Hawke's Bay State of the Environment 2018 - 2021

Regional phosphorus story

12. Phosphorus impacts

Phosphorus on land

Phosphorus behaves very differently to nitrogen. It usually binds with soil and dissolves slowly in water over time, and in most cases, it doesn't readily leach through the soil profile like nitrogen does. Therefore, phosphorus usually enters waterways attached to eroding sediment via surface runoff, rather than through soil and groundwater.

However, there are exceptions because soil type influences how strongly phosphorus is bound to the soil. It is more likely to leach through organic or peat soils, which commonly occur in areas that were heavily drained (i.e., that used to be shallow lakes or wetlands). Significant amounts of dissolved phosphorus can enter waterways through subsurface drains in these areas. Even soils with good phosphorus retention can only hold onto so much, and excessive fertiliser use can supersaturate soils, at which point the phosphorus is readily leached.

Some soils have naturally higher levels of phosphorus, such as those derived from mudstone. However, most of this phosphorus is tightly bound in the soil and is not easily available to plants. Most soils in Hawke's Bay, and New Zealand generally, have a naturally low amount of available phosphorus. Low natural fertility has been exacerbated by human activities such as widespread burning and over-grazing, which removed established forests that had previously retained and recycled the limited nutrients that were available. The pastures that replaced the forest were less capable of preventing erosion. The shallow, low fertility soils left behind after erosion were unsuitable for agricultural development, especially on the steeper hill country areas.

Aerial topdressing started in New Zealand as a solution to these soil fertility problems. Pioneering techniques emerged in the 1930s, and took off after World War II, when returning RAF pilots used their skills to modify Gypsy Moth aircraft for spreading fertiliser and clover seed (Figure 12-1). Phosphorus fertiliser enabled clover to grow, and the clover increased soil nitrogen content, which enabled improved pasture to be established across most of the farmed areas of Hawke's Bay. It also meant soil nutrient levels were substantially higher than natural levels across most of the region from the 1950s onwards.

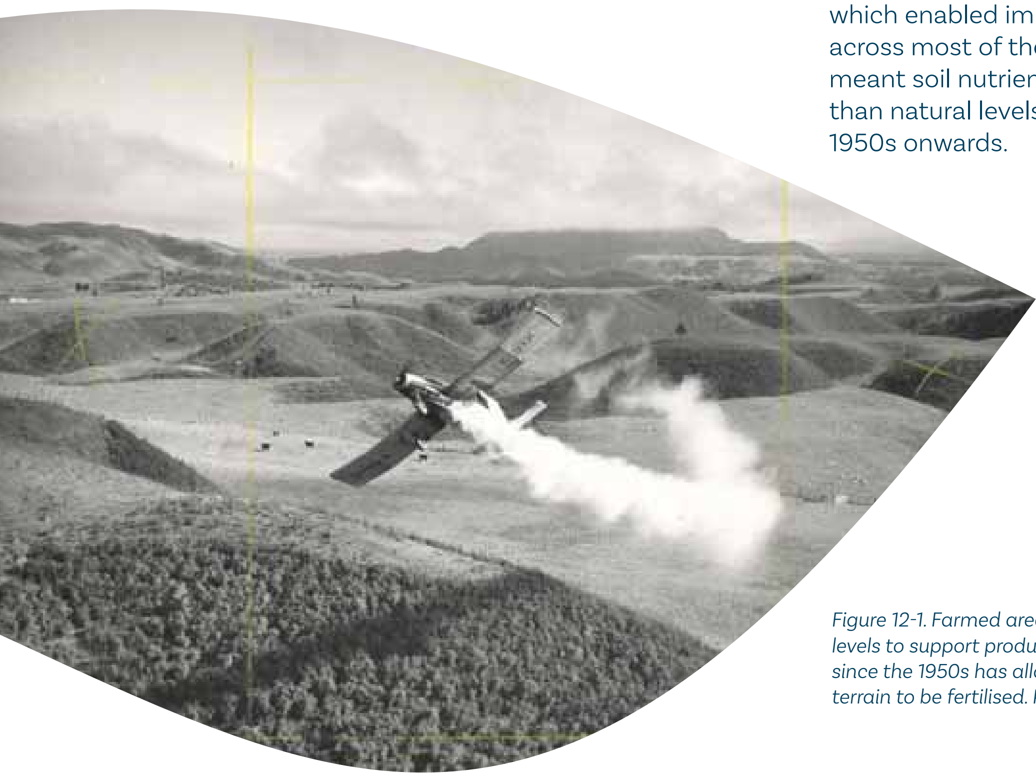

Figure 12-1. Farmed areas of New Zealand have enriched phosphorus levels to support productive agriculture. Widespread aerial topdressing since the 1950s has allowed even the most remote areas and difficult terrain to be fertilised. Photo Credit: Fletcher Trust Archives, P4070/12.

Figure 12-2. An algal bloom in Tūtira Lake. The green shades are high concentrations of actively growing algae. When cells start to die and decay, they can produce the blue/white froth seen here. The common name blue-green algae is accurate in terms of colour, but the organisms involved are actually cyanobacteria, not algae.

Phosphorus in our waterways

Plants and algae need much less phosphorus than nitrogen to grow well. Naturally, phosphorus usually occurs at very low levels in freshwater, so small increases can have a big effect on waterway health. For example, all of the cells combined from the worst algal blooms we have seen covering all of Tūtira Lake (Figure 12-2) only contained about 350kg of phosphorus, which is equivalent to 1 teaspoon of superphosphate (9.1% P) per 10m³ of water.

For comparison, an average sized sheep and beef farm in Hawke's Bay would apply more than 500kg of phosphorus across the farm in a single fertiliser application, although not necessarily every year. An average dairy farm operation will apply more than 500kg of phosphorus across the farm in most years. Orchards and crops require more phosphorus than pasture.

In 2019, an estimated 7150 tonnes of phosphorus fertiliser were applied in Hawke's Bay. Although most of this will not enter waterways, these numbers illustrate how much phosphorus agriculture requires, versus how little can trigger algal blooms and other environmental effects in freshwater. It is therefore important to minimise the amount of phosphorus loss from the land.

A measure of available soil phosphorus, called Olsen P, is typically managed in agricultural landscapes above 20mg/l, whereas levels need to average less than 10mg/l across the landscape to meet environmental targets. HBRC has conducted soil monitoring on many different land cover types across the region (Figure 12-3). Indigenous forest soils had a median Olsen P of 3mg/l and a maximum value of 6mg/l. In contrast, many farming systems were above 20mg/l, which substantially increases the risk of phosphorus leaching into waterways.

An additional factor that exacerbates the loss of phosphorus into water is artificial subsurface drainage. Many cropping, vineyard, and orchard sites with very high available soil phosphorus occur on soils with low phosphorus retention and artificial drainage.

The phosphorus added to these sites has a high risk of leaching into waterways. In such situations, an easy step for reducing the risk of phosphorus loss is to only apply as much fertiliser as needed. Testing the soil to determine how much fertiliser is needed should be standard farming practice, and it is expected to be part of all future farm environmental management plans (FEMPs).

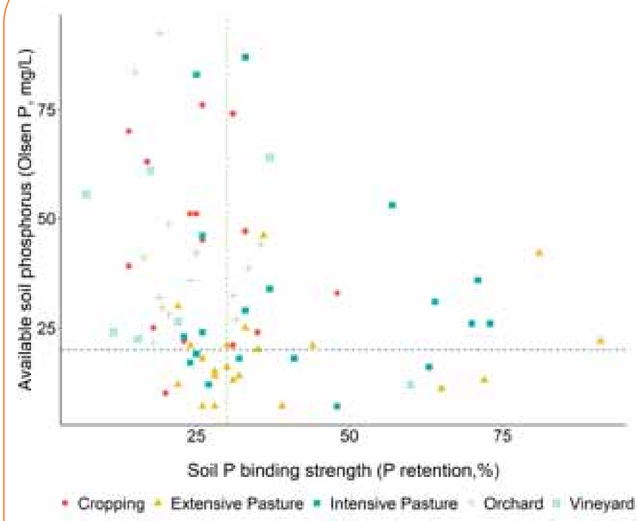

Figure 12-3. Available soil phosphorus versus phosphorus retention at soil monitoring sites on different farming types around Hawke's Bay. Above the horizontal dashed red line (Olsen P = 20mg/l), the risk of phosphorus loss to waterways is increased. To the left of the vertical dashed blue line (retention of 30%), phosphorus retention is considered 'low' or 'very low'. Indigenous and exotic forest classes are not displayed.

Rivers and lakes

The results from our monitored river and stream sites in Hawke's Bay show that phosphorus is usually elevated above natural levels (Figure 12-4). This can contribute to problematic algal growth in freshwater habitats. Almost half of the monitored river sites in Hawke's Bay are in the D band for dissolved phosphorus, which indicates substantial elevation above natural reference conditions and a high risk that sensitive organisms may be lost. Less than 20% of our monitored river sites are in the A band, which suggests no adverse impacts from phosphorous at these sites are expected.

Most monitored lakes in Hawke's Bay are also in the D band, although Tūtira has shown improvement in recent years and is currently in the B band.

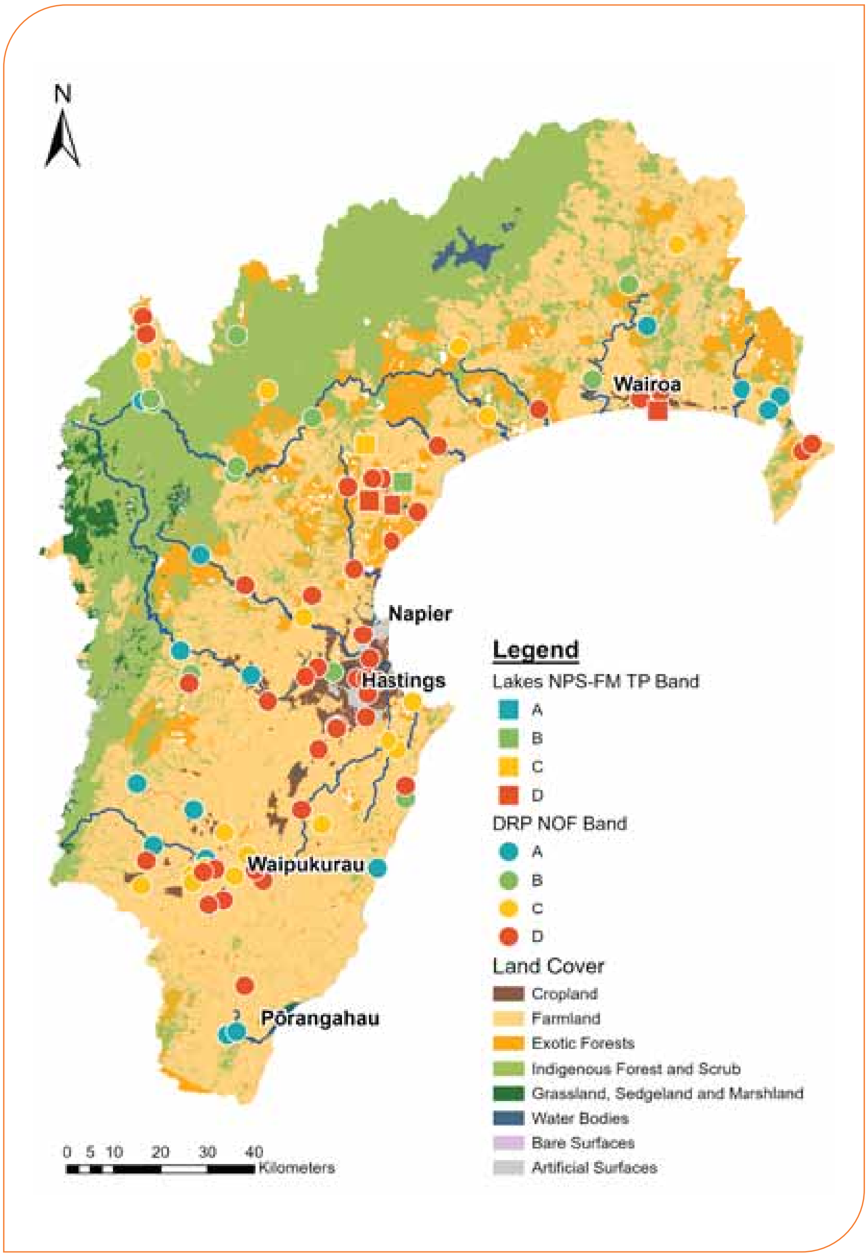

Figure 12-4. Phosphorus levels in rivers and lakes according to the bands outlined in the National Policy Statement - Freshwater Management (NPS-FM). NPS-FM bands range from A (good) to D (poor). TP = Total Phosphorus, DRP = Dissolved Reactive Phosphorus. Most modified areas of Hawke's Bay have elevated phosphorus, and almost half of the monitored river sites are in the D band.

Aquifers

Dissolved Reactive Phosphorus (DRP) concentrations can be elevated in some aquifers that have low oxygen (reduced conditions). These situations are typically driven by low water movement through the aquifers, which means oxygen is not replenished. However, such 'stagnant' aquifers may not contribute much phosphorus to surface waters, because the volume of water moving through and out of these aquifers is thought to be low.

Figure 12-5. Algal bloom in the Clive River in 2015.

Estuaries and coast

Phosphorus in rivers is carried into estuaries, and most estuaries in Hawke's Bay have similar dissolved phosphorus median levels to estuaries nationwide. However, in the Waitangi and Ahuriri Estuaries, phosphorus levels are two to three times the national average. In the Waitangi Estuary, high phosphorus levels can get stuck in the tidal arm of the Clive River due to the force of the Ngaruroro River, which can lead to blooms at the interface between the fresh and saltwater (Figure 12-5).

The open coast is different to estuaries. In Hawke Bay, about 84% of phosphorous is derived from the ocean rather than land-based sources.

Phosphorus management

Freshwater surface bodies are usually the most vulnerable to increases in phosphorus from human activities. Achieving targets will be a challenge, because the level of phosphorus required for conventional farming is higher than the level required for healthy waterways. Additionally, phosphorus that was applied decades ago may still be slowly leaching from the soil, even if no further fertiliser is added. A study by AgResearch and Lincoln University suggests that phosphorus levels may take 100 years to drop to natural levels in some Hawke's Bay soil types.

Nonetheless, waterway health can still be improved through mitigations that lower long-term phosphorus leaching. For example, fencing off and planting waterways provides a buffer strip to catch sediment and associated phosphorus. Hill country erosion control also helps keep sediment on the land and away from waterways, and riparian vegetation improves habitat quality. These actions benefit ecosystem health in many ways, so although it may take some time to reduce phosphorus leaching, the other associated benefits will be observable in our waterways sooner.