The Effects of Climate Change on Riparian Zones in Ireland

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Abstract

Throughout Ireland, the establishment of riparian zones (buffer strips) to reduce the concentration of nitrate draining from agricultural fields to adjacent streams and lakes is actively encouraged by Teagasc, the Agricultural and Food Development Authority. Despite the establishment of riparian buffer strips throughout Ireland, a report published by the Environmental Protection Agency (EPA) (Water Quality in 2020, an Indicators Report) states that “nitrate levels in rivers, groundwater, and estuaries in the south, southeast, and east of Ireland are too high”. The EPA report also states that reducing the nitrate levels must be a priority and the next Nitrates Action Programme must deliver reductions in nitrogen losses to water.

Exacerbating the problem is that climate change is now affecting Ireland, resulting in more intense storms and rainfall events. The increase in precipitation is likely to increase nitrate runoff from agricultural fields, which, in turn, will increase nitrate loads to lakes and coastal areas. This makes it imperative that more efficient use of buffer strips that maximize the reduction of nitrate in runoff while minimizing land set aside as buffer strips, to make the use of riparian buffers more appealing to farmers, be implemented.

This research will expand upon the concepts presented in last year’s talk. It will also discuss how the use of riparian buffers for the purpose of reducing nitrate runoff can: (1) provide other benefits in protecting water quality from climate change, (2) coincide with other land use goals, such as the reestablishment of riparian woodlands, and (3) suggest that a pilot study in a watershed to evaluate the ideas presented here could be established through a partnership between the EPA, Teagasc, the Office of Public Works, universities, and farmers.

Problem: Elevated NO_3 loads from agriculture to surface waters could be exacerbated by climate change

- WFD River Basin Management Plan – 3rd Cycle – June 2021

- Elevated nitrogen concentrations in waters is one of the factors that leads to poor water quality outcomes in all waters. Estuaries and coastal waters, and groundwater drinking water supplies are particularly at risk.
- There are a number of key catchments of concern with elevated nitrogen concentrations along the south, southeast and east coasts including the Maigue/Deel, Bandon, Lee, Blackwater, Suir, Nore, Barrow, Slaney, Tolka/Liffey and the Boyne river catchments.
- Nitrogen concentrations in waters have been increasing since 2013 — between 2013 and 2019, all but one of the catchments of concern showed increasing trends in the amount, or load, of nitrogen discharging to the sea via our rivers.

- The nitrogen load discharging to sea needs to be reduced in the catchments of concern to support healthy aquatic ecosystems. The scale of reduction needed ranged from zero in some years, to just over 8,000 tonnes of nitrogen in the Barrow catchment in 2018.
- The data show that in the predominantly rural catchments, more than 85% of the sources of nitrogen in the catchment are from agriculture, from chemical and organic fertilizers. In contrast, the majority of the nitrogen in Liffey/Tolka catchment, which incorporates Dublin City, is from urban waste water.
- Maps have been developed of the critical source areas for nitrogen. These are the highest risk areas in the landscape where nitrogen from agriculture leaches to waters. Measures to reduce leaching should be targeted in the critical source areas, in the catchments of concern, to deliver maximum environmental benefits.

Natural attenuation of nitrate occurs in riparian zones

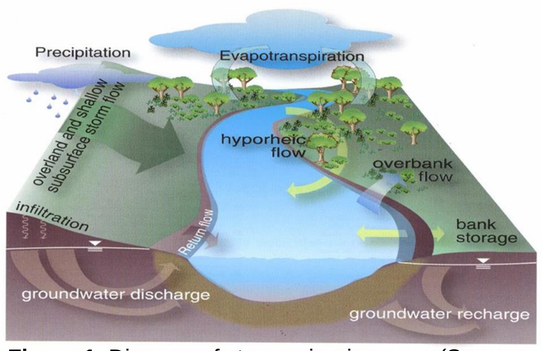


Figure 1. Diagram of stream riparian zone (Source: National Research Defense Council, 2002).

Assimilatory Nitrate Reduction – Uptake by vegetation and microbes, its reduction to ammonium, and its incorporation into biomass.

Dissimilatory Nitrate Reduction – Denitrification:

$5CH_2O + 4NO_3^- \Rightarrow 2N_2 + 4HCO_3^- + CO_2 + 3H_2O$

These processes also occur in stream channel sediments.

Effective use of riparian buffers can mitigate two potential negative effects of climate change – increases in nitrate loads and stream temperature

Nitrate runoff attenuation is most effective when all groundwater flows through the riparian zone and is less effective in situations where some or all groundwater bypasses the riparian zone.

First-order streams contribute nearly 70% to the mean annual stream flow and 65% of nitrate flux to higher order streams (Alexander et al., 2007).

Wooded riparian zones can reduce stream temperatures – Bowler, D.A. et. al. (2012).

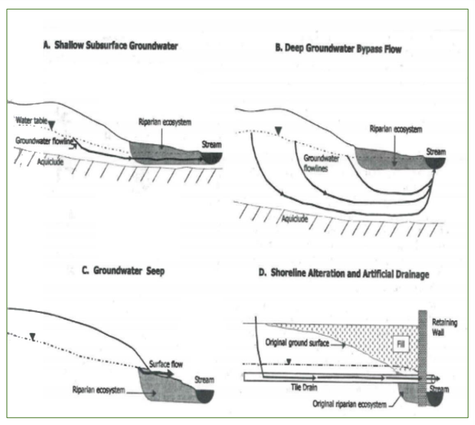


Figure 2. Nitrate attenuation is most effective in scenario A and much less so in scenarios B, C, and D.

Step 1: Identify problem areas from existing data from https://gis.epa.ie/EPAMaps/Water

Rivers experiencing agricultural pressures have been mapped

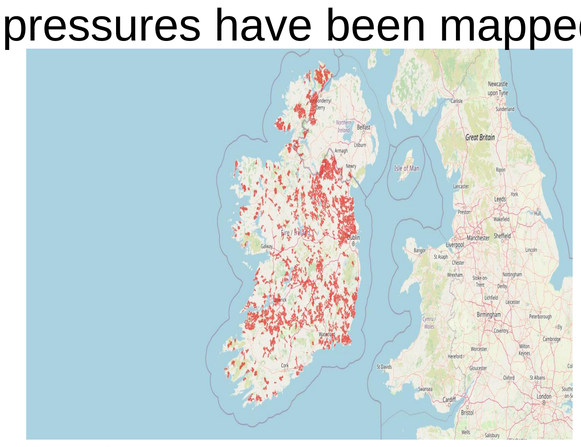


Figure 3. Rivers with high nitrate concentrations have been mapped throughout Ireland

Sub-catchments have been mapped

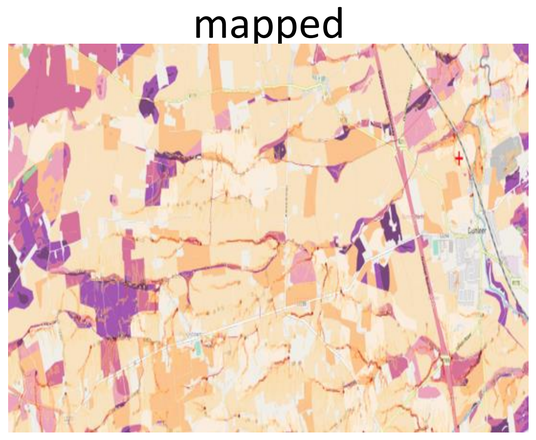


Figure 4. Mapping of sub catchments allows for the most efficient location of riparian zones

A pilot study can be identified with GIS coverages which identify sub catchments experiencing high stream nitrate concentrations.

Step 2: Refine placement of riparian buffers by additional data collection

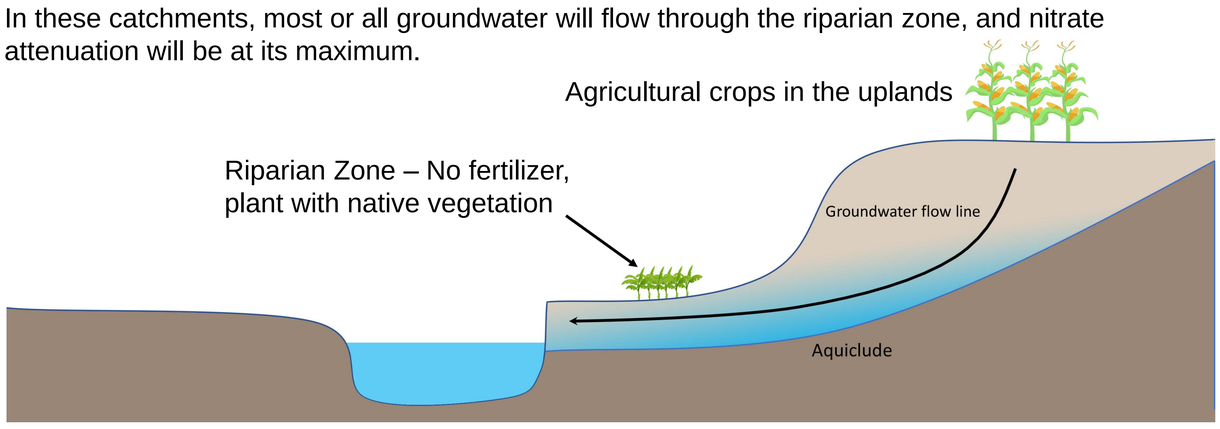
Collect water quality samples and measure streamflow at the mouth of tributaries and between tributaries during: (1) high flows, (2) low flows, and (3) bracket fertilizer application.

Comparing the loads of nitrate at the mouths of 1st order tributaries and along stream reaches between tributaries can determine which riparian zones are sources of nitrate and which are sinks.

Once the riparian zones contributing the largest load of nitrate measured at the mouth of the watershed has been determined it will be necessary to determine the width of the riparian zone needed to reduce the load of nitrate discharging from the riparian zone.

Potential Solution – 1st and 2nd Order Catchments

In these catchments, most or all groundwater will flow through the riparian zone, and nitrate attenuation will be at its maximum.

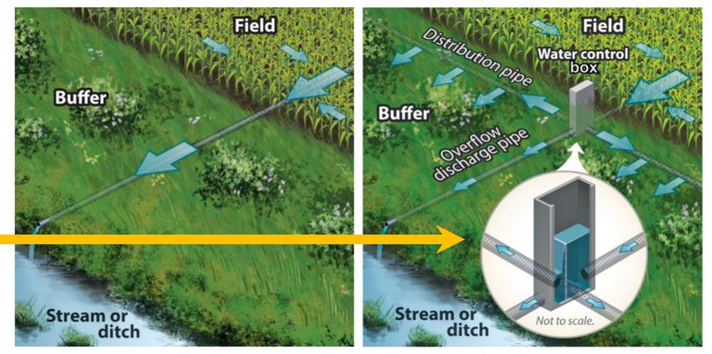


Potential Solution – 3rd Order and Larger Catchments

Consider restricting agricultural to the uplands.

Use alternative methods such as different types of:

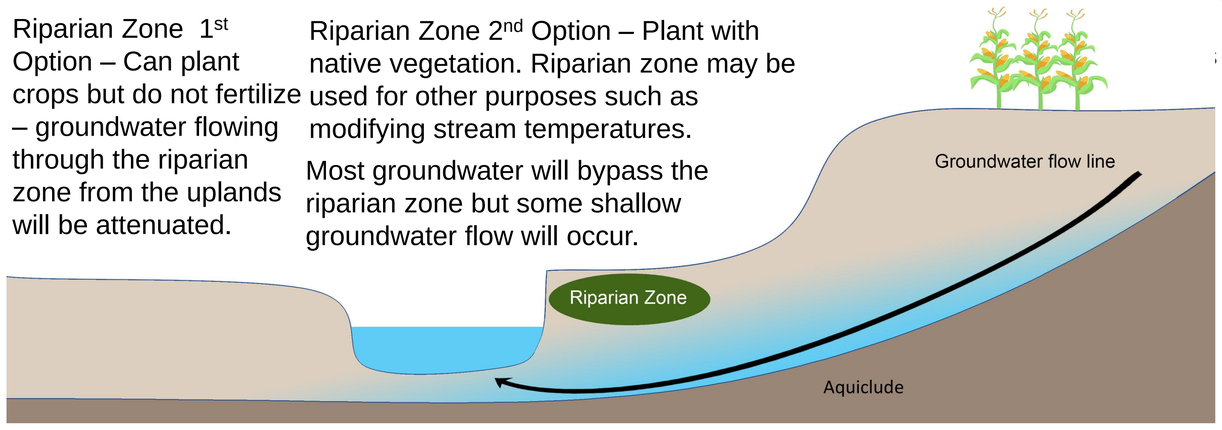
- Fertilizer
- Farming techniques
- Saturated buffers
- Denitrification bioreactors
- Artificial wetlands
- References 3-7



Riparian Zone 1st Option – Can plant crops but do not fertilize – groundwater flowing through the riparian zone from the uplands will be attenuated.

Riparian Zone 2nd Option – Plant with native vegetation. Riparian zone may be used for other purposes such as modifying stream temperatures.

Most groundwater will bypass the riparian zone but some shallow groundwater flow will occur.



Conclusions

Uniform width of riparian zones may not be the most efficient use of these buffer zones. Establishing riparian zones mainly in the headwaters can efficiently reduce nitrate runoff from the adjacent agricultural field and dilute nitrate delivered downstream from larger order sub catchments.

In larger order sub catchments alternate nitrate attenuation techniques should be implemented on the agricultural fields.

Riparian zones In larger order sub catchments can be used to reestablish native woodlands and reduce stream temperatures.

This strategy may result in less land set aside as riparian buffers and be more agreeable to farmers.

References

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