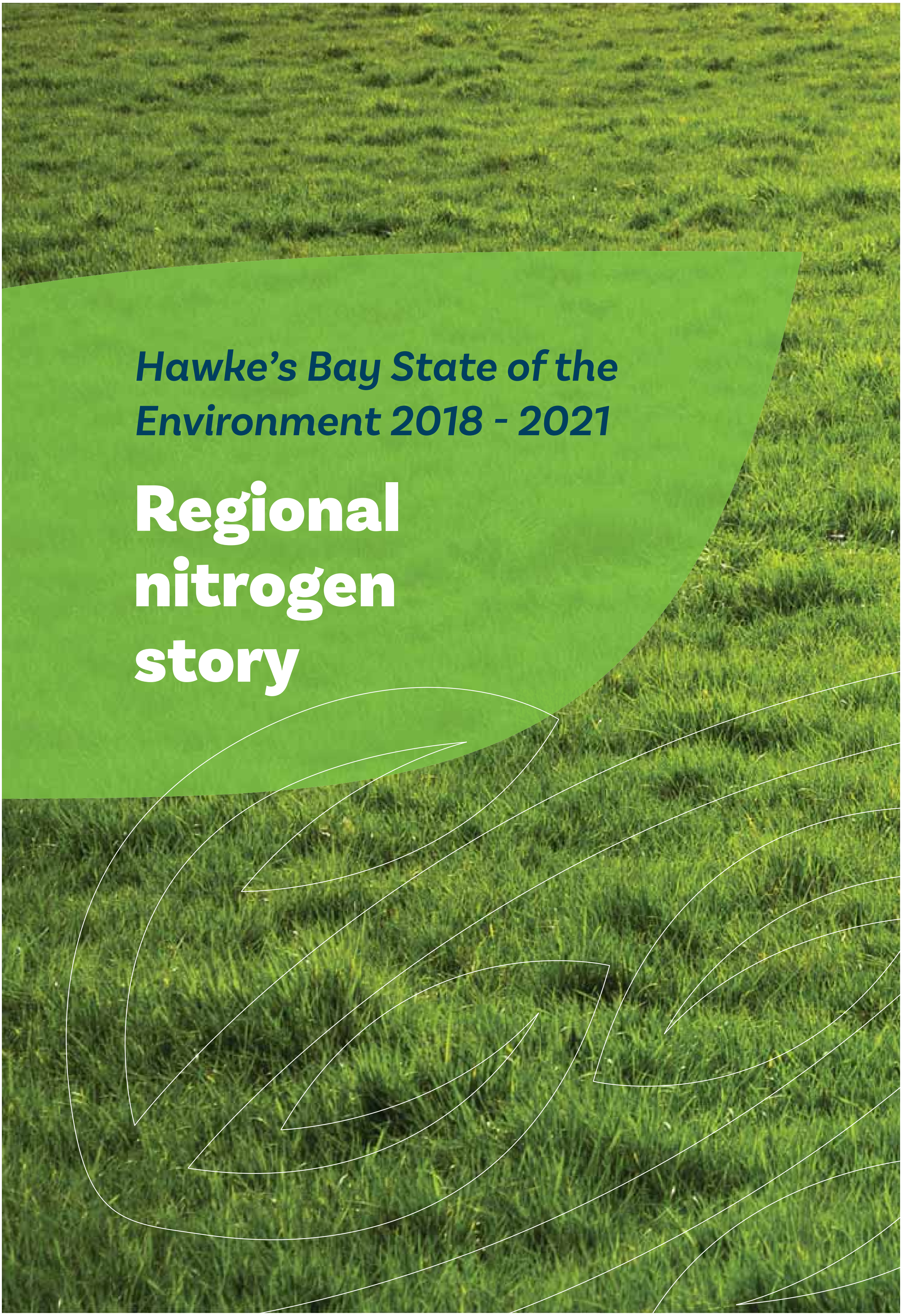

Hawke's Bay State of the Environment 2018 - 2021

Regional nitrogen story

11 Nitrogen impacts

Elevated nitrogen in waterways is almost always due to human influences, and it contributes to problematic levels of plant and algal growth. At higher concentrations, certain forms of nitrogen are toxic to stream life.

Nitrogen is one of the most important nutrients for living organisms, and although it's abundant around us, it's not simple for plants and animals to access. About 80% of the atmosphere is nitrogen gas, and in this state, it is inaccessible to most life forms. However, it becomes available when specialised microbes convert atmospheric nitrogen into ammonia, and other microbes then convert that ammonia into nitrate and nitrite (Figure 11-1). These are the forms of nitrogen, collectively termed dissolved inorganic nitrogen (DIN), that are accessible to plants, and can lead to prolific plant growth.

Another way for plants to get nitrogen is through symbiotic relationships with specialised nitrogen-fixing microbes, which occur in leguminous plant species such as clover and lucerne. Some cyanobacteria, including some toxic species, are also able to fix atmospheric nitrogen. This biological fixation pathway is how nitrogen naturally enters ecosystems.

Through the agricultural revolution, humans developed techniques to harness atmospheric nitrogen and create synthetic chemical fertilisers. The boost in food production from chemical fertilisers has allowed the global population to multiply by five times, from 1.6 billion in 1900 to almost 8 billion people today (Figure 11-2). New Zealand's population is tiny on a global scale, but has nevertheless grown at a similar rate, with fewer than 1 million people in 1900 and more than 5 million today. New Zealand produces enough food to feed an estimated 40 million people, and nitrogen is a fundamental building block for food production.

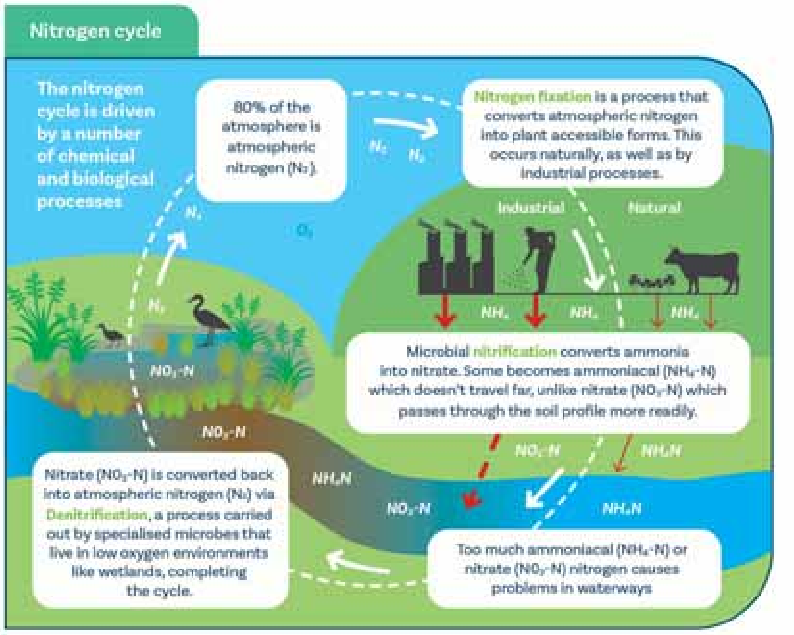

Figure 11-1. The nitrogen cycle.

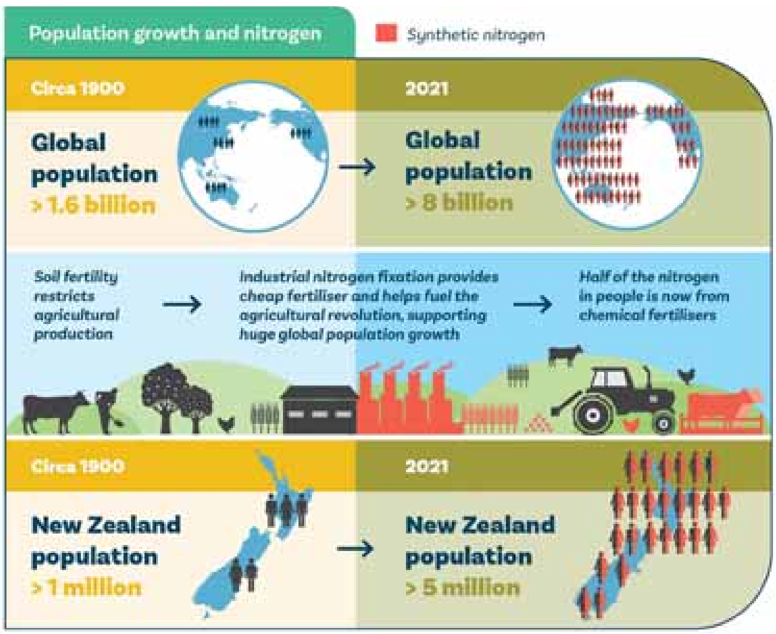

Figure 11-2. Industrial nitrogen fixation helped fuel the agricultural revolution, which supported huge population growth in New Zealand and around the world.

Most of the nitrogen lost from pastoral systems is through urine from stock. Intensification of our agricultural systems has meant more stock per hectare, which has led to the production of more urine. The nitrogen in stock urine is highly concentrated; it is equivalent to applying about 1000kg of nitrogen per hectare (albeit in very small patches).

Plants cannot absorb such concentrated amounts of nitrogen, and so some of it travels into groundwater and streams. The biggest nitrogen problems in our waterways occur where intensive land use occurs above permeable soils, or occupies a large proportion of a catchment. Hotspots include the Tukituki catchment in Central Hawke's Bay and the Taharua River of the Mohaka catchment.

Figure 11-3 shows nitrogen levels in lakes and rivers around the Hawke's Bay region. Most of the intensive farming in Hawke's Bay is concentrated in the darker areas of this map. The highest nitrogen levels occur in the Taharua River and Tukituki River catchment around Central Hawke's Bay (southwest) where groundwater is well oxygenated (limited de-nitrification so nitrate stay in the groundwater longer). Lower reaches of the TANK catchments (dark area in the middle) benefit from both dilution by clean mountain water and reducing groundwater conditions in parts of the Heretaunga aquifer beneath the intensive farming.

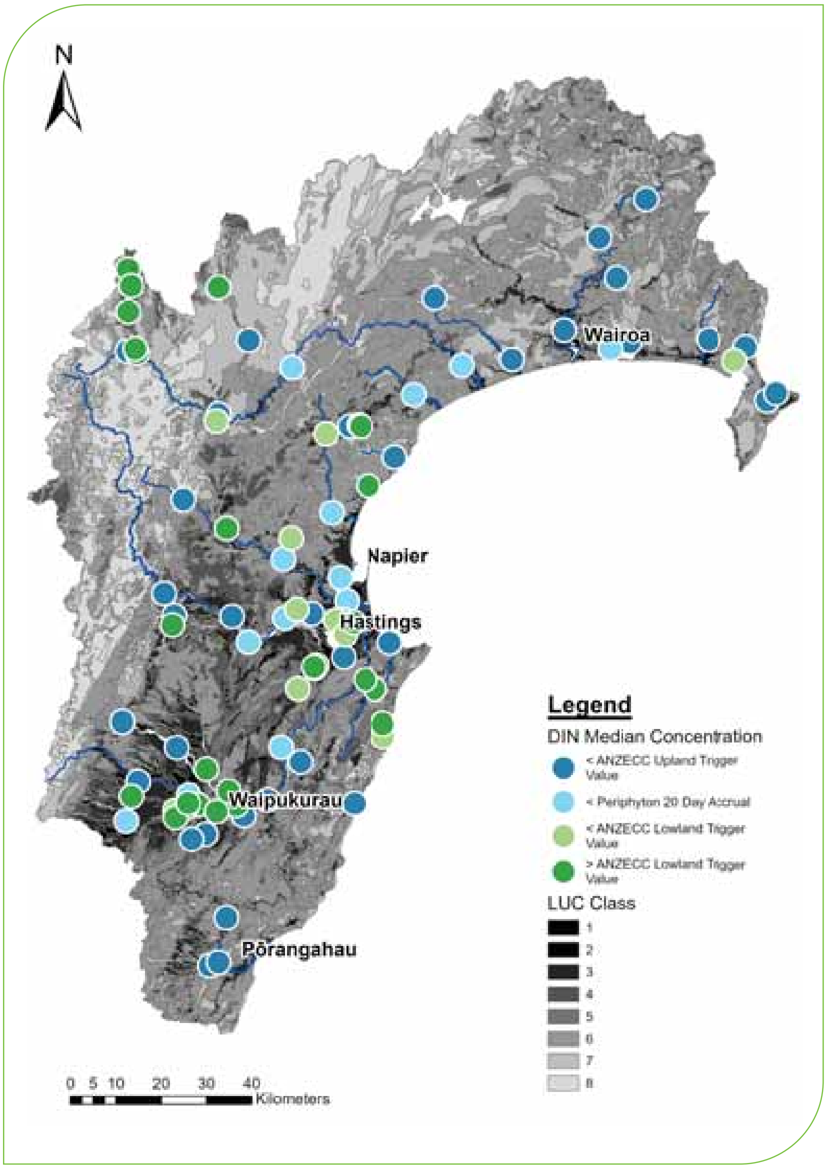

Figure 11-3. Median dissolved inorganic nitrogen (DIN) concentrations at river monitoring sites around Hawkes Bay relative to ANZECC upland and lowland (2000) and Biggs (2000) periphyton accrual values. LUC = Land Use Capability class. Lower LUCs (darker) are landforms that can support more intensive farming forms. Higher LUCs are typically steeper areas that are limited to low intensity farming or forestry or are not suitable for farming.

Intensive farming does not always mean waterways have elevated nitrogen levels. Some microbes fix nitrogen from the atmosphere (nitrogen fixers), and other microbes can convert nitrate back into atmospheric nitrogen (denitrifying bacteria). Low oxygen conditions favour denitrifying bacteria – and when intensive land use occurs over organic soils or low oxygen aquifers – most of the leached nitrate can be converted to inert nitrogen gas.

When water passes through large wetlands, the same process occurs. In other words, the nitrogen is converted from a 'problematic' form into a harmless gas. We observe evidence of this in aquifers with low oxygen levels, which are aquifers with so-called 'reducing' conditions. These reducing aquifers typically have low levels of nitrogen despite being under intensive farming. Nitrogen problems in our groundwater are typically limited to aquifers that are well oxygenated (Figure 11-4).

While most rivers and lakes tend to be phosphorus limited, marine environments are often more sensitive to nitrogen enrichment, and therefore increases of nitrogen here can fuel algal blooms. Estuarine areas, as the transition between fresh and saltwater, can be more sensitive to phosphorus increases in the upper reaches, and more sensitive to nitrogen increases closer to the ocean. Between Cape Kidnappers and the tip of Mahia Peninsula, about 50% of the coastal nitrogen comes from rivers, compared with only 15% of phosphorus.

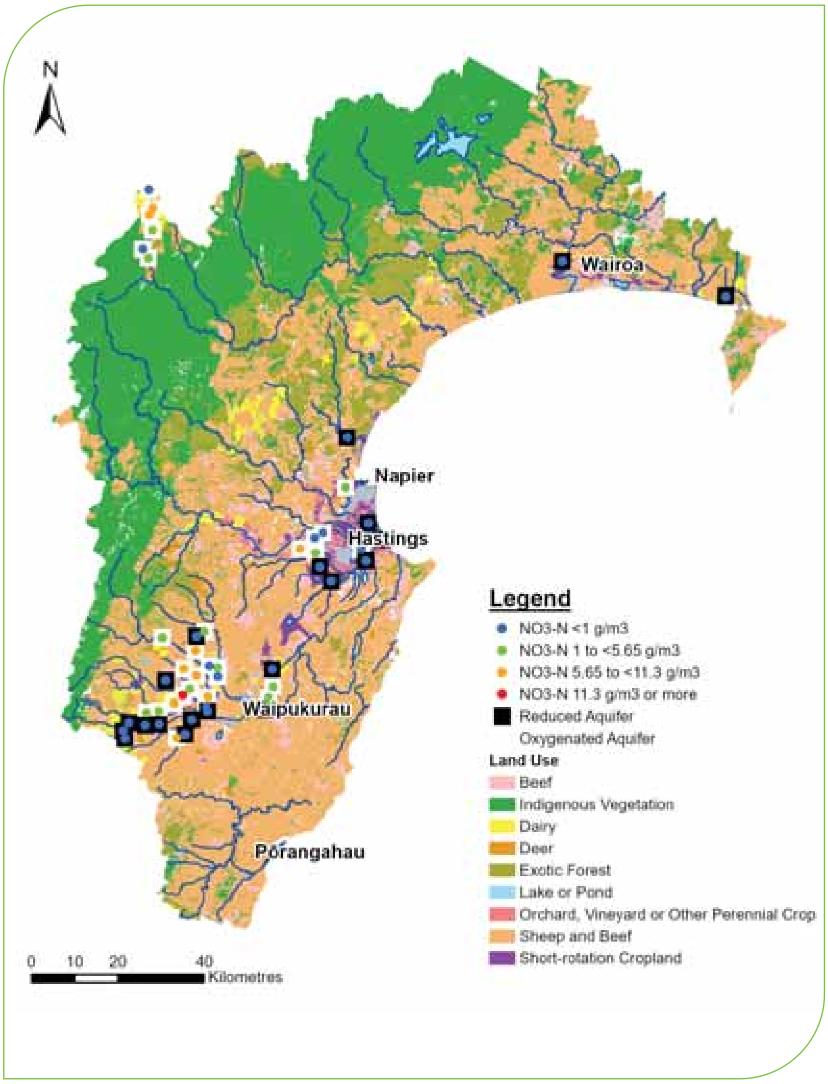

Figure 11-4. Reduced aquifers (black squares) have low oxygen levels and a higher rate of denitrification than well oxygenated aquifers (white squares). High nitrate concentrations (orange or red circles) are found in oxygenated aquifers, compared with the consistently low nitrogen levels (blue or green) found in reduced aquifers. The source of nitrogen is predominately from farming activities (especially more intensive farming activities) that occur above the aquifers.

High nitrogen concentrations in rivers can lead to high nitrogen concentrations in estuaries. For example, most of the rivers and streams we monitor in the Tukituki catchment have significantly higher nitrogen concentrations than most other Hawke's Bay rivers. Consequently, the Tukituki estuary has the highest dissolved inorganic nitrogen (DIN) concentration of all estuary sites in Hawke's Bay. According to New Zealand's Coastal Water Quality Assessment, Hawke's Bay's estuaries have higher annual median nitrogen concentrations than similar systems elsewhere in New Zealand, although river mouth dynamics and different amounts of seawater exchange can make it difficult to compare estuaries on different coastlines.

Currently, nitrogen concentrations in coastal waters in Hawke's Bay are within the range observed at other New Zealand sites. However, some coastal sites have elevated levels of nitrogen compared to other sites regionally. Awatoto, for example, had the highest DIN concentration between 2016-2021, with an estimated 64% of nitrogen coming from nearby river systems and wastewater treatment plant outfalls.

High nutrient concentrations on the coast can support increased productivity in the form of phytoplankton (small algae) growth (Figure 11-5). Algal growth at Awatoto is higher than other open coast sites nationally, suggesting the high nitrogen loads from rivers and wastewater outfalls may support increased productivity.

Figure 11-5. A short-lived algal bloom was captured by Napier City's webcam starting off the coast from Awatoto. These photos span a period of three hours, at 14:33 (top left), 15:53 (top right), 16:33 (bottom left) and 17:33 (bottom right).

Nitrogen impacts on ecosystem health

The impacts of dairy farming, and the corresponding nitrogen in nearby waterbodies, are often the focus of national discussions around water quality. But nitrogen is just one of many important factors influencing ecosystem health. Hawke's Bay has its own unique context, and a very different land-use intensification history than regions like Canterbury, Waikato, and Southland (Figure 11-6).

Between 1991 and 2019, nitrogen applied to land across New Zealand has increased from approximately 62,000 tonnes to 452,000 tonnes. However, land-use intensification peaked earlier in Hawke's Bay, and patterns of land use were remarkably steady between 2001 and 2018 (Table 11 1). Over a similar period, nitrogen fertiliser use increased by more than three times across the country, compared with a far more modest increase of only 6.5% in Hawke's Bay. This could be due to relatively smaller portion of dairy farms in Hawke's Bay, which is major land use that receives most of nitrogen fertiliser in agriculture[1].

Because urine patches are a major source of nitrogen lost to waterways, the type and number of stock have a major influence on nitrate leaching. Urine from dairy cows is typically more nitrogen-rich than urine from beef cattle, which is in turn higher than urine from deer and sheep. All stock classes in Hawke's Bay have undergone a substantial decline in numbers since 2002, and while the herd size of dairy cattle doubled between 1999 and 2002 (not shown in Table 11-1), it has decreased 10% since this peak.

Nitrogen is at problematic levels in parts of the Ruataniwha Plains (Tukituki) and in the Taharua River (Mohaka) because of intensive farming practices. However, phosphorus, sediment, faecal contamination, and degraded riparian habitat are more widespread problems in Hawke's Bay. These problems are caused by a number of different land-use practices, not just intensive farming.

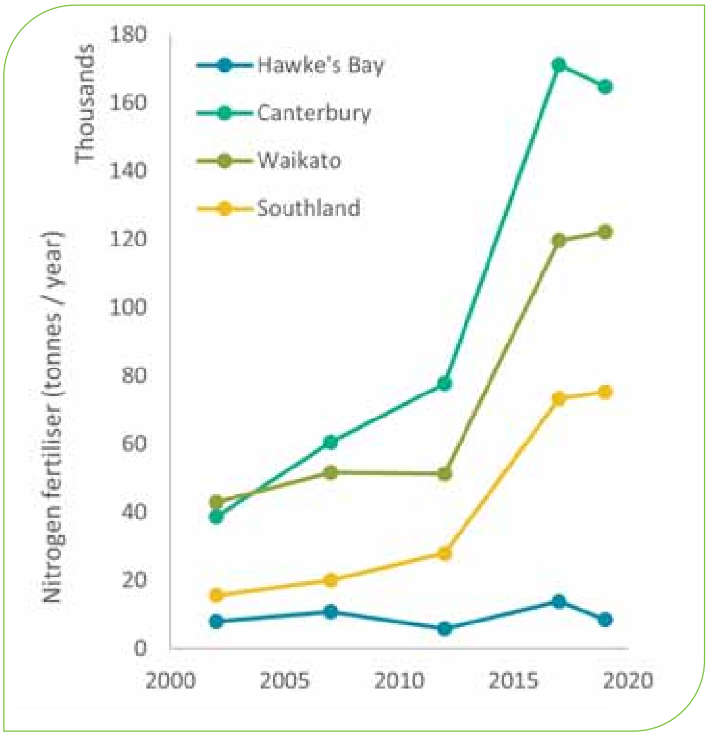

Figure 11-6. Nitrogen fertiliser use in different regions of New Zealand over the last 20 years. Its use in Hawke's Bay has stayed relatively stable since the early 2000s, in contrast to sharp increases in nitrogen use in Canterbury, Waikato, and Southland, where much of the dairy expansion has occurred. Data from Stats NZ.

Table 11-1. Change in land cover, stock populations, and fertiliser use in Hawke's Bay compared with New Zealand nationally.

Land Cover (1000s of Ha)	Hawke's Bay			New Zealand		
	2001	2018	% change	2001	2018	% change
High producing pasture	733	726	-1.0	8632	8684	0.6
Indigenous vegetation	521	521	-0.1	11641	11573	-0.6
Exotic forest	179	183	2.0	2114	2137	1.1
Other	31	32	1.9	1997	2020	1.2
Low producing pasture	30	32	6.4	1782	1754	-1.6
Cropping	17	18	7.4	366	369	0.7
Orchards/Vineyards	15	16	6.1	78	105	35.6
Stock Type (1000s of head)	2002	2019	% change	2002	2019	% change
Sheep	3789	2876	-24.1	39572	26822	-32.2
Beef cattle	556	449	-19.3	4491	3890	-13.4
Dairy cattle	89	78	-12.3	5162	6261	21.3
Deer	127	61	-51.7	1648	810	-50.8
Nitrogen fertiliser use (tonnes)	2002	2019	% change	2002	2019	% change
	7922	8438	6.5	185513	614191	231.1
Phosphorus fertiliser use (tonnes)	2007	2019	% change	2007	2019	% change
	9793	7157	-26.9	150818	112996	-25.1

1 https://www.fertiliser.org.nz/Site/about/fertiliser_use_in_nz.aspx