Quantifying excess nitrogen loads in fresh water

WHO IS THIS RESEARCH BRIEF FOR?

Regional councils and unitary authorities

Primary industry bodies

Catchment groups

Farm advisors

Farmers and growers

Central government

RESEARCHERS

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Land Water People

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PROJECT TIMELINE

June 2016 – December 2019

Key points

This research provides an assessment of where reductions in nitrogen emissions are required to achieve the requirements of existing national regulations, and the amount by which this is necessary.

The research estimates current nitrogen concentrations and annual loads in New Zealand's streams, rivers, lakes and estuaries. Current loads were compared to maximum allowable loads (MAL), which were based on existing regulatory criteria. This enabled excess nitrogen (the amount by which current nitrogen loads exceed the MAL) to be quantified.

This analysis produced a map showing spatial variation in excess loads, which identifies regions and catchments that require the largest reductions. (Data and modelling limitations and uncertainties mean catchment-specific assessments should be regarded as indicative.)

Researchers defined catchment 'pressure' as the amount by which the current nitrogen load exceeds the MAL under current regulations. At least 43% of New Zealand's agricultural land (31% of New Zealand's total land area) is in catchments that are under pressure.

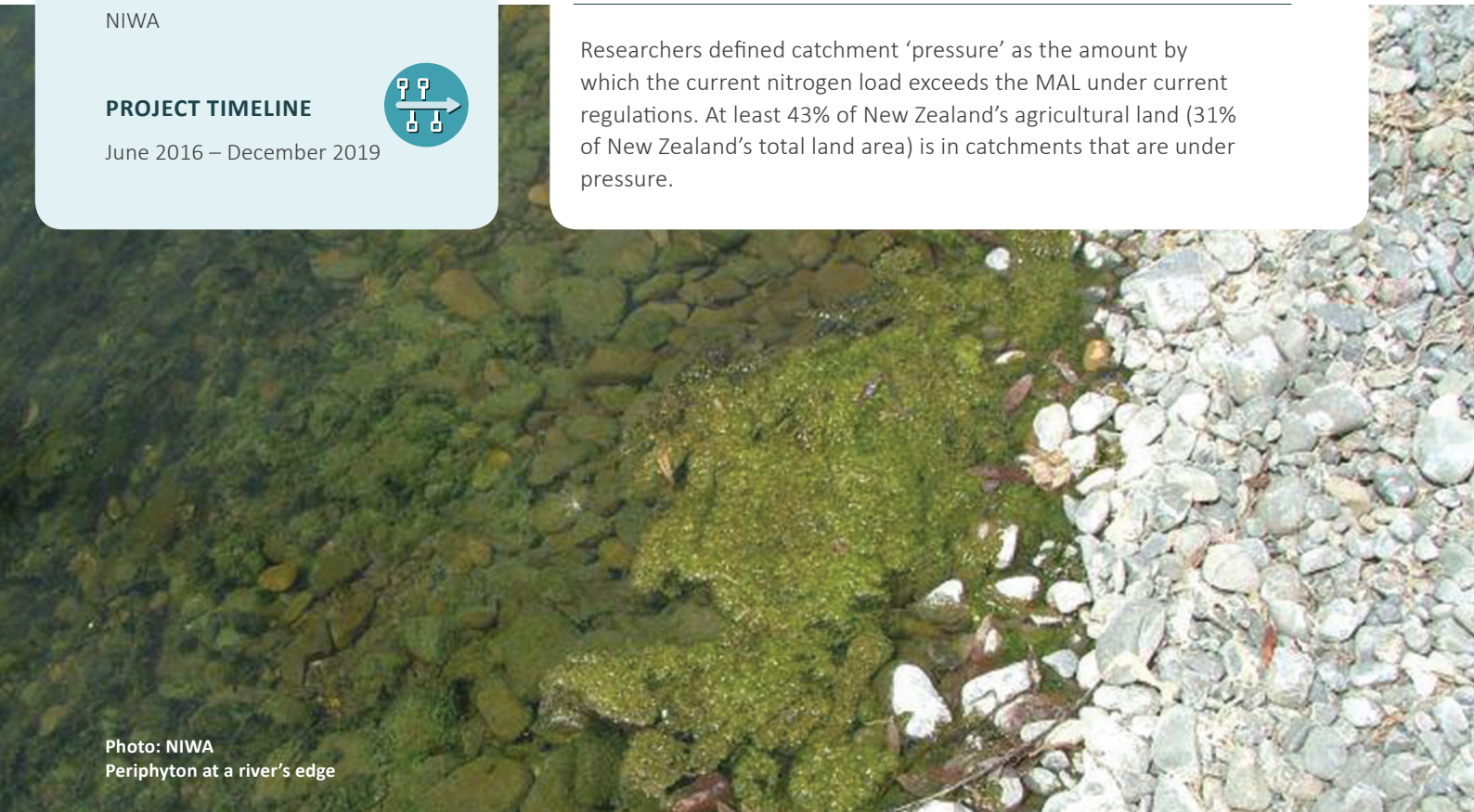


Photo: NIWA
Periphyton at a river's edge

Photo: NIWA
Middle reaches of the Tukituki River, February 2011

How can this research be used?

The 'pressure map' produced by this research will give land stewards a clearer understanding of the pressure their catchment is experiencing. When the nitrogen load is larger than the MAL, the catchment is said to be 'overallocated'. When a catchment is overallocated, the actions required to reduce nutrient loads would need to be spread throughout the catchment. The map helps visualise the effort required on land throughout regions and catchments.

At the national to regional scale, this research identifies the catchments most in need of regulatory intervention.

At the catchment scale, the quantification of the catchment pressure can inform land use and management decisions. It will enable neighbouring landowners to approach catchment-scale issues together.

At the farm scale, the emission reductions to reduce nitrogen loads to the MAL are not necessarily uniform within a catchment. However, the excess nitrogen load, expressed as yield, broadly indicates the extent to which individual farms need to reduce their nitrogen discharges.

New environmental policy and freshwater objectives will be guided by measurable environmental outcomes linked to many upstream sources. The Ministry for the Environment used the analysis technique developed by this research to test the effects of new policy options.

Additional research from Our Land and Water has examined how better practice and action has affected water quality over the last 20 years and how much more could be done in the next 15 years (McDowell et al, 2021). This work will help farmers, catchment groups and others see how far actions can take us in meeting regulatory criteria.

An interactive map of New Zealand showing total nitrogen in excess of current regulatory criteria and the reduction potential has been created (**tinyurl.com/OLW-map**).

Why is this issue important?

Over the past decade, New Zealand central and regional government has increasingly recognised the cumulative effects of decisions on individual farms on catchment water quality. These cumulative effects can improve or degrade water quality.

Nitrogen emissions from many locations in a catchment accumulate as water moves from mountain to sea and cause a decline in freshwater quality that has been unacceptable to many New Zealanders.

If loads from all farms upstream are mitigated sufficiently to reduce catchment loads to below the MAL, the cumulative positive effects of these reductions will be observed in the receiving environment.

National regulations now require environments with current loads that are greater than the MAL to be managed back to an acceptable state. Existing requirements for managing water quality in lakes (total nitrogen bottom lines), rivers (periphyton bottom lines) and estuaries (trophic indicators) require nitrogen reductions in some catchments.

Additional requirements, such as a bottom line for dissolved inorganic nitrogen concentrations in freshwater, may be introduced in future national policy. A broader range of objectives, such as ecosystem health attributes, may also lead to changes in the target state.

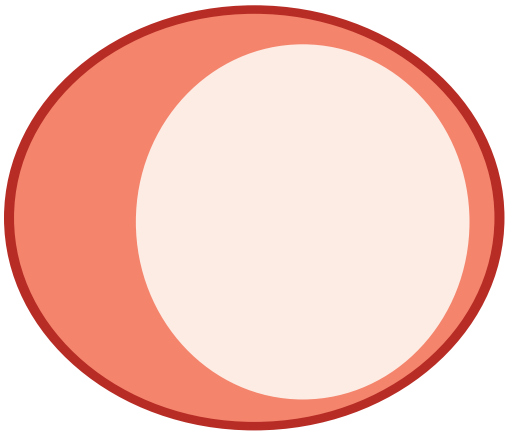
What did we do?

The research team integrated a variety of models and data sources to estimate the current load of nitrogen and the maximum acceptable load (MAL) of nitrogen that can be emitted and still achieve bottom lines under current (2020) National Objective Framework criteria for periphyton in rivers, for total nitrogen in lakes, and derived criteria to achieve acceptable trophic states in estuaries.

Their analysis compared the current total nitrogen (TN) loads in all streams, rivers, lakes and estuaries in New Zealand (from mountains to sea) with the MAL under current regulations.

This work identifies catchments where total nitrogen emissions to water are in excess of regulatory requirements, using the catchment pressure indicator (ratio of TN to MAL). The excess load, which is the amount by which the current TN load exceeds the current MAL, was then calculated and mapped.

Quantifying N excess load



Nitrogen excess load = current TN load – MAL

Pressure = current TN load / MAL

LEGEND

- Current Total Nitrogen (TN) load
- Nitrogen excess
- Maximum Allowable Load (MAL)

Photo: NIWA
Underwater photograph of filamentous green algae growing on cobbles in the middle reaches of the Tukituki River

What did we find?

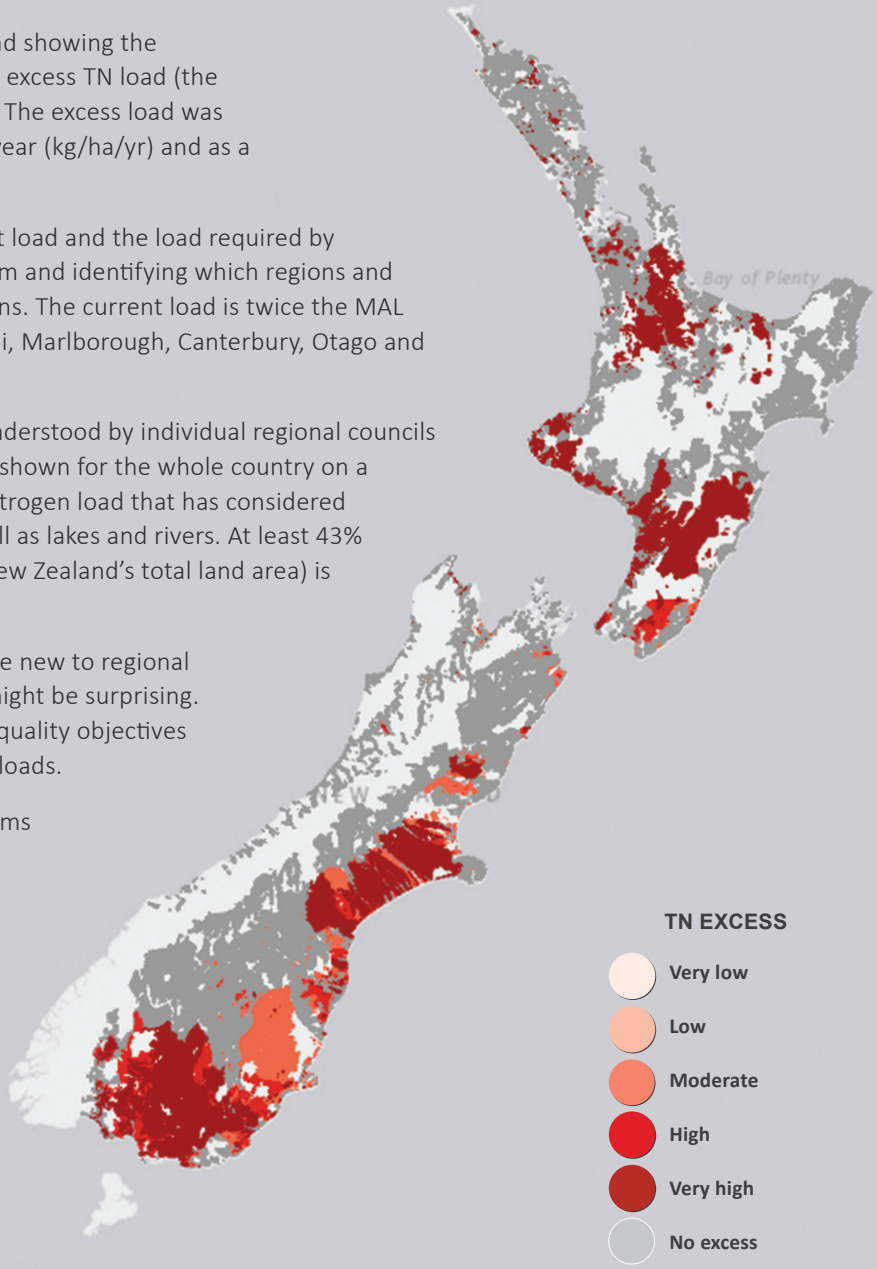
This research produced a map of New Zealand showing the catchments that are under pressure, and the excess TN load (the amount by which TN load exceeds the MAL). The excess load was expressed as a rate per catchment area per year (kg/ha/yr) and as a percentage (%) of current load.

This map shows the gap between the current load and the load required by regulation, quantifying the size of the problem and identifying which regions and catchments require the largest load reductions. The current load is twice the MAL in parts of the Waikato, Manawatu-Wanganui, Marlborough, Canterbury, Otago and Southland.

Many of the patterns on this map are well understood by individual regional councils and unitary authorities but have never been shown for the whole country on a single map. This is the first study of excess nitrogen load that has considered environmental objectives for estuaries as well as lakes and rivers. At least 43% of New Zealand's agricultural land (31% of New Zealand's total land area) is in catchments that are under pressure.

Although the patterns on the map may not be new to regional councils, the proportion of the excess load might be surprising. The load reductions required to meet water quality objectives in some regions are large relative to existing loads.

This analysis expresses excess nitrogen in terms of yield (mass per unit area, or kg/ha). This has greater meaning to regulators and land managers because these units are comparable with farm nutrient budgets.



See zoomable interactive map at ***tinyurl.com/OLW-map***

A note on uncertainty

Our analysis combines several sets of models and modelled predications and is subject to uncertainty. These uncertainties were quantified by the study (Snelder et al, 2020).

All the analytical results have greatest uncertainty at the individual site scale. Because errors associated with individual receiving environments can be positive or negative, and therefore tend to cancel each other out, the regional and national scale estimates of excess load are more reliable than those for individual catchments or rivers, lakes or estuaries. We are very confident that current nitrogen loads are above the levels allowed by national regulations in 9 of the 15 regions of New Zealand.

Next steps

Additional research has estimated the potential contaminant load reductions from full implementation of all known and emerging on-farm mitigation actions (McDowell et al, 2021). In some catchments, a combination of de-intensifying land use and land use change will be required to meet objectives.

To allow businesses to thrive, practices and land use change need to be facilitated well and at a pace that allows time for production systems to adapt. There are two fundamental mechanisms to facilitate change and achieve objectives:

- robust advice that is targeted to specific farms and catchment conditions to achieve change pragmatically; and
- effective oversight of plans to implement advice and monitor whether catchment water quality is improving, acting where it is not.

This research focussed on excess nitrogen load. However many other pressures are faced by land, water and people: contaminants (phosphorus, e.coli, sediment), greenhouse gas emissions, and adapting to a changing climate. Our Land and Water is funding new research (Land Use Opportunities: Whitiwhiti Ora) that will consider these pressures, building on the work of the Land Use Suitability research programme, which included the pressure indicator research in this document. This research aims to identify a much greater range of suitable land opportunities and a greater diversity of benefits for New Zealand.

Further research is required to demonstrate cross-sector land use options. Our Land and Water is developing a programme of place-based research, which will showcase integrated research to demonstrate the transition to new options that enhance te Taiao. This research is intended to scale out land-use options, and give land stewards confidence to implement change.

Key publications

Nitrogen loads to New Zealand aquatic receiving environments: comparison with regulatory criteria, Ton H. Snelder, Amy L. Whitehead, Caroline Fraser, Scott T. Larned & Marc Schallenberg (New Zealand Journal of Marine and Freshwater Research, July 2020) **doi.org/10.1080/00288330.2020.1758168**

Implications of water quality policy on land use: A case study of the approach in New Zealand by R. W. McDowell, P. Pletnyakov, A. Lim and G. Salmon. Marine and Freshwater Research, October 2020 **doi.org/10.1071/MF20201**

Quantifying contaminant losses to water from pastoral land uses in New Zealand III. What could be achieved by 2035? McDowell, R. W., Monaghan R.M., Smith, C., Manderson, A., Basher, L., Burger, D.F., Laurenson, S., Pletnyakov, P., Spiekermann, R., Depree, C. (New Zealand Journal of Agricultural Research, 2021) **doi.org/10.1080/00288233.2020.1844763**

Essential freshwater: Impact of existing periphyton and proposed dissolved inorganic nitrogen bottom lines Ministry for the Environment with assistance from the LUS research team (Publication reference number ME 1467, September 2019) **www.mfe.govt.nz/publications/fresh-water/essential-freshwater-impact-of-existing-periphyton-and-proposed-dissolved**

The land use suitability concept: Introduction and an application of the concept to inform sustainable productivity within environmental constraints R.W. McDowell, T. Snelder, S. Harric, L. Lilburne, S.T. Larned, M. Scarsbrook, A. Curtis, B. Holgate, J. Phillips, K. Taylor (Ecological Indicators, August 2018) **doi.org/10.1016/j.ecolind.2018.03.067**

Anthropogenic increases of catchment nitrogen and phosphorus loads in New Zealand Snelder T, Larned S, McDowell R (New Zealand Journal of Marine and Freshwater Research, October 2017) **doi.org/10.1080/00288330.2017.1393758**

Estimation of nutrient loads from monthly water quality data Snelder TN, McDowell RW, Fraser C (Journal of the American Water Resources Association, December 2016) **doi.org/10.1111/1752-1688.12492**

Research Findings Brief: Assessing the effectiveness of on-farm mitigation actions, Our Land and Water (Toitū te Whenua, Toiora te Wai) National Science Challenge 2020

Our Land and Water (Toitū te Whenua, Toiora te Wai) is working towards an agri-food and fibre system that enhances the vitality of te Taiao with a diverse mosaic of land uses that improve the health of land, water and people.

Our Land and Water is one of 11 National Science Challenges that focus on defined issues of national importance identified by the New Zealand public.

Our Land and Water is hosted by AgResearch, funded by the Ministry of Business, Innovation and Employment, and supported by 16 partner research organisations.

Please use the following citation

Research Findings Brief: Quantifying excess nitrogen loads in fresh water, Our Land and Water (Toitū te Whenua, Toiora te Wai) National Science Challenge 2020

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