Key points

- Riparian bufferstrips separate agricultural land from watercourses and have to perform a number of functions including protecting the aquatic environment from the impact of agricultural pollutants.
- In their most basic form, riparian bufferstrips comprise a 2m uncultivated strip as required by the General Binding Rules for Diffuse Pollution. Under some stewardship schemes these are planted with grass. However, many more benefits can be gained by making these environments more biologically-diverse, including enhanced biodiversity of both plants and insects and production of useful biomass.
- Designer bufferstrips, where specific nutrient accumulating species are promoted, have the potential to sequester large amounts of nutrient into their biomass, but also alter greenhouse gas emissions.
- Research also shows that biomass removed from such bufferstrips is not effective by itself as a fertiliser replacement in the form of a green manure, but could be effective if part of an integrated nutrient management system supplementing, and part replacing, chemical fertiliser.
- These 'designer bufferstrips' have demonstrated benefits in capture of eroded soil and nutrients from adjacent arable land and multiple benefits can be gained from the material produced. However, consideration of species selection is needed to avoid increased greenhouse gas emissions.

Further resources

More information on this work, and other work, can be found below and by contacting tim.george@hutton.ac.uk or marc.stutter@hutton.ac.uk

Related External Documents

A Greener Scotland

http://www.scotland.gov.uk/Topics/Environment

EU Water Framework Directive

http://ec.europa.eu/environment/water/water-framework/

EU Nitrates Directive

http://ec.europa.eu/environment/pubs/pdf/factsheets/nitrates.pdf

http://www.scotland.gov.uk/Topics/farmingrural/Agriculture/Environment/NVZintro

Climate Change (Scotland) Act 2009

http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/climatechangeact

RESAS Strategic Research Programme: Environmental Change: Water and Renewable Energy (Theme 2)
http://www.gov.scot/Topics/Research/About/EBAR/StrategicResearch/future-research-strategy/Themes/Theme2

Designing bufferstrips to allow recycling of nutrients away from the riparian zone and provide wider ecosystem benefits

The James Hutton Institute

SEFARI LEADING IDEAS FOR BETTER LIVES

Scottish Government Riaghaltas na h-Alba gov.scot

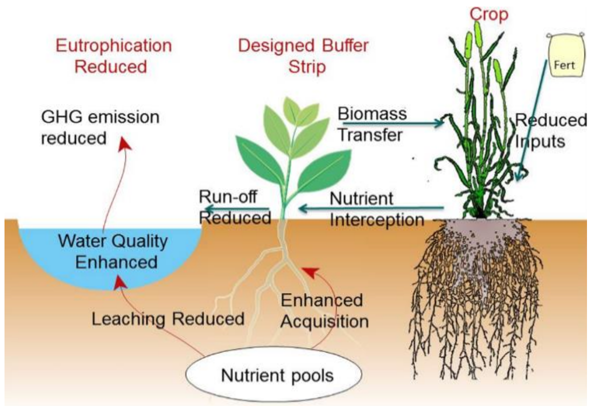
Introduction

A riparian bufferstrip is an area of land which separates agricultural land from watercourses and is maintained in permanent vegetation that helps to control soil and water quality and has other environmental benefits. Bufferstrips alongside water courses and water bodies are important in protecting and promoting biodiversity and in improving water quality and run-off.

There are a range of benefits associated with riparian bufferstrips including:

- reducing run-off into watercourses and therefore reducing flooding
- providing space for natural fluvial processes
- stabilising banks and reducing soil erosion
- providing habitat corridors
- improving landscape aesthetics

By selecting the type and make-up of the vegetation in the bufferstrips it is possible to provide valuable material for use elsewhere in the system or in the landscape. It is possible to provide biomass in the form of mown green manure or coppice wood which is variously useful as an alternative nutrient source, biomass for energy production and other coppice products such as weaved fences. These products add an economic, as well as environmental, benefit to riparian bufferstrips, potentially removing some of the barriers to their uptake by land managers.



Research

- Our interdisciplinary research examines how changing the vegetation of the riparian bufferstrip impacts their ability to sequester nutrients in soils, impacts the availability of nutrients in the soil leachate and alters the greenhouse gas emissions from margins in close proximity to watercourses.
- In addition, we have performed glasshouse based species screening experiments and green manure assessment experiments, while also assessing whether it is possible to promote specific species in riparian bufferstrips in the field.
- Our results indicate that material taken from bufferestrips and used as a green manure can replace some of the fertiliser inputs needed by the adjacent crop, but there is potential to introduce weeds to the arable system. No additional benefit was seen in selecting certain species for the bufferstrip on the basis of their nutrient accumulating abilities.
- Selecting grass species for different stages of bufferstrip development based on root physiological traits could help to reduce the amount of P in the soil leachate, but may enhance the greenhouse gas emissions. A combination of broadleaved and grass species has the optimal benefit on both the P and N cycle in bufferstrips.
- Research suggests that a number of innovative options are open to land managers to make more of the riparian margins, but further research is needed to assess what the most effective species selections are to optimise benefits and minimise detrimental effects to the wider environment.

Policy Implications

- *The need to reduce agricultural inputs, GHG emissions, and losses of mineral elements to the environment is implicit in many recent policy documents and can be contributed to by closing the agricultural nutrient cycle.*
- *Capturing nutrients in riparian bufferstrips and recycling these nutrients via movement of green manure from buffers to crops will help reduce inputs and minimise pollution. Reducing the use of fertilisers can help towards meeting Scotland's energy efficiency targets (Climate Change (Scotland) Act 2009), and improve water quality by contributing to N management strategies for nitrate vulnerable zones (NVZs) and P-fertiliser management.*

Is green manure from riparian buffer strip species an effective nutrient source for crops?

Brown LK, Kazas C, Stockan J, Hawes C, Stutter M, Ryan CM, Squire GR, George TS.

Journal of environmental quality (2019) 48:385-93.

Agriculture needs to reduce the inputs of inorganic fertilizers and close the loop on nutrients that can otherwise become environmental pollutants. This can be achieved by promoting recycling of nutrients within the agricultural landscape. We investigated the extent to which plants found in riparian buffer zones have the potential to provide nutrients to crops as a green manure, through plant growth and decomposition studies. Under controlled conditions, species typical of Scottish riparian bufferstrips were tested for their ability to accumulate biomass and nutrients in tissue under N- and P-replete conditions and whether this ability enhanced the utility of the resulting green manure in promoting crop growth. In this proof-of-concept study, we found that green manure derived from riparian bufferstrips did not effectively replace inorganic fertilizer and only had a significant positive effect on growth, yield, and nutrient accumulation in barley (Hordeum vulgare L.) when it was integrated with the addition of inorganic fertilizers (Figure 1). The individual species tested varied in the amount of P they accumulated in their tissue (1.38–52.73 mg P plant−1), but individual species did not differ in their ability to promote yield when used as a green manure (Figure 2, 3). Our results indicate that selecting certain species in the bufferstrip, on the basis of their nutrient accumulating abilities, is not an effective way to increase the utility of bufferstrip green manure as a nutrient source for crops.

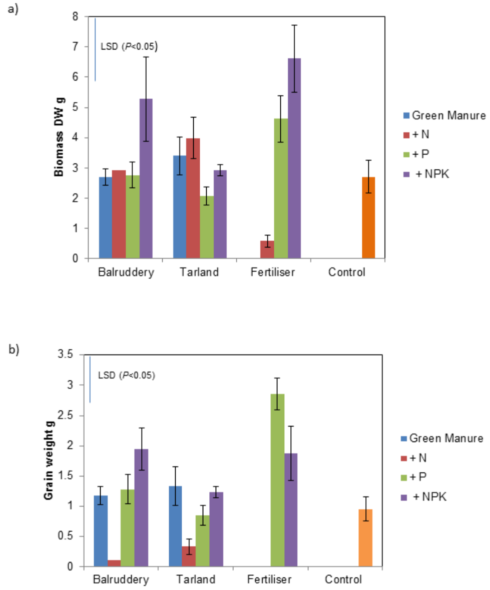


Fig. 1. (a) Biomass production (dry weight [DW]) and (b) yield of barley grown in soils amended with green manure and green manure integrated with N (+N), P (+P) and fertilizer (+NPK) compared with a NPK (fertilizer) and no addition control (Exp. 1). All soils, except the no addition control, received the equivalent of 50 kg P ha−1 and 250 kg N ha−1 (Supplemental Table S2). Green manures were sourced from existing conventionally managed buffer strips at Balruddery and Tarland in the northeast of Scotland. The data are the mean of six replicates and the error bars represent +/- 1 SEM. A LSD for the interaction is presented on the graph to allow comparison between treatments.

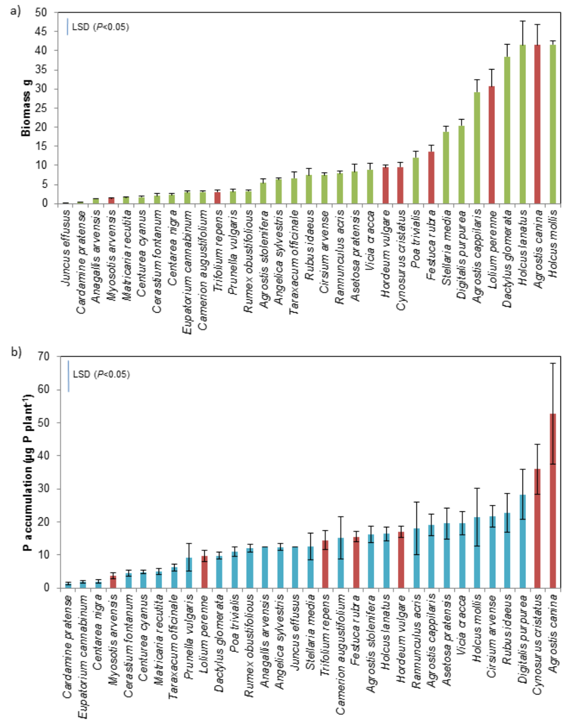


Fig. 2. (a) Biomass production and (b) P accumulation of a range of common buffer strip species grown for 12 wk in a sand–compost mix amended with N and P to levels typical of a riparian buffer strip, such that these nutrients are in excess of requirement (Exp. 2). Red bars represent the species which were selected for further study on impact on plant growth and supply of nutrients to soil. The data are the mean of six replicates and the error bars

represent +/- 1 SEM. A LSD for the main effect of species is presented on the graph to allow comparison between species.

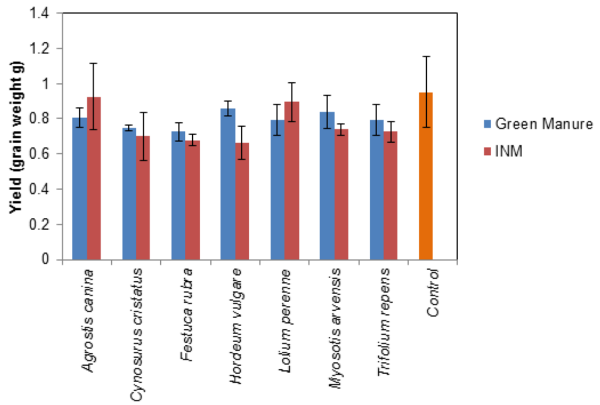


Fig. 3. Yield of barley after growth in soil amended with green manure from specific individual species typical of riparian buffer strips in Scotland and the same sources of green manure when applied in an integrated nutrient management (INM) system where half of the required nutrient is provided as inorganic sources (Exp. 3). All soils received the equivalent of 50 kg P ha−1 and between 100 and 500 kg N ha−1 (Supplemental Table S2), dependent on the N/P ratio of the material added. Plants were grown for 14 wk in controlled conditions and compared with an unfertilized control. The data are the mean of six replicates and the error bars represent +/- 1 SEM. No LSD is presented as there were no significant differences observed.

Phosphorus leaching from riparian soils with differing management histories under three grass species.

Roberts WM, George TS, Stutter MI, Louro A, Ali M, Haygarth PM.

Journal of Environmental Quality (2020) 49:74-84.

To increase soil P supply, plants release carbon-based exudates from their roots into the rhizosphere, however if more P than required is brought into solution, additional P could be available for leaching from riparian soils. Soil columns containing a riparian arable and bufferstrip soil, that differed in organic matter contents, were sown with three common agricultural and riparian grass species. The P loads in leachate were measured and compared to those from unplanted columns, which were 0.17 ± 0.01 mg kg-1 and 0.89 ± 0.04 mg kg-1 for the arable and buffer strip soil, respectively. A mixture of ryegrass and red fescue significantly (p ≤ 0.05) increased dissolved inorganic P loads in leachate from the arable (0.23 ± 0.01 mg kg-1) and bufferstrip soil (1.06 ± 0.05 mg kg-1), whereas barley significantly reduced P leaching from the buffer strip soil (0.53 ± 0.08 mg kg-1) (Fig 1). This was dependent on the dissolved organic carbon released under different plant species and on interactions with soil management history and biogeochemical conditions, rather than on plant uptake of P and accumulation into biomass (Fig 2, 3). This suggested that the amount and forms of P present in the soil and the ability of the plants to mobilise them could be key factors in determining how plants effect leaching of soil P. Selecting grass species for different stages of buffer strip development, basing species selection on root physiological traits and correcting soil nutrient stoichiometry in riparian soils through vegetative mining could help to reduce this contribution.

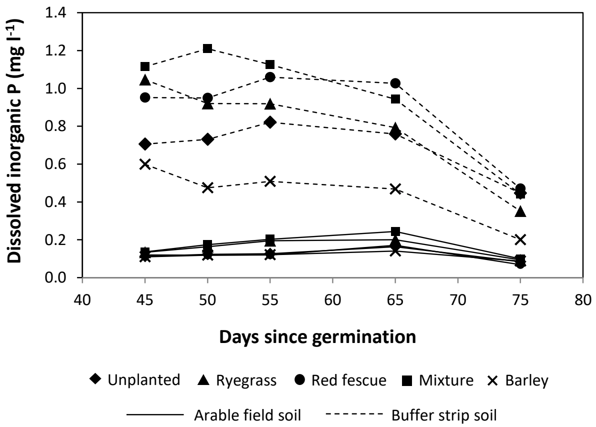


Figure 1. Temporal trends in mean dissolved inorganic P concentrations by plant treatment within each soil separately.

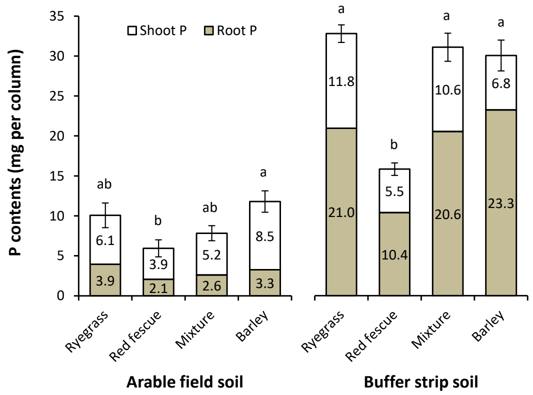


Figure 2. Mean and standard error for total plant P contents by plant treatment within each soil showing the contribution of root and shoot P. Different letters between plant treatments within each soil indicate a significant difference in means at the *p*≤0.05 significance level as determined by linear modelling.

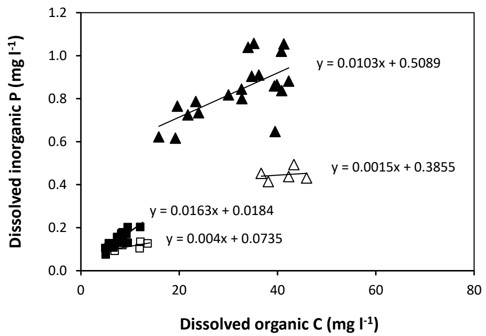


Figure 3. Relationships between dissolved inorganic P and dissolved organic carbon concentration within the field soil (squares) and the buffer soil (triangles). Opacity indicates a combination of unplanted, ryegrass, red fescue and mixture treatments and transparency indicates barley treatments.

Impacts of plant species assemblage on cycles of nutrients in bufferstrip soils and potential mitigation of pollution to the atmosphere and water in the wider environment

Lawrie K. Brown, Eve Daniel, Marc Stutter, Timothy S George

The sustainability of agriculture needs to be improved, in particular we need to maintain and enhance yield of crops while reducing the environmental impact of agricultural practices. In order to do this, we need to find ways to reduce the loss of inorganic fertilisers to the wider environment and 'close the loop' of nutrients such as nitrogen and phosphorus, which can become pollutants of the atmosphere and water. One way to achieve this is to apply agroecological theory to cropping systems and manage zones where nutrients accumulate in the landscape, such as riparian buffer zones, to optimise benefits to the environment. Here we investigate the impacts of altering the plant species assemblage in riparian buffer zones on the availability and movement of key polluting nutrients, N and P, within these accumulation zones.

Following the establishment, in 2015, of riparian bufferstrips with a range of known plant species composition including wildflower, grass and designer (selected for ability to accumulate nutrients in tissue, see above) mixes, we have continued to assess the N and P dynamics in soil, water and atmosphere annually and compared results to a bare fallow (no plants) and a plant fallow (natural seed bank). Each year we have taken soil samples, pore water and headspace gas samples throughout the growing season, which have been variously analysed for C, N and P content and we have been able to quantify potential water pollutants and greenhouse gas emissions from the different treatments.

Our results show that there was little impact of different plant species assemblage on soil nutrient accumulation and availability. However, there was an apparent accumulation of carbon and phosphorus in the bufferstrips with plants compared to the bare fallow after 5 years. The greatest increases were in the designer and wildflower treatments (dominated by broadleaf species), which had statistically more C and P, although these were not significantly different from other planted treatments, including the industry standard grass bufferstrips.

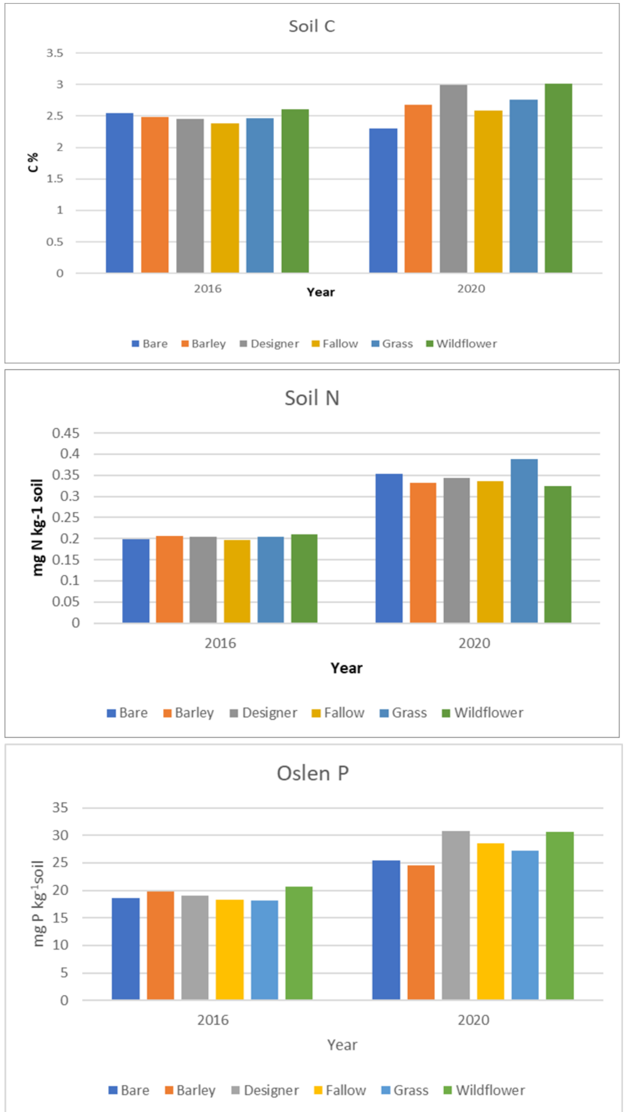


Fig. 1 Soil nutrient availability (C, N, P) in soils sampled from riparian bufferstrips established for 5 years with distinct plant species assemblages.

Despite the lack of impact of species assemblage in bufferstrips on soil availability of N, there is a clear effect on soil pore water concentrations of N. Our data clearly demonstrate that the concentrations of nitrate in pore water was greatly decreased in planted bufferstrips compared to bare fallow, greatly decreasing the pollution threat posed to adjacent water course, when buffers are planted. This again was most apparent in treatments dominated by broadleaf species as opposed to grasses.

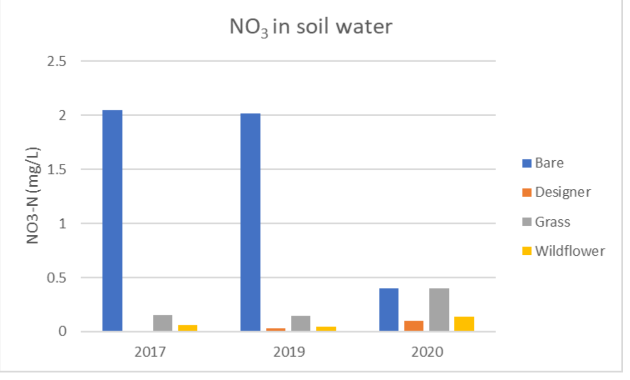
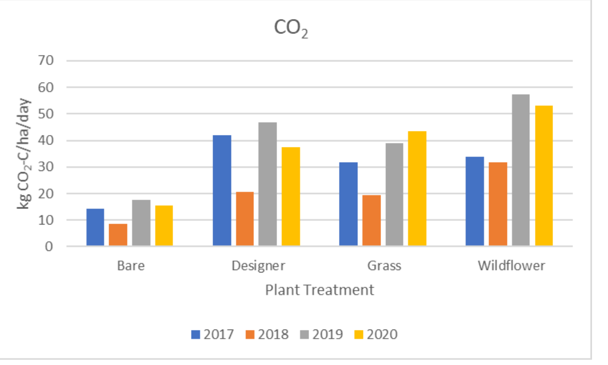


Fig. 2 Soil pore water nitrogen content (NO_3) in water sampled from riparian bufferstrips established for 5 years with distinct plant species assemblages.

Of most interest were the results for greenhouse gas emissions from bufferstrips. Our data demonstrated that while planting buffers led to greater emissions of both CO_2 and N_2O compared to a bare fallow, planting buffers with broadleaved dicotyledenous species led to a much lower rates of N_2O emissions when compared to grass buffers in certain years. This suggests that the selection of plant assemblage can have a profound effect on the greenhouse gas emissions from buffers and this can be greatly improved compared to the industry standard grass buffers.



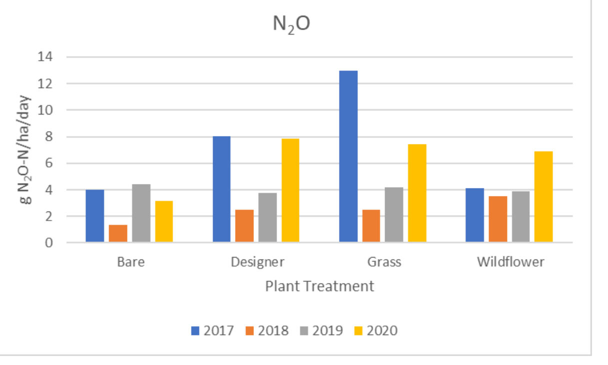


Fig. 3 Gas headspace greenhouse gas emissions (CO_2, N_2O) from riparian bufferstrips established for 5 years with distinct plant species assemblages.

In conclusion, our results demonstrate that bufferstrips planted with broadleaved species, where specific nutrient accumulating species are promoted, have the potential to sequester large amounts of nutrient into their biomass, altering the nutrient cycle in bufferstrip soils and impacting greenhouse gas emissions positively, compared to the industry standard grass buffers. The research suggests that a number of innovative options are open to land managers to make more of the riparian margins, but further research is needed to assess what the most effective species selections are to optimise benefits and minimise detrimental effects to the wider environment.