SQUANDERED

THE DEGRADATION OF NEW ZEALAND'S FRESHWATERS

Dr Mike Joy

Dedicated to all the parents who grew up in swimable rivers

Figure 1*. Pristine New Zealand in advertisements.*

Introduction

The first New Zealanders inherited a stunningly beautiful, physically and biologically diverse and unique South Pacific paradise. To see a reminder and proof of this you can still find it in our National Parks, and much of the Conservation Estate *(Figures 1 and 2)*.

These pristine protected places are spiritually, culturally and aesthetically very important to many New Zealanders, who, like me, grew up believing that living here made us the luckiest people in the world. I felt so privileged to be born in New Zealand, where we had a feeling of security from the environmental ravages happening in the rest of the so-called developed world.

I can describe how much it meant to me but I can't begin to express the huge cultural and resource significance of healthy ecosystems to Māori. The best I can do to portray this is to quote a proverb from the Whanganui River iwi:
'Ko au te awa, ko te awa ko au' (I am the river and the river is me).

Figure 2. *An example of a pristine New Zealand river: the Mokihinui River, North Westland.*

Unfortunately, the impacts of the environmental degradation I will outline in this book are not shared evenly by all New Zealanders. For many, the idyllic remaining protected places are rarely if ever seen except on a screen, as many cannot afford to visit National Parks. Worse, where the low income majority of New Zealanders' live, conditions are completely different. Generally, they live where the impacts accumulate: in the lowland rivers and lakes, estuaries, and harbours that are now degraded and mostly unusable for food gathering or recreation.

Ironically, the economic elite are insulated from this loss of recreation, food and spiritual nourishment; they rarely have to see the degradation as they can afford to drive and fly to pristine New Zealand or overseas and never have to face this reality. However, for the poor, the ability to get food from rivers and harbours is important for survival, and thus their loss is far worse.

In 2013 Sir Edward Thomas[1] described the negative impacts of neo-liberalisation on New Zealand both socially and economically, and I was struck by how this has been paralleled in what has happened environmentally, the same movement of resources from all to a select few – private gain through public loss.

1. http://www.brucejesson.com/?page_id=349

In this book I want to try and show how in the last few decades' environmental protection was deregulated, allowing a few to profit by polluting on a massive scale and how that has led to the destruction we see today. I want to show also how this reality is denied and covered-up so that relatively few are aware of the full extent of the damage.

Notwithstanding these attempts by industry and government to obscure the harsh reality, some truth is obviously getting through, because when New Zealanders are polled the majority rate freshwater degradation as their biggest worry as every year this becomes more important to New Zealanders[2].

To begin to understand and appreciate the environmental situation in New Zealand, one must see the magnitude of the transformation the country went through over the last century. The scale of change is incredible; for an example, the 'before and after' maps in figures 3 and 4 show vividly the dramatic change wrought on forests and wetlands in the Manawatu. The pictures show graphically the loss of nearly 99% of the Manawatu's wetlands, from around one third of the region to almost nothing now.

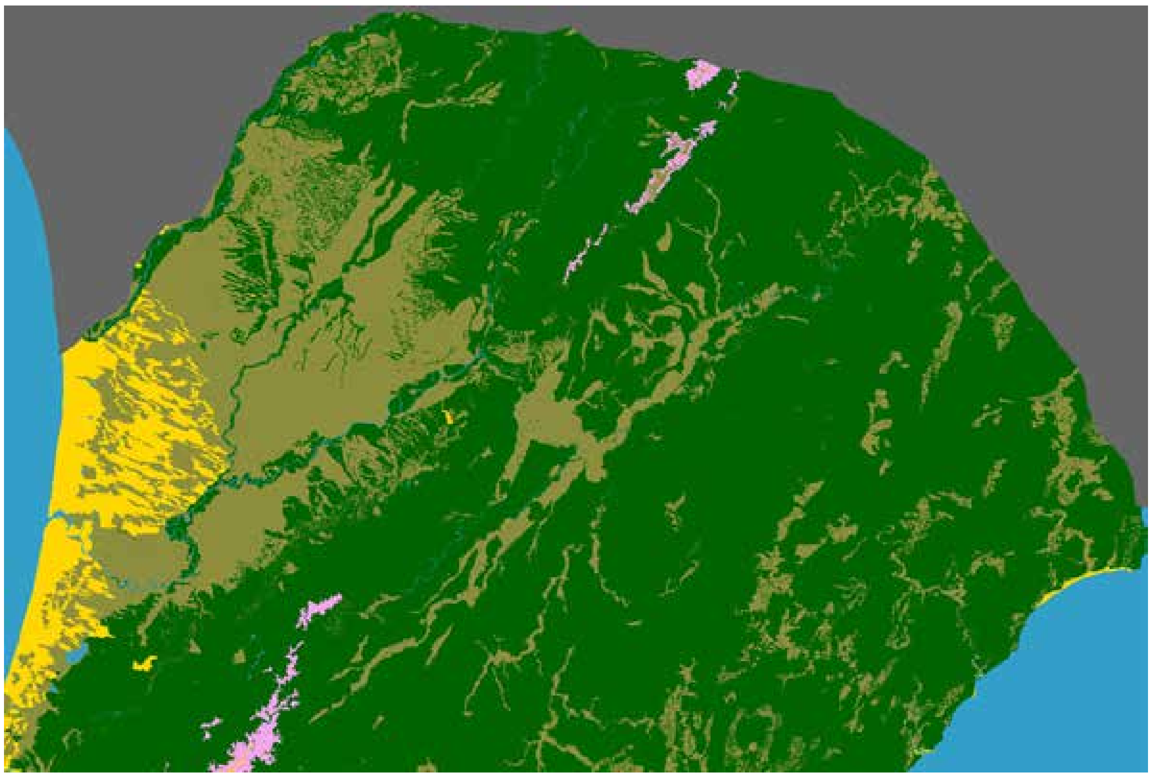
Ecologist Geoff Park summed up the impacts and extent of this change when describing New Zealand's loss of lowland wetland ecosystems when he said **"… in no other kind of ecosystem has the elimination of indigenous biodiversity been so comprehensive"**[3]. Moreover, it's not just the loss of habitat for fish and birds, and of beautiful places, but the loss of an incredibly productive ecosystem to be replaced by one of much lower productivity. The value to all New Zealanders of intact wetlands is immense; wetlands are the kidneys of our waterways, and their value as filters, bio-accumulators, and flood energy dissipaters is almost immeasurable.

---

2. Hughey, K.F.D., Kerr, G.N. and Cullen, R. 2013. Public Perceptions of New Zealand's Environment: 2013. EOS Ecology, Christchurch. vi+115 pp. ISSN 2230-4967

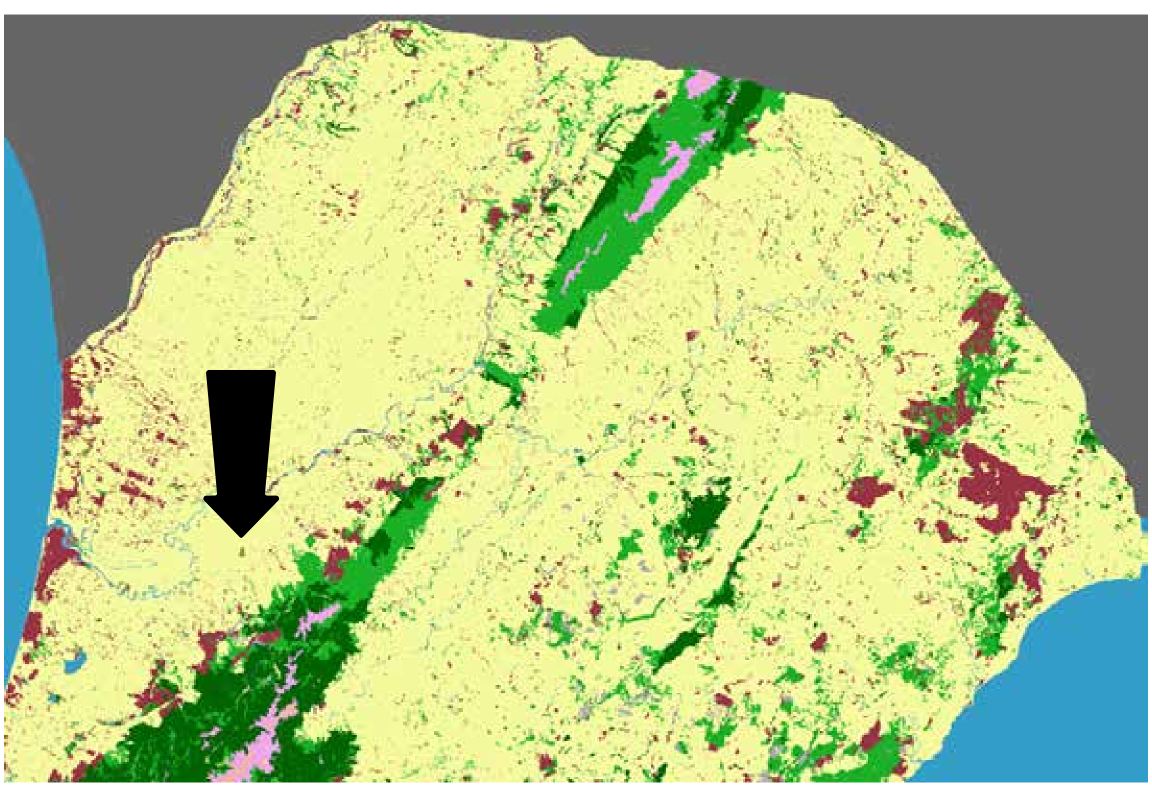
3. Park, Geoff. Nga Uruoa; The Groves of Life – Ecology & History in a New Zealand Landscape

Figure 3. Manawatu before human arrival



There were just three vegetation types. Green is indigenous forest; olive green is wetlands and yellow is dunelands.

Figure 4. Manawatu now



The dominant beige colour is pastoral farmland, dark green is indigenous forest, light green is scrub and purple is exotic forest. The black arrow points to the remaining wetlands.

Courtesy of Dymond J and Aussiel AG – Landcare Research

To Māori, wetlands were vital to their existence. Fundamentally they were the larder. As freshwater ecologist and fish biologist Bob McDowall put it in his book Ikiwai: **"although for Maori [wetlands] were priceless assets – rich, self-renewing sources of food and fibre, to Pakeha they were something useless to turn into excellent farmland"**[4].

If the cultural, aesthetic and recreational values of this loss aren't convincing enough, then the economic argument is overwhelming. For example, the Manawatu wetlands that were destroyed in 200 years have been valued at more than $40,000 per hectare per year[5]. This is their monetary value if you were to replace the services existing wetlands give with services like nutrient stripping, mitigating flood impacts, water storage and much more. As a stark comparison the best you could expect from a dairy farm would be $3,000 per hectare per year. Now wetlands are being created at great expense all over New Zealand to take nutrients from freshwaters, a service once provided for free.

To give these number some international perspective, recent work by Robert Costanza revealed that the value of global ecosystem services in 2011 was $125 trillion/yr[6], up from 33 trillion in 1994[7], and the loss of eco-services from 1997 to 2011 due to land use change was US $4.3–20.2 trillion/yr. These numbers highlight the inadequacy of our accounting systems that we call our 'economy'. Crucially, as long as we keep ignoring the value of healthy ecosystems, the longer we will destroy and devalue them.

---

4. R. M. McDowall, Ikawai: Freshwater Fishes in Māori Culture and Economy, Canterbury University Press, Christchurch, 2011, 832 pp, ISBN 978-1-877257-86-5

5. http://www.waikatoriver.org.nz/wp-content/uploads/2014/09/32-Non-Market-Values.pdf

6. Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S., Kubiszeqski, I., Farber, S., Turner, R. (2014). Changes in the global value of ecosystem services. Global Environmental Change, 26, 152-158.

7. Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van der Belt, M. (1997). The value of the world's ecosystem services and natural capital. Nature, 387, 253-260.

Figure 5. *Excess nutrients cause growths of algal mats like this from the Oroua River*

ASSET STRIPPING

Intact healthy ecosystems are our national assets, just as much as or more so than power companies or museums, but we have been stripping them for a long time. We have removed more than 70% of our indigenous vegetation and this loss is not just historic, we are still losing it fast. The loss of native habitat in agricultural land in the last sixty years has been extensive, for example, in 1950 53% of agricultural land was covered in indigenous vegetation and that has shrunk to less than 8% now[8]. When we look at ecosystems, the numbers reveal the extent of the changes with now more than two-thirds of New Zealand ecosystems listed as threatened[9].

---

8. Moller, H., C. J. MacLeod, J. Haggerty, C. Rosin, G. Blackwell, C. Perley, S. Meadows, F. Weller, and M. Gradwohl. (2008). Intensification of New Zealand agriculture: implications for biodiversity. New Zealand Journal of Agricultural Research

9. Walker, S., Price, R., Rutledge, D., Stephens, T., Lee, W.G. (2006) Recent loss of indigenous cover in New Zealand, Available on-line at: http://www.nzes.org.nz/nzje

Figure 6. *Algal mats in the Matakana River*

Freshwater assets

Our freshwater assets are clean healthy functioning freshwater ecosystems. The asset stripping of freshwaters has been through the:

- Removal of wetlands and their crucial functions
- Pollution of lakes, rivers and groundwaters with nutrients, sediment and pathogens
- Removal of water from rivers
- Use of rivers as dumping grounds for industrial and municipal waste
- Physical impacts on rivers of damming and stop-banking

NUTRIENTS

The impacts of nutrients on freshwater biodiversity and health are secondary. It's not the nutrients (mainly nitrogen and phosphate) *per se* that are problematic, rather the secondary changes in ecosystem processes these nutrients cause. Rivers respond to nutrients the way your lawn would if you piled on fertiliser, they cause abundant plant growth. For rivers, the plants are algae and they bloom. You may have seen it – mats of slimy growth on river beds like in figures 5 and 6, and soupy green smelly water in slow moving parts of the river.

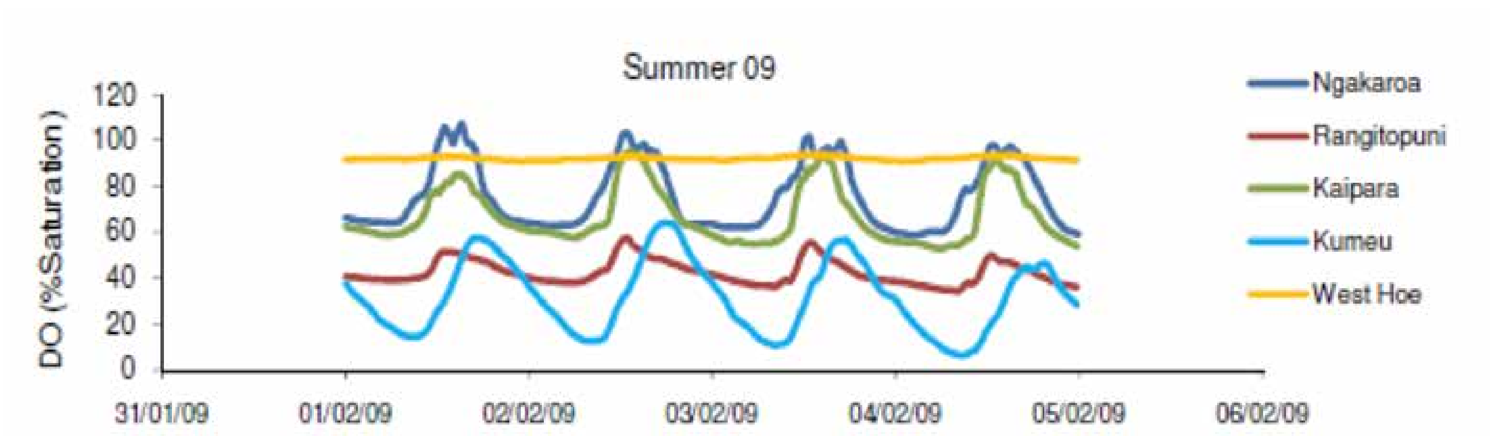


Figure 7. *Dissolved oxygen levels in some Auckland Streams*

Like all plants, the algae photosynthesise – they take up oxygen at night and produce it during the day as they respire, so too much nutrient causes huge daily swings in oxygen as shown in a number of Auckland streams in Figure 7. The oxygen levels peak in late afternoon around 3pm and the lowest points are in the early morning around 3am.

In contrast, a healthy stream has constant oxygen (the West-Hoe Stream), but as they become more enriched with nutrients and the algal/plant life blooms, then the more it fluctuates. These changes are harmful and eventually lethal for the river ecology, making it impossible for fish and insects to live except for a few hardy species who can gulp oxygen off the surface like goldfish in a bowl. Plus the bed substrate becomes coated with the algal mats, restricting food and habitat availability for stream life. The changes caused by the excess nutrient driven growth makes the stream unattractive for bathers and fishermen as well.

Aerial view of Canterbury New Zealand

The national water quality situation

For New Zealand freshwaters, the dire and deteriorating state of water quality is clear. There are obvious worsening nutrient, pathogen and sediment impacts, especially in the intensively farmed and urban areas of New Zealand. The following maps showing the state of water quality from NIWA modelling reveal the spatial extent of the issues and the problem areas[10]. The rivers are represented by lines and the colours show the predicted levels from the sample sites (black dots). These predictions fill in the gaps between the sample sites. The models have all been validated and are very accurate – that is they match reality well. The hotter colours on the maps (oranges and reds) represent levels exceeding guideline pollution levels.

10. *Unwin, M. J., & Larned, S. T. (2013). Statistical models, indicators and trend analyses for reporting national-scale river water quality) (NEMAR Phase 3). NIWA.*

The modelling by NIWA shows clearly that total nitrogen and nitrate nitrogen exceed guideline levels in most lowland areas in farming catchments. The following trend graphs show that the proportion of sites exceeding the threshold for total nitrogen that would trigger nuisance algal growth has been increasing over the last two decades.

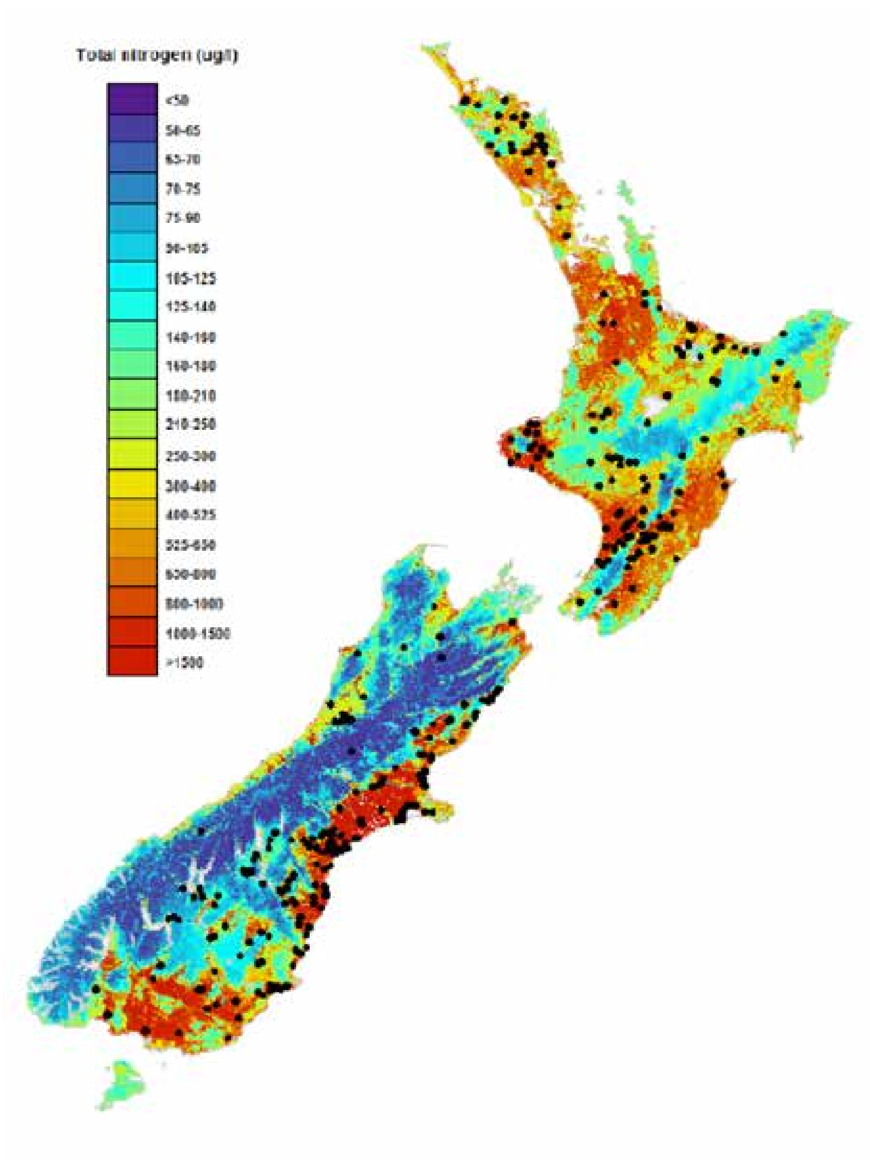


__Figure 8.__ Modelled current state total nitrogen for New Zealand rivers. The ANZECC guideline value is 660 so all rivers dark orange or red exceed guidelines for triggering nuisance algal growth.[10]

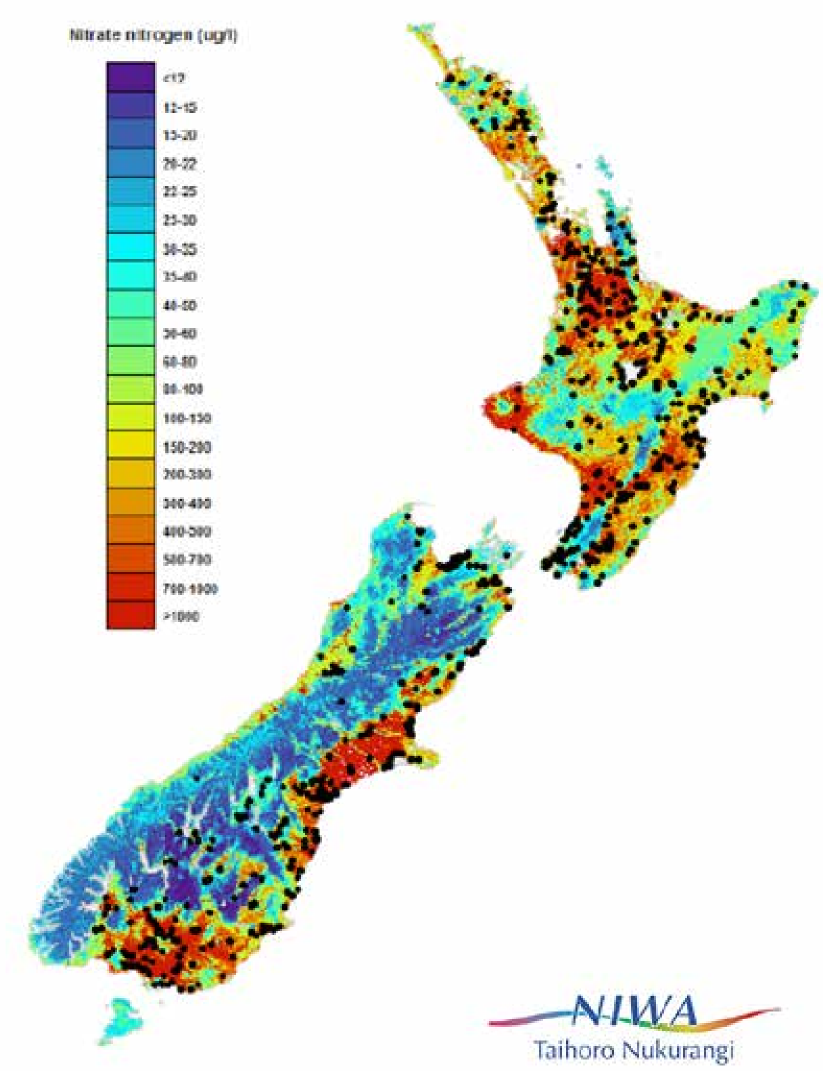


__Figure 9.__ Modelled current state nitrate nitrogen for New Zealand rivers. The ANZECC guideline value is 440 so all rivers dark orange or red exceed guidelines for triggering nuisance algal growth.[10]

Looking at the trends over time in the large regional council database of sites, it is clear that nitrogen in rivers has been increasing (over the last 24 years that records have been kept) and that the levels at sites in pasture catchments far exceed the levels at sites in native vegetation.

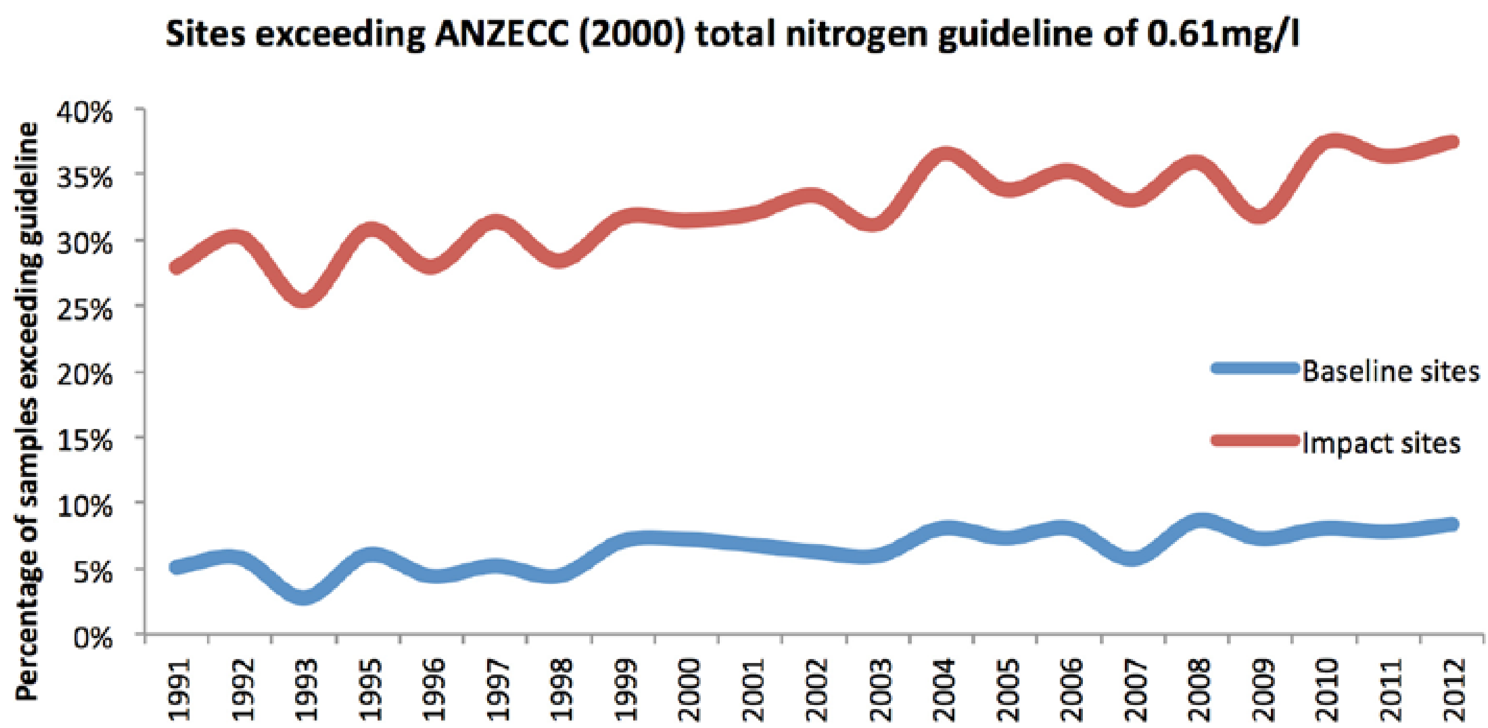


Figure 10. *This graph shows the trends over the last 20 years for total nitrogen at the National River Water Quality Network (NRWQN) which monitors 77 sites throughout New Zealand. The red line shows the number of impact sites (sites impacted by development) exceeding the ANZECC guideline of 0.66 mg/l. In 1990 around 27% of sites exceeded the limit and by 2012 around 37% exceeded. The baseline sites are those in catchments with little or no development. In 1990 around 5% exceeded the limit and by 2012 it was close to 8%.*

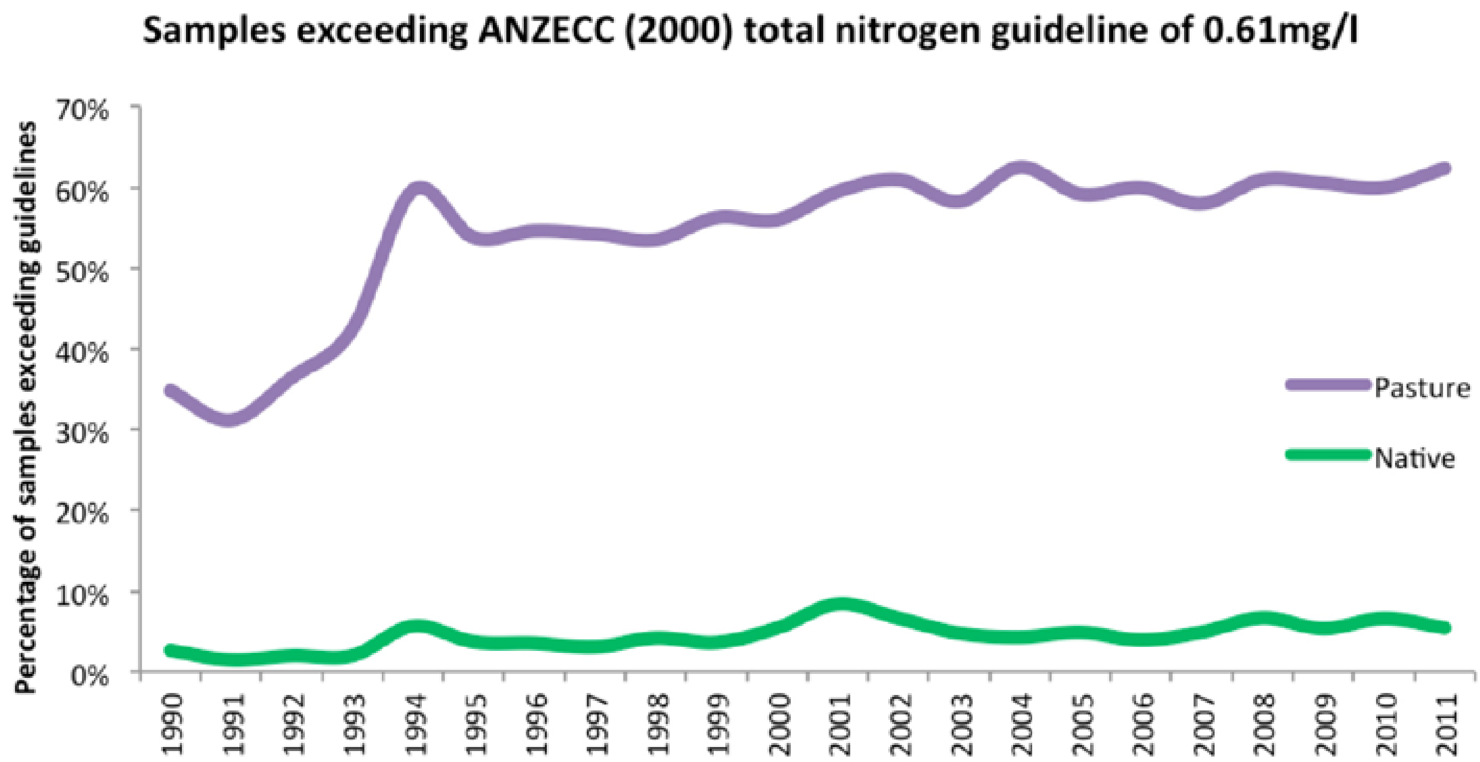


Figure 11. *This plot shows the proportion of samples from the approximately 300 sites from around the country sampled by Regional Councils that exceed the ANZECC total nitrogen guidelines for the two main land cover classes – native vegetation and pasture.*

As with nitrogen, the modelling by NIWA shows clearly that phosphorus exceeds guideline levels in most lowland areas in farming catchments; the notable difference from nitrogen is North Canterbury where phosphorus levels are lower. The trend graph show that the proportion of sites exceeding the threshold for phosphorus that would trigger nuisance algal growth has been decreasing since the mid-1990s. Looking at the trends over time it is clear that phosphorus has been declining over all sites since peaks in the middle nineteen nineties *(Figure 13)*.

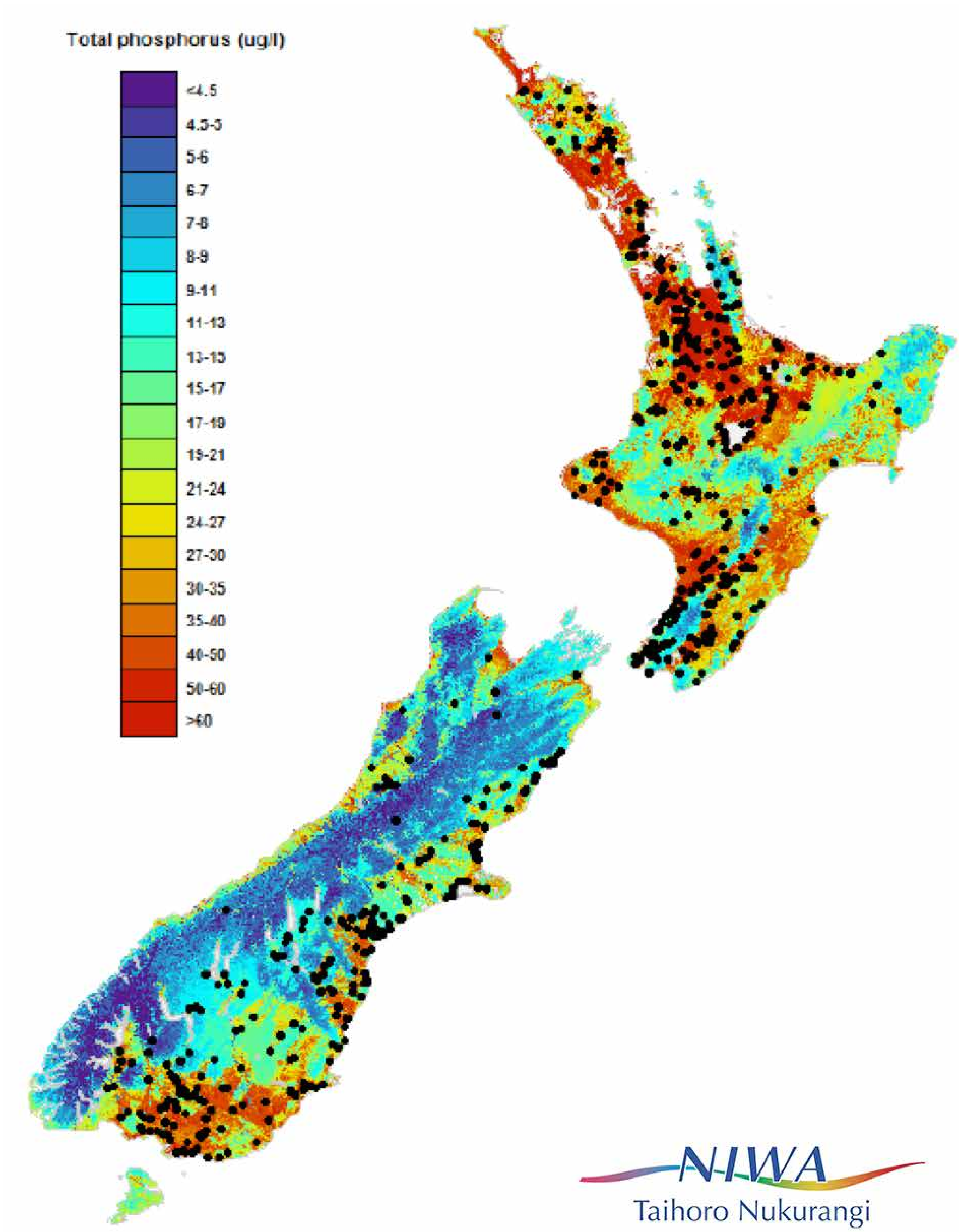


Figure 12. *Modelled current state of phosphorus for New Zealand rivers. The ANZECC guideline value is 33µg/l so all rivers dark orange or red exceed guidelines for triggering nuisance algal growth.*[10]

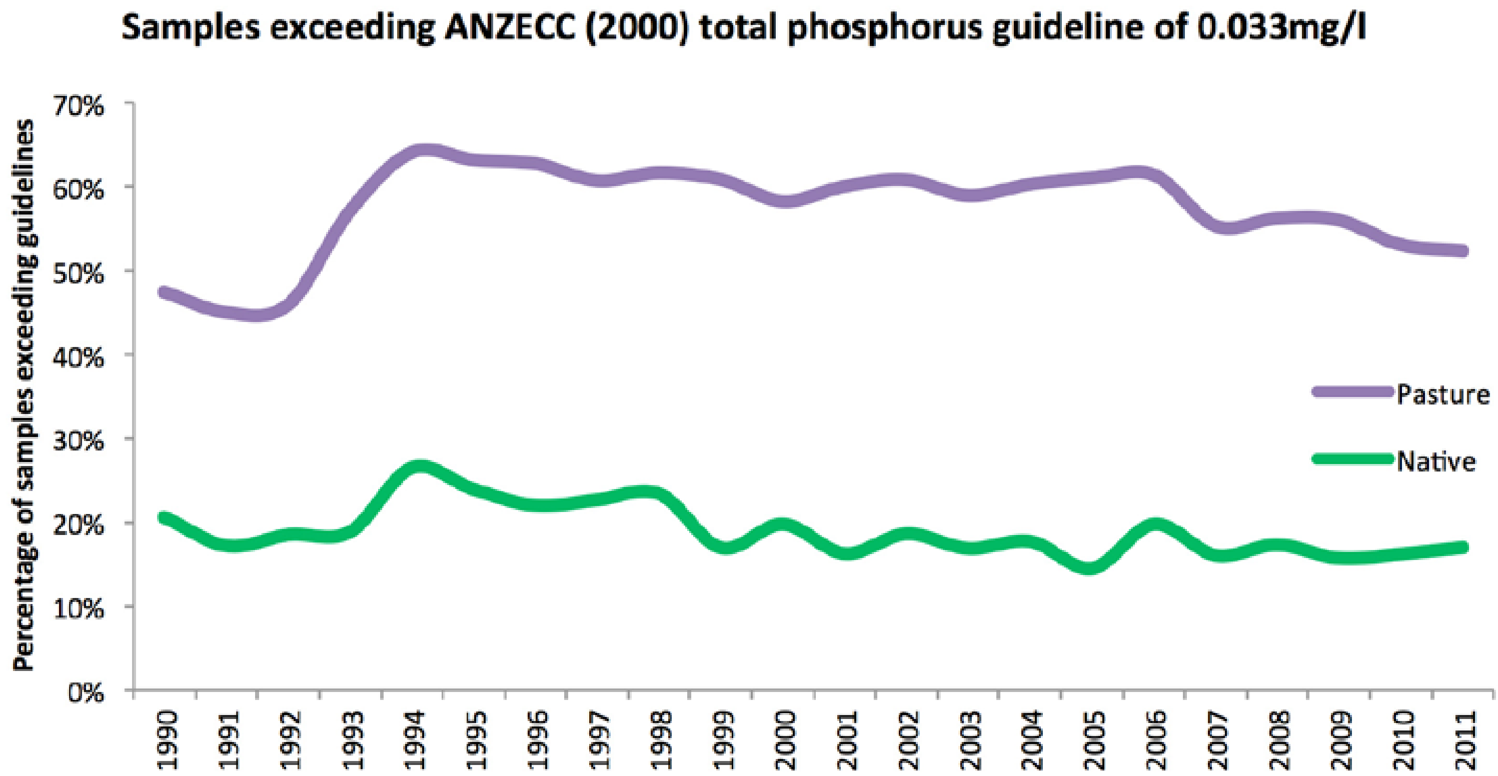


Figure 13. *This plot shows the proportion of samples from the approximately 300 sites from around the country sampled by Regional Councils that exceed the ANZECC total phosphorus guidelines for the two main land cover classes.*

BIOASSESSMENT

The life in the stream is the best measure of the health of waterways and stream invertebrates are great indicators as they integrate all the process and chemistry of the ecosystems. Invertebrates have lifecycles of many months or years so they reflect the health of freshwater ecosystems much better than the one-off chemical samples. The Macroinvertebrate community index (MCI) is a commonly used measure of organic enrichment based on the response of the individual species to increasing nutrient levels.

The modelled MCI scores in the following graphic clearly show the areas with polluted waterways in New Zealand; these areas are mainly located in lowland New Zealand where intensive agriculture occurs. However, the West Coast of the South Island, the East Coast around East Cape, and the Coromandel Peninsular show that high scores do exist in lowlands without development.

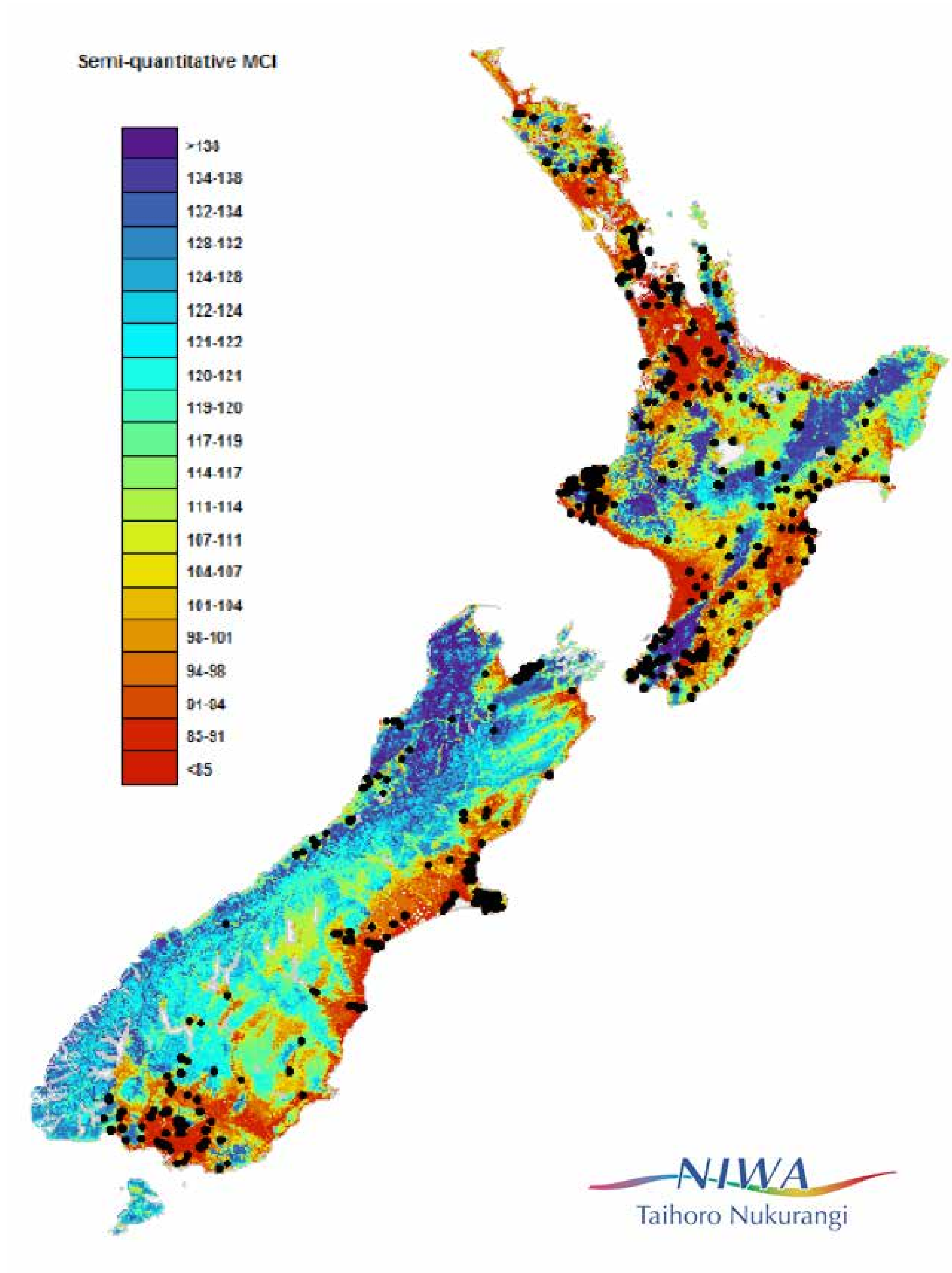


Figure 14. *Modelled current state for the Macroinvertebrate Community Index. A score of < 80 is severely polluted, and 80 -100 is moderately polluted, 100 – 120 is doubtful water quality and > 120 is healthy. Accordingly, dark orange and red waterways are severely or moderately polluted.*[10]

LAKES

The statistics for lake impacts show the impact of excess nutrients with 44% of monitored lakes being so polluted by nutrients they are now classed as 'eutrophic': that is they have more nutrient than they can assimilate so they have 'flipped' to another trophic state, thus they are now eutrophic or worse[11]. As with rivers, the impacts of nutrients and sediment excesses are many but include: toxic bacterial blooms (planktonic rather than on the substrate as in rivers) and pathogen increases affecting human health; and ecosystem impacts like weed and algal blooms, oxygen depleted dead zones, and much more. Notably most of these eutrophic lakes are in lowland areas, 64% are in pasture catchments. While 43% of monitored lakes are healthy, notably, nearly all of these are in alpine or conservation catchments[10].

GROUNDWATER

Groundwaters in developed catchments are all undergoing degradation with nitrate levels rising at 39% of monitored sites and groundwater pathogen levels exceeding human drinking standards at 21% of monitored sites[12]. A large proportion of drinking water in New Zealand is sourced from groundwater but the majority of private bores are not tested so this statistic is likely to be an underestimate.

HUMAN HEALTH

Human health issues associated with freshwaters are generally from faecal contamination as well as zoonoses like cryptosporidium, and toxic algae and cyanobacteria. New Zealand has ominous freshwater human health issues with rates of waterborne disease; the Ministry of Health estimates show that 18-34 thousand New Zealanders contract waterborne diseases every year[13]. While not all these cases will come from bathing, the Ministry says that these numbers are an underestimate as many cases are not reported. New Zealand now has the invidious statistic of the highest global per-capita frequency of the zoonoses coliform enteritis, campylobacteriosis, cryptosporidiosis and salmonellosis.

---

11. Verburg, P., Hamill, K., Unwin, M., & Abell, J. (2010). Lake water quality in New Zealand 2010: Status and trends. NIWA.

12. Daughney, C. J. and M. Wall. 2007. Groundwater quality in New Zealand: State and trends 1995-2006. GNS Science Consultancy Report 2007/23

13. Ball, A. 2006. Estimation of the burden of water-borne disease in New Zealand: preliminary report. Prepared as part of a Ministry of Health Contract for scientific services by ESR, Wellington

Figure 15. *This photo is the Manawatu River bed near Palmerston North city showing black felt like mats of cyano-bacteria.*

Benthic cyanobacteria mats like those in the photo from the Manawatu River *(Figure 15)* can become toxic and there are instances around New Zealand where dogs and horses have died drinking river water and licking these mats. It seems it will only be a matter of time before a child dies after ingesting some of this.

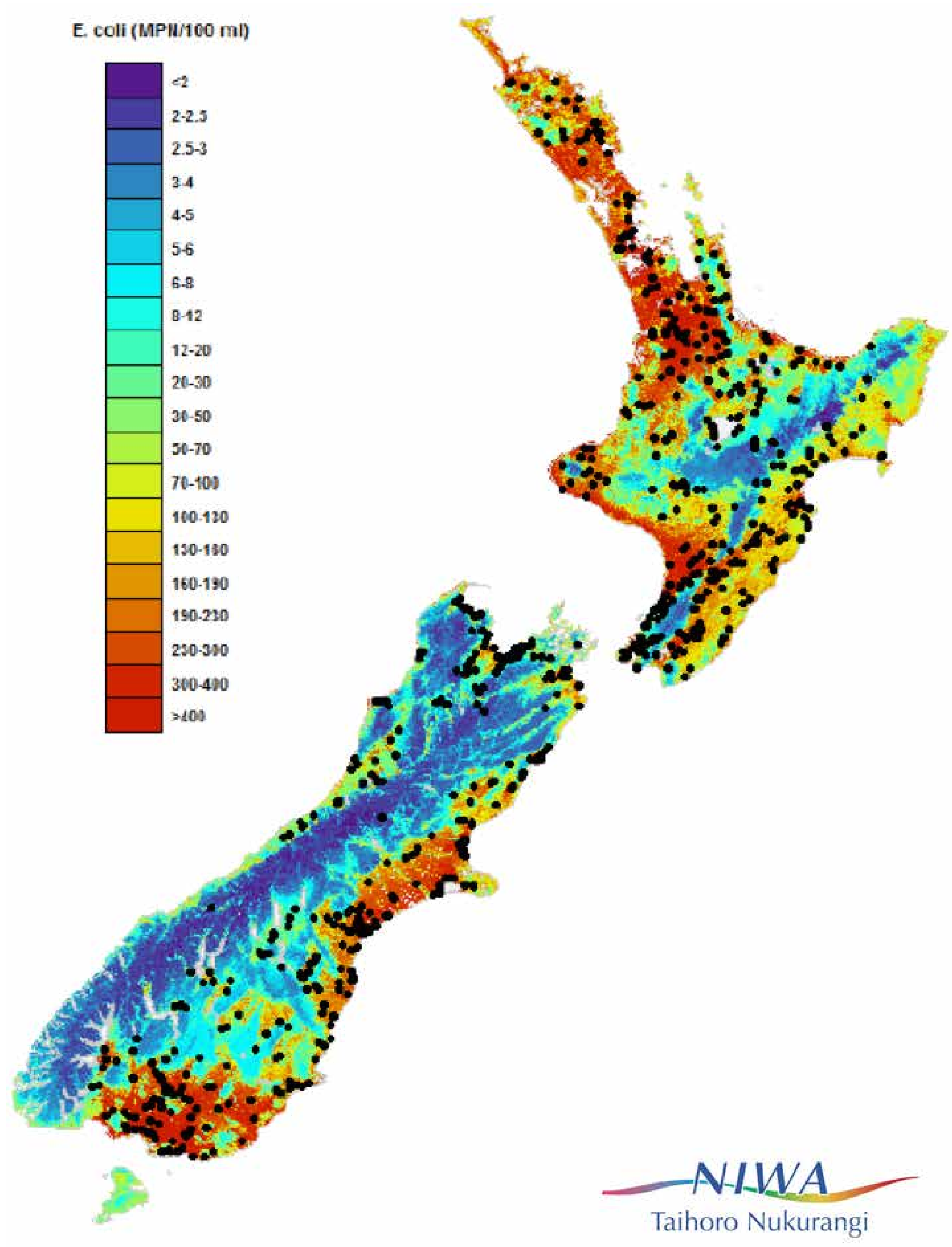


Figure 16. *Current state E. coli (faecal pathogen indicator) distribution. The ministry of Health guideline level for contact recreation is 260 MPN/ml so all dark orange and red waterways are unsafe to swim in[10].*

The latest modelling of the levels of E. coli (the indicator faecal contamination organism) done by NIWA shows the contact recreation standard is exceeded at 62% of all water bodies in New Zealand[14] making in dangerous to swim at these sites. That means 62% of all water bodies would fail 95th percentile levels, or in other words of these sites 95% would fail to meet the standard. The map in figure 16 shows clearly that again the worst areas for faecal contamination are in the intensively farmed and lowland urban areas where impacts accumulate.

14. *Draft Regulatory Impact Statement: Proposed amendments to the National Policy Statement for Freshwater Management 2011 NIWA.*

Part of the Manukau Harbour

SEDIMENTATION

Sedimentation of waterways has both ecological and economic impacts on freshwaters but also it represents a major asset loss. The loss of soil, one of our most valuable assets and with it carbon storage, is nothing short of environmental vandalism. The sediment lost from land then goes onto have many impacts on freshwater. I will briefly describe first the physical impacts and then the biological.

When excess sediment is continually deposited in rivers it builds up the beds so they become higher than the surrounding land. This requires stop-banking all the way to the sea, but then the tributary rivers must have flap gates to stop the main river flowing back on the plains. When these flap gates close as the main river rises the tributaries must be pumped over the banks; there are huge energy costs to achieve this. The ongoing future costs of this type of management of rivers will become astronomical.

Sediment impacts on stream ecology in many ways. One is in the form of suspended sediment (dirty brown water). While discoloured water reduces feeding opportunities for fish and effects ecosystem processes through reduced light penetration, the biggest impact is the loss of habitat through sediment deposition. This is because most New Zealand fish are benthic (that means they live resting on the bottom of the river, as opposed to pelagic which is swimming in the current off the bed), and research including ours[15] has shown some spend a considerable proportion of their time in the substrate below the stream bed. This use of the gaps between rocks and boulders (interstitial spaces) in the stream bed makes them very susceptible to sediment build-up because deposited sediment fills the interstitial spaces where they live, thus, severely reducing the amount of available habitat. Many New Zealand streams are now impacted by the extent of deposition of fine sediment, drastically reducing the number of individuals that can occupy any given stretch of river.

The sediment impacts don't end in rivers. The sediment eventually makes its way into harbours and estuaries and now most are so choked with sediment from land-use change that ecosystem level changes have occurred, altering vegetation patterns and oxygen variation. The sediment and nutrients have led to many impacts on these crucial nursery areas for many oceanic fish species, many of these are commercially harvested species for example snapper now have a severely reduced nursery range due to smothering of eel-grass in nursery areas.[16]

---

15. McEwan, A. J. and M. K. Joy. (2014). Diel habitat use of two sympatric galaxiid fishes (Galaxias brevipinnis and G-postvectis) at two spatial scales in a small upland stream in Manawatu, New Zealand. Environmental Biology of Fishes 97:897-907.

16. Morrison, M. A., M. Lowe, D. Parson, N. Usmar, and I. McLeod. (2008). A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand. Report, NIWA, Auckland.

Banded kokopu (Galaxias fasciatus) Motuihe Island

BIODIVERSITY

All the impacts described so far plus many more I don't have time to discuss, including exotic species introduction, have had a major impact on biodiversity. Tellingly, New Zealand now has the highest proportion of threatened and at risk species globally[17]. Around one-third (2,788) of all plants and animals are listed as threatened or at-risk and a further one-third are listed as 'data deficient' so numbers could be way worse if the resources and scientists were available to investigate further[18].

One of the most telling biodiversity figures is for freshwater species, revealing the extent of the damage done to waterways. 74% of the fifty-one native freshwater fish species are listed as threatened with extinction as well as New Zealand's only mussel and freshwater crayfish[19]. The number of threatened freshwater fish species has grown rapidly over the last few decades from around 20% in the early nineties to the shocking 74% now *(Figure. 17)*.

---

17. http://mro.massey.ac.nz/bitstream/handle/10179/1246/01front.pdf?sequence=2

18. http://hdl.handle.net/10179/1246

19. Goodman et al. (2014), Conservation Status of NZ Freshwater Fish, 2013. New Zealand Threat Classification Series 7. Department of Conservation, Wellington.

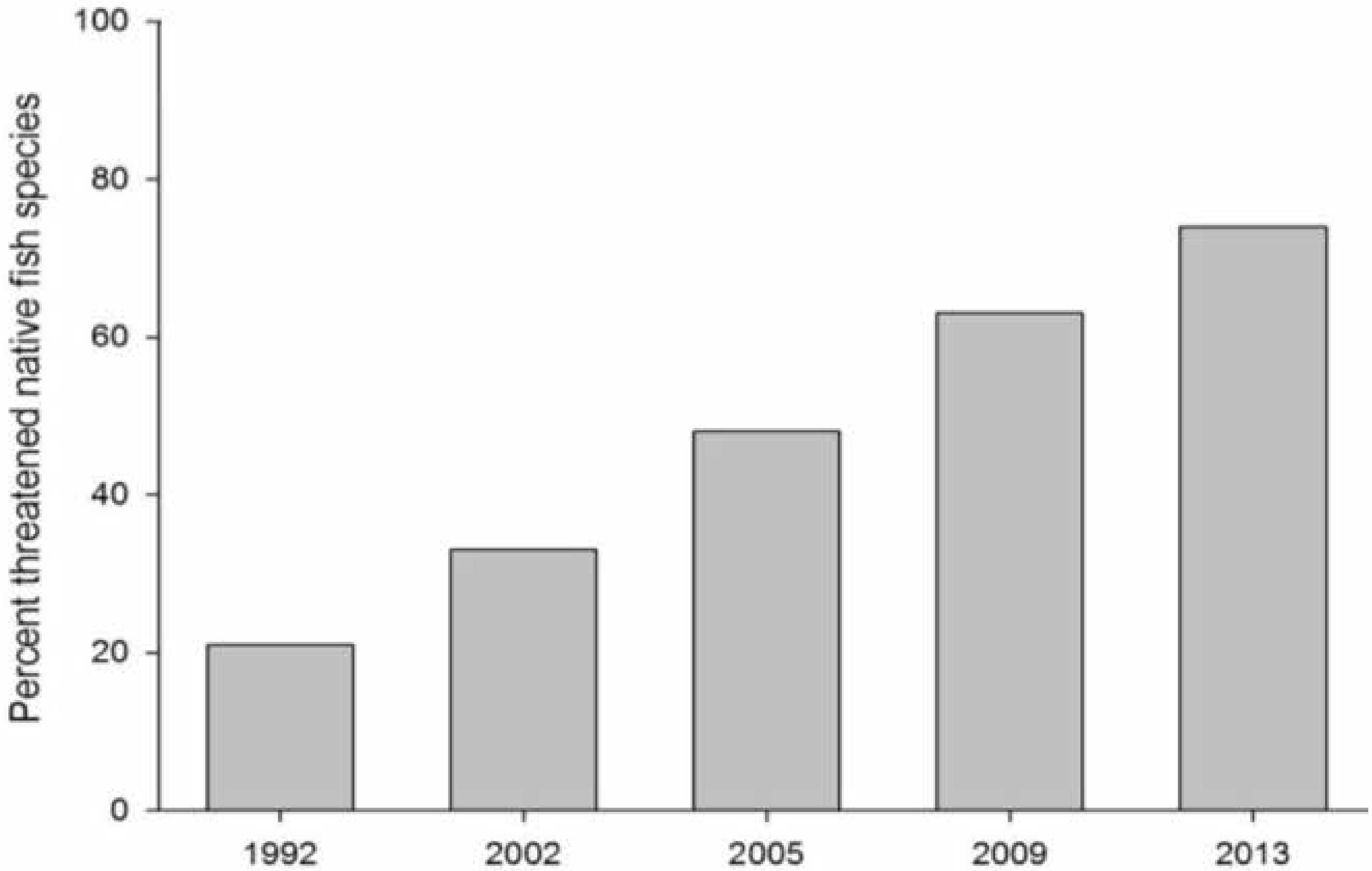


Figure 17. *Changes in the proportion of threatened freshwater fish in New Zealand 1992 – 2013*

This proportion of threatened freshwater fish species is the highest I can find anywhere in the world, and this statistic reveals so much about the degradation of freshwaters in New Zealand because these fish respond to all the changes in river health; they are effectively freshwater 'miners canaries'.

My research using around forty years of data from thirty-thousand samples in the New Zealand freshwater fish database shows that if native fish continue to decline at the rate they have for the last 40 years, then they will be extinct by the year 2050.

The plight of these native freshwater species reveals even more about how conflicted freshwater policy is, as none of the species have any protection under law. Bizarrely, the New Zealand Freshwater Fisheries Regulations 1983[20] offers no protection to native fish apart from specific protection for one species: the Grayling that went extinct in 1930. If it wasn't whacky enough to have passed a law to protect a fish species that went extinct fifty years earlier, then the fact that we give introduced trout (which compete with and predate our native species) complete legal protection by not allowing them to be bought or sold adds insult to injury.

20. http://www.legislation.govt.nz/regulation/public/1983/0277/latest/DLM92492.html


Fertiliser application

SOIL HEAVY METAL CONTAMINATION

A vital asset for New Zealand is healthy soils, but one of the many consequences of agricultural intensification is soil compaction and a build-up of heavy metals. In New Zealand's case, most of the phosphate fertiliser liberally applied from the 1940s until recently came from the Pacific island of Nauru. While Nauru was a cheap relatively accessible source of phosphate, the down side, apart from the destruction of Nauru, was that the phosphate contained naturally high levels of cadmium.

To mine the phosphate, Nauru was stripped of meters of its soil cover which contained thousands of years of accumulated bird guano, which had over time concentrated marine derived cadmium. It was processed into the fertiliser super-phosphate, and then top-dressed in New Zealand. Over the intervening time the metal has built up to danger levels in New Zealand soils.

The problem for humans is that plants take up cadmium from the soil so this carcinogen is ingested when humans and animals consume them, and then slowly builds up in organs. It's very hard to decide on a safe level of cadmium in soils to keep our intake below danger levels. Currently food standards are used as a guide. The theory is that if soil cadmium is kept below a certain level it should mean that in vulnerable crops like potatoes, onions, root and leafy vegetables, and most grains, the standards will be met and we will be safe.

The issue is cadmium does not readily leave the environment so even incredibly small amounts add up over decades. The trigger danger level in New Zealand soils has been set at 1mg/kg (1 part per million), and as an example of the extent of the issue, in 2004 around 160,000 ha of the Waikato Region exceeded this level, and at this rate, by 2043 57% of the Waikato Region will exceed it[21].

This 1mg/kg is the point that would have seen all the land exceeding this level officially labelled as a contaminated site under the Biosolids Act. However, in another example of 'head-in-the-sand' management this land can no longer be classed as contaminated because recent changes to legislation removed agricultural land from any heavy metal contamination classification.

Fortuitously for the dairy industry, cadmium ingested by cows doesn't get passed to milk or we would have been banned from export markets decades ago. Instead of going to the milk, cadmium accumulates in the body like it accumulates in soil. In mammals it accumulates in the major organs (kidneys and liver). As a result, the sale of these organs from cattle and sheep over 18-24 months old are banned for human consumption in New Zealand.

We know very little about the health effects of long-term cadmium accumulation so the supposedly safe levels of consumption are changing globally. However, if we use the European Union standard then the latest results of our 5 yearly total diet survey shows that New Zealand toddlers, infants and children already eat cadmium at, or near, the EU limit and the rest of us are not far behind. The World Health Organisation standard is more lenient and New Zealand uses this limit so the figures look a bit better.

This is a crucial issue for New Zealand's food security; the intensively farmed areas that are contaminated with cadmium are the areas we will need to grow food. This means the only productive future use for this land will be growing trees or producing milk. As with the freshwater issues, there is ongoing increasing pollution in the face of these obvious environmental impacts. Every year, about two million tonnes of superphosphate fertiliser is applied to pastoral and horticultural soil in New Zealand, so that means we are adding a whopping 30-40 tonnes of cadmium per year.

---

21. Kim, N.D. (2005). Cadmium Accumulation in Waikato Soils. Environment Waikato Technical Report 2005/51

The threatened koura or freshwater crayfish (Paranephrops planifrons) Karekare Auckland

New Zealand's freshwater crisis – how did it happen?

It must be obvious to all from what I have revealed here is that we have an unprecedented and mostly hidden environmental crisis, predictably showing up first in freshwater ecosystems. The causes are many and complex, from introduced species, vegetation clearance on steep land, and wetland drainage over many decades (much subsidised by government), but now the biggest impact has been building over the last few decades and that is the intensification of agriculture mainly related to the dairy industry. The last few decades have seen a massive expansion and intensification of agriculture. This has occurred because the regulation or enforcement of nutrient losses has been largely absent, effectively incentivising pollution.

The freshwater quality and biodiversity declines described so far have been driven by excess nutrients and sediment and invasive species and this has been exacerbated by the taking of water and controlling of river flows for irrigation and hydroelectricity.

The obvious question is: How did this happen given all the environmental protections we have with the much lauded Resource Management Act 1991 (RMA)?

The answer is simple – we failed to control the impacts by deregulation or not regulating the major impacts or enforcing laws. While clearly the RMA says all the right things about protecting the environment, the reality is that we have the crisis we have because the biggest impacts, namely intensification and vegetation clearance, were not constrained. Thus, deregulation is not good for agriculture as the 'clean-green' image is vital for marketing, so any decline in environmental quality harms primary producers, so declines are effectively an 'own goal' for them.

THE RECENT CHANGES IN LAND-USE

The biggest change in landuse in recent history has been the intensification of agriculture revealed by a four-fold increase in dairy production since 1992 to nearly twice as many cows[22]. It must be noted however, that this level of intensification is possible only through a massive increase in imported fertiliser and animal feed. For example, over the last few decades New Zealand has had:

- The highest rate of increase in phosphate use in the OECD (most of this fertiliser is imported from Morocco).
- More than 800% increase in nitrogen fertiliser use and almost all is unsustainable synthetic nitrogen produced from fossil fuels (note that in the past farmers fixed nitrogen from the atmosphere using clover). Around a third of the nitrogen is produced from Taranaki gas fields and the rest from the Middle East.
- An enormous increase in palm kernel expeller (PKE) for dairy feed. New Zealand now imports more than 1.6 million tonnes per year, making us the single biggest palm kernel importer globally.

22. *http://www.stats.govt.nz/infoshare/*

HOW INTENSIFICATION IMPACTS ON FRESHWATERS

For many New Zealanders, the relationship between the increasing the number of cows and environmental impacts is not clear. Notwithstanding from the obvious and well known human health and physical degradation impacts of having cows wandering into waterways, coupled with the dairy shed waste discharged into rivers, the hidden, but major impact is less obvious – it's the cow urine. The problem is the large volume of urine, mostly nitrogen, landing on a small patch of ground, too small in area for the grass to take all of it in, so most of it moves down past the shallow root zone and down through the soil. This nitrogen percolates eventually through the soil into water, either groundwater storage areas or laterally into streams and then lakes and estuaries.

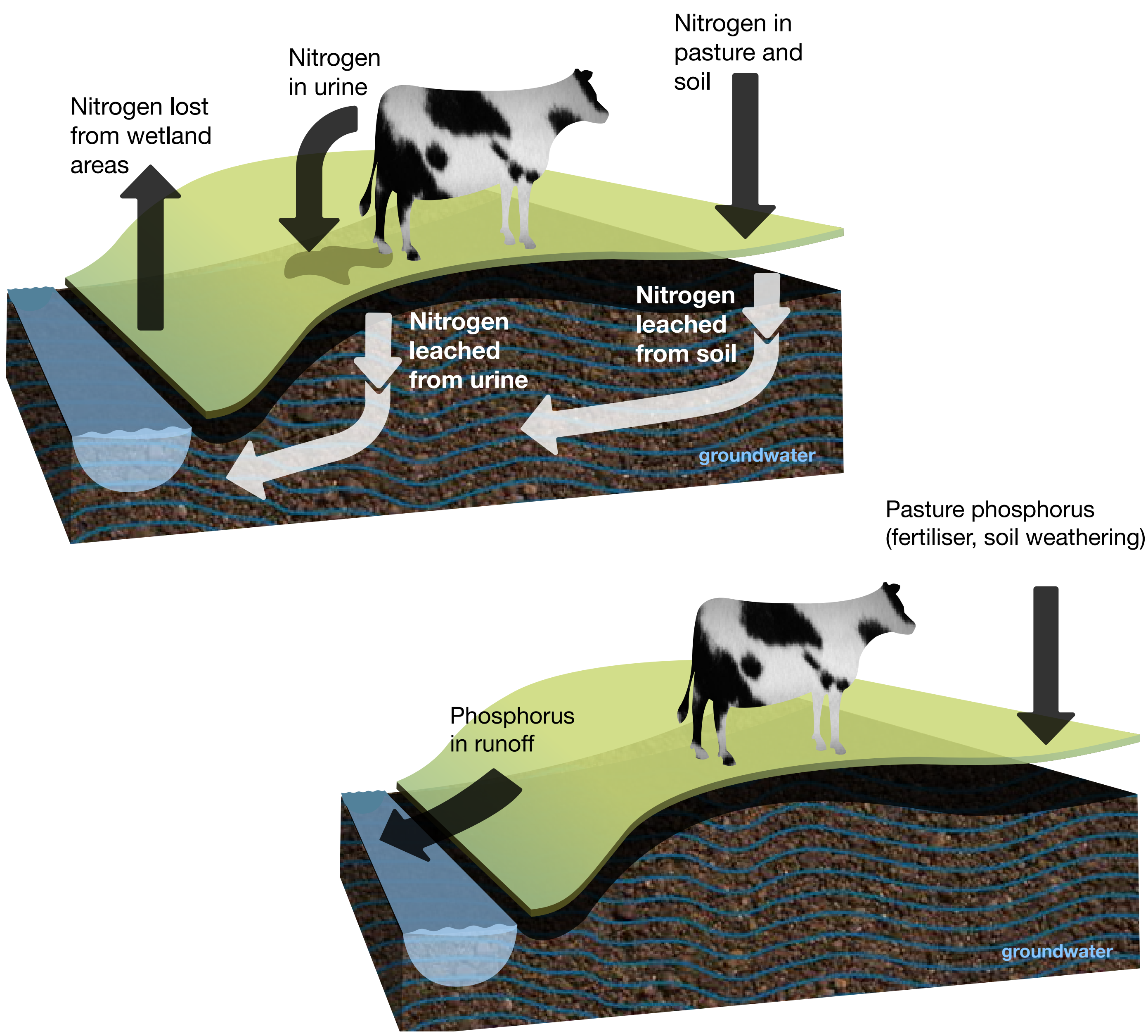


Figure 18. *Pathways for nutrients to water. Phosphate and pathogens mostly travel overland attached to sediment, but nitrogen is via urine and travels down and sideways into groundwater or rivers then lakes. (Graphic adapted from the Ministry for the Environment)*

The amount of nitrogen leaking out of individual farms is easily calculated and so the costs for cleaning it up from waterways can be estimated. For example, the farm that was the recent recipient of the Ballance Farm Supreme Environment Award leaches on average forty-eight kg of nitrogen every year for every hectare. So for this 1014 ha farming operation, close to four million cubic meters of water are polluted past the drinking water standard (11.3 mg/l World Health Organisation limit for drinking water) and way past ecological limits (0.61mg/l) each year (1kg of nitrogen mixed with 88.6 cubic meters of water will take it past the 11.3mg/l limit). To get water back to below the drinking water standard costs at least 50 cents per cubic meter.

So for this single farm the cost to clean up the water it polluted in one year back to meet the human health standard, not even the ecological health level, would be around two million dollars a year. Extrapolating that out for the whole country in dairy using the average rate of nitrogen leaching then the bill for each year comes to around 2.6 billion dollars.

Another way to explain how these costs to the environment that are not paid for by the dairy industry (known as externalities) is to use the example of the Rotorua Lakes clean-up initiative. In this case, experiments were done to try and remove some of the nitrogen (causing ecological issues) from the lake using floating wetlands. This process mimics the natural processes done by natural wetlands and involves harvesting the plants that have taken up the nitrogen after they mature. Using this process, it cost at least $240,000 to remove one tonne of nitrogen (note this cost could be reduced over time). The alternative is to go to farms in the lake catchment and look at the loss of revenue from using less nitrogen to stop it leaching into the lake. The trials showed an average loss of revenue of $6,000 for not using one tonne of nitrogen[23] versus $240,000 to remove it. In other words, it is thirty-seven times cheaper to not pollute than it is to clean up afterwards.

---

23. Ledgard, S., Judge, A., Smeaton, D. C., & Boyes, M. (2010). Greenhouse gas emissions from Rotorua dairy farms: Summary report

THE NITROGEN BOMB

Excess nitrogen leaking from agricultural systems is not just a New Zealand issue, it is a huge global environmental problem labelled by some as the 'nitrogen bomb'[24]. In the early twentieth century, the process was discovered to allow for the creation of nitrogen from fossil fuels. Previously nitrogen was fixed from the atmosphere by plants and microbes. Now humans have changed the natural cycle immensely; we now produce more nitrogen artificially than all natural processes combined[25]. Only a small amount of this nitrogen makes its way into the food we are producing; most ends up waterways causing many problems including massive dead zones like that off the Mississippi River[26].

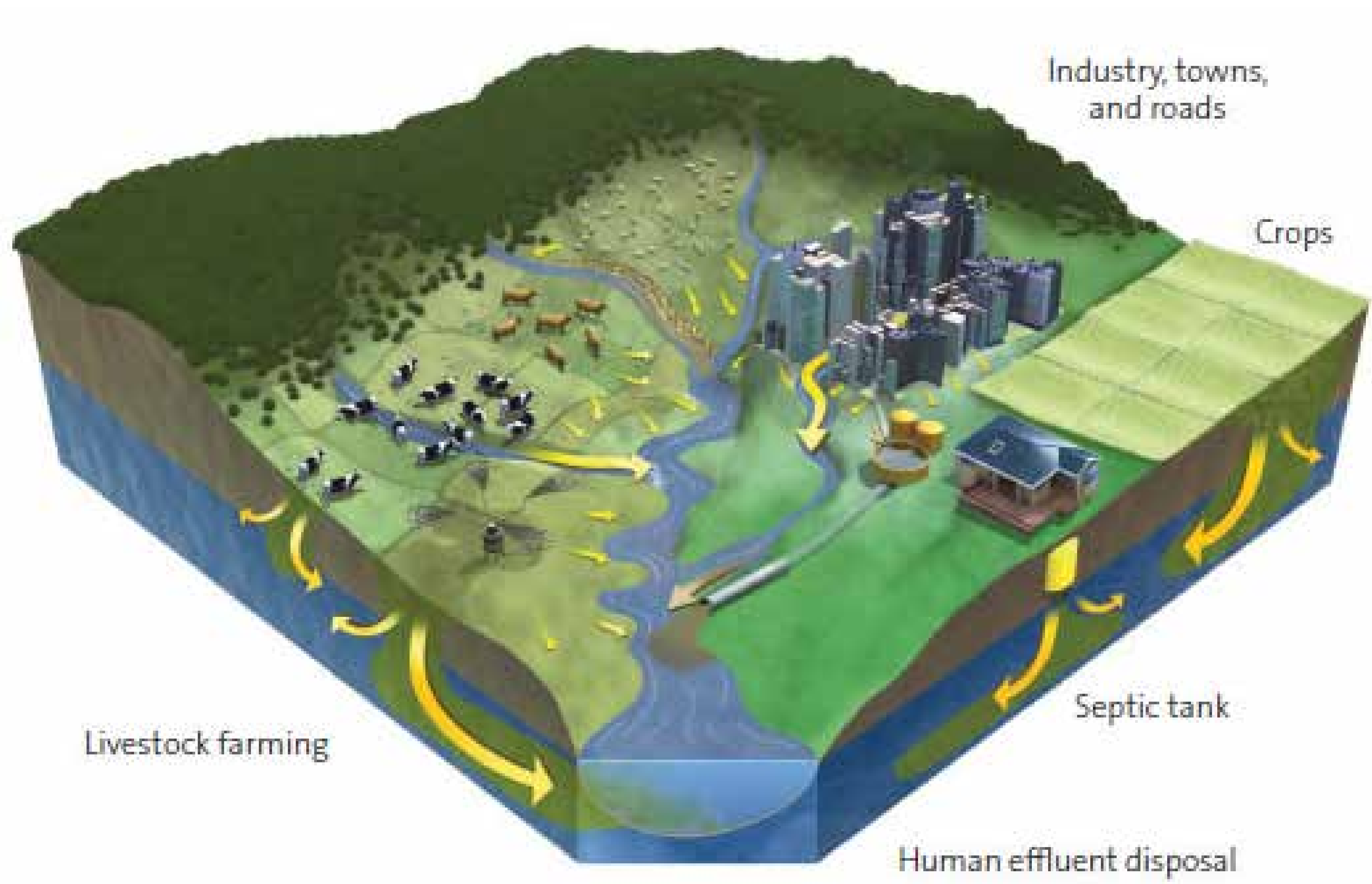


__Figure 19.__ The pathways for nutrients into waterways. The gold arrows show the pathways overland and through the subsurface of nutrients, and pathogens. (Graphic from Ministry for the Environment)

---

24. http://discovermagazine.com/2001/apr/featbomb

25. http://www.millenniumassessment.org/en/index.html

26. Cheryl Lyn Dybas (2005) Dead Zones Spreading in World Oceans. BioScience 55 (7): 552-557.doi: 10.1641/0006-3568(2005)055[0552:DZSIWO]2.0.C

WHERE THE ENVIRONMENTAL LEGISLATION FAILED

The graphic showing the pathways for nutrients *(Figure 19)* reveals where freshwater environmental protection in New Zealand failed. Only two of the multitude of ways that nutrients enter waterways were controlled by resource consent 1) Pipe dairy shed effluent and 2) Point source discharges from wastewater treatment plants and industry. The dairy shed effluent is at most only 20% of the problem as the cows are only in the shed for a few hours a day, and the industrial outfalls are typically only a few percent of the nutrient loads in New Zealand Rivers. The main pathway via urine patches for nitrogen and via sediment for phosphorus have not been limited or taxed.

ON-FARM SOLUTIONS

One of the biggest barriers (and has been the case for many decades) to improving environmental performance on farm in New Zealand is that the return on capital or profit for farmers has been minimal and the profits are only realised when selling the property in the form of (tax free) capital gains. Most dairy farms could significantly cut pollution and make more profit, by reducing cow numbers (intensity). The graphic in figure 20 shows this theoretically, how increasing intensity past a certain point results in a levelling off of production through biological limits meaning reducing productivity and profit, but crucially environmental impacts increase exponentially.

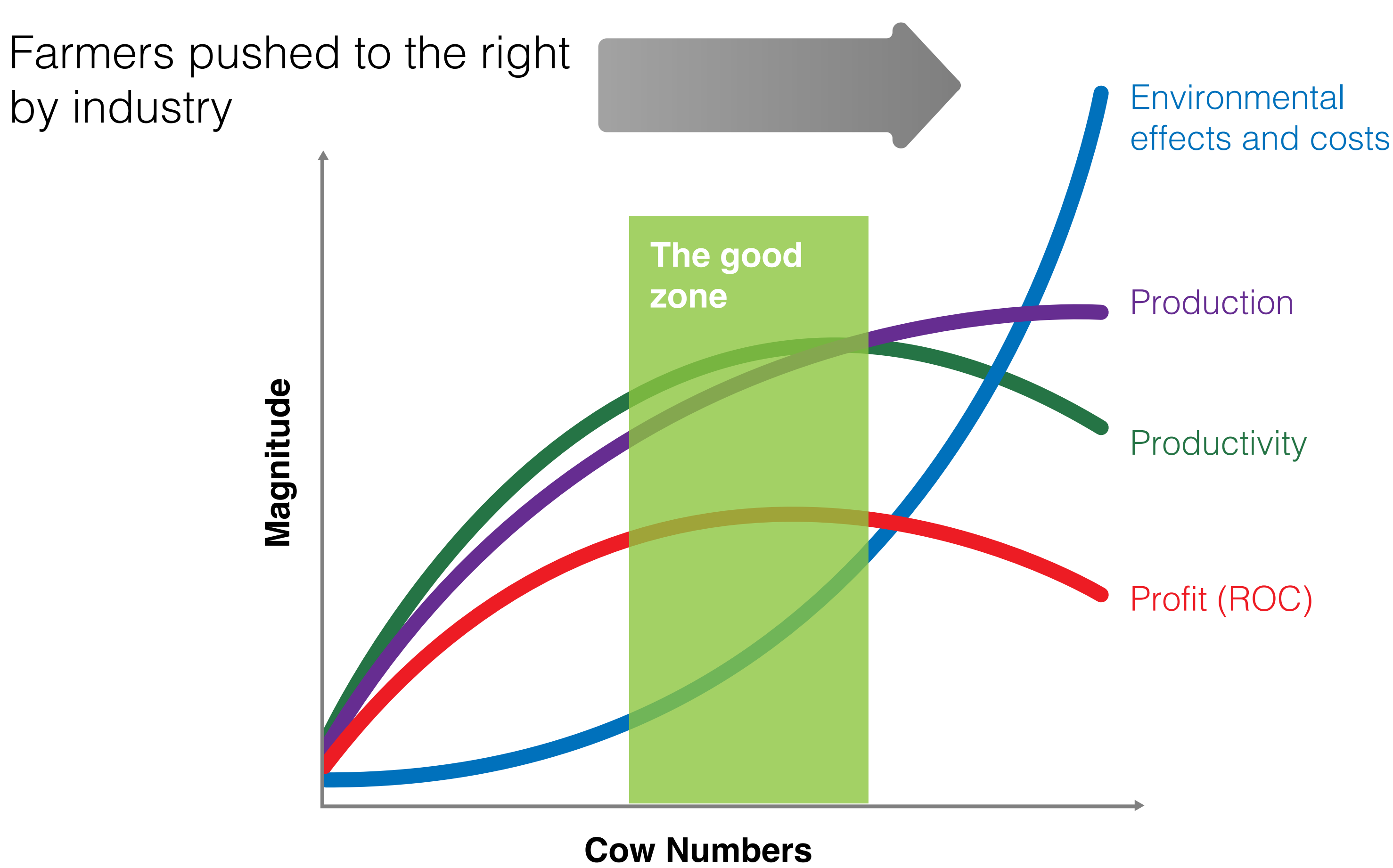


Figure 20. *Graphic representation of intensification – adding cows on profit production, productivity and environmental impacts.*

This relationship can be seen clearly with figures from a real farm currently milking 620 cows. The modelling of reducing intensity shows that by reducing cows (moving from the right to the left on graph in figure 21) through different nutrient scenarios profit increases moving to the left on the graph and it's not until cow numbers are reduced to 390 that profit drops below where it was at the 620 cow level.

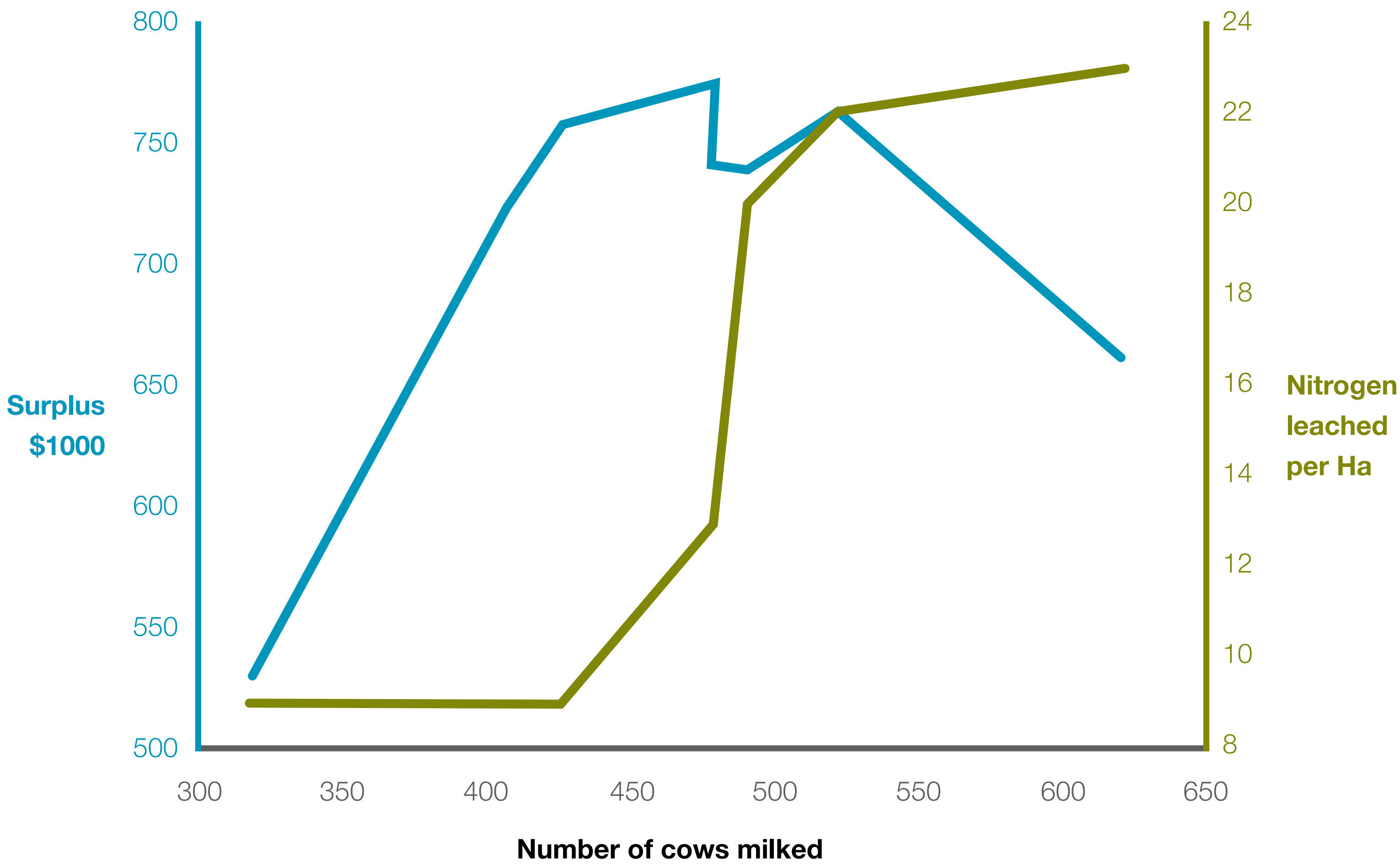


Figure 21. *Modelled changes in profit and nitrogen leaching (from overseer) with reduction in intensity from current level on a real farm of 620 cows. (Numbers from Tom Phillips, Massey University)*

Crucially, the reduction in nitrogen pollution is reduced four fold while making the same returns. So why do farmers farm to the maximum (right side of figure 21)? To some extent it is in an effort to maximise production per hectare which will increase land value. But also considerable pressure is on farmers from banks, Fonterra, and their research arm Dairy New Zealand, as well as the Ministry for Primary Industries, the New Zealand government and many others to maximise production in a drive to maximise profits and GDP. These two graphics show clearly the issues facing farmers that are not of their making rather because of a lack of a price on pollution and a lack of a capital gains tax. Thus, the reality is that pollution is incentivised.

The Wairoa River in Northland

The government response: cover-ups and weakening protections

Obviously, the impacts revealed here will have massive, probably unaffordable costs for future generations and have and will continue to decimate our priceless 'clean-green' image. So the question must be: what has the response from the government been to this massive failure?

As an example, in July 2013 to much fanfare the Ministry for the Environment (MfE) made the announcement that for the last ten years water quality was stable or had improved at most monitored sites *(Figure 22)*. The data they used was from more than three hundred sites around New Zealand collected by Regional Councils and added to the seventy-seven National Water Quality Monitoring Network[27] (NWRQN) sites.

This statement made no sense to many freshwater scientists in New Zealand, myself included, as it flew in the face of all the research being done by independent researchers. Closer inspection revealed that MfE had erroneously used the word stable when in fact what had happened was that the vast majority

27. *https://www.niwa.co.nz/freshwater/water-quality-monitoring-and-advice/national-river-water-quality-network-nrwqn*

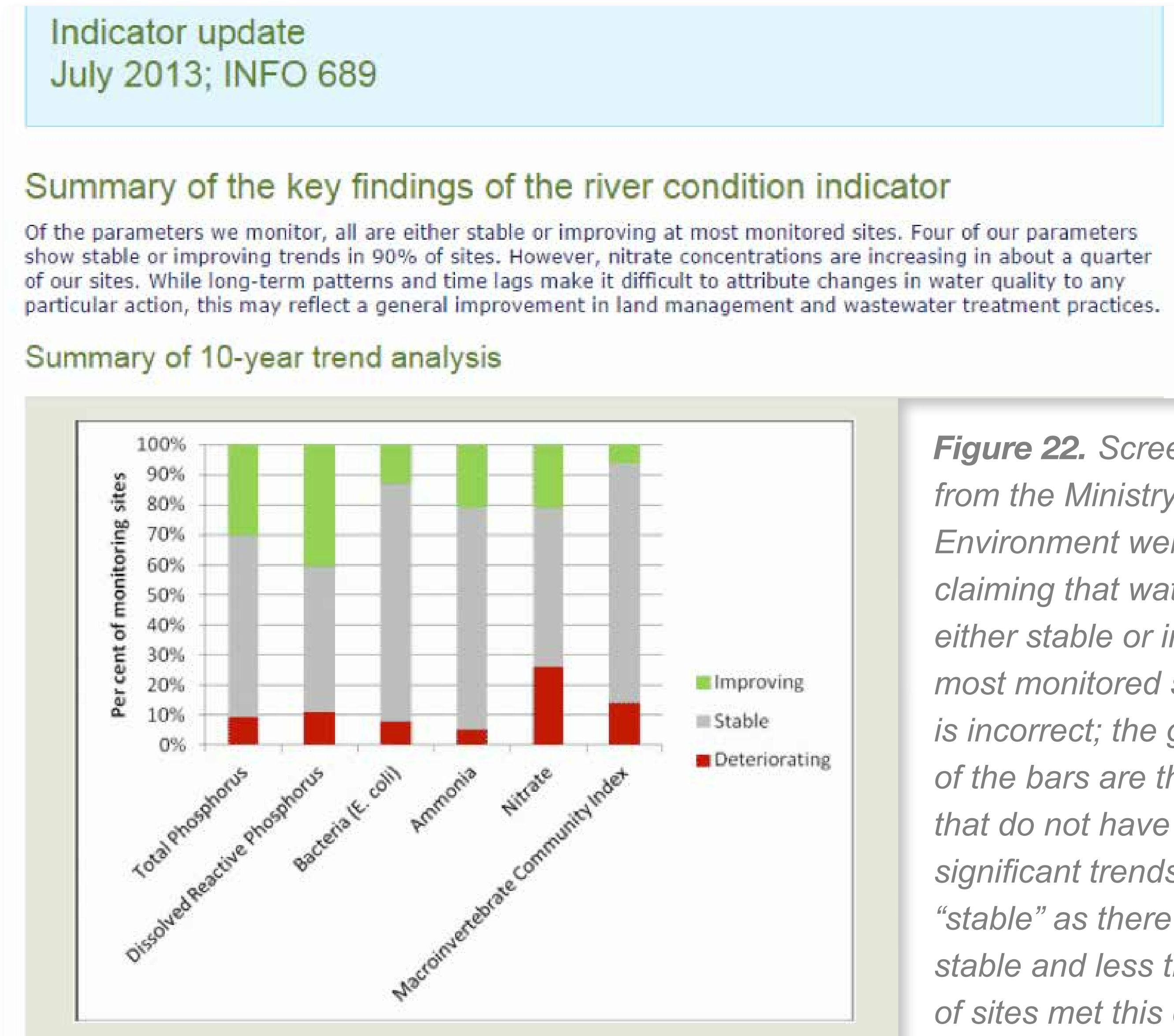


Figure 22. *Screen capture from the Ministry for the Environment webpage claiming that water quality is either stable or improving at most monitored sites. This is incorrect; the grey areas of the bars are the sites that do not have statistically significant trends. This is not "stable" as there is a test for stable and less than 10% of sites met this criteria. (Graphic from Ministry for the Environment)*

of sites (the grey portion of the bars in the graphic) did not have statistically significant trends because the time period (ten years) chosen was too short. Most of these sites are in fact showing declines in water quality but there are simply not enough data points over ten years to make them statistically significant. By labelling these non-significant sites 'stable', the majority of New Zealanders assumed this implied they had not got worse. This is not the case; it is just that by choosing a short time period reduced the number of data points, making statistical significance less likely.

Importantly, there is in fact an accepted statistical test for a 'stable' trend and when this is applied less than 10% of the sites were genuinely stable.

The reality is opposite to the claims from the MfE. In fact most sites are worsening over 20 years and show no sign of improvement apart from phosphate, but this is reducing at twice as many natural sites (those with no development in catchment) than it is in pasture catchment sites, revealing that claimed "improvement in land management practice" is not having any effect.

Analysis of the national monitoring sites for the last 25 years show the reality is that the vast majority of sites are getting worse *(Figure 23)*. One of the most concerning issues was that even when the Ministry staff admitted that this information they had on their webpage for more than a year was completely incorrect, they would not remove it or tell New Zealanders that they had been misled[28].

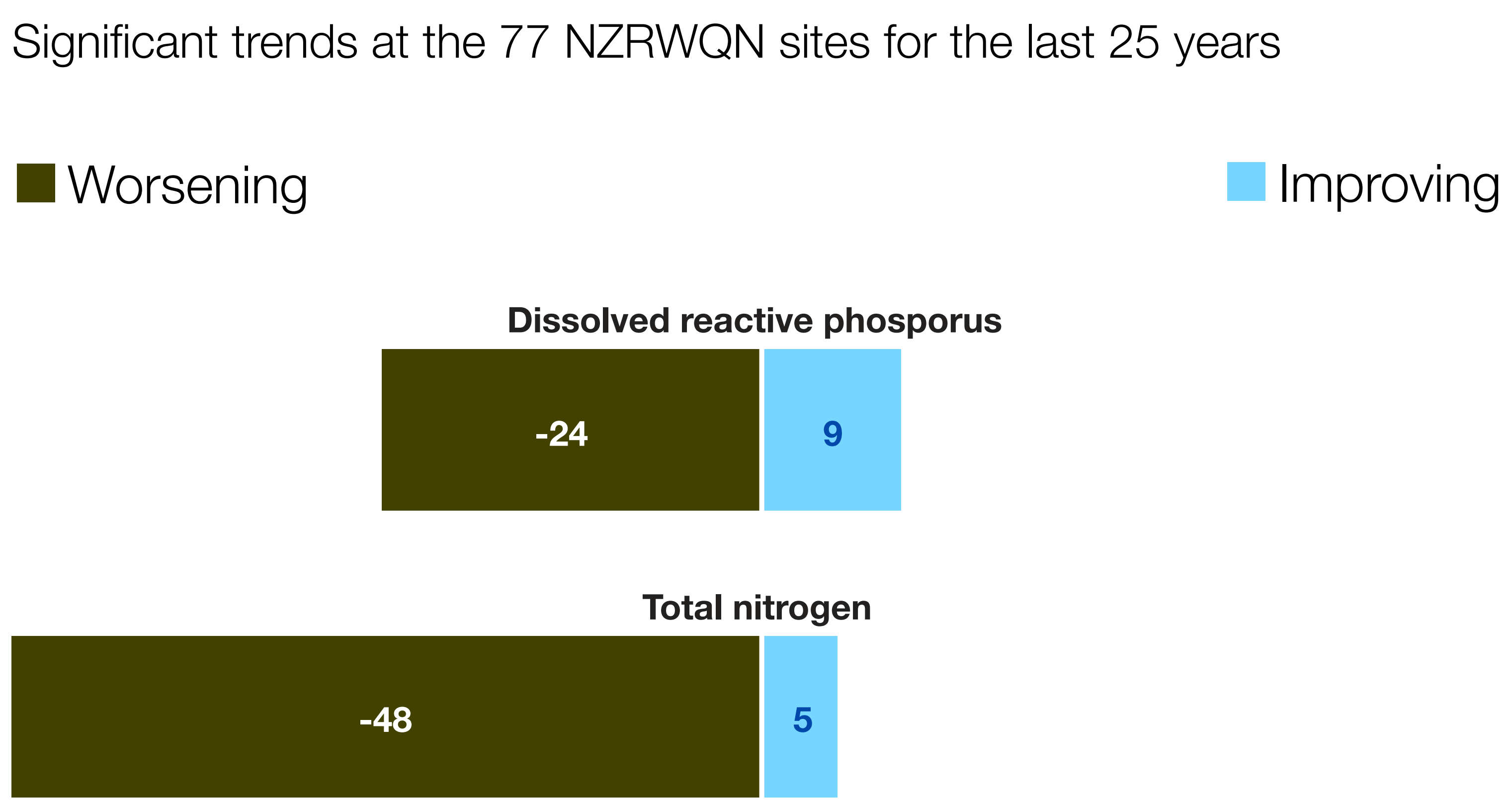


Figure 23. *Significant changes in nitrogen and phosphorus at the 77 NZRWQN[29] sites over the last 25 years.*

The next example of the government response to the freshwater crisis was the development of a new freshwater policy and legislation with a National Policy optimistically labelled ‘A Fresh Start for Freshwater’.

In 2011, a National Policy Statement (NPS) on freshwater in New Zealand was finally enacted, almost two decades after it was due, and then in 2013/14 the supporting National Objectives Framework (NOF) was implemented. This framework gives limits and numbers to achieve the goals of the NPS[30].

---

28. http://www.radionz.co.nz/news/national/256807/public-’misled’-over-river-quality

29. https://www.niwa.co.nz/freshwater/water-quality-monitoring-and-advice/national-river-water-quality-network-nrwqn

30. http://www.mfe.govt.nz/fresh-water/freshwater-management-nps

The NPS has ambitious sounding expectations for "maintaining or improving freshwater quality" but, crucially, the numbers and limits in the NOF just don't match up with these aspirations, rather they allow for much worsening. Worse still, most of the parameters used in the past to measure the health of freshwaters are not included in the NOF[31].

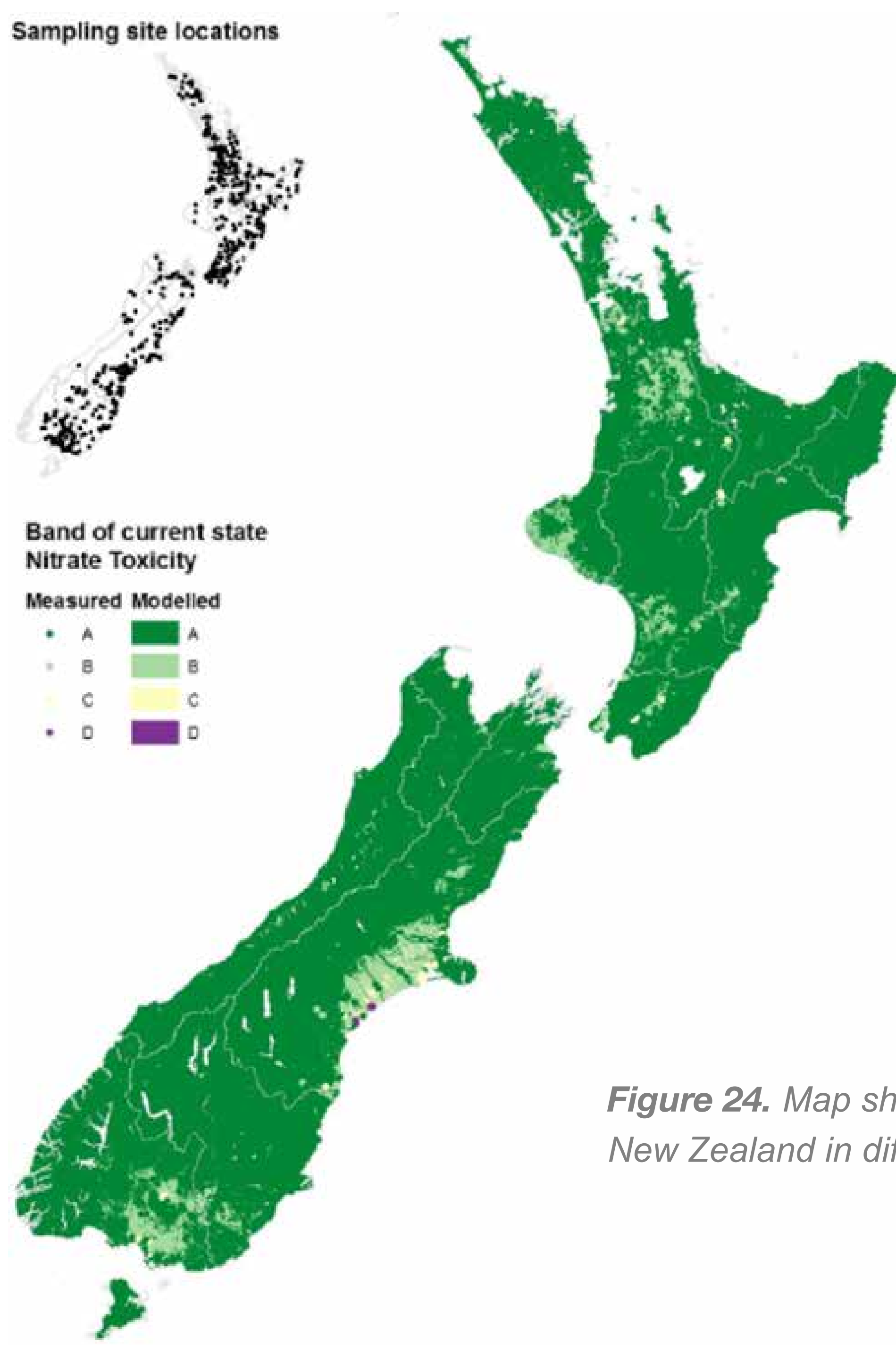


Figure 24. *Map showing the rivers in New Zealand in different nitrate bands.[10]*

As an example of the weakening of standards was the inclusion of only one nutrient in the NOF (nitrate) and the new limits are a tenfold weakening of previous limits, going from the ANZECC[32] guideline level of 0.61mg/l to the new bottom line of 6.9 mg/l. The quality bands (A, B & C) for water quality were set so that less

31. http://www.sciencemediacentre.co.nz/2014/07/03/freshwater-national-standards-set-experts-respond/

32. http://www.environment.gov.au/water/publications/quality/australian-and-new-zealand-guidelines-fresh-marine-water-quality-volume-1 than one percent of the rivers in New Zealand would breach the bottom line and most would score an 'A'[33] *(Figure 24)*.

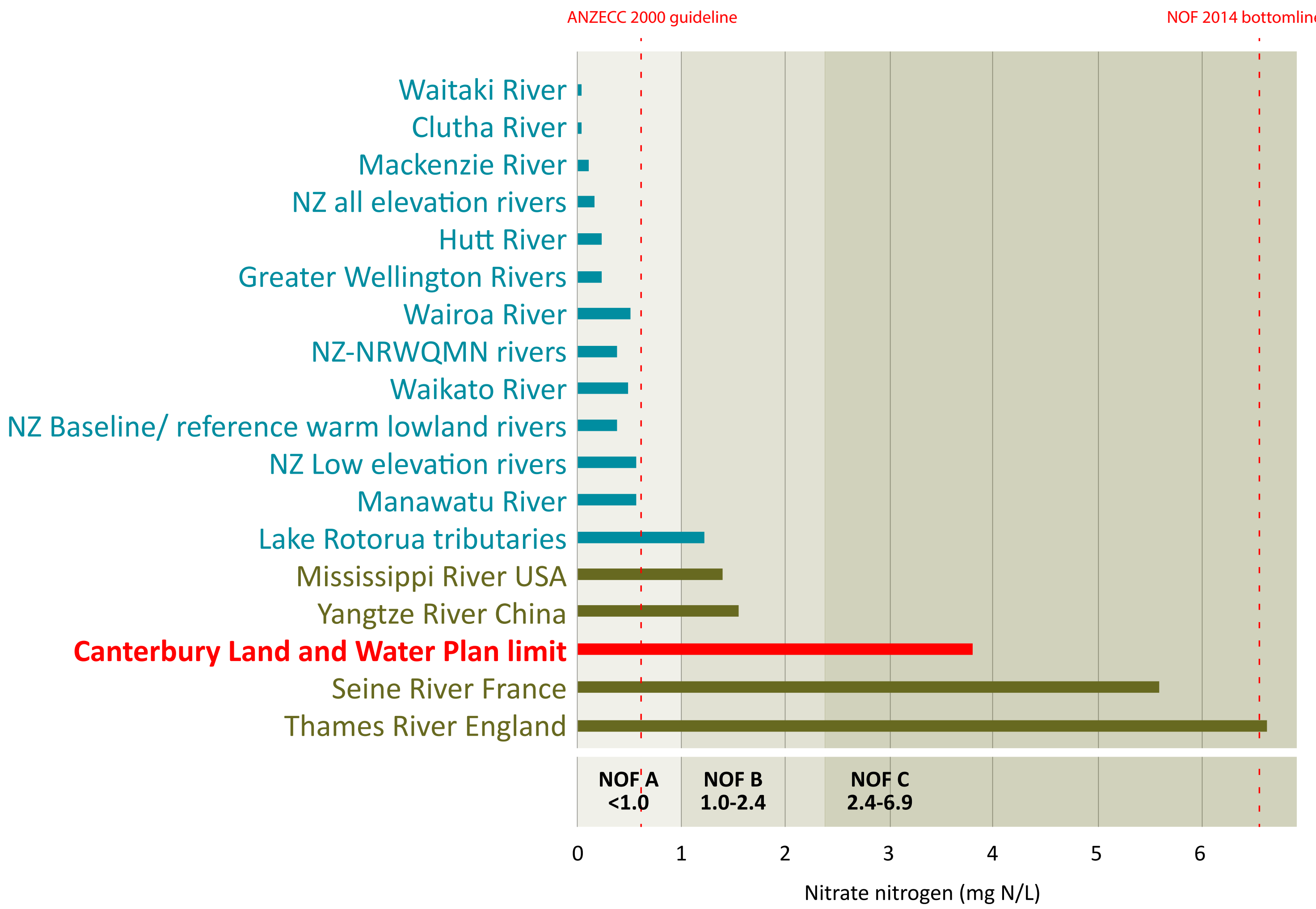


Figure 25. *Graph comparing the median levels of nitrate nitrogen from a range of rivers in New Zealand and overseas. The three bands shown are from the National Objectives Framework 2014. The ANZECC guideline trigger level for nitrate nitrogen (0.61 mg/l) is shown as a dotted line.*

To give some idea of just how much ground was given here, comparison with other countries shows that some of the most nutrient polluted rivers in the world like the Yangtze in China and Mississippi in the USA would score a B under this new ranking *(Figure 25)*. The map of nitrate levels in Figure 8 reveal that much of New Zealand rivers already exceed the ANZECC nitrate guideline limits, and that this weakening in the NPS was a purely political response, shifting the goal posts to suit the present situation.

As well as weakening limits, the NOF also omits most of the waterway health assessment tools regularly used such as oxygen variability, temperature extremes, deposited sediment, and crucially any of the well-developed biomonitoring tools such as the Macroinvertebrate Community Index *(see Figure 14)*. The other

33. Unwin, M. J., & Larned, S. T. (2013). Statistical models, indicators and trend analyses for reporting national-scale river water quality) (NEMAR Phase 3). NIWA.)

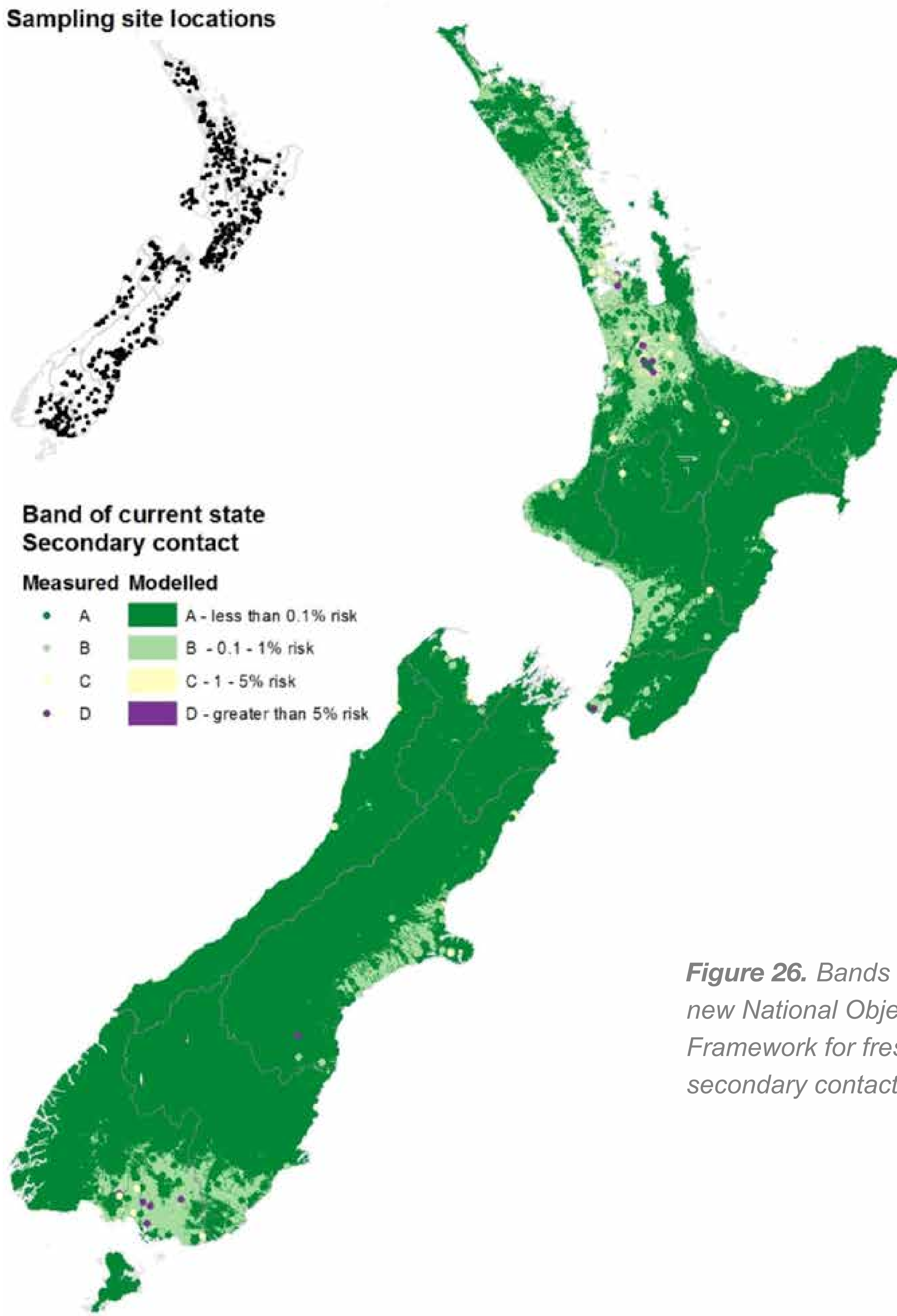


Figure 26. *Bands for the new National Objectives Framework for freshwater secondary contact.*[10]

obvious omissions are any assessment of the health of groundwater and estuaries and notably the omission of benthic cyano-bacteria: the stuff that kills dogs and, as I mentioned, will likely kill children.

The Ministry of Health Contact Recreation limit was dropped and replaced by a new level called ‘secondary contact’, once more a massive weakening of protection. This new limit is to protect people in boats or waders, not people swimming!

Figure 26 shows that the new limits (secondary contact) mean that most of New Zealand waterways score an A or B. Contrast this with Figure 16 showing that 62% of all New Zealand rivers exceed the Ministry health limit of 260 E.Coli mp/ml, the limit at which water is safe for swimming. This is another stark example of shifting the goalposts to accommodate the current situation and give head-room for further agricultural intensification.

The Waipoua River in Northland is banked by the Waipoua Kauri Forest

Swimmers in the Waikato river

Where to from here?

Some really strong messages come through from exposing the hidden facts on the state of New Zealand's environment. What is revealed is a comprehensive failure of environmental protection. The sad reality is that there will likely be even more weakening of already ineffectual protection with the proposals soon to be tabled in Parliament to 'streamline' (gut) the Resource Management Act (RMA). The plans are to take important clauses from the Act and to further limit public participation in the resource consent process. Thus, it seems clear nothing has been learned, not only did we not learn from other countries mistakes we haven't even learnt from our own past failings.

In the 1980s there was clearly a realisation that we had some big environmental problems and these concerns resulted in commitments made at the Rio Earth Summit, and embodied in the RMA were aspirational objectives to protect the environment. However, a pattern is emerging that ambitious statements and proposals are enacted in legislation but then not backed-up by action, either protection or enforcement. Clearly the example has repeatedly been that the exploiters win out over the environment every time, usually erroneously in the name of protecting the economy.

COMMUNITY ENGAGEMENT AND COLLABORATION

One of the new approaches from government around freshwater ‘development’ (usually irrigation and agricultural intensification) schemes is called “community collaboration”. This started with the Land and Water Forum, and the Zone Committees in the Canterbury region. The reality of this however, is that the process is totally unbalanced in favour of the exploiters. The exploiters are heavily represented and, because they are well funded and resourced, they can outlast the unpaid and un-resourced conservation driven participants through the deliberately drawn-out laborious process. The industry stakeholders can afford to employ consultants to write voluminous and very technical reports and economic analyses that drain the limited resources of the protectors trying to interpret and counter their conclusions.

While these processes sound like a good idea the reality is that they become a subtle form of blackmail, with the community given the illusion of an option to choose between jobs and wealth in exchange for accepting environmental degradation. The process has become more and more unprincipled with, for example, the sacking of the Canterbury Regional Council and their replacement with Government appointees, and the use of tax and ratepayers money to finance irrigation schemes. The irony of the Government claiming to want more community participation while at the same time removing the democratically elected Regional Council over water issues and reducing public participation through the achieved and the proposed changes to the RMA seems to have been missed by most pundits.

Another flaw with this collaboration approach is that the while a community upstream might well reluctantly agree to allow pollution for purported economic gains the reality is that their community doesn’t have to live with full consequences, rather the downstream communities do. And of course the mostly forgotten harbours and oceans will not continue to assimilate the impacts forever. Irrespective of any of these impacts, it is simply not acceptable to farm, or operate any business for that matter, in a manner that causes pollution. Unacceptable not just because of the impacts but also because the very nutrients that are being lost are extremely valuable and produced from fossils fuel or rock.

FAILING TO ACCOUNT FOR EXTERNALITIES

The environmental protection failings mainly stem from Government departments making decisions based on calculations of growth, employment, asset values, and returns on investments both private and public but completely ignoring largely unquantified negative externalities.

This central government failure to account for the loss of ecosystem services and biodiversity, which lies at the heart of this environmental crisis, is to a large extent because there is no inclusion of environmental degradation or the value of ecosystem services in national accounting. Incongruously, the value of services we derive from nature is considered to be zero by Treasury economists even though studies have shown it to massively exceed the gross domestic product of all countries[34].

An example would be that the cost-benefit analysis of deep sea oil prospecting changes completely when the costs of climate change are factored in. Likewise the revenue gains from intensive milk powder production would also be negligible were the costs of mitigating freshwater impacts factored in, let alone the costs from human induced climate change.

A wetland in KareKare

34. Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van der Belt, M. (1997). The value of the world's ecosystem services and natural capital. Nature, 387, 253-260.

THE RISKS OF DOUBLING AGRICULTURAL PRODUCTION

Recently, the government outlined plans to double agricultural output as part of their 'export double' agenda[35]. Unless drastic changes involving strengthening and enforcement of environmental protection are made, this push for more growth will result in exponential increases in environmental impacts already outlined in this talk. The push for more production will lead to increased economic risk through increased dependence on imports of fossil fertiliser and imported feed like palm kernel and genetically engineered feed[36], as well as the inevitable increased greenhouse gas emissions.

The reality is that the present intensive dairy farming modus operandi is not sustainable. We are really just mining the environment. Because the impacts are not being paid for or mitigated we are effectively taking from future generations or natural capital asset stripping. The future is more polluted rivers, lakes, groundwater, estuaries and near-shore marine environments. While in the past we could excuse some of the damage incurred through ignorance, now it is vandalism because the impacts have been clearly documented.

35. ttps://www.national.org.nz/news/news/media-releases/detail/2013/02/05/investment-innovation-needed-for-food-export-growth

36. http://www.nzherald.co.nz/opinion/news/article.cfm?c_id=466&objectid=10847195

THE FUTURE

Trying to change the direction of farming in New Zealand will not be easy. It will be like trying to turn a huge oil tanker, but it must be done and should have begun decades ago. First we must accept the reality and stop the denial that I have revealed here from government and industry. So we must measure the meaningful things the right way, and we must have independent and honest environmental reporting.

The best way for New Zealand to add-value to our produce is through receiving a premium for our 'clean-green' image. This is why we must at all costs preserve that image.

We must immediately cost the impacts and value the gains of stopping declines. It is clear that if the externalities of dairy farming in New Zealand are valued they would likely match or even exceed the revenue[37].

Until we put some kind of cost in the form of a charge on polluters or pay a premium on nitrogen efficiency then we are incentivising pollution. So we must start measuring nitrogen efficiency and rewarding the most efficient and penalising the least. The measure of nitrogen efficiency is simple: it's the kilograms of milk solids produced divided by the amount of nitrogen leached. These numbers are already available to all dairy farmers so could be implemented immediately. Milk companies could pay a premium to the most efficient and regional councils could give rates reductions to these farmers too. In both company and council examples, this could be fiscally neutral by taking from the bottom third and giving to the top third.

Crucially we must immediately stop the procrastination; we must get the science back and get rid of the politics. We must accept the reality that we can't collaborate away environmental reality. Community agreement won't stop the reality of impacts once the conditions for declines and biodiversity losses exist.

---

37. Foote, K. & Joy MK (2014). The true cost of milk: Environmental deterioration Vs profit in the New Zealand dairy industry, presented at the 2014 NZARES conference. http://ageconsearch.umn.edu/handle/187496

At the many talks I have given to farming groups the usual response is "that's all very grim, so now give me some solutions", which translated means give me some (preferably technical) solution so that we can keep doing what we are doing because I'm not prepared to stop doing what I am doing. Of course this is not possible to really achieve improvements, so we must make these simple changes. We must:

- Put a cost on pollution (or premium on not polluting)
- Farm for profitability not for capital gain
- Immediately move away from fossil fertiliser
- Immediately move away from imported fertiliser and feed

Families swimming in the Waikato river

Any questions or comments please contact:

DR. MIKE JOY

Senior Lecturer; Environmental Science/Ecology

Ecology group – Institute of Agriculture and Environment – (PN-624)

Te Kura Matauranga o nga Taonga a Papatuanuku

Massey University
Private Bag 11 222
Palmerston North 4442
New Zealand

Ph. 64 6 3569099 ext 84834

m.k.joy@massey.ac.nz

www.researchgate.net/profile/M_Joy

www.massey.ac.nz/massey/initiatives/sustainability/people/mike-joy.cfm

www.massey.ac.nz/massey/expertise/profile.cfm?stref=851830

www.massey.ac.nz/~mkjoy

www.longfineel.co.nz