Harnessing the power of nature: arable edges and hedges

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In arable landscapes, field margins, buffer strips and hedgerows support a multitude of species including birds, pollinators, natural enemies and small mammals. These linear features help wildlife to move across our countryside connecting semi-natural habitats. Building nature networks is key to helping wildlife respond to environmental change, including climate change. Field edges and hedges deliver a range of ecosystem services; they lock up carbon helping farms move towards net zero, they intercept pollutants protecting watercourses; and they can slow water flow reducing flood risk. The ability of these habitats to provide ecosystem services is strongly influenced by their management and placement within the landscape. Here we provide guidance on how to manage arable field edges and hedges to optimise the benefits gained to production, the environment and wider society.

Challenges faced by agriculture

To feed a growing and more affluent population, it is predicted that we will need to produce 60% more food globally by 2050[1]. The agriculture sector, however, has faced turbulent times with price inflation, external shocks (e.g. COVID pandemic, Ukraine war), the withdrawal of pesticides and escalating fertiliser costs. Furthermore, the frequency of extreme weather is predicted to escalate with periods of drought and flooding becoming more frequent. Already in Scotland we are seeing impacts of such extreme weather on crop yield. It is not just climate change that threatens food security, as we lose species, farmland ecosystems become more vulnerable and less resilient to environmental change. From individual farms to the boardrooms of transnational companies, climate change and biodiversity loss are becoming increasingly recognised as primary risks to food security.

To tackle these challenges, the Scottish Government is committed to stem biodiversity loss by 2030 and become net-zero by 2045. To help meet these ambitious targets, agricultural policy has been restructured with Scotland aiming to become a world leader in sustainable and regenerative agriculture. Moving to more regenerative approaches that harness nature's ecosystem services to enhance production provides a promising solution to reconcile food production, climate change and biodiversity goals. Such approaches also reduce dependencies on synthetic inputs, boosting profitability and production whilst working positively with nature.

Managing field edges and hedges to support natural enemies and insect pollinators is key when transitioning to regenerative agriculture. These habitats support a range of beneficial insects including spiders, ladybirds, parasitic wasps and insect pollinators. The creation of these habitats need not adversely impact on farm profitability. Research found that converting 8% of cropland to wildlife habitat increased yield in adjacent fields with effects becoming more pronounced over time[2]. In targeting field margins where crop yields are often typically lower, field edges and hedges integrate seamlessly in arable systems, so why not enhance them and reap the rewards that these habitats deliver to your farms?

Level of services provided

Low

Medium

High

Flower-rich field margins

- Cultural
- Natural pest control: Spiders and ground beetles
- Pollination: Foraging
- Biodiversity
- Natural pest control: Hoverflies and parastic wasps
- Clean water

Grassy field margins

- Carbon
- Biodiversity
- Pollination: Nesting
- Protects soil from erosion
- Natural pest control: Spiders and ground beetles
- Clean water

Hedgerow

- Carbon
- Cultural
- Natural pest control: Hoverflies and parastic wasps
- Protects soil from erosion
- Remove air pollutants
- Pollination: Nesting
- Natural pest control: Spiders and ground beetles
- Natural flood management
- Biosecurity
- Pollination: Foraging
- Biodiversity
- Clean water

Buffer Strip adjacent to watercourses

- Carbon
- Cultural
- Natural pest control: Spiders and ground beetles
- Natural flood management
- Biosecurity
- Pollination: Foraging
- Biodiversity
- Stabilise river banks
- Reduces liver fluke risk
- Natural pest control: Hoverflies and parastic wasps
- Protects soil from erosion
- Clean water

Flower-rich field margins and their ecosystem services

Flower-rich field margins are typically sown with a variety of wildflowers which bring colour and wildlife to our countryside. In providing nectar and pollen, they enhance pollinators and support natural enemies to harness biodiversity-based ecosystem services. Furthermore, the presence of these strips, buzzing with insect life, boosts the publics' perception of Scottish farms.

Pollination contributes to yield in a range of crops with dependence on insects varying from 25% of yield in oilseed rape and beans to over 60% of yield in apples[3]. Enhancing the abundance and diversity of pollinators has a key role to play in closing yield gaps in insect pollinated crops. Pollinators need a range of resources including nesting sites, resources for larvae and a constant source of pollen and nectar. Flower-rich field margins have a key role to play in providing forage. Legumes such as clovers and bird's-foot trefoil provide protein rich pollen and their deep flowers benefit long-tongued bumblebees which are crucial pollinators of field beans.

Including open flowers such as wild carrot, yarrow and oxeye daisy will provide resources for the adult stages of natural enemies such as parasitic wasps, lacewings and hoverflies. Research indicates that flower-rich field margins enhance pest control in the adjacent crop by 16% on average[4]. With aphids developing resistance to pesticides, we are becoming increasingly reliant on natural enemies to control aphid populations and the viruses they transmit. Insects will start to use floral strips almost immediately; however, it will take time for populations of local pollinators and natural enemies to build up and positive impacts on production may take 3-4 years to observe.

It is not only insects that benefit from flower-rich field margins. These margins provide highly profitable foraging habitat for bats and a variety of insectivorous birds including grey partridge, swallows and yellowhammers.

What does a good flower-rich margin look like?

Field margins that are botanically rich with a range of different flower structures will benefit the widest variety of insects. As flower-rich margins tend to flower quite late in the season, place them near habitats that flower early in the season (e.g. hedgerows and woodland edges) to ensure continuous forage for insects that are less mobile (e.g. solitary bees)[5].

Placement
Place in sunny locations adjacent to other features that provide complementary resources (e.g. hedgerows, stonewalls).

Structural diversity
Flowers, seeds and tussocky grass provide a range of resources for different species.

Diverse native flowers
Prolong the flowering period and provide a variety of floral structures. Include legumes to provide nutrient rich pollen for bees.

Width
Wide strips provide more resources and create a bigger buffer against infield practices. Aim for margins that are at least 4-6m wide.

Risks to flower-rich margins and management to minimise these risks

Risks	Actions to reduce risks
Pesticide drift: Herbicides that target broad-leaved weeds also kill wildflowers when they drift into the field margin. This results in margins dominated by grass species. It is also important to protect margins from broad spectrum insecticides which will adversely impact on a range of insects living in the margin.	Reduce reliance on pesticides and ensure use is targeted through integrated pest management techniques. Provide a buffer zone adjacent to field margins, use low drift nozzles and avoid spraying when windy to further protect field margins from pesticide drift.
Nutrient enrichment: Many wildflowers thrive in nutrient poor soils. Field margins are often nutrient rich due to runoff and drift of inorganic fertilisers. Nutrient rich margins benefit nitrogen loving plants species such as cleavers, nettles and field thistles. These species will outcompete more delicate wildflowers.	Undertake soil analyses and use precision agricultural techniques to ensure nutrient inputs meet crop demands. As with pesticides, maintain a buffer zone, use drift reducing technology and prevent spraying in windy conditions. During establishment of flower-rich margins, remove the top 5cm of soil to reduce soil fertility and prolong the lifespan of the margin[6].
Seed mixes focus on pollinators: Mixtures that benefit pollinators may not be suitable for natural enemies that can't access nectar in deep flowers (e.g. clovers and vetches). Often combining different mixes to benefit natural enemies and pollinators results in certain plant species dominating[7].	Discuss with ecologist/seed merchants to determine a mix to suit your soil and goals of the strip (e.g. pollination or natural enemies). To benefit both, planting in blocks or in different field margins will help ensure flowers in both mixes persist. A ratio of 4kg/ha of wildflowers to 10 kg/ha grasses is recommended.
Degeneration: As flower strips age, they typically lose species as competitive grasses and weeds start to dominate. Flowers become less abundant, and the wildlife value of the strip deteriorates.	Graze or cut and lift the vegetation late in the season once flowers have set seed. Include yellow rattle, a parasite of grass, to restrict grass growth[8]. Cut different sections of the margin each year to increase structural and botanical diversity. Problem weeds should only be controlled using spot sprays.
Competition with semi-natural habitats: There is a risk that introducing high value nectar resources could draw pollinators from adjacent semi-natural habitats, resulting in deterioration of pollination in these habitats.	Select native wildflowers in mixes, allow margins to regenerate naturally or spread with green hay (i.e. hay collected from local flower-rich habitats such as nature reserves) to provide a cheap means of establishment and ensure local species.
Non-native invasive plant species: Field margins are at risk from invasive species such as Himalayan balsam with risks escalating when margins are next to roads, lay-bys and footpaths.	Learn to recognise key invasive species and take action if these species are present in field margins. Once invasive species take hold they are extremely difficult to eradicate thus early detection and control is vital.

Economic costs and funding support for establishing flower-rich field margins

Costs for establishing a grass and wildflower mixture including ground preparation is approximately £2,860 per ha with establishment using green hay significantly lower at approximately £1,300 per ha (Lynne Bates, Scottish Wildlife Trust[9]). Under the Agri-Environment and Climate Scheme (AECS) you can claim £495.62 per hectare per year for Grass Strips in Arable Fields[10].

Grassy field margins and their ecosystem services

Grassy field margins are areas of permanent, undisturbed vegetation around the edge of cereal fields. They're less "pretty" than flower-rich field margins but provide a range of important ecosystem services and often support native flower species albeit at lower densities.

Grass provides dense, year-round, ground cover which makes undisturbed grassy field margins particularly effective at trapping soil particles during vulnerable periods (during winter and also during spring and autumn cultivations), protecting watercourses from sedimentation and pollutants. The dense vegetation also slows down the flow of surface waters and the deep root structure of grasses, such as cocksfoot, increases water infiltration into the soil. Grassy field margins therefore regulate water flows protecting soils from erosion and reducing flood risk.

Tall dense tussocky grasses create unique microclimates that buffer weather extremes and thus provide excellent overwintering habitats for natural enemies including ground beetles, spiders and parasitic wasps. Many of these species emerge early in the season and provide an important first line of defence against crop pests including aphids, and slugs.

Many grassy field margins have been undisturbed for decades and as a result they can provide stores of carbon. When protected from spray drifts these margins also support a range of native wildflowers and a diversity of grass species. Grasses such as Yorkshire fog, fescues and meadow grass provide caterpillar food plants for a variety of butterflies including meadow brown, small skippers and small heath. Small mammals such as bank voles and harvest mice also find shelter in these field margins and in turn, they provide food for mammals (e.g. stoats and weasels) and birds of prey (e.g. kestrels and owls). Abandoned small mammal burrows provide nesting sites for bumblebees.

What does a good grassy field margin look like?

Grassy field margins with continuous ground cover and a variety of different grass species, wildflowers and plant structures (e.g. seeds, grassy tussocks, and shorter dense areas) will optimise the benefits these margins provide.

Year round vegetation cover
Provides overwintering sites, intercept pollutants and reduce flood waters.

Native grasses and flowering plants
Tussock forming grasses provide overwintering sites and native flowers provide pollen and nectar.

Structural diversity
A variety of grass heights and structures (e.g. grassy tussocks, seeds) will provide habitat for a wide range of wildlife.

Lack of competitive species
Lack of nutrient loving species such as nettles, docks and cleavers which can dominate grassy margins and reduce botanical diversity.

Risks to grassy field margins and management to minimise these risks

Risks	Actions to reduce risks
Nutrient enrichment: Runoff and spray drift can result in a dominance of nutrient loving plant species which will outcompete native grasses and wildflowers.	Combine nutrient budgets with precision agriculture to ensure nutrient inputs meet crop demands. Reduce drift using drift reducing technology and prevent spraying in windy conditions. Create a buffer zone adjacent to field margins to protect margins from agrochemicals.
Pesticide drift: Broad spectrum insecticides could impact on natural enemy populations in field margins. Broad-leaved herbicides will prevent native wildflowers establishing in field margins.	Monitor pests and spray insecticides only where economic thresholds are reached. Use technologies to prevent spray drifts, maintain a buffer zone and avoid spraying in windy conditions.
Lack of native wildflowers: When grasses dominate, wildflowers can struggle to survive thus reducing the value of these margins to wildlife.	Use green hay or include perennial wildflowers (e.g. knapweed, oxeye daisy) and legumes (e.g. clover and meadow vetchling) to increase floral resources. Cut during the first summer to prevent weeds from flowering and allow sown species to establish in more open swards.
Ploughing and compaction: Many insect predators overwinter in undisturbed field margins. Ploughing and replanting these strips can have adverse impacts on these beneficial arthropods.	Prevent compaction by limiting vehicle movement in grassy field margins. Avoid soil disturbance particularly during winter when natural enemies are overwintering.
Scrub encroachment: While it is important that margins are left undisturbed to protect overwintering invertebrates, without management scrub will eventually encroach.	Cut grassy margins in sections to encourage a diversity of sward structures. Ensure some areas are left uncut each year so tall tussocky swards form providing overwintering sites for natural enemies and improving carbon storage[11].
Climate change: Climate change could impact soil temperature and moisture which adversely affects carbon sequestration in grass strips. Higher temperatures and drought can increase emissions.	Above and below ground carbon stocks vary with soil, climate and management with limited evidence on increased plant richness on carbon stocks[12]. Soils don't store carbon perpetually and eventually an equilibrium is reached.

Economic costs and funding support for establishing grassy field margins

These costs were published in 2015, an updated cost is also included to account for inflation at 3.29% per year in brackets. Capital cost: £0.3 (£0.61) per m for 2m wide field margin. Annual cost: £0.5 (£1.02) per 100m for 2m wide strip grass maintenance[13]. Under the AECS you can claim £495.62 per hectare per year for Grass Strips in Arable Fields[14].

Hedgerows and their ecosystem services

Hedgerows are linear habitats consisting of closely grown woody shrubs which sometimes are interspersed with trees. They are a well-loved feature of the British countryside, have provided a natural barrier between fields for hundreds of years and are intertwined with the way we farm. Hedgerows can benefit agricultural production, and it is estimated that for every £1 invested in hedgerows, farmers see a £1.73 return from higher crop yields and reduced spend on pesticides[15]. Hedgerows play a vital role in providing ecosystem services benefitting wildlife and production whilst providing wider benefits to society.

Hedgerows support a diversity of species, including 82 species of conservation concern such as brown hairstreak butterflies and yellowhammers. Hedgerows provide nesting, shelter and overwintering sites. The flowers support a diversity of insects while berries produced in autumn help sustain birds over winter. Creating networks of semi-natural habitats through our countryside, hedgerows act as superhighways connecting habitats. Visible from the air, species such as bumblebees and bats use them to navigate.

Hedgerows provide resources for many species that are crucial to agricultural production. Shrubs such as hawthorn and blackthorn provide valuable forage for pollinators early in the season, while bramble, dog rose, and ivy provide resources later in the season. These floral resources also help support the adult stages of natural enemies such as parasitic wasps and hoverflies. Bumblebees and solitary bees often nest at the base of hedgerows and this tussocky vegetation provides overwintering site for predatory insects such as wolf spiders and rove beetle.

The hedgerow itself provides shelter and overwintering sites for hoverflies, butterflies and natural enemies such as ladybirds[16].

Hedgerows not only enhance biodiversity but also sequester and store carbon above and below ground, helping landowners offset greenhouse gas emissions. On average 31% more carbon is stored in soil surrounding hedgerows compared to grassland[17]. Carbon storage is greatest in tall dense hedgerows and can further be enhanced by allowing some trees to grow. To reduce the risk of hedgerow trees casting shade onto adjacent crop, tree planting should focus on hedgerows that run north to south.

Hedgerows reduce the risk of soil erosion and the dense vegetation at the base of hedgerows intercepts soil particles. The deep roots of hedges increase the rate that water infiltrates into the soil, slowing water flow and reducing peak flood levels during heavy rainfall[18].

What does a good hedge look like?

The ecosystem services that hedgerows provide depend very much on the condition of the hedgerow. Tall, dense, structurally sound hedgerows support a range of woody species provide the widest range of benefits.

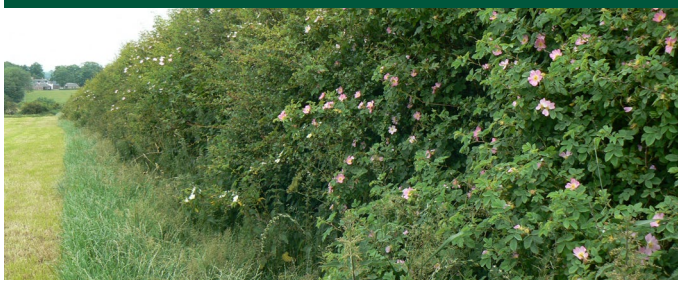
Tall, dense and wide
Better at sheltering crops and store more carbon. Aim for a minimum height and width of 1.5m.

Continuous hedgerow
Gappy hedgerows are less effective wildlife corridors. Replant gaps with a range of native shrubs (e.g. hawthorn, hazel, holly and dog rose).

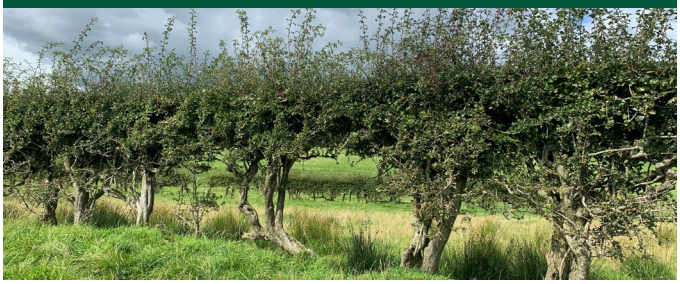
Diverse species and structural complexity
Provide resources that support a range of species including birds, pollinators and natural enemies. Selecting native species grown locally can further enhance their value.

Diverse vegetated base
Protect hedgerow bases from spray drift to encourage a floristically diverse border and provide additional habitat for wildlife.

Good quality hedgerow

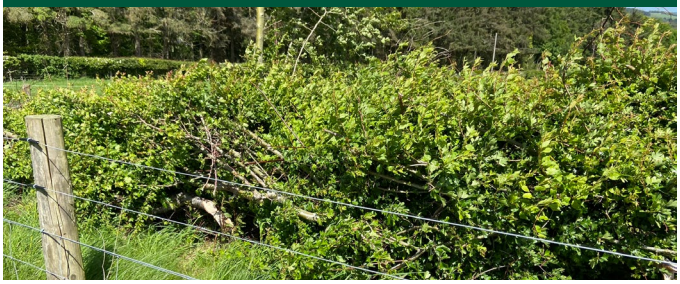


Poor quality overtrimmed hedgerow



Traditional hedge laying

Conservation hedge laying



Wildlife and/or Conservation hedge laying offer a cheaper and quicker method of rejuvenation to traditional laying. Conservation hedge laying involves cutting the stems at the base and laying the branch stems on both sides of the hedge. Wildlife hedging is even quicker and cheaper. Here stems are cut and the whole hedge is simply pushed over – often with machinery.

Risks to hedgerows and management to minimise these risks and optimise benefits

Risks	Actions to reduce risks
Disturbance: Ploughing near the hedgerow base can damage the root system and destroy herbaceous vegetation growing there. Herbaceous vegetation provides a range of resources for wildlife including overwintering sites for natural enemies and floral resources for pollinators.	Leave a vegetated base of at least 2m on either side. Vegetation should be cut and removed or grazed late in the year to allow for flowering plants to set seed and to reduce the soil nutrient level. Leaving some areas undisturbed and encouraging tussocky grasses to grow can provide nesting sites for bees and overwintering sites for natural enemies.
Over trimming: When trimmed at the same height each year, gnarled scars form at the trimline. Additionally, as woody plants typically flower and produce berries in the second year of growth, annual cutting reduces resources for wildlife.	Reduce cutting intensity (e.g. once every three years) and allow the hedge to gradually grow taller and wider. Stagger cutting across the farm to ensure that some hedgerows remain uncut allowing them to flower and produce berries[19]. Allowing some trees to grow tall will increase the carbon stored in the hedgerow and provide additional habitat for wildlife.
Neglect: Without management, hedgerows will typically grow into a line of trees. While treelines provide important habitats, they support different species and lack the dense structure which provides excellent nesting and overwintering habitat. Over time, even well managed hedgerows will start to degenerate as older shrubs die, leaving gaps impacting the structural integrity of the hedge.	Trimming every three years will help hedgerows maintain a dense structure. This will not however prevent the hedgerow from degenerating. Hedgerows will need to be rejuvenated (e.g. hedge-laying after 15 years, coppicing after 25 years). Refer to page 9 for further explanation on conservation hedge laying for hedgerow rejuvenation.
Invasive species: Giant hogweed and Himalayan balsam can quickly spread along hedgerows, and areas with a high footfall (footpaths, lay-bys) are particularly vulnerable. Invasive species quickly outcompete native plant species, reducing botanical diversity.	Early detection and control (i.e. by mechanical or chemical means) is key as once established, invasive species are difficult and costly to eradicate.
Climate change, pests and disease: As our climate changes, some species may be unable to adapt, and additionally we may see new species of pests and diseases emerging. Ash dieback is prevalent in hedgerows across Scotland.	Including a diversity of species in the hedgerow will build resilience to climate change, pests and disease. Trees with ash dieback should be regularly monitored to ensure that they remain structurally sound particularly when near buildings, foot paths and roads.
Grazing by both livestock or native species: Livestock and wildlife browsing can impact hedgerow condition, resulting in hedgerows that are gappy at the bottom. Hedgerows are particularly vulnerable during establishment; grazing can result in saplings failing.	Stock fencing/electric fencing will help protect the hedgerow base. The use of tree guards will protect newly planted shrubs from voles and hares. To allow the hedgerow to gain density at the base, tree guards should be removed when the shrubs are big enough to withstand grazing pressure.

Economic costs and funding support for establishing and maintaining hedgerows

The economic cost of establishing and managing hedgerows varies based on farming system and topography. These costs were published in 2010, thus cost adjusted for inflation at 3.45% is included in brackets. Costs of rejuvenating hedgerows vary from £1,241 (£1,994) for traditional hedge-laying, to £644 (£1,035) for conservation hedging and £225 (£362) for coppicing (excluding fencing)[20] for 100m stretches. Under AECS it is possible to claim £1.20 per m per year for establishing a new hedgerow with additional capital costs to cover planting/replanting (£5.40 per m), coppicing (£3.75 per m), fencing (up to £5.50 per m), and tree guards (up to £1.80 per m)[21]. It is worth noting that a hedgerow carbon code is currently in development which would enable farmers to trade carbon credits[22]. Other costs associated with establishment and maintenance can be found below based on a case study of 162ha Crainoch Farm[23].

Annual Marginal Costs	Per Hectare (£)
Loss of gross margin due to taking land out of production (likely to be higher in arable enterprises)	36.99
Hedge trimming every other year	2.96
Hedge planting costs (amortized over 15 years @ 4%)	60.71
Total	**100.65**

Buffer strips adjacent to watercourses and their ecosystem services

Buffer strips are placed in the interface between aquatic and terrestrial habitats (i.e. the riparian zone) and as such they play a key role in protecting watercourses from diffuse pollution. Their close interactions with watercourses mean they offer a much wider range of ecosystem services when compared to non-riparian field margins.

In arable landscapes, the banks of rivers and streams have historically been uncultivated and protected from agrochemicals. As a result, they are often botanically diverse and support specialist wetland plants such as marsh marigold, water mint, and valerian. These unique habitats support a variety of semi-aquatic species including amphibians, dragonflies, water voles and kingfishers. As rivers are inherently linked, targeting restoration measures to riparian zones will enhance ecological connectivity through catchments.

Vegetated grassy buffers play a key role in trapping pollutants by filtering runoff through dense vegetation to protect watercourses from agrochemicals. The rough vegetation also slows the flow of water, regulating the rate that water enters waterbodies during periods of heavy rain. Wooded buffers with their deep tree roots are even more effective in the infiltration of surface water to further reduce flood risk. Vegetation and soil properties differ between wooded and vegetated buffers, thus 3D buffers that combine a zone of wooded trees with a grassy zone can optimise benefits to both water quality and flood defence.

Open vegetated buffers can provide diverse floral communities benefitting pollinators. However, the tree canopies of wooded buffers provide shade which stabilises water temperatures and results in stretches of cooler waters where aquatic species can retreat during periods of extreme heat. Wooded buffers also sequester and store carbon above and below ground, helping to improve the carbon footprint of the farm. To retain the inherent diversity of riparian zones, woodland creation and vegetated buffers should be spatially targeted to optimise the benefits gained and maintain a diverse range of habitats.

What does a good buffer strip look like?

3D buffers with multiple zones (e.g. vegetated zone, ridges and wooded zones) will deliver the greatest diversity of outcomes. Careful design is needed to avoid taking large areas of out production particularly in arable landscapes. Where 3D buffers are not viable, selection of buffer type will be dependent on the outcomes desired.

Wide strips (i.e. 6m)
Wider buffer strips create a greater barrier between infield operations and the watercourse, increasing the chance that pollutants will be intercepted and providing suitable habitat for native species.

Presence of trees
Tree roots help stabilise riverbanks, reducing the risk of banks eroding. They also provide shade helping aquatic systems adapt to climate change and provide organic matter to support aquatic food webs.

Diverse plant species and structures
3D buffers that combine trees, more flexible stems, grass tussocks, deep rooted and complex fibrous rooted species will optimise the interception of nutrients, increase water infiltration and support biodiversity.

Diversity at the catchment scale
Watercourses are inherently dynamic and it is important that actions do not simplify rivers at the catchment scale. Spatially target the placement of wooded and more open vegetated buffer to optimise benefits whilst enhancing the diversity of the watercourse.

Risks to buffer strips and management to minimise these risks and optimise benefits

Risks	Actions to reduce risks
Nutrient enrichment: As nutrient laden soils are intercepted, buffer strip soils can become saturated over time. There is therefore a risk that older buffer strips could act as a source of pollutants. Furthermore, as nutrient levels build up, native wildflowers will be lost to more competitive nutrient loving species.	Take action to reduce pollutants at source (e.g. nutrient budgets, winter cover, precision agriculture and conservation tillage). Prolong the buffer's lifespan through mechanical removal of saturated soils or biomass removal through grazing or mowing. In removing vegetation, these actions will reduce the efficiency of the buffer strip in the short term so timing should coincide with periods of low risk.
Non-native invasive plant species: Watercourses facilitate the spread of invasive plant species including giant hogweed, Himalayan balsam and Japanese knotweed. In Scotland, it is not uncommon to see all three species present along riverbanks. These species quickly outcompete native plants, reducing the biodiversity value of the habitat.	Early detection is key as once established, invasive plants species are difficult to eradicate. Vigilance and early action to control invasive plants species through chemical or mechanical means is important. Checking upstream for the presence of invasive plants can help determine if your land is at risk.
Differences between wooded and grassy buffers: Wooded and grassy buffers differ in the types of pollutants they intercept and retain. During winter, ground cover is denser in grassy buffers than wooded buffers making them more efficient at intercepting pollutants during this period. Furthermore, as the nutrient demands of trees typically decrease with age, wooded buffers can become less effective over time.	Think 3D! 3D buffer strips combine a combination of vegetation types and include design features such as ridges, soil bunds/sediment traps to optimise the interception and retention of pollutants. Consider subsurface flows, soil nutrient characteristics, and pollution pathways to determine the best way to establish your 3D buffer.
Landscape simplification: With the benefits of riparian tree planting becoming increasingly recognised, it is important that tree planting targets do not result in the loss of high quality and botanically diverse open herbaceous buffer strips.	Take a catchment approach to riparian restoration where different measures are spatially targeted to optimise the ecosystem services delivered within a landscape. Ensure that restoration maintains a diversity of habitats including grazed, wooded and herbaceous riparian zones.
Scrub encroachment: Herbaceous grassy buffers can be particularly rich in biodiversity, supporting a range of wetland specialists. If left unmanaged, these buffers can become dominated by scrub reducing their biodiversity value.	Graze or mow herbaceous buffers to reduce nutrient loadings and promote biodiversity. In bathing water catchments, graze outside of the bathing season to reduce risk to human health. Take care to avoid compaction which would reduce the strip's effectiveness in mitigating diffuse pollution and water infiltration.

Economic costs and funding support for establishing and maintaining buffer strips adjacent to watercourses

Costs of the creation and maintenance of riparian buffer strips will depend on their design. These costs are published in 2002, thus cost adjusted for inflation at 3.29% are included in brackets. For an arable farm, approximate costs of establishing a 2m wide herbaceous buffer strips will cost approximately £0.30 (£0.61) per m with maintenance costs of approximately £0.50 (£1.02) per 100m[24]. These costs do not take into account costs associated with land taken out of production. Under AECS you can claim £495.62 per hectare per year for establishing water margins in grassy fields[25].

Unintended consequences

Taking land out of production to create field edges and hedges could result in a reduction in agricultural yield. This could increase Scotland's dependency on imports and shift production to other countries with less stringent environmental legislation. Offshoring food production could increase GHG emissions through conversion of semi-natural habitats to cropland and transportation of food[26].

Climate change is already impacting on food production. For example, global wheat yields are stagnating and showing more variability.

The wider adoption of agroecological farming can restore soil health and biodiversity, shaping more resilient landscapes and reducing nature and climate risks in the long term[27]. A growing body of research is showing agroecological methods that enhance soil fertility and pollination services can close yield gaps[28]. Thus a balance can be achieved in improving the sustainability of the UK food system while reducing its offshore biodiversity and GHG footprint.

Additional information and support

Flower-rich field margins

- Permanent wildflower margins and corners | Farm Wildlife
- Managing arable farm land | Plantlife
- Wildflower mix | CFE Online

Grassy field margins

- Managing arable farmland for biodiversity | Farm Advisory Service
- Natural enemies leaflet | Farm Advisory Service
- Wildlife and farming handbook

Hedgerows

- Thematic document - Hedgerows | NatureScot
- Hedgerow Management | Biodiversity | Farm Advisory Service
- Working together for the UK's hedgerows | Hedgelink
- People's Trust for Endangered Species | Hedgerows

Buffer strips

- Thematic Document - Water Margins | NatureScot
- 3D Buffer Zones | Helping farmers in Scotland | Farm Advisory Service
- Water Margins | Helping farmers in Scotland | Farm Advisory Service

Plant Health Centre
Scotland's Centre of Expertise

CLEAR
Collaborative Landscape planning for Enhanced Agrobiodiversity and Resilience

Scottish Government
Riaghaltas na h-Alba

This document was created by SAC Consulting, funded with support from the Universities Innovation Fund (UIF), from the Scottish Funding Council (SFC).

This document draws from the following research projects:

- Plant Health Centre: The impact of agricultural policy reforms on plant health risks in Scotland: Guidance on maximizing plant health benefits
- FACCEJPI: Collaborative Landscape planning for Enhanced Agrobiodiversity and Resilience
- Rural and Environment Science and Analytical Services Division of the Scottish Government through their Strategic Research Programmes: 2022-2027: Theme C

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