CatchmentCARE
Community Actions for Resilient Ecosystems

An assessment of ease of SRC Willow implementation throughout the catchment with consideration of varying terrain and soil types for development elsewhere

Report: Chris Johnston, Linda Walsh (Agri-Food & Biosciences Institute)

Contents

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1. Introduction

An estimated total area of approximately 6.5 ha of Short Rotation Coppice (SRC) willow has been planted in 2018 and 2019 within the catchment at the AFBI farm at Hillsborough. The areas were all permanent grassland prior to planting with willow. The willow has established well and the first harvest of some of the 2018 planted willow has been completed early in 2020.

Lidar imaging (Figure 1) and interpretation of the site and maps with digital terrain modelling was undertaken to reveal spatial locations within selected sub-catchments where hydrological connectivity via overland flow could exist. It is suggested that the targeting of willow plantations to these areas should have the greatest impact in terms of reducing input of overland flow to water bodies (Anon, 2016). Using this data in discussions with the farm manager, where current and future land-use and other trial land requirements were considered, areas where willow could be planted was agreed.

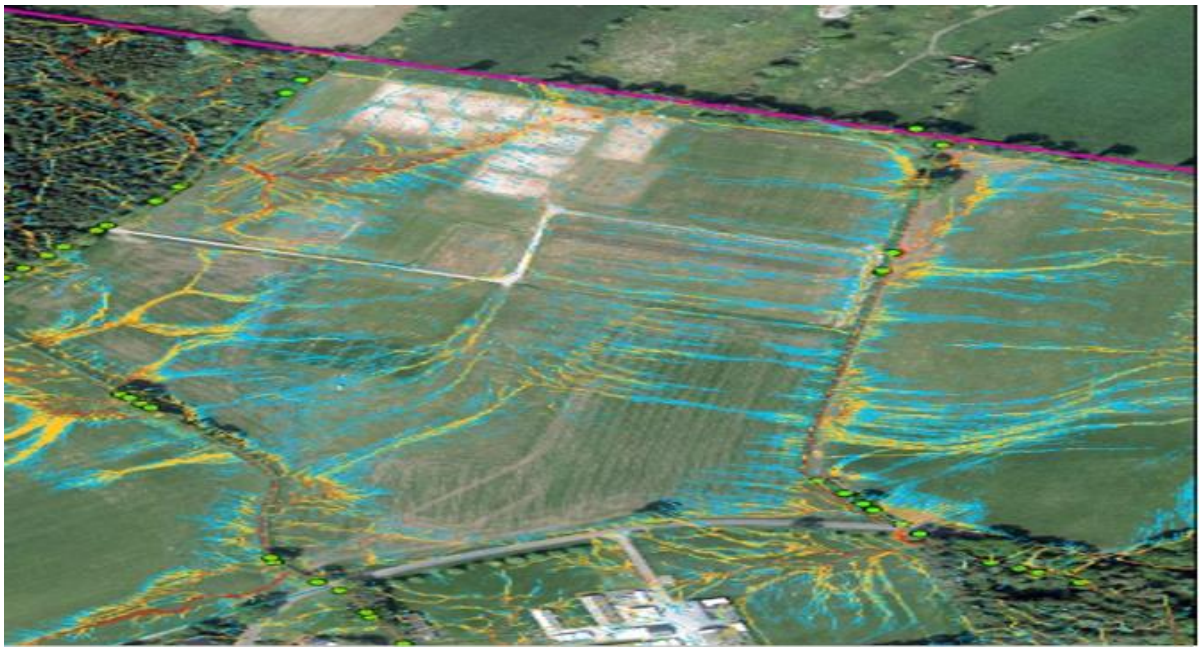


Figure 1: Lidar imaging of AFBI Farm Large Park sub-catchment indicating areas of hydrological connectivity with the water body

For the Whitehill sub-catchment at AFBI farm, approximately 2.0 ha of planting area was isolated and prepared for willow planting (Figure 2). Figure 3 illustrates clearly the established and growing willow plantation. Water samplers were setup in locations above and below the willow buffer strips (Figure 2). The samplers were programmed to collect one composite water sample per day which is analysed for P, N, sediment, conductivity, pH on an ongoing basis.

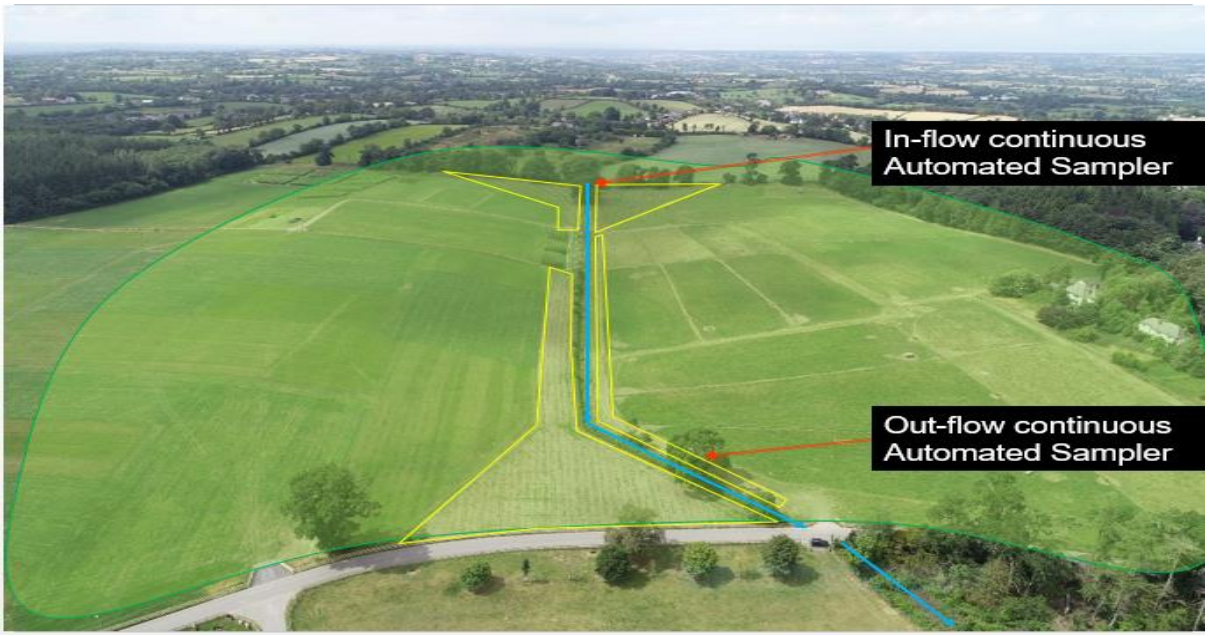


Figure 2: Highlighted areas indicating zones for willow planting with position of water samplers

Figure 3: Established willow in the main sub-catchment

Figure 4 illustrates a LiDAR map showing Critical Source areas (red) and areas of hydrological sensitivity (yellow). During 2018 and 2019 the areas highlighted in green were planted with SRC willow to intecept these routes of overland runoff. Furthermore, other areas marked in blue are ear-marked for further planting.

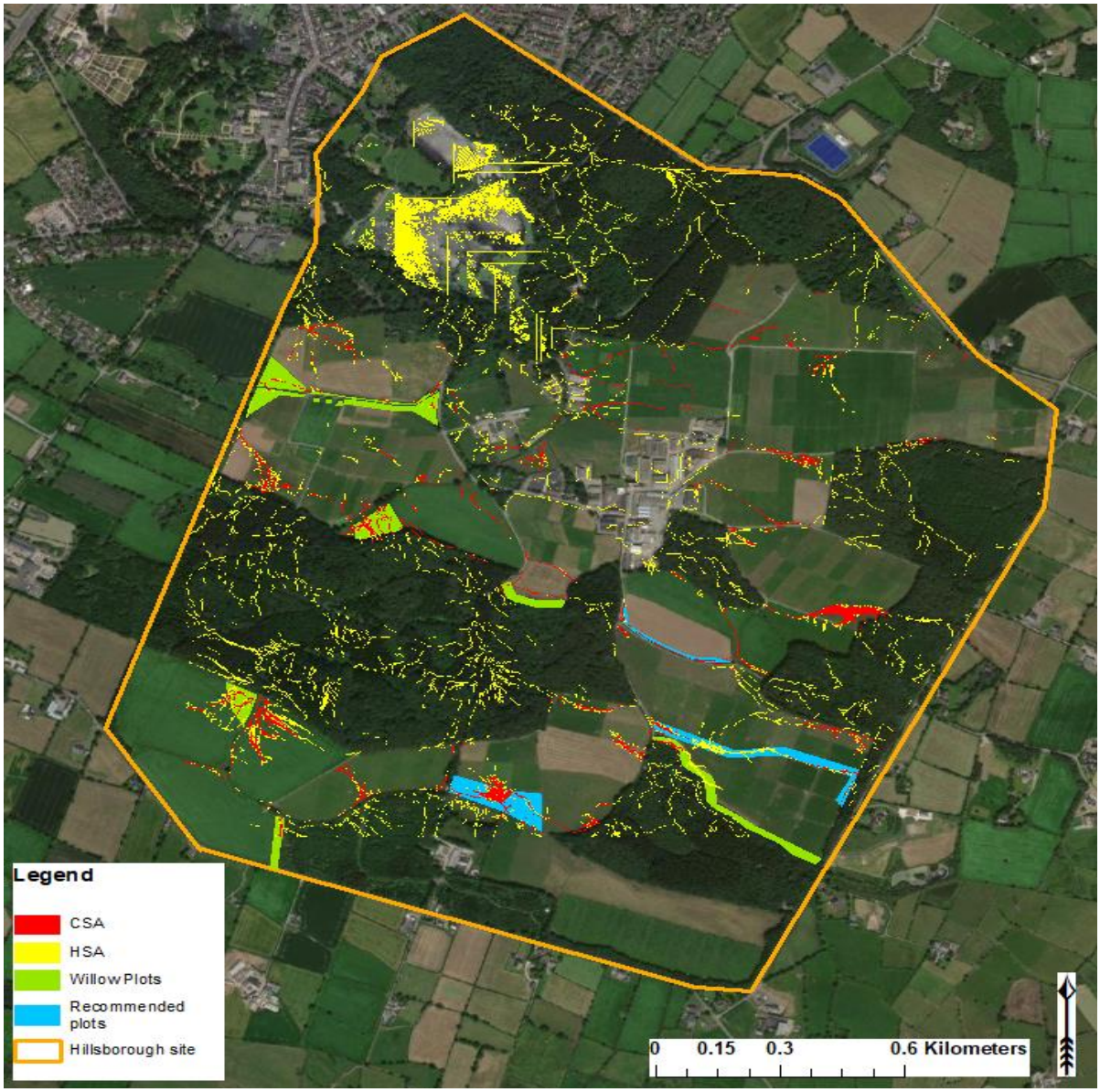


Figure 4: Location of Sub-catchments at the AFBI Hillsborough farm

Some of the sub-catchments were planted over a 2-year period due in part to land area availability or ability to access due to ground conditions. Figure 5 illustrates the taller willow planted in 2018 towards the corner of the field with the newly planted willow from 2019 towards the grassy area of the field.

Figure 5: Sub-catchment with taller willow which was planted in 2018 and additional area with smaller willow planted 2019

2. Establishment of willow crop / site maintenance and harvesting

Generally there are five main factors for growing and establishing willow successfully in any environment: site location, planting stock and land preparation, crop spacing, planting and weed control. However, planting in a catchment as an intervention for mitigation of runoff and protection of waterways, has a number of further factors which must be considered.

2.1. Site location

Willow is not a demanding species in terms of its site requirements and will grow well on an open sunny site. It will flourish on a wide range of soil types and environmental conditions, and in common with other crops, productivity will be determined by soil fertility. It prefers good moisture retentive soils (with good drainage) which remain damp all year round as willow thrives in such conditions. It will grow well in a wide variety of soils and is fairly tolerant with regard to soil pH within the range of 5.6 -7.5. However, light sandy soils, particularly in drier areas, may have a problem with moisture availability and highly organic or peaty soils should be avoided as initial weed control, which is vital, will be extremely difficult. Medium to heavy clay-loams with good aeration and moisture retention are ideal, although they must have a capability of allowing a minimum cultivation depth of 200-250mm to facilitate mechanical planting (Caslin et al., 2015).

In addition to these normal factors, access for machinery required for ground preparation, planting and harvesting also needs to be considered when assessing the site location for riparian strips. Normally the area identified for planting will be part of a larger field. Depending on the field use (e.g. if there are livestock present) it may be necessary to fence off the willow area from the main part of the field. The following figures 6 and 7 illustrate good locations for buffer strips of willow. These areas have long rows of willow which land preparation, planting and harvesting machinery can travel along easily and efficiently. Ideally access gates will be positioned at each end of the willow plantation to allow entrance and exit points without the need for turning and

the associated possible damage to willow stools or machinery tyres.

Figure 6: Ideal site location for riparian buffer strip (approx. 1.7 ha)

Figure 7: Good location for willow buffer strip at side of field

Figure 8: Willow riparian buffer strip with long runs and tight corners

In some field situations the Lidar imaging and digital terrain mapping indicated an area at the corner of the field which clearly indicated high risk of over-land flow and hydrological connectivity to the surface water body and therefore planting it with willow would be likely to intercept and reduce this. Such areas can be seen in the above image (Figure 8) where there is a good location with a long strip along either side of the field stream and then two areas at the corners of the fields which have been planted with willow. Although the location of these sites for catchment purposes is good, machinery access at the corner areas is tight and therefore more of a concern. As the willow rows need to run across the field in order to maximise the potential of the intervention (surface roughness and overland flow impedance), access for machinery to such areas becomes problematic as the willow establishes. Access at the early stages, when preparing ground and planting, was not an issue as with no fence erected access was good. The tight corners become problematic at the later stages for any maintenance purposes and for harvesting as any necessary fencing would be present at that time. Initially the option to erect an electric fencer was considered rather than erecting permanent fencing as this would be less expensive and could be easily taken down when harvesting. However, depending on the stock type present this is likely to not always be viable.

Such areas where access is restricted and tight can also be problematic when the

crop is ready for harvesting. The most appropriate harvesting window for SRC willow is from leaf fall to bud-burst, or flushing in the spring. In normal conditions, this gives a three to three and a half month period from December to mid-March. There are a number of approaches to harvesting; direct chip, whole rod, billet and bale harvesting, and each has its own advantages and disadvantages (Caslin et al., 2015). Currently the method most commonly used in Northern Ireland is direct chip harvesting where the crop is cut and chipped in a single pass. The resulting biomass material must either be used immediately in suitable applications or artificially dried immediately following harvest to prevent deterioration. Most of the machinery developed for this type of operation has been designed to harvest the double row in a single pass, and essentially have modified harvesting heads fixed to standard forage harvesters. Due to the weight (approximately 12 to 13 tonnes) and size of such machinery, this equipment is most suited to large areas of willow plantations. Smaller lighter harvesting equipment is an option which needs to be considered for these catchment situations. For the Hillsborough farm a smaller double row harvester which was semi-mounted to a tractor was used. This equipment is lighter and more easily manoeuvred which meant that smaller areas can be harvested with minimal damage to stools and minimal rutting of ground.

2.2. Site Preparation

Ground preparation includes tractor access with attached equipment including sprayer, plough and power-harrow. The soil needs to be free from grass, weeds and other vegetation. This is normally achieved by spraying overall with a contact or translocated herbicide. The site then needs to be cultivated to a minimum of 25 cm to provide a good free soil structure for the new willows to become established. To achieve this the ground is usually ploughed and left until the soil has dried out. When conditions are suitable the ground is power-harrowed in preparation for planting.

In addition to the normal considerations with regard to site location, it will often be the case that the areas identified from the Lidar imagery as areas contributing to nutrient runoff, will correspondingly often be some of the wettest areas of the field. This was certainly the case with the Hillsborough site which had implications for gaining access with the necessary equipment required to prepare ground and for planting operations and in some areas of some fields it was not possible to use mechanical planting at all. Access for site preparation is also very much dependent on the weather conditions, e.g. planting some of the areas in 2019 was extremely difficult due to excess rain. These conditions resulted in late planting in one particular area with poor establishment of willow cuttings. In some areas it was also necessary to hand plant some of the willow material.

2.3. Spacing

Over the years, much information has been collected on a wide range of planting densities (Dawson et al., 2005), Bullard et al. (2002a), (Bullard et al., 2002b), McCracken et al. (2011). To facilitate mechanical harvesting and machinery access, the crop is normally planted in double rows 0.75m apart with double rows spaced at 1.5m. An in-row spacing of 0.6m gives an initial planting density of approximately 15,000 cuttings per hectare. Establishment should, in good conditions, be in excess of 90%. This, together with a natural loss of stools in the early rotations, should produce a cropping density of at least 13,500 cuttings per hectare (Caslin et al., 2015). When willow is being planted for use as a buffer strip, consideration should be given to possibly increasing the planting density by planting the willow cuttings closer together and thus creating more of a buffer with greater potential to uptake overland flow. For the Hillsborough sub-catchment an in-row spacing of 50cm was used.

2.4. Planting

The best time for planting in Northern Ireland conditions is generally between April and early June. Planting is normally accomplished using a step planter on the back of a tractor. This equipment is considerably heavy and was not suitable in some situations due to rainfall, wet conditions and resulting trafficability of the soils.

Figure 9: Planting willow in double rows with step-planter for riparian protection

Figure 10: Planting willow across corner of field with step-planter21

Caslin et al. (2015) detailed that where possible, rows should be planted parallel to the longest axis of the field in order to maximise machine efficiency and to avoid running rows across steeper slopes, as this will create difficulties in holding machinery in the row. Some of the willow was planted across the rows with the ground getting steeper across the incline (Figure 10). This was not an issue during the planting process however there were implications during maintenance of the crop for weed control purposes (section 2.5).

2.5. Weed Control

Salix (willow) generally grows vigorously, however during the first two or three years, it is important to minimize competition from weeds giving the new plants time to become well established. Maintenance of the crop post-planting for the first year is crucially important and this cannot be over emphasised. After planting, sites are normally sprayed with residual pre-emergence herbicides. There is a limited window of opportunity to apply pre-emergence spray before bud burst and this is of course all weather dependent. For the planting in some of the sub-catchments, pre-emergent spraying was not possible due to a variety of reasons. When the willow was planted at AFBI Hillsborough (May 2018), the ground was particularly dry and warm with suitably good weather conditions. Shortly after planting there was persistent rainfall which meant that it was not possible to undertake the necessary spray activities. Due to the heat in the ground and the sudden presence of moisture, green shoots emerged very quickly from the willow cuttings. This meant that when the rain had stopped it was not possible to pre-

emergence spray as the willow was actively growing. As a result there was excessive weed growth which proved difficult to manage. This is likely to have contributed to a poorer establishment of the willow crop with weaker stems which were not as capable of competing with the weeds which were present. It should be noted however that 2018 was a record year in terms of prolonged sunshine and heat with little to no rainfall. As such, it is likely that normal planting and establishment processes should stand and be the recommendations for riparian and bio-filtration block plantings. 3 shoots which grow to a maximum height

Following emergence of the willow, the main weed control alternatives include:

2.5.1 Hand Weeding

For a small scale planting use of a hoe is practical however it is a time consuming process which needs to be undertaken on a regular basis throughout the growing season and can be labour and time demanding. Due to the scale and area planted at AFBI Hillsborough, this was not considered practical, nor indeed is it ever likely to be within any catchment. However, as this was the only weed control method that was viable in some areas, hand weeding was necessary to control particularly strong species including thistles and large docks which were present. This is with particular reference to the knowledge and technology transfer site.

2.5.2 Inter-row mowing

This is also an option for larger plantations as it controls weeds between the rows and the clippings can be left behind as a form of mulch. This system increases the amount of natural insect life to thrive, many of which are ecologically beneficial Pleasant (2012). In some areas, grass and weeds which were growing between the rows of willow, were mowed with a small ride-on mower which was able to travel between the wider 1.5m spaces between the double rows.

2.5.3 Mulching

Another option for weed control is mulching. A landscape fabric or heavy grade silage sheeting can be used, the landscape fabric has the advantage of letting rainwater penetrate as well as near 100% weed control. Both materials are black and speed up the process of soil warming in spring. This method has the advantage of giving an early boost to spring growth as well as good moisture retention throughout. Due to the scale of operation, this method of mulching was not used for the catchment, nor is ever likely to be practical within any catchment. Mechanical mulching with an inter-row cultivator was used. Normally a machine which attaches to a tractor is used and is best suited to mulching / inter-row cultivating either after cut back after the establishment year, or after harvest as at that stage the willows are established and rooted into the ground. At the early stage of establishment, after the initial planting of the cuttings, great care needs to be taken not to dislodge the willow cuttings as they will have fragile roots and shoots in the early development phase. Inter-row cultivation with a small garden sized

tractor with suitable attached rotavator was used for the AFBI Hillsborough catchment. However, in some areas this proved problematic due to the planting of willow across rows on sloping ground. As the soil was loose, there was some machinery slippage. In the early stages of growth, this method of inter-row cultivation is most suitable for level ground. Later, when the willow has established a good root system and the loose soil has firmed up, the use of the inter-row cultivator is more suited to the rows planted on sloping ground. It is important to note that if it had been possible to spray the sites (post-planting pre willow emergence) then the need for weed control would hopefully not have been as much of an issue.

2.6. Harvesting

The willow buffer zone at Hillsborough which was planted in 2018 was harvested in 2020 with a smaller lighter harvester attached to a tractor (Figure 11).

Figure 11. Harvesting of willow buffer zone May 2020 with tractor mounted harvester.

An alternative harvest methodology, which would arguable suit the maintenance and management of these interventions even better, would be bale harvesting with on-farm drying and big-bale combustion. This supply chain would negate the requirement for drying infrastructure which is likely to be the limiting factor within the Northern Ireland intensive livestock agricultural landscape. A bale harvester is a lot more capex intensive than a small chip harvester however (Figure 12).

Figure 12: Bale harvester with big bale furnace combustion

3. Summary

The well documented pollution of water courses due to nutrient run off (sediment bound and dissolved phase) from agricultural land practices flowing into rivers results in excess nutrients such as phosphate and ammonium entering this environment, this results in excess vegetative growth depleting oxygen within the water and causing eutrophication. This has resulted in the deterioration of the majority of water courses in Northern and the Republic of Ireland.

As well as buffering diffuse pollution by intercepting and trapping or utilising the nutrients, such targeted biomass interventions can also serve to reduce sedimentation in rivers, increase bank stabilisation, reduce flooding, intercept pesticide, sequester carbon as well as providing ecosystems services such as increasing biodiversity and offering habitat corridors. These services make the use of woody crops more attractive than using fencing to mitigate nutrient run-off. SRCW are especially suited to growth in an Irish climate and can withstand hydric soils and excess nutrients. Following initial costs and labour associated with the establishment, the crop is relatively low maintenance.

The use of SRCW has been advocated by the Sustainable Agricultural Land Management Strategy as a landscape intervention to mitigate pollution, as detailed in Recommendation 3c: “Target water quality interventions on at least 4,000 ha of land”

The full potential of SRCW has yet to be realised in Northern Ireland or the Republic of Ireland. This may be as a result of a lack of information on the potential area which could be used for SRCW and also landowners and farmers unaware of the benefits of SRC willow for nutrient management, flood prevention and also a potential cash crop if utilising by biomass.

Planting willow as water quality protection interventions is an excellent example of

how sustainable land management can contribute to the 'circular economy' since the woody strips will address the potential environmental impact of agriculture and will also then support farm activities with the biomass produced being used as a bio-resource post-harvest while delivering further environmental and social benefits beyond the farm.

The ease with which it was possible to establish these HSA plantings was affected by some significant barriers. The main issues came down to weather conditions; specifically the amount of rainfall with associated waterlogging of some areas leaving access for machinery difficult. Some of the areas identified as most suitable for willow planting intervention had tight corners and had necessary fencing requirements to keep stock out of the area, resulted in issues for machinery access (which was necessary for land preparation, planting, maintenance and harvesting). The slope of the ground and direction of rows of willow also caused some concern at the time of establishment of the crop with regards weed control. This was mainly due to the weather conditions and the fact that some of the sites had not been sprayed post-planting with pre-emergence herbicides. If the spraying had taken place, it is considered that the weed control issue and slope of the ground would not have had such an impact. The use of smaller, lighter harvesting equipment attached to a tractor, rather than the conventional self-propelled equipment used in larger plantations, is considered to be most suitable for these smaller riparian areas of willow due to ease of operation and impact on willow stools.

4. Land area theoretical potential for SRC willow implementation

In order to explore the potentials for willow planting using these criteria and discussed principles, an activity was undertaken with the aim of identifying the area that could potentially be used for SRC willow riparian buffer to mitigate diffuse pollution and improve the water quality of a catchment using a GIS method based on site characteristics. In this case we choose the cross border Blackwater Catchment and this process is summarised in a storyboard link EU-CatchmentCARE interactive map.

In order to do this we used GIS mapping to define the area of study and then identified site characteristics which are relevant to water courses. Riparian borders are areas of land adjacent to a watercourse, stream, river and lake which are important for the local ecology, nutrient cycling between the land and water and can also impact the hydromorphology.

To investigate the total area and potential locations most suitable for SRCW a decision support method using the Geographic information system (GIS) tool and existing available data sets on different variables within a catchment was developed. Based on intercepting areas at most risk from overland nutrient flow on site characteristics to prioritise areas

which would benefit from the immediate implementation of this approach.

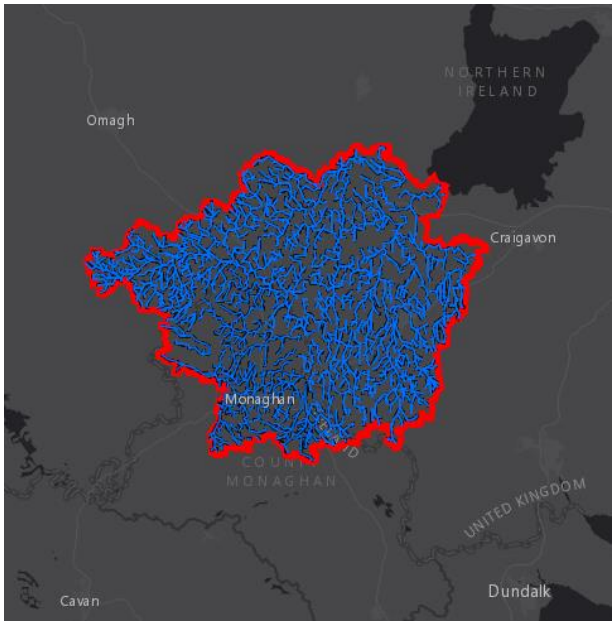
A GIS method for identifying suitable areas has the advantage over field based site evaluations as it can quickly access multiple site characteristics and cover a much greater area.

4.1. Water Course Buffer

To identify the areas within the Blackwater suitable for SRCW riparian buffer planting, the initial step was to identify all the water courses within the catchment from the WFD Status datasets from the EPA and DAERA. The area of riparian buffer zone in the catchment was calculated by including a 10m buffer zone either side of the water courses, an area of 3,720 ha. The Blackwater Catchment is part of the larger catchment; Lough Neagh-Lower Bann Catchment. The catchment spans cross-border across Armagh, Tyrone and Monaghan is approximately 1,500 km^2.

Based on site characteristics most relevant to nutrient overland flow the below data sets were selected within GIS to facilitate the selection of areas of suitable agricultural land and the removal of areas unsuitable for SRCW plantation. Utilising GIS basemaps of the data sets, the layers were overlaid on the 10m buffer strip either side of a water course.

Once all unsuitable areas were removed (non agricultural areas, areas over 15 % slope, unsuitable soils such as peat), the final data estimates that based on thetotal river network across the Blackwater catchment of approximately 3312.38 km, an estimated total area of land suitable for Willow plantation within the buffer is 3,020 ha of a total area of riparian buffer (10m zone either side of a water course) being 3,720 ha.



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