling for kiwifruit indicates that there would be higher water demand by the industry in regions such as Waikato and Hawke's Bay and variable demand in other regions like Southland towards 2090.[71] In light of the physical impacts of climate change, this increased future demand needs to be balanced when considering expansion of horticulture as a way to reduce emissions.

17.5.4 Policy synergies

Many of the actions that are taken on-farm to improve fresh water in Aotearoa would also deliver emissions reductions.

The National Policy Statement for Indigenous Biodiversity, the Biodiversity Strategy and programmes such as Predator Free 2050 could provide synergies with climate change mitigation policies if support for biodiversity outcomes on productive land is recognised in a tangible way. In its current version the draft policy recognises the role of landowners, communities and tangata whenua as stewards, but does not mention how they would be supported to achieve the outcomes.

Policy would need to be designed to make the most of the co-benefits and reduce the negative impacts of land-use change and agricultural practice change. It would also need to be designed in the context of how different land uses and practices could integrate in a mosaic landscape, factoring in the impacts of land-use change on rural communities and what this means for the whole food and fibre production system.

17.6 Environmental and ecological impacts from actions to reduce emissions from waste

Reducing waste generation will help reduce litter. This is because as we decrease our use of throwaway packaging and single use items, there will be less waste generated to enter the waste stream. Furthermore, transitioning to a circular economy where resources are valued and reused will mean that waste will go from something to be disposed of to a valued commodity which could be reinserted back into the production chain. The cumulative effect of this would be to decrease the amount of potential litter such as packaging and coffee cups that are frequently found on our beaches, and in our rivers and natural environment.[72]

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[69] The BERG estimates that that biogenic emissions from dairy are about 12 tCO_2e per hectare and between 3.5-2.1 tCO_2e for sheep and beef. They estimate that biogenic emissions from horticulture range from 0.17-1 tCO_2e per hectare. (Reisinger et al., 2017)

[70] (Norris et al., 2017)

[71] (Ausseil et al., 2019)

[72] ('National Litter Audit 2019', n.d.)

Our ambition to increase the amount of food and garden waste composted could increase the supply of compost available to farmers. Effective use of compost can help farmers improve and restore nutrients to their soils,[73] although some work may be required to overcome barriers to usage, such as distribution. Additional environmental benefits, such as for water quality, could also be realised if more farmers are then able to use compost to replace some synthetic fertilisers. In this way, an increased supply of compost as an alternative fertiliser input could be an important enabler for farmers transitioning to organic production systems.

The focus on improving and extending landfill gas capture could help improve the environmental quality around landfills. Landfills that accept high volumes of organic waste with low performance or non-existent gas capture systems will have lower air quality through bad odours or fugitive emissions escaping from landfill. Capping and lining landfills as part of gas capture also improves leachate management and reduces the potential for contamination of nearby soil and water streams. Modern landfills with high-performance gas capture systems have a lower footprint on the local environment and the wider environment through reducing methane emissions.[74]

[73] (Adugna, 2018)
[74] (Sullivan, 2010)

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