WATER

FORDING THE RAPIDS

Charting a course to fresher water

Eric Crampton

THE NEW ZEALAND INITIATIVE

www.nzinitiative.org.nz

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Published by
The New Zealand Initiative
PO Box 10147
Wellington 6143
New Zealand
www.nzinitiative.org.nz

ISBN
978-0-9951311-8-7 (print)
978-0-9951311-9-4 (online)

RR64

Printing arranged by True North New Zealand Ltd

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About the New Zealand Initiative

The New Zealand Initiative is an independent public policy think tank supported by chief executives of New Zealand businesses. We believe in evidence-based policy and are committed to developing policies that work for all New Zealanders.

Our mission is to help build a better, stronger New Zealand. We are taking the initiative to promote a prosperous, free and fair society with a competitive, open and dynamic economy. We are developing and contributing bold ideas that will have a profound, positive and long-term impact.

ABOUT THE AUTHOR

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ACKNOWLEDGEMENTS

The author acknowledges and thanks those who have generously given their time and expertise to provide comments on earlier drafts or discussion of the framework here developed, including Nick Clark, David Cooper, Mike Joy, Mark Milke, John Penno, John Raffensperger, Clint Rissmann, and Te Maire Tau. All errors and omissions remain the responsibility of the author.

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Providing future generations with rivers and aquifers at least as clean as our generation found them requires durable freshwater management systems that can stand the test of time.

Regulatory measures can improve outcomes for now. But sustained improvement may require substantial and costly changes in land use – at least in some places. Imposing substantial cost on existing users of water resources, whether these users be farmers or council wastewater facilities, makes it harder to sustain support for necessary changes.

Finding cost-effective solutions allows more good to be done. Finding solutions that build support among the communities that have to live with the changes also matters. Regulations that bankrupt farms needing to service existing debt, or that impose high cost on councils with weak stormwater and sewage networks, risk being overturned with changes in government.

If people expect the regulatory system to break down, they will not make the investments necessary to effect lasting change.

Better systems are needed and are possible.

This report argues for cap-and-trade approaches to freshwater management, based on a strengthened version of the Taupō nutrient management system, beginning in areas large enough to warrant the approach – like Canterbury and Waikato.

Taupō's nutrient management system shows that cap-and-trade approaches can work for dispersed pollution.

But it can be improved upon, in the longer term.

Taupō's system focuses on one pollutant, nitrogen, but different places have different problems ranging from phosphorous and sediment to *E. coli*. Targeting one pollutant, when many pollutants can matter, risks worsening those not targeted.

The smart market approach pioneered by researchers at the University of Canterbury and the RAND Corporation makes it easier to set cap-and-trade systems that enable trading while respecting multiple environmental limits. The mapping approach developed by Land and Water Science can track the consequences of changes in the intensity of agricultural land use over a dozen pollutants.

Combined, they would enable catchment-level cap-and-trade management of a wider set of pollutants. Building the system would take time; it can only be a solution for the longer term. Regulatory approaches, like those currently underway, will still be necessary for the shorter term.

But for the longer term, a smart cap-and-trade market in water quality would provide the kind of durable system that can withstand changes in government.

It would help to find the lowest cost ways of improving the quality of our lakes, rivers, and aquifers – making larger improvements easier.

Providing farms and councils with tradeable rights within the system, and sharing the burden of reducing environmental footprints, ensures a just transition. A just transition is important in its own right, and is also important in strengthening support for the system over decades to come.

It can be done. And our waterways deserve it.

INTRODUCTION

Fresher waters – but only if we can reach them

No good course lay before Odysseus navigating the straits home after the Trojan Wars. But some options were worse than others. Sail too close to the ravenous six-headed sea monster Scylla and six of his sailors would be eaten. Sail too close to the whirlpool Charybdis on the other side and he would lose the entire ship. Beyond the straits lay the promise of home, refuge and peace. The trip had to be made for the reward on the other side was too large to forgo. But every path was fraught.

So too the course for any New Zealand government wishing seriously to address declining water quality in our rivers, lakes, aquifers and beaches.

Doing nothing, waiting too long, or doing too little risks sinking some of our country's more hard-pressed water catchments. Heavy nutrient and pollutant loadings kill wildlife, make rivers unswimmable, and risk causing difficult-to-reverse damage to aquifers.

But pressing forward too quickly with regulations poorly suited to local circumstances can easily and quickly bankrupt farms while imposing severe costs on councils needing to upgrade wastewater infrastructure. Scylla taking yet another family's farm would be bad enough. But nightly news reports of Scylla's latest damage would risk the regulatory ship lurching towards Charybdis.

Odysseus needed to find the course home that risked the fewest of his sailors' lives while steering from the maelstrom on the other side. New Zealand must find the right course – and stay the course – to sustainable freshwater management.

Minister for the Environment David Parker's ambitious Essential Freshwater programme will help arrest the decline in water quality. But improving future water quality requires building durable institutions that can withstand changes both in government and voter priorities. In late August 2020, National promised to repeal or review regulations passed as part of the National Environmental Standard for freshwater should it form government after the October 2020 election.[1] Labour won the election, but sound freshwater management needs more solid foundations. Encouraging appropriate investment to improve water quality over the longer term, requires establishing an overall management system that will survive beyond the current electoral cycle.

This report builds on and extends The New Zealand Initiative's prior work on cap-and-trade systems for freshwater management. In *Refreshing Water: Valuing the Priceless* (2019), we argued that cap-and-trade systems form the most promising basis for bringing catchments within sustainable environmental limits.

Environmental caps are not new. In places where aquifers are at or above their sustainable limits, new consents are not issued. But converting existing water-drawing consents held by councils, irrigators and commercial users into tradeable permits makes it easier to find the best ways to reduce overall water use. Rights issued to existing consent holders would erode over time to help bring catchments within sustainable limits. Crown buy-back and retirement of additional rights would share the burden of achieving environmental goals.

Allowing trading of drawing rights makes it far easier to achieve any desired reduction in water use. Requiring all users to scale back by 20% ignores differences in water users' ability to draw water in different places. Achieving water reductions can be relatively easy for some users, but exceptionally costly for others. The environmental impact of reduced water use can depend heavily on the location of that reduction – for instance, reductions upstream can have effects downstream.

The smart-market system proposed in *Refreshing Water* built on the joint pioneering work at the University of Canterbury and the RAND Corporation. Their trading platform embeds environmental constraints into the operation of the system. Doing so substantially reduces the cost of trading water drawing rights and achieving better outcomes.

Water trading *is* possible, and water is already traded on platforms like Hydro Trader, but trading is difficult. Buyers and sellers must find each other, which can be tough when parties can have distinct need for water in different periods. As drawing water in diverse places can have different environmental effects, all proposed trades must be approved by regional council to ensure the trade does not worsen environmental quality. These frictions can stymie trading. Smarter markets can turn systems that look more like barter into markets that run more like a stock exchange – at least in catchments large enough to warrant the cost of setting up the system.

When trading is easy, the combination of reductions in granted rights over time and Crown buy-back of rights can find the best ways of reducing overall water use. If the environmentally sustainable cap in a region is 20% below currently consented permission to draw water, water drawing rights will be valuable. The first to sell drawing rights back into the system, whether to the Crown or to other users needing to top-up their allocations, will be those who can most cost-effectively reduce their own water use. If water is particularly expensive on marginal irrigated land upstream, rights-holders in those places selling their drawing rights back into the system and changing their land use will be compensated automatically. A just transition to more sustainable land use practices is built in.

This compensation principle would ensure the political durability of the freshwater management system. The value of the water implicit in irrigation consents is already accounted for in the price paid for the land holding that consent: land with an irrigation consent sells for a substantial premium over land without. Currently, the two sell as a bundle. Buy the consented land and you get the land and the consent. Making it easier to buy and sell only the land, or only the water drawing right, makes the owner better off by opening up new options; owners of land without water rights also gain the option to purchase water. Extinguishing water drawing rights by ceasing to renew consents and putting water up for Crown auction would bankrupt farms in which mortgages were predicated on having paid for water when purchasing the land. Buying water every year while paying off the debt that covered an abolished irrigation consent would be impossible.

Because irrigation consents are an administrative permission rather than a durable property right, it can be tempting to view bankruptcies resulting from making the wrong bet about water rights renewal as a normal commercial loss. But water reform that would bankrupt many water users would make it rather difficult to build user support. The system would become politically fragile, with voter support waning due to real hardship. And if users expect the system to collapse under political pressure, that situation would not encourage the longer-term changes necessary for improving environmental outcomes.

A cap-and-trade system that places all water users – whether rural, urban, agricultural, commercial or residential – on a level playing field also appeals to basic fairness and equity. Reforms focused on any particular sector not only risk missing opportunities to more cost-effectively reduce water use but can also breed resentment.

We explored these issues in *Refreshing Water*.[2]

These issues become more complex when considering water quality. Different places face different challenges, with nitrate pollution of rivers and aquifers more important in some water catchments, silt and sediment in others, and bacterial contamination in still others.

A successful cap-and-trade system managing freshwater quality must be able to handle the most important sources of pollution in any particular place while leaving room for managing others as conditions change.

It must recognise that identical agricultural practices can have vastly different environmental effects depending on topography, soil type and the underlying geology and hydrology.

It must bake environmental sustainability into the system so that environmental limits are not a secondary consideration.

It must encourage the discovery and adoption of better practices by providing incentives to make environmentally effective changes.

It must place town and country on an equal footing to ensure that we collectively seek the best ways of reducing environmental burdens and find equitable and fair solutions.

It must be politically sustainable over time.

This can be done.

We provide here a high-level analysis and outline of a better freshwater management system for the longer term. Getting there will yet require substantial work.

CHAPTER 1

Turbulent rivers and treacherous shoals

Turbid waters

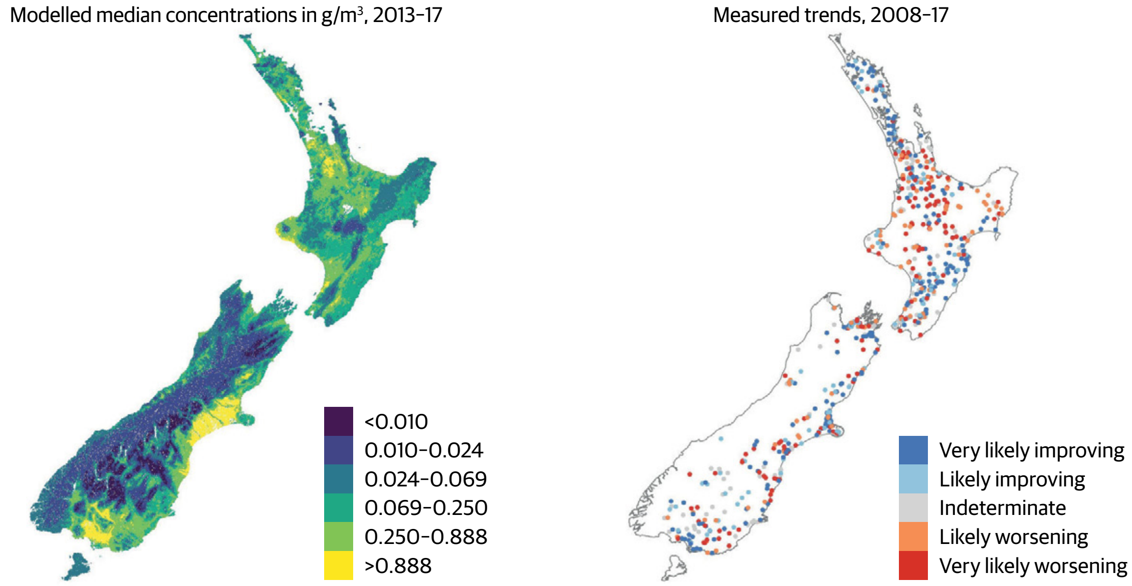
Many of New Zealand's rivers, streams and lakes are under strain.

Declining freshwater quality has recently sparked Treaty claims: Ngāti Kahungunu and Ngāi Tahu are seeking shared control over freshwater management.[3]

Agricultural intensification is worsening water quality in rural areas, despite recent improvement in some areas, but urban water quality is also poor in many areas.

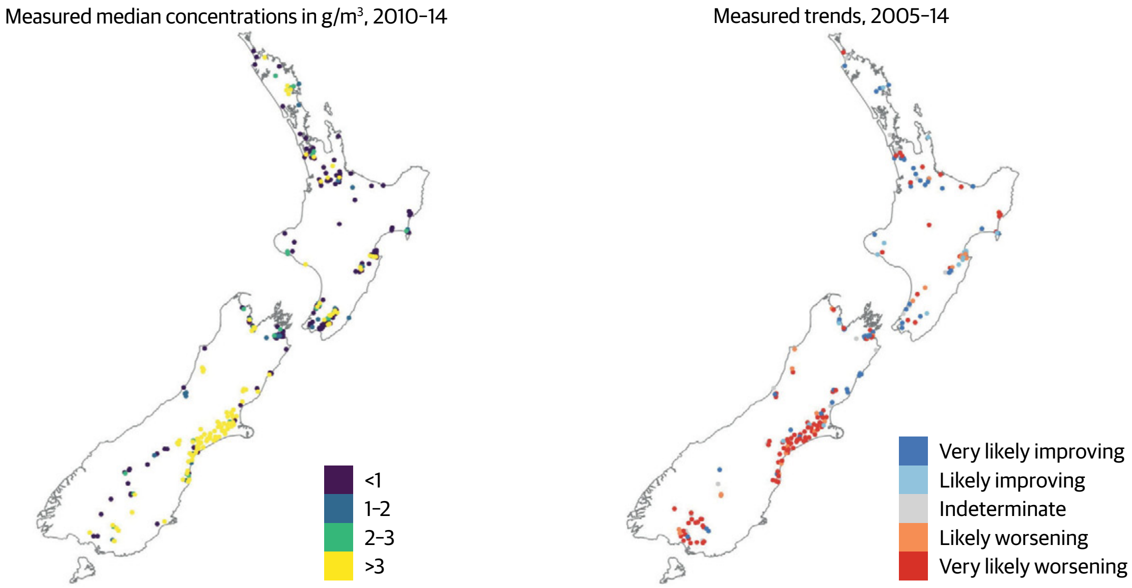
The joint reporting series from the Ministry for the Environment and Statistics New Zealand, *Our Freshwater 2020*[4] and *Environment Aotearoa 2019*,[5] summarised the nation's current water quality.[6] Indicators for nitrate-nitrogen, phosphorous, *E. coli* bacteria and turbidity (as a proxy for suspended sediment) show differences across the country. While the nitrate-nitrogen burden (see Figure 1) in Canterbury and Southland are comparable in many places, more sites in Southland report improving conditions. Groundwater nitrification is worse in Canterbury than on the West Coast or Taranaki (see Figure 2), despite modelled nitrate-nitrogen leaching from livestock seeming more substantial in Taranaki than in Canterbury (see Figure 3). Taranaki has worse outcomes in terms of other indicators like *E. coli*. River quality varies considerably across the country as well (see Figure 4). Focusing on nitrate pollution alone would be a mistake in a multi-pollutant world. Measures that reduce nitrate leaching also can have unintended consequences for other pollutants – if those pollutants are not monitored and targeted.

Figure 1: River water quality nitrate-nitrogen concentrations for all land-cover classes



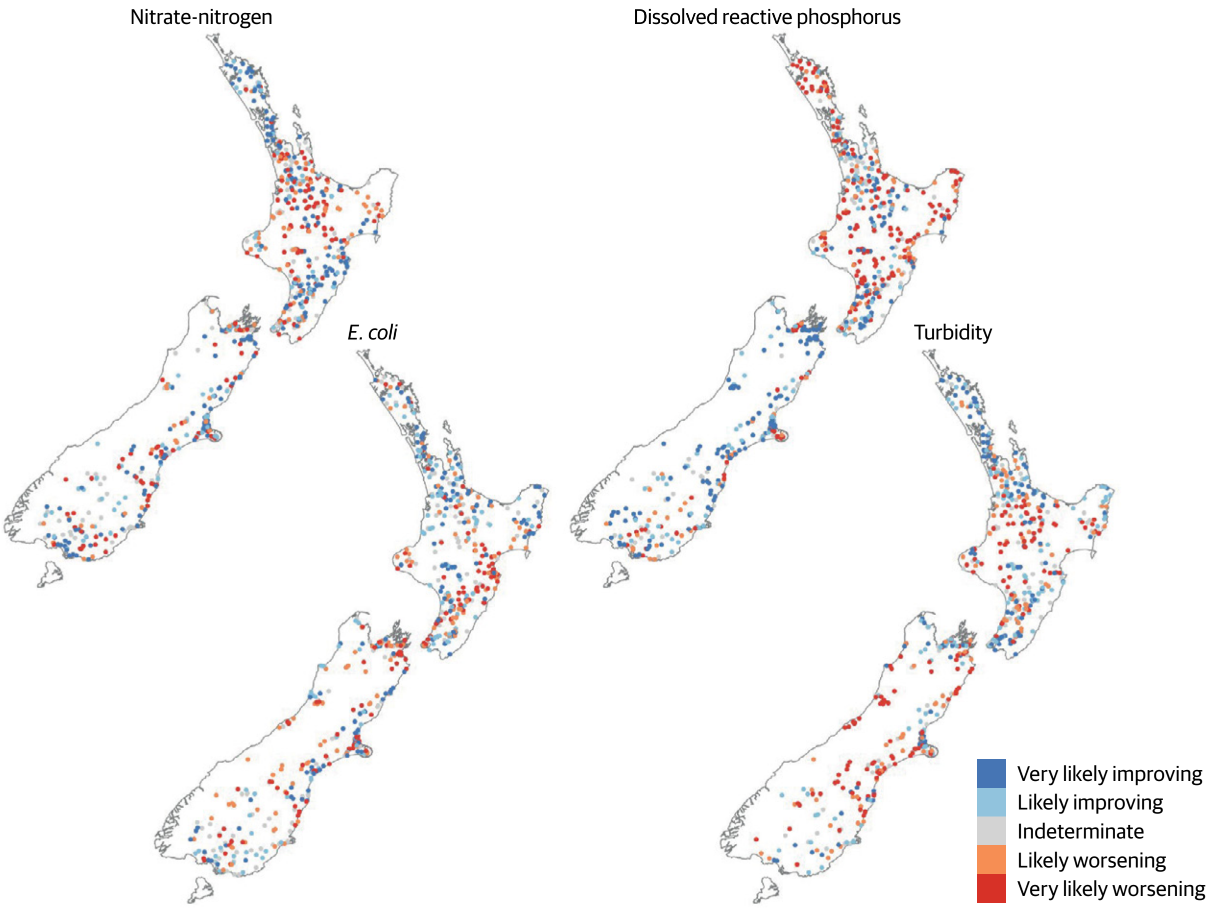
Source: Ministry for the Environment, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 49.

Figure 2: Groundwater quality nitrate-nitrogen concentrations for all land-cover classes



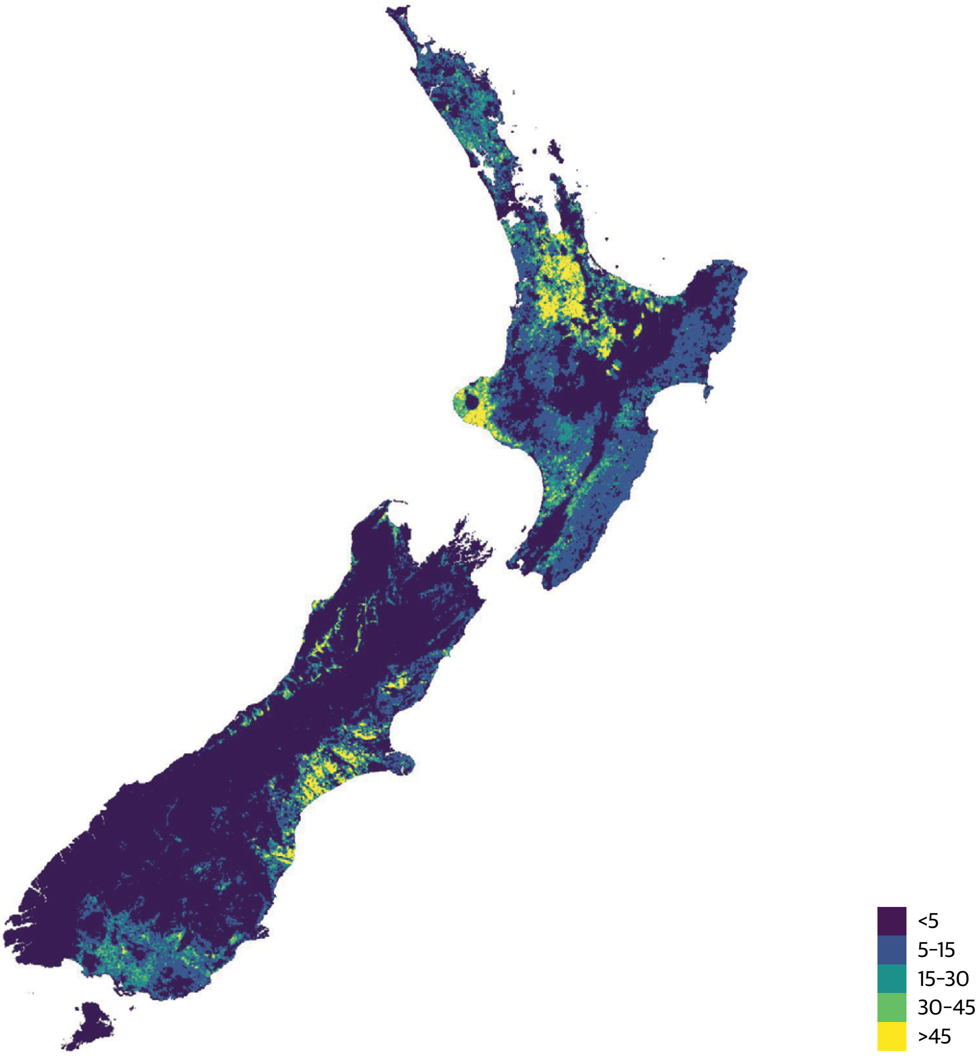
Source: Ministry for the Environment, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 51.

Figure 3: River water quality measured trends for all land-cover classes, 2008–17



Source: Ministry for the Environment, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 55.

Figure 4: Modelled nitrate-nitrogen leached from livestock, 2017 (kgN/ha)



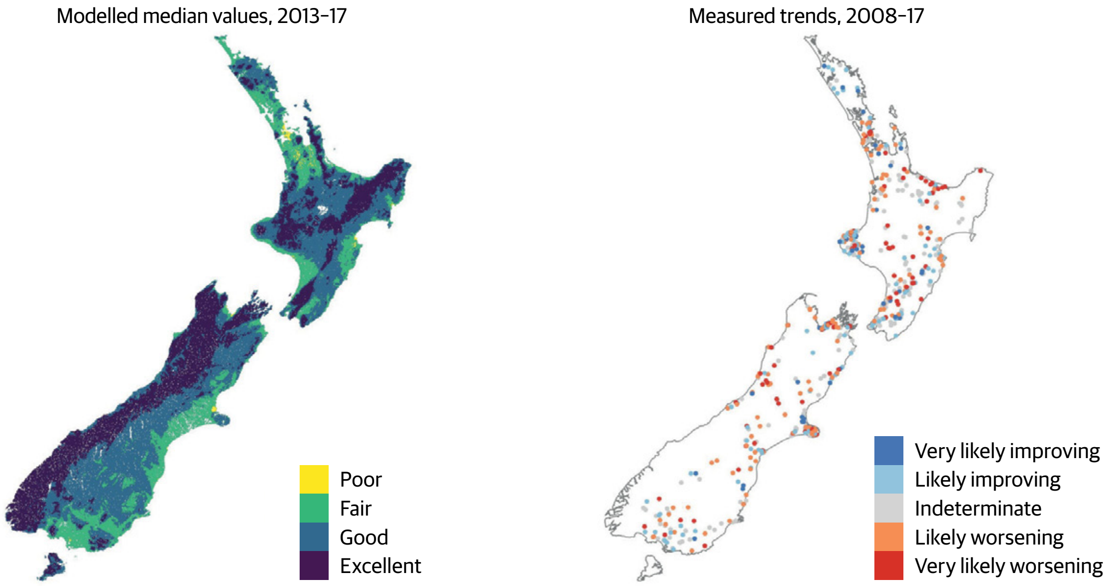
Source: Ministry for the Environment, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 59.

All this information matters.

High nitrate levels in aquifers affect drinking water and bring risk of colon cancer and other health problems.[7] The Ministry of Health's Chief Science Adviser, Dr Ian Town, is chairing a review of potential adverse consequences of nitrate exposure.[8] *E. coli* makes rivers unsafe for recreational activities. Nitrogen, phosphorous and sediment all affect not only the recreational and aesthetic value of rivers and lakes by worsening water clarity and encouraging algae blooms but also the ability of those waterways to sustain life.[9]

Macroinvertebrate health, as measured by the Macroinvertebrate Community Index (MCI), if measured frequently enough and to a high standard, can form a rough summary statistic for overall water quality. Compared to areas of natural land cover, the MCI is 15% worse in agricultural areas but 31% worse in urban areas.[10] While MCI ratings in agricultural areas range from fair to good, Auckland and Christchurch are easily found in the yellow blotches of poor river conditions in Figure 5.

Figure 5: River macroinvertebrate community index scores



Source: Ministry for the Environment, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 20.

It may be surprising to find that river quality is *worse* in urban areas than in agricultural areas. While media coverage in the past decade, and regulatory interventions, focused on problems in agriculture, urban areas carry blame too. Agricultural areas are obviously larger in size than urban areas. But where 29% of rivers (by length) flowing through areas of native land cover do not meet Default Guideline Values (DGV) for total nitrogen, 86% of rivers in pastoral areas fail to meet those values compared with 94% of urban rivers. The pattern repeats across the range of contaminants (see Tables 1 and 2).[11] While less than 1% of river length in areas of natural land cover fail to meet *E. coli* standards, 25% fail in pastoral areas and 45% – almost half – fail in urban areas.

Kaiwharawhara Stream, running down to Wellington Harbour from Ngaio and Khandallah, shares *E. coli* contamination rates with the worst 25% of monitored sites across the country – with nary a sheep or cow in sight.

This is not a new problem. Wellington Water notes that contamination in Owhiro Bay has been dangerously high for the past two decades.[12] But councils ignore the maintenance of underground infrastructure until the accumulated mess becomes apparent – and rather more expensive to fix.

Table 1: River water quality (modelled) in pastoral land catchments compared with native catchments

		Modelled median value of water quality variable, 2013–17		River length (km) that does not meet ANZG DGV	
Water quality variable	Units	Pastoral land cover	Native land cover	Pastoral land cover	Native land cover
Total nitrogen	mg/m³	738.6	115.9	162,475 (86%)	57,027 (29%)
Nitrate-nitrogen	mg/m³	246.6	25.6	155,000 (82%)	26,610 (13%)
Ammoniacal nitrogen	mg/m³	8.3	4.0	94,237 (50%)	29,464 (15%)
Total phosphorus	mg/m³	32.5	8.3	169,142 (90%)	50,977 (26%)
Dissolved reactive phosphorus	mg/m³	14.6	4.4	144,191 (77%)	45,270 (23%)
E. coli	cfu/100 ml	195.0	13.3	47,314 (25%)	1,117 (0.6%)
Turbidity	NTU	2.9	1.3	117,343 (62%)	22,962 (12%)
Clarity	m	1.7	3.3	13,499 (7%)	1,467 (1%)

Source: Ministry for the Environment, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 50.
Note: Water Quality Australia, "Australian and New Zealand guidelines for fresh and marine water quality," Website (2018) does not include a DGV for *E. coli*, so the expected concentration for natural conditions is based on the guideline value determined by Richard W. McDowell, Ton H. Snelder and Neil R. Cox, "Establishment of Reference Conditions and Trigger Values for Chemical, Physical and Microbiological Indicators in New Zealand Streams and Rivers" (Mosgiel, New Zealand: AgResearch, 2013). Because of the way a DGV is defined, under natural conditions, it is expected that about 20% of river length will not meet the DGVs and about 5% of river length will not meet the *E. coli* guideline.

Table 2: River water quality (modelled) in urban land catchments compared with native catchments

		Modelled median value of water quality variable, 2013–17		River length (km) that does not meet ANZG DGV	
Water quality variable	Units	Urban land cover	Native land cover	Urban land cover	Native land cover
Total nitrogen	mg/m³	992.2	115.9	3,153 (94%)	57,027 (29%)
Nitrate-nitrogen	mg/m³	497.8	25.6	3,214 (96%)	26,610 (13%)
Ammoniacal nitrogen	mg/m³	29.9	4.0	3,020 (90%)	29,464 (15%)
Total phosphorus	mg/m³	43.3	8.3	3,267 (98%)	50,977 (26%)
Dissolved reactive phosphorus	mg/m³	20.5	4.4	3,104 (93%)	45,270 (23%)
E. coli	cfu/100 ml	399.9	13.3	1,512 (45%)	1,117 (0.6%)
Turbidity	NTU	4.4	1.3	2,276 (68%)	22,962 (12%)
Clarity	m	1.5	3.3	163 (5%)	1,467 (1%)

Source: Ministry for the Environment, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 66.
Note: Water Quality Australia, "Australian and New Zealand guidelines for fresh and marine water quality," Website (2018) does not include a DGV for *E. coli*, so the expected concentration for natural conditions is based on the guideline value determined by Richard W. McDowell, Ton H. Snelder and Neil R. Cox, "Establishment of Reference Conditions and Trigger Values for Chemical, Physical and Microbiological Indicators in New Zealand Streams and Rivers" (Mosgiel, New Zealand: AgResearch, 2013). Because of the way a DGV is defined, even under natural conditions, it is expected that about 20% of river length will not meet the DGVs and about 5% of river length will not meet the *E. coli* guideline.

The poor state of urban waterways is summarised in Box 1.

Box 1: Urban waters

The Wellington Region has 16 freshwater catchments, from Wellington City to the Whareama River east of Masterton, and 65 monitoring sites.*

These are results from some urban monitoring sites, where agricultural discharge is less likely to affect water quality:

- Kiawharawhara Stream at Ngaio Gorge:
  - *E. coli*: Worst 25% of all sites – trend "Very likely degrading"
  - NOF Band E: "For more than 30% of the time, the estimated risk is >50 in 1000 (>5% risk). The predicted average infection risk is 7%."
  - Nitrogen: Worst 25% of all sites on two of three measures – trend "Very likely improving"
  - Phosphorus: Worst 25% of all sites on two measures – trend "Very likely degrading"
- Karori Stream at Makara Peak Mountain Bike Park:
  - *E. Coli*: Worst 25%, NOF Band E – trend "Very likely degrading"
  - Nitrogen: Worst 25% of sites on all three measures, but likely improving
  - Phosphorous: Worst 25% of all sites on one measure, worst 50% on the other, but likely improving on both
- Porirua Stream at Wall Park:
  - *E. coli*: Worst 25%, NOF Band E – trend "Very likely degrading"
  - Nitrogen: Worst 25% on two measures, worst 50% on the other – trend "Indeterminate to very likely degrading"
  - Phosphorous: Worst 50% on both measures – "Very likely degrading"
- Hutt River:
  - Water quality generally worsens downstream into the urban environment, but typically remains at least within the best 50% of all sites for *E. Coli*, nitrogen and phosphorous.
- Waiwhetu Stream, in Lower Hutt:
  - *E. Coli*: Worst 25% of all sites, NOF Band E
  - Phosphorous: Worst 25%
  - Nitrogen: Worst 50% on two of three measures, and worst 25% on the third.

Among purely urban sites in Auckland:

- Omaru at Maybury Street, near Point England Park:
  - *E. coli*: Worst 25% of all sites, NOF Band E – trend "Likely degrading"
  - Nitrogen: Worst 50% on two measures (and "Likely degrading"), and worst 25% on the last measure (but "Likely improving")
  - Phosphorous: Worst 25% of all sites by both measures
- Otaki Creek in Papatoetoe: "Otaki Stream has limited public access, poor water quality, and currently has low recreational value."
- Oakley Creek near Unitec and Waterview:
  - *E. coli*: Worst 25% of sites
  - Nitrogen: Worst 25% on two of three measures
  - Phosphorous: Worst 25% of sites.

Similarly, in Christchurch, only the most upstream sites in the Heathcote[13] are not in the worst 25% for *E. coli*, though quality improves slightly upon meeting the estuary.

* See Land Air Water Aotearoa, "Wellington Region River Quality," Website. Clicking other parts of the map provides results from different regions.

Poor urban water quality can stem from various sources but is primarily a story of ageing water infrastructure and too-often poor quality legacy water connections on private land. Occasional failures of trunk infrastructure bring breaches of consent conditions and warnings against swimming.[14] But ongoing seepage from other pipes brings high base rates for contaminants like *E. coli* in urban streams. A Wellington Water official informs us that roughly half the problem is from ageing pipe seepage in council networks. The remaining seepage is from private property where poor legacy plumbing[15] causes wastewater to flow into stormwater networks, and onward to streams and the harbour.

Fortunately, problems in urban water quality are getting recognition. High profile breaches of Wellington's sewage networks have led to greater reporting of underlying issues about long-term seepage from wastewater systems and the consequences of those systems designed to overflow into creeks and streams during heavy rains. In February 2020, *Metro* magazine reported on Auckland's problems in graphic terms – sensitive readers may wish to skip ahead:

> In the evening, the Newmarket Stream smells like shit. Not the whole length of it, but if you wander through the gully down by Newmarket Park and trace the winding track to the overflow point at what is appropriately known as Hells Gate, there are moments when the scent on the breeze is unmistakably that of human shit. And, unfortunately for Stephen Morse, his Remuera home is often directly upwind.
>
> The smell is the worst on a weekday morning, when everyone is shitting and showering in unison before heading off to work. The second-worst time is when he arrives home, just before dinner. "It makes me sick to my stomach," he says. …
>
> Like much of central Auckland, Newmarket has a partially combined stormwater and wastewater (sewage) network, so there are huge swathes of the city where the pipes built to take the water from our toilets and showers are the same ones that rainwater flows into. The pipes are supposed to carry their load south to the Māngere Wastewater Treatment Plant, but when it rains, many of them overflow (as they're designed to do) to designated spill points, and all that churned-up, shitty water is discharged into our creeks and streams, onto our beaches, and into our two harbours.[16]

Auckland Council under Mayor Phil Goff is making laudable efforts to clean up the mess, but the situation had been allowed to persist for decades by councils that neglected infrastructure projects. Encouraging ongoing investment in maintenance over costly attempts to rectify decades of neglect is needed now.

Essential Freshwater, essential economics

New Zealand is a small country but it contains almost a globe's worth of geography. A three-hour drive across South Island takes you from urban beaches and braided rivers through cropland and irrigated pastures. From there, you climb on to highland stations and alpine passes, then down through rainforests onto pastureland irrigated naturally by almost three metres of rainfall each year.

It makes for stunning scenery, not to mention appealing and accessible locations for movie filming.

It also makes it tough to implement policies based on assumptions that one size can fit all.

Any reasonable attempt to improve environmental quality must account for local conditions. The best ways of boosting water quality standards will necessarily vary from place to place along with the magnitude of the underlying problem, local conditions and land use.

The costs of meeting a fixed national standard will also vary considerably from place to place – and can be rather high. In 2017, Environment Canterbury informed the government that bringing water quality in Lake Ellesmere up to national water quality guidelines would require shutting down the dairy industry in Selwyn District and lead to losses to the order of $300 million per year.[17]

Since the 2017 election, regulatory efforts to improve freshwater quality have redoubled. Minister Parker's Essential Freshwater programme aims to stem the decline in freshwater quality and provide a basis for longer-term improvement.

Government action was and is necessary. Freshwater quality featured prominently in the 2017 election and voter demands for improvement were obvious.

But doing the most good requires finding effective ways of improving freshwater quality and equitably sharing the burden of achieving those outcomes. The most cost-effective and practical changes in one place may not be suitable elsewhere. Blanket standards are unlikely to be cost-effective or effective.

As Julia Talbot-Jones explained in her submission on the government's discussion document "Action for healthy waterways – A discussion document on national direction for our essential freshwater," improving freshwater quality is essential but:

> Some blanket standards, such as restricting further intensification, could impose unnecessary costs on some landowners. Not all regions are experiencing the same levels of degradation. In some regions it may actually be more efficient for some landowners to intensify land use on part of their title – an option which will be unavailable to them under the proposed NES-FW.[18]

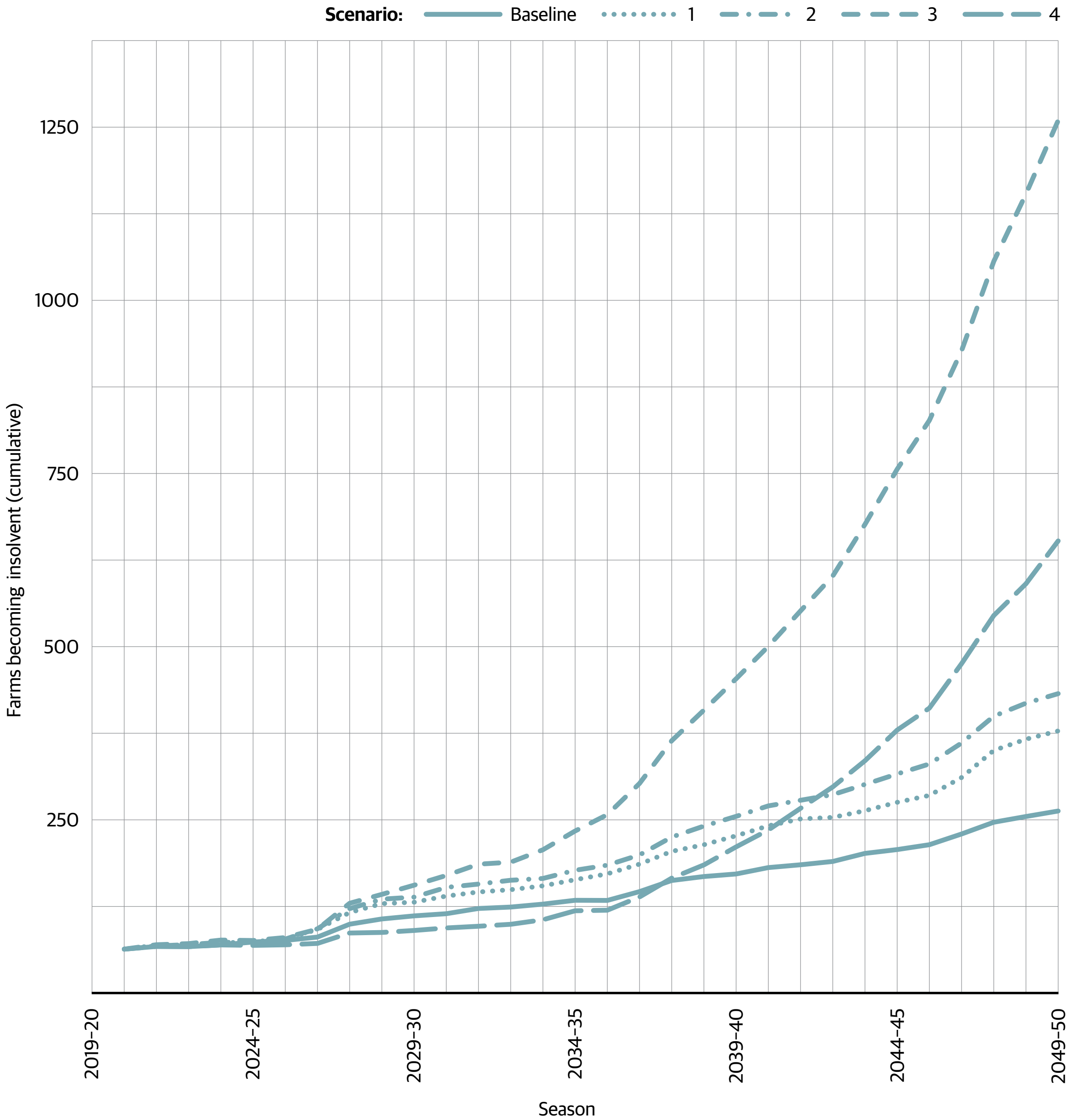
She also expressed concern over the lack of assessment of the economic costs and benefits of the new standards.

DairyNZ has estimated the potential effects of the Essential Freshwater programme on the agricultural community. Its report[19] suggests milk production would fall about a third between 2040 and 2050, and even more when the effects of methane restrictions are added. It forecast an increase in farm insolvencies from 2% to 11% because of tighter freshwater restrictions. Effects would vary across the country:

> The economic impact of Essential Freshwater is significant at the regional level, though the exact impact varies. Dairy profits are predicted to be negative in the Northland and Taranaki regions by 2045–50. Further, profit is predicted to fall by 70% in the Waikato region and by 50% in both Canterbury and Southland in this period. Waikato, Canterbury, and Southland experience a decline in production of around 33%, 50%, and 35%, respectively, by 2045–50.

Figure 6, from DairyNZ, tracks the cumulative number of farm insolvencies under different scenarios.

Figure 6: Cumulative number of farm insolvencies under different scenarios



Source: Graeme Doole, "Economic Impacts of the Essential Freshwater Proposals on New Zealand Dairy Farms," Report prepared for DairyNZ (Hamilton: 2019), p.36.

DairyNZ does note an interesting implication of coming restrictions on agricultural greenhouse gas emissions. While adding methane restrictions further reduces milk production, it also *reduces* the number of farm bankruptcies. Why? Farms are granted tradeable credits in the Emissions Trading Scheme (ETS) for their methane emissions. When tighter nutrient regulations mean shifting to less intensive forms of production, those farms can sell valuable ETS credits that are no longer required, helping ease their transition.

We might take projections from DairyNZ about the effects of tighter regulations with some scepticism, as it is not a neutral party in this area. But economist Ian Harrison of Tailrisk Economics has also raised concerns about the quality of the economic analysis supporting the government's freshwater proposals.[20] He notes that the swimmability benefits of stock exclusion from rivers may overstate the human health benefits of the policy, and that the value placed on ecosystem services provided by protected wetlands seem inadequately supported; together, these two benefits form the bulk of tallied benefits.

The costs of the set of regulatory proposals could be warranted if they are the lowest cost way of improving freshwater quality, and if people put a high enough value on improving the quality of water in our rivers, aquifers and harbours.

But substantial problems remain. The Essential Freshwater framework insufficiently reflects differences in the cost of improving water quality in different places. It is possible to get better outcomes overall by reducing the intensity of dairying in some areas, offset by smaller increases in intensity elsewhere. Blanket restrictions against intensification prevent taking those opportunities. This makes achieving the necessary overall improvement more costly than it needs to be.

As most rivers run through pastoral landscapes, those areas receive the greatest focus. Urban waterways are in very poor shape but, until recently, have received less attention. Bringing stormwater and wastewater up to standard would prove expensive for cities.[21] Agricultural communities know that the government would prefer to impose regulatory costs on the countryside, where fewer voters live, than force urban councils into costly but necessary infrastructure upgrades. Many water treatment plants do not fully comply with their consent conditions, including up to half the treatment plants in Waikato. And it will be at least two years until New Zealand's recently established water regulator, Taumata Arowai, will begin monitoring wastewater networks.[22]

Tullock's Scylla: the Transitional Gains Trap

A thorny political problem circles an increasingly serious environmental problem.

Agricultural communities expecting regulatory measures with little consideration of costs, or recognition of the work already undertaken to improve environmental quality, will baulk at tighter standards. Farms that are already highly leveraged can easily be bankrupted or have their profitability sharply reduced by tighter standards or substantial and uncompensated changes in land use or on-farm practice.

In 1975, American economist Gordon Tullock described such a situation as a Transitional Gains Trap.[23] In places where adding a few cows to a dairy herd has been a by-right activity, the value of that right has been incorporated into land prices, along with the value of any water drawing rights. Buying a farm implicitly also buys those rights – farms with irrigation consents trade at substantially higher values than farms without them. Mortgages are predicated on expectations that rights to draw water for land with irrigation consents, and rights to land use were included in the initial purchase price. Those farms then only earn a normal rate of return on the capital investment. But shifting the regulatory settings to require those farms to purchase annual water rights or purchase annual emissions rights means those farms effectively pay twice for the same thing. Farmers *thought* they were purchasing an ongoing right when they bought the property and set their land price expectations accordingly. Being made to pay an annual fee for something they *thought* was already covered in the initial purchase price can be devastating.

Imagine a council decides every property must pay an annual occupancy fee of $2,800 per person on top of existing rates. For a home valued at the median house price of $685,000 with four occupants, the present discounted value of that annual fee is about a third of the value of the home. If you had known that the council planned to impose such a fee before purchasing the home, you would have sharply changed your strategy at the house auction. Land prices would fall where buyers expect such a large annual fee.

If the council proposed annual occupancy fees that would wipe off about a third of the value of urban properties while requiring substantial annual payment, how much effort would homeowners, collectively, put into convincing the council *not* to impose the fee? Tullock argued that, collectively, investment in avoiding the rule change could add up to as much as the cost of the rule change.

That collective effort to avoid a loss-imposing rule creates Tullock's trap. No council would impose a levy of that magnitude on homeowners for precisely this reason. But water rights implicit in the value of an agricultural property a decade ago constituted up to a third of the value of an agricultural property,[24] and land use rights implicit in our regulatory structures made up an additional and uncalculated part of the value of that land. It explains the difficulty of introducing the necessary environmental quality improvements: the Crown wishes to impose the vast majority of the costs on one sector – but without compensation.

On a smaller scale, consider recent changes to the West Coast Regional Council's Soil and Water Plan. Central government insisted, through appeals to the Environment Court, that the council protect more wetlands under its Soil and Water Plan. Five thousand hectares may be affected, with landowners required to undertake costly ecological assessments to determine whether those wetlands require even further protection. While the Crown may assist with the costs of fencing the now-protected land, it will not compensate landowners for the regulatory taking.

Additional wetland protection might be the best way of improving water quality on the West Coast, but it is harder to tell whether that is the case when protection can be imposed without compensation. Regulators may be less likely to weigh costs they need not account for. But if it is the best solution, it has been perhaps unnecessarily delayed because failure to compensate affected landowners made it unduly contentious. The Environment Court decision was rendered in 2012 but the council signed off on the changes eight years later.[25]

Changing how we think about sharing the burden of reaching better environmental outcomes is not merely a question of equity or just transitions. Both those considerations are individually tremendously important and necessary on any path to better outcomes. Substantial improvements in environmental quality will not come for free – they require finding the most cost-effective solutions, and sharing the burden of enacting them equitably.

Other options will cost more to achieve less. Worse, they risk the regulatory ship lurching from Tullock's Scylla of farm bankruptcies and ratepayer protests at the cost of urban infrastructure renewal back towards the environmental Charybdis of doing too little to reverse declines in water quality.

We need to chart the course between.

CHAPTER 2
Safer crossings

What does a good system look like?

Voters mostly agree on what 'good' water outcomes look like: clean streams and rivers, harbours safe for swimming, and healthy aquifers. But what kind of institutional system can best get us there?

Conditions vary considerably across the country. So do the costs facing different farms, factories and councils in changing practices or upgrading infrastructure to reduce environmental burdens.

As central government does not know the costs of improving environmental quality in different regions, it cannot set regulations to implement the most effective ways of avoiding environmental problems. It also means problems for the government in sharing the burden of achieving outcomes with local entities; an offer to share costs would invite inflated estimates of the costs.

A good system encourages all of us – urban or rural; agricultural, commercial, industrial or residential – to discover what we can each do to improve freshwater quality. It creates incentives to pursue the most cost-effective ways of achieving improvement and do the right thing.

But "doing the right thing" is harder than it sounds. For example, an urban homeowner could pay for a smoke test to ensure sewage pipes on their property are in good order. Or they could divert their funds towards other methods that might do more good – like upgrading neighbourhood stormwater infrastructure, or wetland restoration elsewhere. We all have limited resources; figuring out how best to use them is critical to reduce environmental burdens effectively.

A good system helps discover what can do the most good and provide incentives to do them.

A good system recognises environmental limits, as well as the costs involved in achieving outcomes. A national standard that requires bringing all waterways up to a common high standard is unlikely to do the *most* good because it will necessarily involve a lot more investment in some places than in others. Would Environment Canterbury closing the Selwyn dairy industry to bring Lake Ellesmere up to national standard be the *best* possible way to fix national water quality at that cost, if some of the existing cost estimates are correct? Or should it rather shift some of that costly effort to improve water quality in urban rivers, or other streams entirely?[26]

New Plymouth has estimated that back-up storage to prevent overflow into streams during heavier rains would cost $450 million – more than three times the annual council water infrastructure budget.[27] Should New Plymouth council spend the $450 million on improving overall water quality in the district, or on other areas where the funds are more needed? Or could Environment Canterbury have misjudged the costs of improving water quality at Lake Ellesmere if there were better ways of encouraging farms to find the most effective solutions? A good system helps reveal the actual costs of lifting each waterway to a higher standard so we can collectively choose well.

The Auditor General's 2020 summary of its work in freshwater management highlighted the need for a more strategic and integrated approach. The report noted difficulty in assessing whether public expenditure on freshwater clean-up is effective, or effectively targeted.[28] It also noted a lack of agreement within the public sector on priorities for freshwater management. That lack of agreement is understandable where different agencies have different objectives.

Economists typically recommend price mechanisms in cases where it is easier to see the environmental costs of broadly dispersed activities than to see the costs individuals face when mitigating those costs. Pollution taxes, for example, encourage people to avoid pollution up to the point where the next task in mitigating pollution is more expensive than simply paying the tax or fee.

Those systems can be very effective. Rather than requiring bureaucracies to guess what regulatory measures might cost-effectively reduce pollution, environmental taxes harness dispersed knowledge no bureaucracy can ever access. A council planner can never tell whether it is harder for one person to avoid driving during rush hour compared with another person. Applying a congestion charge during rush hour lets us decide for ourselves whether to take the busiest routes or wait for off-peak hours. Knowledge about who among us can most cost-effectively avoid adding to rush-hour congestion simply cannot exist without the discovery process that prices encourage. Even individuals affected by the charges might only discover their best responses as they adapt to the charges they face.

Pollution taxes can consequently be very appealing. But they are the wrong instrument when thinking about freshwater abstraction and quality.

Economist Martin Weitzman demonstrated that when the costs of exceeding an environmental limit are potentially high, and when responses to prices are relatively uncertain, capping the total amount of polluting activity under a cap-and-trade system is preferable to a pollution tax.[29]

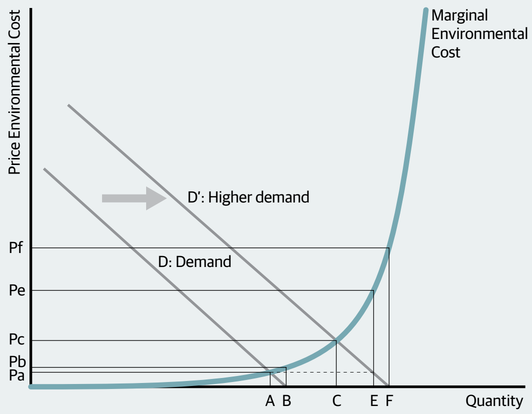
In theory, pollution taxes and cap-and-trade regimes can provide the same result. Different pollution tax levels will result in different levels of pollution. People will make efforts to avoid emissions up to the point that it is more costly to avoid emissions than to pay the tax. Those levels of emissions added across all emitters will be the remaining amount of pollution. A cap-and-trade system sets a hard limit on the total amount and provides tradeable emissions permits – like those in New Zealand's carbon ETS. People try to avoid emissions until it becomes cheaper to buy a permit. Prices and quantities in the two systems can be equivalent.

But when it is hard to tell just how people will respond to a pollution tax, and when the costs of emissions can increase quickly when aggregate emissions are unexpectedly higher, a cap-and-trade system is less risky. Emissions into streams and waterways have nonlinear costs. Broadly speaking, the first herd of cattle near a fast-flowing, high-volume river does almost no harm; any effluent is rapidly diluted. But the hundredth herd might push the river into eutrophication, where excessive algae growth sparked by excess nutrients depletes the river of oxygen and kills wildlife. It is easier to estimate the nutrient loading a river might be able to handle than to guess at the pollution charge that would maintain a healthy river.

This result is illustrated more formally in Box 2.

The Initiative's *Refreshing Water* report described a smart-market water trading system developed by researchers at the University of Canterbury and the RAND Corporation. The system incorporates environmental bottom-lines into the trading mechanism. Doing so ensures respect for environmental limits and reduces trading costs substantially compared with current systems. The smart-market system is summarised in Box 3.

Box 2: Prices or quantities? Pollution taxes versus pollution permits[30]



When the environmental costs of an activity are unpriced, demand for the externality-generating activity will be high. Suppose that, in an early period, demand for the activity follows the schedule D. It is downward sloping: if there were a price on the activity, people would undertake less of it. The downward-sloping nature of the curve reflects that some agents will have higher costs than others for reducing their own externality generating activity, and that different activities provide different amounts of value to the acting agent. If the price levied on the activity were high, agents would find it effective to use measures to reduce that activity until the point that the costs of those measures exceeded the pollution charge.

In the initial state, D, agents would undertake quantity B of the activity because there is no cost faced by the actor for undertaking the activity. Environmental costs associated with the activity would be Pb. The socially optimal quantity of the activity, A, and associated environmental cost, Pa, is lower than B and Pb. But the distance between Pa and Pb is relatively small.

When demand for the activity increases from D to D', perhaps because of a change in demand for the goods provided through the activity in question, associated environmental costs can begin to increase sharply. The socially optimal amount of the activity, C, is only somewhat lower than the amount F that obtains in the absence of a price on the externality. But the environmental cost Pf is far in excess of Pc.

We can now compare a cap-and-trade system to a pollution or water extraction charge. At demand level D', an environmental charge of Pc per unit of the activity would result in the socially optimal amount, C. Similarly, setting a cap under a tradeable quota system of C would result in no more than C, and would result in a per-unit value of the tradeable permit of Pc. The price and quantity are simultaneously determined. If we have a lot more certainty about the curvature of the blue curve demonstrating the marginal environmental costs of the activity than we do about the location of the demand curve, setting a quantity cap can be far better than setting a pollution charge. Suppose a council estimated that the catchment could withstand no more than C amount of the activity, and estimated that underlying demand for the activity followed the initial demand curve D. If it set a pollution charge of Pa, it would achieve the optimal amount of the activity – unless demand were actually D'. If demand were actually D', quantity E of the activity would be undertaken at the far higher environmental cost of Pe. Using a tax can be very risky where environmental costs can be sharply increasing in the amount of the activity and when demand is uncertain.

If the council had instead set a catchment-level cap of C when underlying demand for the activity were D', the cap would be optimal. If actual demand were higher than D', the trading price for permits would increase, but no more of the activity could be undertaken. If actual demand for the activity followed D rather than D', the cap would not bind – there would be no price on the activity, but the excess environmental cost is relatively small.

While it is possible to construct a tax that mimics the effect of any cap on a quantity of output, or a cap that mimics the effect of a tax, caps are preferable when the environmental costs of overshooting an expected quantity of output are very high.

Source: Eric Crampton, "Refreshing Water and Valuing the Priceless: New Zealand's Freshwater Allocation System Has Run Its Course," *Policy Quarterly* 15:3 (2019), 62–69, 64.

Box 3: Excerpt from Refreshing Water: Valuing the Priceless

John Raffensperger and Mark Milke developed the model for a smart water market system that does more than just swap the old classified ads for Trade Me – it also bakes environmental sustainability into the DNA of the trading system.*

How does it work? Let us view it first from the perspective of the user, then step back to see how the model achieves environmental sustainability.

Water users within a trading catchment log into the electronic trading system. They can submit bids to purchase water allocations from others or offer to sell water from their own allocation. A user could even offer to sell much of their water allocation if the price is high enough or ask to buy large amounts of water if the price is low enough, and scale their buy-and-sell orders at prices in between.

After the market closes, the trading system runs. Every user is informed what the price is likely to be and asked to confirm their buy and sell offers around that price. The system runs again, tells everyone the price of water at their location, and how much they were able to purchase or sell.

Running in the background are hard environmental constraints. Hydrological mapping lets the system know the effects of drawing water from aquifers and rivers at different places within the catchment. It then incorporates the downstream effects of upstream water drawing into its workings – and generates different prices for water at different places in the system.† It also ensures that any trading outcome is consistent with rivers being able to meet a minimum flow constraint, with the maintenance of sustainable aquifer levels, and with aquifer pressure at sea level remaining high enough to prevent salt-water incursion.

This kind of smart-market trading can be transformational. Currently, water trading requires buyers and sellers to find each other to structure their transaction to suit their needs, and to bring the proposed trade to council for approval. Council needs to check the proposed trade to ensure it does not result in overallocated catchments or other adverse consequences because water drawn from different places can have different effects. And all this is complicated by a water consents system that ties the right to draw water with particular water uses.

Separating the right to draw water from the right to use water in particular ways makes it easier to trade in water. With the smart market system incorporating hydrological mapping, trades do not need any separate approval process.

All substantial water use would be incorporated within the system, including water abstraction for urban residential, agricultural, industrial and commercial purposes – although not all water users would need to actively participate in the system. Councils able to reduce urban water use, for example by metering water use and repairing leaky pipes, would immediately see financial benefits because they would be able to sell their surplus water within the trading system.

As an added benefit, the system automatically creates information about the potential cost of increasing river flow above the guaranteed minimum flow.§ Doing the most good possible for the environment and the country as a whole requires knowing where the greatest opportunities lie.

Source: Eric Crampton, "Refreshing Water: Valuing the Priceless" (Wellington: The New Zealand Initiative, 2019), 18–19.
* John F. Raffensperger and Mark W. Milke, *Smart Markets for Water Resources: A Manual for Implementation* (Springer, 2017).
† Note that the use of the term 'cap' is here shorthand. The system would allow a more complex set of subcatchment-specific constraints. I thank Mark Milke for the reminder.
§ Technically, inverting the value of the coefficient attached to a constraint in a linear optimisation reveals the shadow price of the constraint. See discussion in John F. Raffensperger and Mark W. Milke, *Smart Markets for Water Resources*, op. cit. Chapter 3.

Cap-and-trade systems are also more successful at addressing equity issues inherent in sharing the burden of improving environmental outcomes.

As discussed in *Refreshing Water*, allocating tradeable water permits to those with existing consents – agricultural, commercial, industrial or residential – and extra to iwi in areas where iwi water rights are not extinguished by contract, treaty or sale can help effect a just transition.

In the case of water abstraction, where existing rights to draw water exceed sustainable limits, the burden of reducing overall use can be shared between existing water users and the public more broadly. Allocated tradeable rights can erode over time. Reduction in existing users' rights to draw water would form their share of the burden of reaching sustainable outcomes. At the same time, Crown buybacks of water rights within the trading system can place some of the burden on the public more broadly and more equitably through the tax system. If people in Auckland want higher flows in rivers in the Canterbury Plains, the burden should be spread more broadly than among current consent-holders.

This initial allocation helps existing users when changing their own land use. Consider a highly leveraged dairy farm on marginal land. Under a water tax or charge for water abstraction, that farm will never afford the water necessary to continue operating. The water is more valuable in other uses, and the value that farm gets from the water will be less than the cost of the water. Because the value of water consents was already worked into the purchase price of the land, the farm will soon be financially under water, unable to afford both the mortgage on the loan it took out to buy the land with an irrigation consent, and annual charges for the water the farmer assumed were already included. Someone else would buy the land at a lower price and shift it to less intensive use.

A cap-and-trade scheme providing rights to existing users changes the equation considerably. A marginal dairy farm would not be forced out of business. Instead, it would need to closely look at its balance sheet. Because rights erode over time, it must purchase more water rights over time to continue business as usual. But a farm getting relatively little value from its water will be better off selling its valuable water rights and using those revenues to transition to other land uses.

Compared to other ways of easing the burden on those bearing the costs of meeting stricter environmental regulations, rights allocations under cap-and-trade arrangements have advantages. Other schemes require finding ways of deciding who needs to be compensated, and at what levels. Deciding which claims are real and which are inflated can be difficult.

Under a cap-and-trade system, those reducing environmental burdens are compensated when they sell surplus tradeable rights. Those who sell rights back into the system will be those rights-holders who find it easiest to take actions that improve environmental quality. The system then:

- discovers who is best placed to make the most cost-effective changes in improving environmental quality;
- encourages those who are best-placed to make those changes; and
- compensates those whose actions help reduce environmental burdens and consequently assists their transition.

But can it work for water quality as well as freshwater abstraction?

Wastewater is messy

When an urban water authority finds a smelly mess, figuring out the source of the problem is harder than you might think. It is not always a burst sewer main or a wastewater system designed to overflow into streams when rainwater flows into sewer pipes. Raised *E. coli* levels at monitored locations could be due to smaller problems near the sensors, or bigger problems further up the pipes that have diluted along the way. Workers need to trace the problem to the source because the issue could lie well upstream.

Cap-and-trade systems for freshwater abstraction are relatively simple. Water drawn from rivers and aquifers can be metered. River flows and aquifer levels can be monitored. Meters on pumps can be audited against tampering.

Cap-and-trade systems for diffuse-source waterway pollutants are harder to implement. If a monitor on a river or stream shows elevated nitrate levels, the problem could be the farm next to the river, an industrial source upstream, or a distant farm connected to the river by an underground stream.

Worse, nutrient discharge can affect nearby aquifers and lakes only with potentially long lags that depend on the underlying geology. In the Lake Taupō catchment, where a nutrient trading scheme has been in operation since 2011, the effects of decades of heavy nitrogen use will continue to flow into the lake through underground streams for decades to come. That means a catchment around a sink like a lake or aquifer does not need a simple annual cap; it needs caps for each of the future years that can be affected by current emissions.

To further complicate the issue, nitrogen and nitrates are not the only pollutants that matter. In some places, sedimentation occurs due to erosion from sensitive hillsides. Urban catchments with substantial runoff from roads bring different kinds of pollution as well. Restrictions focusing on a single set of pollutants can have unforeseen and detrimental consequences if they encourage changes in practice that mitigate the targeted pollutant by increasing other kinds of pollutants.

It all may seem impossibly complex, but that's where technology helps.

Lake Taupō's nitrogen market has demonstrated the feasibility of cap-and-trade systems for dealing with nitrogen emissions while discovering areas requiring strengthening in any broader application. Nutrient management plans developed by farms produce modelled nutrient outflows using the Overseer farm management system. Farms reducing their nutrient outflow can sell some of their freed-up nutrient allocations to other farms requiring greater allocations or to the Lake Taupō Protection Trust, which buys and retires emissions permits.

Non-profit research institute Motu has provided the most rigorous evaluation so far of the Taupō nutrient management trading system. When the system was adopted in 2011, it was not known whether cap-and-trade systems could work with diffused, non-point-source pollutants like nitrogen runoff from farms. Cap-and-trade has a well-proven record for sulphur dioxide emissions from industrial smokestacks, but none for dispersed sulphur dioxide emissions from car tailpipes.

On evaluating the system, Motu concluded:

> We can state with confidence that it is technically feasible to include non-point sources within a cap-and-trade water quality market, that such a market can function, and that once property rights are clearly established, the additional cost of allowing trading is low.[31]

Motu also concluded that the transactions costs of trading within the system limit the effectiveness of the system, that policies improving the transparency of prices and improving market liquidity would help, and that improvements are needed in Overseer – the management system farms use to estimate nutrient outflow from on-farm input measures like fertiliser use and stocking levels.[32]

Nutrient trading in the Lake Taupō market is far from simple; the transactions cost of trading is substantial. Waikato Regional Council's information sheet explaining the process is reproduced in Box 4.

Box 4: Trading nitrogen in the Lake Taupō Catchment[33]

Buying or selling nitrogen

If you farm under a resource consent and you want to change your existing farming practices which will increase your TAND OR you want to sell your excess nitrogen then you will need to find a consented farmer to buy your excess nitrogen or sell you additional nitrogen. Alternatively, if you are selling nitrogen the Lake Taupō Protection Trust may be interested in purchasing this from you.

To do this, you will need to make an application specifying how you intend to operate under your revised nitrogen cap.

Process:

- find and buy or sell nitrogen from/to a consented farmer (or to the Lake Taupō Protection Trust) and agree on:
    - price
    - quantity
    - date of transfer (we suggest it might be best to reflect these terms in a legal agreement)
    - prepare a NMP that shows how you will operate under your new cap (the seller will need to do this for their farm too)
  - apply (both parties) for consent to formalise the trade of nitrogen – make sure you supply an electronic copy of your new NMP (prepared in Overseer).

Leasing nitrogen: increasing or decreasing your nitrogen discharge

If you want to lease additional nitrogen and you farm under consent or operate under either of the Permitted Activity Rules OR you farm under consent and want to lease out excess nitrogen to another farming operation then you will need to find someone to lease nitrogen from/to.

Process:

- find another farmer to lease nitrogen from OR someone who will lease your excess nitrogen and agree on:
    - price
    - quantity
    - length of lease with a start and end date (we suggest it might be best to reflect these terms in a legal agreement)
    - prepare a NMP that shows how you will operate under your new cap (the seller will need to do this for their farm too)
  - apply (both parties) for consent to formalise the lease of nitrogen and detail the terms of the agreement in the application – make sure you supply an electronic copy of your new NMP (prepared in Overseer).

Source: Waikato Regional Council, "Nitrogen sourcing and trading in the Lake Taupo catchment," Website.

The problem is not *just* that any proposed transfer requires careful accounting to ensure that the increase in nitrogen outflow from the purchasing property is comparable to the decrease in nitrogen outflow from the selling property. Use or sale of emissions rights will always require an audit process ensuring that on-farm practice matches the emissions permits held by the farm. A trading scheme would risk failure if it did not ensure an effected trade resulted in comparable environmental effects.

Furthermore, would-be traders need to find partners with equivalent and offsetting needs, and producing nutrient management plans can be complex. The result is a complex barter market intermediated through application to councils. High trading costs limit trading gains and consequently increase the cost of reducing overall emissions levels.

Thesis work by Anne Spicer investigated farmer responses to Taupō's system and documented changes in land use consequent to the imposition of caps on Taupō's total nutrient loading.[34]

> In the Taupo situation farmers have found several 'ways out', and these are encompassed in the five dominant landscape paths that evolved after the early 2000s. These paths are:
>
> 1. Business as usual – i.e. continue with the same land-use and farm system, at the same stocking rate,
> 2. Reducing farm production levels – as a result of selling nitrogen and reducing stock units/ha, often without apparent reinvestment on-farm (although investment in land outside of the Catchment or outside of farming might occur)
> 3. Changing land-use – by trading nitrogen and either intensifying land-use (such as converting to dairy) or de-intensifying (by planting trees),
> 4. Changing land-use or farm system without trading– by intensifying on part of the farm, or intensifying on land outside of the Catchment, or by changing to a more profitable stock type,
> 5. Restructuring the farm – by introducing non-traditional sources of income such as undertaking secondary processing, and developing a provenance or brand,
>
> An estimated 25% of the land in the study area has not changed land-use nor farm practices since the early 2000s (i.e. the benchmarking years). This business as usual category includes sheep and beef farmers, dairy support farms and dairy platforms. Some of these farmers were comfortable operating under a cap but others reported concern about their future since cost increases can no longer be accommodated through practices such as stocking rate increases, and there is currently little technology to implement that will improve productivity without increasing nitrogen discharges.
>
> Current suggestions, such as increasing the ratio of sheep to cattle, may not fit with farm system requirements such as income complementarity, drought response, or pasture management needs. Further, some of these farmers reported a reluctance to change land-use through trading nitrogen because of the likely negative effects on land values and the ability to sell, and because the 2018 review of the Programme may require further reductions in farm discharge levels.
>
> Landscape path two (reduction in production levels) is estimated to have occurred on 43% of the consented land in the study area and therefore makes a significant, but potentially negative, contribution to the government's aim to double agricultural exports by 2025.
>
> In the remaining landscape paths listed above (i.e. changing land-use with or without trading and farm restructuring) farmers have undertaken adjustment changes that may contribute to the achievement of the government's aim. These farmers have

> converted sheep and beef farms to dairy platform or dairy support, converted sheep and beef farms to plantation forest (including 'carbon forests'), amalgamated sheep and beef farms to give a farm of economic size, and introduced secondary processing and product branding. Changes of this type are estimated to have occurred on around 32% of the land in the study area. Expanding these groups further, and thus enabling a viable agricultural sector in the Catchment, appears to be limited by low levels of nitrogen trading as well as by factors such as the current level of technology, getting research undertaken and into OVERSEER®, water availability, the scarcity of carbon contracts, the economics of small sized forestry conversions, small farm sizes and farmer goals.

Spicer concluded that cap-and-trade regimes are potentially suitable for achieving the National Policy Statement's environmental goals and that it has been accepted by the farming community – at least regarding nitrogen. But she also warned that maintaining a viable agricultural sector within those tighter restrictions may require additional research into alternative land uses and nutrient-reducing farm management practices.

But while the Taupō nutrient management regime was reasonably novel when established, other pilots and projects have also demonstrated the potential for trading in water quality. In 2010, the US Environmental Protection Agency (EPA) listed 48 water quality trading programmes in 25 states, including two that allowed trading between nonpoint sources – like Taupō's regime.[35] The World Resources Institute identified 57 programmes worldwide in 2009, including Taupō.[36]

Trading programmes vary depending on the nature of the problem facing the watershed. In some places, agricultural and urban wastewater are the biggest concerns. In others, heavy metals. Some trading programmes even deal with biological oxygen demand and thermal load. In the latter case, a wastewater utility whose warm water discharges hurt the river paid landowners to plant shade trees along riverbanks to reduce water temperature. The 20-year cost of capital improvements to reduce water temperature was estimated at $104 million to $255 million; shade-tree planting cost $12.3 million.[37] Had regulation forced the wastewater utility to reduce water temperature at the point of discharge, rather than allowing it to encourage shade-tree planting, the river would have been no better off but the cost would have been eight to 20 times higher.

The Great Miami River Watershed Water Quality Credit Trading Program, launched in 2006, allowed point-source polluters in Ohio's Miami River watershed to offset their phosphorous and nitrogen discharges. Reductions in phosphorous loading were estimated to cost $23.37 per pound of phosphorous for point-source polluters, but only $1.08 to $8.48 per pound for farms adopting best management practices. Point-source polluters were allowed to pay farms to adopt better management practices to offset their own emissions, reducing the total burden at lower cost.[38]

These kinds of trading systems can also, perhaps surprisingly, improve compliance with water quality rules. Standard regulatory mechanisms require regional councils, or another enforcement agency, to check whether farms, or wastewater plants, or anyone else, is compliant with relevant regulations. Point-source polluters using offsets to achieve compliance can be liable if the farms that sold them credits did not implement promised changes in practice, so they have some incentive to monitor. Unfortunately, this also provides a disincentive to purchasing those credits in the first place.[39]

In 2008, the EPA evaluated water quality trading regimes and recommended them as an option in places where regulatory, economic, hydrologic and geographic conditions were amenable to them. It promoted institutional changes at the EPA to support trading more generally.

The EPA report noted barriers that have prevented trading schemes from achieving their potential, including emissions caps that proved non-binding in some locations, and process impediments within the EPA and state environmental agencies.[40] But it also noted successful measures like the Miami Conservancy District's helping farmers prepare management plans to prepare for trading.

The EPA summarised the economic benefits of some of the trialled water quality trading programmes.

Table 3: Economic benefits associated with select WQT programs

Program	Benefits Described	Information Source
Chatfield Reservoir	Trade allowed point sources to avoid fines that would have resulted from exceeding allocations.	Interview
Great Miami River	Potential cost savings of $314 to $385 million across entire watershed (see text).	Kieser & Associates (2004), p. 4-3
	Estimated cost savings for Dayton Water Department of $44 million if program is implemented over the long term.	Interview
Long Island Sound	Prospective analysis estimated capital savings of $200 million.	WERF (2000), p. 2
	Credit sellers view value of credits sold as a direct economic benefit to them. Stamford annual revenue from credit sales is about $400,000.	Interview
	Credit buyers see economic benefit in being able to delay large investments.	Interview
Neuse River	Point sources realize savings when group permit association handles water quality monitoring; relieved of inefficient cost of performing own monitoring.	Interview
	Trading can accommodate economic/residential growth in a region that would otherwise be constrained under a TMDL allocation.	Interview
Rahr Malting	Non-point phosphorus control costs average $3.07 per pound, compared with point source facility costs of $4.44 to $6.14 per pound.	Fang and Easter (2003), p. 14
	WQT program kept the point source economically viable; would otherwise have had to relocate.	Interview

Source: Environmental Protection Agency, "EPA Water Quality Trading Evaluation: Final Report" (2008), 3-14.

Later evaluation work of the Great Miami River trading scheme by the Miami Conservancy District found that the programme encouraged 467 different projects, with wastewater treatment plants paying agricultural producers to reduce nutrient discharges by the equivalent of 626 tonnes.[41]

Cap-and-trade systems have shown much promise and some success in trials in managing water quality. But dealing with non-point-source pollution remains more challenging. Where substantial improvements in water quality are necessary, the costs of achieving those improvements will be high even under cap-and-trade systems that alleviate those costs. Research into better ways of reducing agricultural nitrogen leaching has progressed.[42] This way, we can build more effective trading systems to make it easier to achieve those gains.

Making cap-and-trade systems succeed in handling the disparate types of runoff from agricultural and urban environments requires modelling systems that can handle each pollutant. It requires setting up appropriate caps on each pollutant in each catchment under a system that integrates town and country, so discharge from a leaky dairy effluent pond is treated comparably to discharge from a town's leaking sewage system. And it requires a trading interface simple enough that users need never consider purchasing allocations in each of the separate markets but instead purchase the bundle of trading rights necessary to accommodate their intended land use.

The technology for doing this has not yet been developed, but the building blocks exist.

The smart market developed by John F. Raffensperger and Mark W. Milke for water abstraction, described in Box 3, incorporates three environmental constraints:

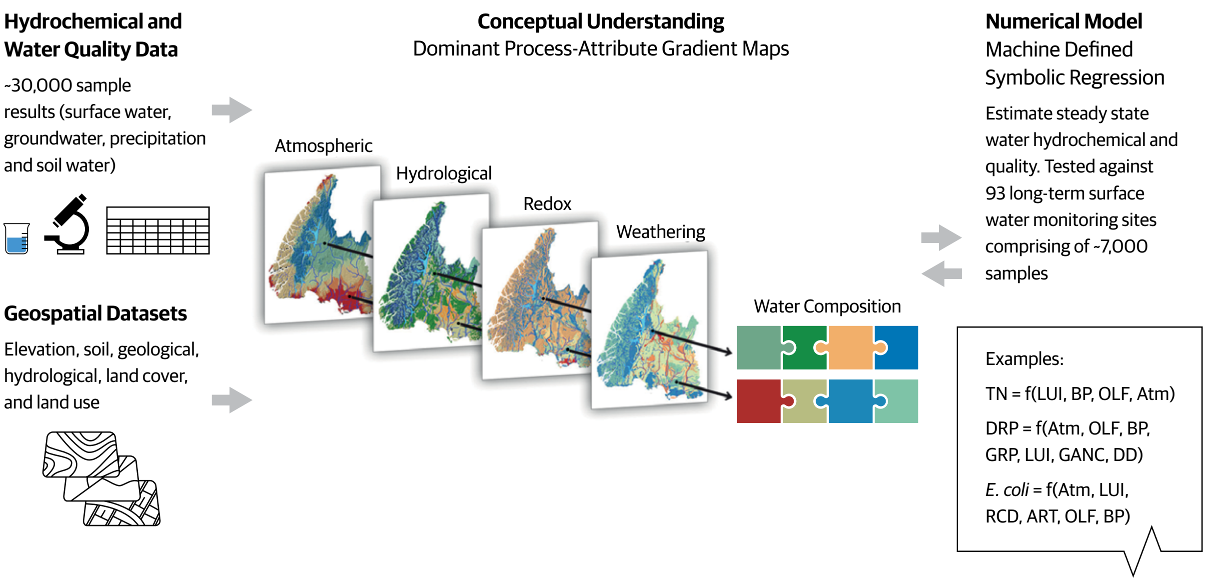
1. all trades consistent with rivers maintaining a set minimum flow;
2. sustainable aquifer water levels; and
3. sufficient aquifer pressure at sea-level to prevent saltwater incursion.

The same kind of optimisation algorithm could incorporate a greater number of constraints for a separate cap-and-trade smart market in nutrients. Aquifer nitrate levels, modelled nutrient concentrations in rivers and streams, sediment load, and *E. coli* levels would be subject to caps reflecting environmental limits.

Where the Raffensperger and Milke system is built on models of the underlying hydrology, smart markets for nutrient trading require more complex modelling of the effects of agricultural intensity on runoff of each of the different nutrients that depend not only on the underlying hydrology but also on topography, land gradient, soil types, and the underlying geology – to name a few.

That modelling work was undertaken for Southland by a team led by Clint Rissmann of Land and Water Science of Invercargill. Participants included researchers from the University of Canterbury, Lincoln University, GNS Science and the University of Waikato; the project was part of the Our Land and Water National Science Challenge.[43] Their modelling tracked the effects of land use changes on total nitrogen, total oxidised nitrogen, total phosphorous, dissolved reactive phosphorous, *E. coli*, and total suspended sediment – taking into account the effects of local conditions. The model can also be used to estimate organic nitrogen and other contaminants, assuming they have been measured across a monitoring network. Figure 7 illustrates their approach.

Figure 7: Effects of local conditions



Source: Clint W.F. Rissmann, et al. "A Hydrochemically Guided Landscape Classification System for Modelling Spatial Variation in Multiple Water Quality Indices: Process-Attribute Mapping," *Science of the Total Environment* 672 (2019), 815–833, 815.

This kind of modelling could underpin smart markets for nutrient management, extending the trading platform developed by Raffensperger and Milke.

The result would be a system with a familiar interface for users, like a strengthened version of Overseer. Because Overseer does not model what happens below the root zone, by itself it would form a weak basis for a nutrient trading scheme. An improved system would be necessary. That improved system could incorporate the effects of a wider set of potential mitigation initiatives, including, for example, wetlands created to reduce nutrient outflow. If supported by the kind of modelling work undertaken at Land and Water, an improved Overseer-style system could assess in more detail the effects of agricultural land use changes on each of the different pollutants in each catchment.

That combination, coupled with the trading mechanism developed by Raffensperger and Milke, would form the basis for smart markets in nutrients. Farmers would input their on-farm practices. The modelling underpinning the system would check the effects of those practices on each of the capped pollutants and tell the farmer the likely combined cost of purchasing the necessary bundle of emissions rights – using prices from the last round of the nutrient auction, or the standing sell orders within the system.

A sufficiently sophisticated system would suggest which changes in on-farm practice could do the most to reduce the cost of those permits. In places where sediment is a challenge, purchasing emissions rights for sediment will be relatively expensive. The system could tell farmers how much they could save on their permit expenditures, or how many permits they could free up to sell if they fenced off sections of paddocks particularly subject to sediment loss.

That combined system would provide a few advantages.

Places where sediment, nutrient outflow or *E. coli* are relatively easily abated and relatively harmful will be the first to sell rights back into the system. Environmental modelling on its own can explain the effects of changes in practices on environmental outcomes, but not which changes together can provide the most cost-effective way of reducing the environmental burden. The trading system backed by sound environmental modelling harnesses local knowledge about what is possible, rather than requiring Ministry or Council officials to prescribe universal solutions.

Rather than go through contentious processes for new irrigation consents that need to try to weigh potential effects on groundwater,[44] landowners would instead need to purchase permits within a cap-and-trade system that ensures environmental limits are respected.

The burden of getting down to environmental limits can be shared between current emitters – agricultural, residential or industrial – and the Crown. Reductions of grandparented allocations over time would represent current-emitters' share; the Crown's contribution would come through additional buy-back and retirement of rights.

The proportion of reductions that should be borne by the Crown as compared to current emitters is a question of equity – and of political economy. If all the costs of improving water quality fall quickly and sharply on current polluters, the system would be hard-pressed to withstand a change in government. It also makes it harder for tighter standards to be implemented.[45] If all the costs fall on the Crown, taxpayer backlash would risk similar effects. Some cost sharing seems appropriate in building a sustainable system.

A principle of the government's Action for Healthy Waterways programme is that polluters should be the ones who pay to reduce pollution levels;[46] consequently, the Section 32 analysis for the programme rejected providing government funding to achieve those objectives. It also warns that schemes paying polluters not to pollute could backfire.

While true in principle, it is also a question of mechanism design. If the government pays a bounty for possums, it also risks encouraging possum breeding. If it pays for the maintenance of predator-free habitats, it encourages people to eradicate predators.

Christopher Costello and Corbett Grainger emphasise the importance of stakeholder buy-in for the success of environmental trading systems. Allocating emissions rights based purely on historic emissions would not only prevent any existing emitters from being made worse off, but would also reward those whose practices led to the greatest volume of emissions. Costello and Grainger suggest, in the context of fisheries quota, allocation mechanisms blending historic take and merit.[47] Here, providing existing emitters with rights reflecting average emissions for their land type, rather than their own emissions, rewards those who have already made improvements while encouraging everyone to find new ways of reducing the burden on the environment.[48]

Emissions rights will be most expensive where the environmental burden is greatest and so too will be the value that a farm can unlock by freeing up emissions rights for sale back into the system.[49]

Further, the system would automatically create difficult-to-obtain information. The algorithm powering the trading scheme automatically shows important differences across catchments.[50] It might be relatively inexpensive to achieve substantial improvements in water quality in some rivers, while very costly to achieve small gains in others. It would be easier to decide where best to concentrate efforts with a better picture of where further investment could do the most good.

None of this can be implemented quickly. But neither can any of the available long-term options. The Section 32 analysis of options to achieve the government's objectives for healthy waterways warned a pollution tax regime would take many years to develop, as well as face difficulties in setting appropriate pollution charges where effects are diffuse and location-specific.[51] The cap-and-trade system proposed here would also take considerable time to develop and implement and could not reasonably form part of any immediate response in improving freshwater quality. But it could be an important institution for achieving durable improvements over the longer term. And, unlike a pollution tax regime, catchment-level cap-and-trade systems would help discover what levels of pollution charges are appropriate in different locales.

Improving freshwater quality will not be costless. Mitigating environmental harms at the lowest cost enables greater improvements in environmental quality. Initial allocations of emissions rights in a cap-and-trade system facilitate a just transition – selling emissions rights can help ease the burden of shifting to alternative land uses in environmentally sensitive places.

Finally, and where possible, having urban and rural emitters within the same system introduces a fundamental fairness. It is difficult to build support for systems that foist too much of the burden on one sector. Farms that have spent years improving their own environments by changing on-farm practices by fencing off streams, riparian planting and restoring wetlands may rightly be vexed by a central government demanding that farms do more while ignoring leaking urban wastewater systems and highly polluted urban streams. Councils having to purchase emissions credits for the damage they do to waterways may prioritise infrastructure maintenance.

Conclusion

Any government committed to improving New Zealand's freshwater quality over the longer term must consider institutions that can deliver outcomes while withstanding changes in government.

Right now, there is a strong and laudable public appetite for improving freshwater quality. But not much will be achieved if policies aimed at cleaning up our rivers, aquifers, lakes and harbours are less than cost-effective. And if those policies quickly bankrupt farms or raise urban rates to intolerable levels, political pressure would see them eroded or abandoned.

The ship of environmental policy would careen from Scylla's rocks back towards the Charybdis of eutrophic rivers, nitrate-contaminated aquifers, and unswimmable beaches.

Sustaining support for better environmental outcomes does not just require the most cost-effective ways of cleaning up the mess, though that task is onerous on its own. It also requires embedding a just transition towards better practices into the system at the outset rather than as an afterthought.

Cap-and-trade systems have proven effective in managing environmental problems. The system pioneered in Lake Taupō demonstrates how the mechanism can work for dispersed-source pollutants like agricultural emissions. New Zealand can build on this work to develop smarter ways of running cap-and-trade systems, making trading simpler while making environmental bottom-lines an integral part of the system's operation.

By carefully allocating initial emissions permits, the government can help build the support of people subject to the system – a constituency with a vested interest in the course that is set. Future governments wishing to abandon this course would face the ire of those whose emissions rights extend into the future.

Cap-and-trade schemes for managing freshwater abstraction, as discussed in our prior report, and for managing nutrient, sediment and *E. coli* levels, as discussed here, are not just the most cost-efficient ways of refreshing our waterways in the catchments large enough to sustain trading. They are also institutional reforms that quickly become politically durable, ensuring that future governments stay the course. Building them will take time. That work should proceed in parallel to regulatory and voluntary initiatives aimed at improving water quality until the longer term solution is ready.

Endnotes

1 Richard Harman, "National backtracks (slightly) on Collins' hardline on water," *Politik* (27 August 2020).

2 Eric Crampton, "Refreshing Water: Valuing the Priceless" (Wellington: The New Zealand Initiative, 2019).

3 Hawkes Bay Today, "Ngāti Kahungunu joins Ngāi Tahu's claim for shared control of freshwater with the Crown" (4 February 2021).

4 Ministry for the Environment and Statistics New Zealand, "Our Freshwater 2020," Environmental Reporting Series (Wellington: New Zealand Government, 2019), 51.

5 Ministry for the Environment and Statistics New Zealand, "Environment Aotearoa 2019," Environmental Reporting Series (Wellington: New Zealand Government, 2019). The 2017 report by Professor Peter Gluckman, Prime Minister's Chief Science Advisor, similarly demonstrated the variable quality of freshwater, the substantial effects of human activity on that quality, and how that quality is improving in some places. Peter Gluckman, "New Zealand's Fresh Waters: Value, State, Trends and Human Impacts" (Auckland: Office of the Prime Minister's Chief Science Advisor, 2017).

6 These cited reports summarise environmental statistics from a range of background sources. In September 2020, Federated Farmers issued a report, "Our Freshwater 2020: Federated Farmers of New Zealand Analysis & Recommendations" arguing that the summary reports draw from the more worrying of the range of figures available in the background reports. The Ministry's reply of 14 September noted that the Ministry had "chosen and reported the most appropriate data available, but acknowledge that our ability to report effectively on the state of the environment can be improved if we can integrate more extensive and higher quality data and analyses." Any implemented cap and trade system should be based on the best available measures of catchment-level water quality.

7 Mary H. Ward, et al. "Drinking Water Nitrate and Human Health: An Updated Review," *International Journal of Environmental Research and Public Health* 15:7 (2018).

8 Dominic Harris, "Rethink over nitrates as Government orders review into link with cancer," *Stuff* (2 February 2020). In February 2021, the taskforce was reported as having submitted its report to the Ministry of Health. See Farah Hancock, "Drinking water nitrate limit 11 times higher than it should be – Health expert," *Radio New Zealand* (9 February 2021).

9 "Nitrogen" here is the sum of organic (both particulate and dissolved), ammoniacal, nitrate and nitrate nitrogen. A nitrate-only focus too easily leads to poor management.

10 Ministry for the Environment and Statistics New Zealand, "Environment Aotearoa 2019," op. cit. 18.

11 Our Freshwater 2020" aggregates nutrients in comparing urban and other land rather than separately reporting each. It also shows that greater percentages of river length in urban land-cover classes exceed expected natural concentrations of nutrients, turbidity and *E. coli* as compared to rivers in pastoral land-cover classes. Ministry for the Environment and Statistics New Zealand, "Our Freshwater 2020," op. cit. No report for 2021 had been released at time of writing.

12 Joel MacManus, "A 'tsunami of faeces' is overwhelming Wellington's urban streams," *Stuff* (14 February 2020).

13 Belinda Margetts and Winsome Marshall, "Surface Water Quality Monitoring Report for Christchurch City Waterways January – December 2019" (Christchurch City Council, 2020).

14 For example, Robin Martin, "Council should've come clean on huge sewage spill – Mayor," *Radio New Zealand* (30 January 2019).

15 For example, recent sewage contamination of Owhiro Stream was caused by a cross-connection of a wastewater pipe into the stormwater system. Wellington Water, "Ōwhiro Bay water quality," Website. See updates for January 2020.

16 Tess Nichol, "Unswimmable Auckland: The problem with our city's beaches," *Metro* (13 February 2020).

17 Charlie Mitchell, "Improving lake to national standard would have 'severe social and economic' consequences," *Stuff* (9 August 2017).

18 Julia Talbot-Jones, "Improvements to the National Direction for Freshwater: Submission to the Ministry for the Environment" (Wellington: Victoria University of Wellington and Motu Economic and Public Policy Research, 2019).

19 Graeme Doole, "Economic Impacts of the Essential Freshwater Proposals on New Zealand Dairy Farms," Report prepared for DairyNZ (Hamilton: 2019).

20 Ian Harrison, "False and Misleading? A Review of the Cost Benefit Assessment of 'Action for Healthy Waterways'" (Tailrisk Economics, 2020). Harrison confirms that the work was undertaken pro-bono rather than as consultancy for industry.

21 Those costs may yet be lifted from councils, along with billions of dollars in piped infrastructure assets, as part of the government's proposed amalgamated water structures.

22 Rachel Thomas, "More than 100 wastewater treatment plants breaching consent," *Radio New Zealand News* (24 August 2020).

23 Gordon Tullock, "The Transitional Gains Trap," *Bell Journal of Economics* 6:2 (1975), 671–678.

24 See Arthur Grimes and Andrew Aitken, "Water, Water Somewhere: The Value of Water in a Drought-Prone Farming Region," Motu Working Paper 08-10 (2008).

25 Lois Williams, "Compensation ruled out for West Coast land reclassified significant natural areas," *Stuff* (12 February 2020).

26 Mike Joy notes vast differences in resource expenditure in reducing nitrate flow into different freshwater catchments. In Rotorua and Taupō, he estimates that taxpayers contribute $40 million to reduce nitrate flow into the lake by 100 tonnes, but government has been unwilling to invest in projects like wetlands to protect Lake Ellesmere that could cost rather less per tonne. See Mike Joy, "Polluted waterways – Why are we subsidising environmental harm?" *Radio New Zealand* (9 April 2021).

27 Robin Martin, "Council should've come clean on huge sewage spill – Mayor," op. cit.

28 Controller and Auditor General, "Reflecting on Our Work About Water Management" (2020). See discussion at 2.13.

29 Martin Weitzman, "Prices vs. Quantities," *The Review of Economic Studies* 41:4 (1974), 477–491.

30 Eric Crampton, "Refreshing Water and Valuing the Priceless: New Zealand's Freshwater Allocation System Has Run Its Course," *Policy Quarterly* 15:3 (2019), 62–69.

31 Suzie Greenhalgh and Suzi Kerr, "The Taupo Nitrogen Market: The World's Only Diffuse Source Trading Programme," Motu Note 20 (2015).

32 Madeline Duhon, Hugh McDonald and Suzi Kerr, "Nitrogen Trading in Lake Taupo: An Analysis and Evaluation of an Innovative Water Management Policy," Motu Working Paper 15-07 (2015). Note that Overseer focuses on nitrate emissions; other emissions can be more important in different places.

33 Waikato Regional Council, "Nitrogen sourcing and trading in the Lake Taupo catchment," Website.

34 Anne Spicer, "Assessing the Consequences of the Lake Taupo Nitrogen Trading Programme in New Zealand, Using a Landscape Approach," PhD Thesis, Lincoln University (2017). The work was expanded in Anne Spicer, Simon Swaffield and Kevin Moore, "Agricultural Land Use Management Responses to a Cap and Trade Regime for Water Quality in Lake Taupo Catchment, New Zealand," *Land Use Policy* 102:1 (2021).

35 See discussion in Terry L. Anderson, Brandon Scarborough and Lawrence R. Watson, *Tapping Water Markets* (New York: Routledge, 2012). Chapter 8 is on-point, with discussion at 119–127.

36 Mindy Selman, et al. "Water Quality Trading Programs: An International Overview," *World Resources Institute Issue Brief* (2009).

37 Ernie Niemi, Kristin Lee and Tatiana Raterman, "Net Economic Benefits of Using Ecosystem Restoration to Meet Stream Temperature Objectives," Proceedings of the Water Environment Federation 9 (2007), 611–619. Cited in Terry L. Anderson, et al. *Tapping Water Markets*, op. cit.

38 Terry L. Anderson, et al. *Tapping Water Markets*, op. cit.

39 Ibid. 125.

40 Environmental Protection Agency, "EPA Water Quality Trading Evaluation: Final Report" (2008).

41 Miami Conservancy District, "Water quality credit trading program: A common sense approach to reducing nutrients," Factsheet (2017).

42 In 2017, Lincoln University's research farm demonstrated that reduced stocking rates, slower grazing rounds, and more efficient nitrogen fertiliser use could reduce nitrate leaching by up to 30% while maintaining farm profitability. See *Stuff*, "Demonstration dairy farm cuts nitrate leaching 30 per cent and stays profitable" (21 September 2017). DairyNZ's Pastoral 21 programme has also shown promise in substantially reducing nitrate leaching. See DairyNZ, "More profit, smaller footprint," *Inside Dairy* (Hamilton: February 2020).

43 Clint W.F. Rissmann, et al. "A Hydrochemically Guided Landscape Classification System for Modelling Spatial Variation in Multiple Water Quality Indices: Process-Attribute Mapping," *Science of the Total Environment* 672 (2019), 815–833.

44 Large projects can be highly contentious. See David Williams, "Uncomfortable truth for big irrigation consent," *Newsroom* (10 April 2021).

45 Mike Joy, for example, criticised the government's Action for Healthy Waterways programme for not including measurable limits on key nutrients. See Mike Joy, "New Zealand government ignores expert advice in its plan to improve water quality in rivers and lakes," Press release, Greenpeace (29 May 2020).

46 Harrison Grierson, "Action for Healthy Waterways Section 32 Evaluation" (Wellington: Ministry for the Environment, 2020). See discussion at 30.

47 Christopher Costello and Corbett Grainger, "Grandfathering by Merit," Chapter 8, in Christopher Costello (ed.), "Distributional Effects of Environmental Markets: Insights and Solutions from Economics," PERC Policy Report (2019), 57–63.

48 Allocating initial emissions permits to properties based on those properties' historic emissions provides windfall gains to those farms that have failed to improve practice and consequently have greater opportunity to make further reductions. Allocations reflecting average emissions would require farms with greater than average emissions to reduce or purchase additional emissions credits.

49 A further but trickier allocation problem remains, but is a problem inherent in any system that seeks to reduce the total loading on a catchment that is at or near its environmental limits. In catchments at their limits, those who first converted from pastoral agriculture to irrigated dairying are locked-in as winners under any system that effectively grandparents existing uses. Frequently, Māori-held land has been disadvantaged by these processes as difficulty in effecting land use changes for land under multiple ownership meant that land was at the back of the queue for dairy conversions, and could be too late to receive an irrigation consent in fully allocated catchments. Every system capping total emissions, or capping total water take, will face this problem – not just trading schemes. Regulatory systems requiring consents for new conversions stymies land use change and locks in existing uses. Trading schemes, at least, make it possible to effect efficient changes in land use while respecting environmental limits.

50 See discussion of dual prices in John F. Raffensperger and Mark W. Milke, *Smart Markets for Water Resources: A Manual for Implementation* (Springer, 2017), 48. Put briefly, each constraint in the system (like caps on river nutrient levels) has an associated parameter that is estimated during the optimisation. Inverting the value of that parameter provides an estimate of the value of small changes in that constraint. A 10% tightening of the cap on nitrogen might be more expensive in one river than a 60% tightening of the nitrogen cap on another river. If the first river has particularly strong cultural or recreational value, it could still be worth prioritising improvement in the first river over the second. Having information about relative costs makes trade-offs possible.

51 Harrison Grierson, "Action for Healthy Waterways Section 32 Evaluation," op. cit.

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The most comprehensive recent analysis of water quality in NZ made it clear that diffuse pollution from intensive farming is the biggest issue for our freshwaters.

> *"The greatest negative impact on river water quality in NZ in recent decades has been high-producing pastures that require large amounts of fertiliser to support high densities of livestock"*
>
> Julian, J.P., de Beurs, K.M., Owsley, B., Davies-Colley, R.J., and Ausseil, A.G.E. (2017). "River water quality changes in New Zealand over 26 years: response to land use intensity." *Hydrology and Earth System Sciences* 21(2), 1149-1171.

This occurred through the failure to limit intensification and the inevitable increase in diffuse pollution by central and local government. As a result, this failure has resulted in the right to pollute freshwaters becoming a property right. This assumed right to pollute has now become a significant component of dairy farm property values in intensively farmed parts of the country. There is now considerable debt accrued by farmers based on the capitalisation of the right to pollute reflected in land values. This means a legislative response to reduce the harm will mean a significant economic loss to landowners so it is very unlikely any government will apply any meaningful limits.

Therefore, I see some kind of cap and buy back scheme as the only approach that will work to limit freshwater pollution. This is based on my experience that the only net improvement in nitrate pollution reduction I have seen occur thus far, has been the Lake Taupo and Rotorua catchments after nitrogen buy-backs.

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$25.00

ISBN
978-0-9951311-8-7 (print)
978-0-9951311-9-4 (online)

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