FARMING FOR NATURE

THE ROLE OF RESULTS-BASED PAYMENTS

EDITED BY

EILEEN O'ROURKE & JOHN A. FINN

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THE KERRYLIFE FRESHWATER PEARL MUSSEL CONSERVATION PROJECT

RICHARD O'CALLAGHAN, PADRAIG CRONIN & PAUL PHELAN

INTRODUCTION

The freshwater pearl mussel *Margaritifera margaritifera* (Linnaeus, 1758) is considered to be the most critically endangered invertebrate species that is protected in Ireland. The freshwater pearl mussel fulfils the criteria of "indictor", "flagship", "keystone" and "umbrella" species, making it an important target species for the conservation of oligotrophic stream ecosystems (Geist, 2010). It is a bivalve, a type of mollusc that is almost completely enclosed between a pair of shells (Figure 5.1). Individuals can grow to >150 mm, building up thick calcareous valves. In natural conditions, their lifespan can exceed over a hundred years. Mussels are benthic, largely sedentary animals with two-thirds of their shell length buried into the gravels of the river bed. For most of its life the mussel is a filter feeder and large quantities of water are pumped through the animal's siphons.

Pearl mussels have a complex life cycle, maturing between seven and 15 years of age. Following fertilisation within the female's brood chamber, the eggs develop into a larval glochidial stage, which are then released into the open water in high numbers in mid-to-late summer. The larval glochidia must encyst onto the gill of their salmonid fish host to continue growing (Österling and Larsen, 2013; Taeubert et al., 2010; Young, 1991), metamorphosing into a juvenile mussel before dropping off the following spring or summer. The few juveniles that survive bury into the river gravels where they will remain for the next 5-7 years until mature enough to withstand the flowing water conditions at the surface of the river bed.

Figure 5.1
Freshwater pearl mussels, *Margaritifera margaritifera* (L.) in the Caragh River.
© KerryLIFE Project

Freshwater pearl mussels have particularly stringent habitat requirements. The open water must be of high quality with oligotrophic conditions or very low nutrient concentrations, especially, phosphorus. They require stable cobble and gravel substrate stabilised by boulders. The substrate must also be free of excessive filamentous algae, rooted macrophages, inorganic silt, organic peat and detritus, to allow free water exchange between the open river and the water within the substrate.

Freshwater pearl mussels are particularly at risk from habitat disturbance during their long lives. The species is subject to pressures including agricultural intensification, clearfell forestry management, pollution, river

engineering, and abstraction. These lead to the deterioration of the river bed, impaired flows and near-bed velocity, and water quality issues such as eutrophication (Bauer, 1988) and increased siltation (Denic and Geist, 2015; Geist and Auerswald, 2007; Moorkens and Killeen, 2014). Even slight alterations or short-term fluctuations of habitat condition can result in the loss of pearl mussels. Together these result in the continuous failure to produce new generations of mussels. The species is also negatively affected by a decline in their host salmonid fish populations and illegal exploitation by pearl fishers.

The best remaining pearl mussel populations are found in countries along the north Atlantic including Ireland, Scotland, Norway, Sweden, Finland and Russia. In Ireland, freshwater pearl mussels are widely distributed, occurring in more than 162 rivers in 104 catchments across 16 counties principally situated along the western sea board from Donegal to Cork and parts of the southeast (NPWS, 2019) (Figure 5.2). Four populations are recorded in Northern Ireland. Populations in Ireland can be divided between those with small relict populations with a few remaining elderly mussels that have not successfully recruited for many years and those with large adult numbers and some recent recruitment. The most important Irish populations and the ones of most international concern are those with populations of 500,000 and 3,000,000

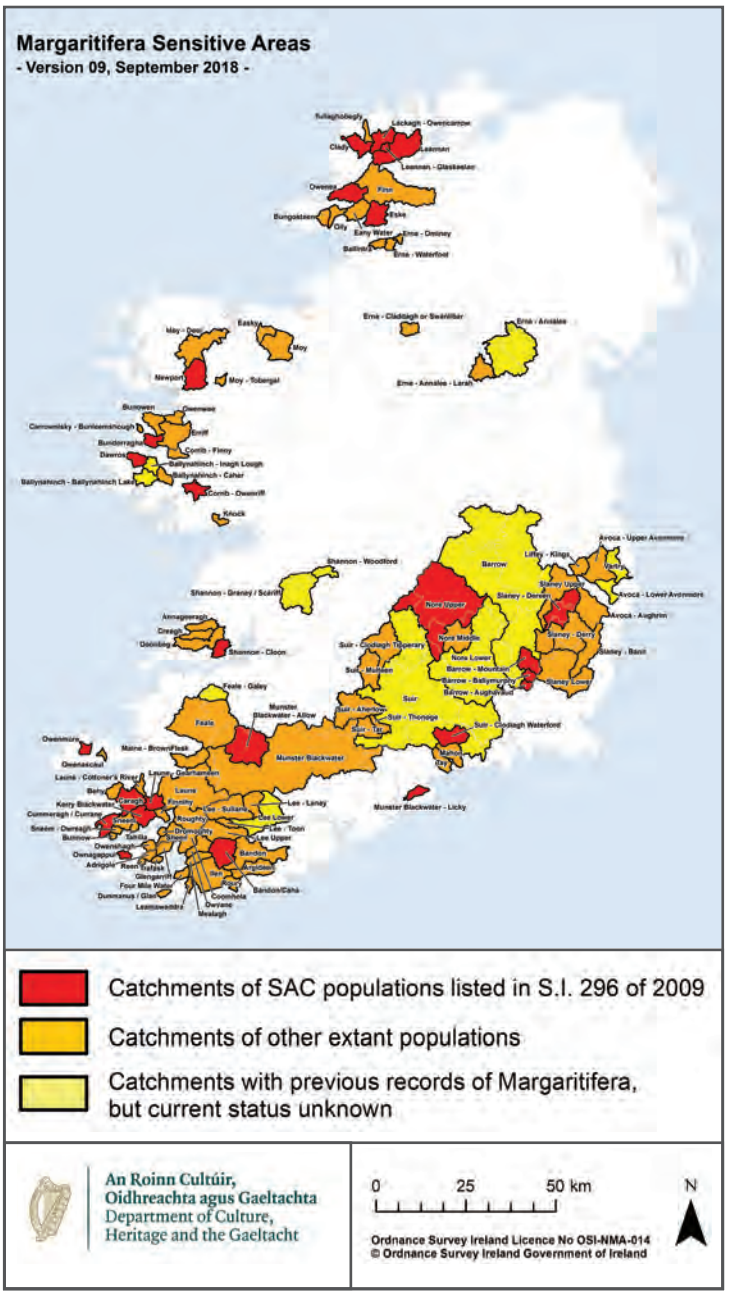

Figure 5.2
Map of the *Margaritifera* sensitive areas in Ireland

individuals. Population estimates based on number of adults visible at the bed surface was estimated to be 12,000,000 in 2006 (NPWS, 2008), 10,990,000 in 2013 (NPWS, 2013), with the 2019 estimate reported as 9,600,000 (NPWS, 2019). This represents an estimated decline of 3% per year.

The current monitoring results indicate that no Irish freshwater pearl mussel population is viable and therefore the population is assessed as Unfavourable Bad. The species is classified as 'Critically Endangered' within Europe by the International Union for Conservation of Nature (IUCN) (Moorkens, 2011) and on the Irish Red Data list (Byrne et al., 2009). It is protected under the Wildlife Act 1976-2000 throughout the state, and by the European Habitats Directive (Council Directive 92/43/EEC) in 19 Special Areas of Conservation containing 27 populations or 80% of the national population (Figure 5.2).

KERRYLIFE PROJECT

The KerryLIFE project was born partly out of Ireland's response to the European Court of Justice Case C-282/02 under the Dangerous Substance Directive and the conservation strategy for pearl mussels in Ireland (NPWS, 2011). There was a clear need to involve key stakeholders in nature conservancy, agriculture, forestry and the community. The National Parks and Wildlife Service of the Department of Culture, Heritage and the Gaeltacht coordinated the bid and commissioned a two-person part-time team to write the funding application. The Department of Agriculture, Food and the Marine, Teagasc, Forest Service, Coillte, Pobal and South Kerry Development Partnership (SKDP) were invited to join the project. Each respective partner contributed technical expertise to the development of the application. The project partners also recognised the critical role farmers and forest-owners play in managing the catchment, and public meetings targeted at farmers were held during the development of the application to take into account their suggestions. A field visit for farmers to the Burren Farming for Conservation Programme was arranged by South Kerry Development Partnership to allow farmers gain a better understanding of what a LIFE project was and how they operate. Farmers quickly realised the benefit of a project that would be designed to "work with their land" rather than for land elsewhere in the country.

The KerryLIFE project is a demonstration project aimed at the long-term delivery of sustainable land use practices that will restore and conserve the freshwater pearl mussel population within the Caragh and Blackwater freshwater pearl mussel catchments. There are four main objectives,

- Demonstrate effective conservation measures on farms and forests to restore the freshwater pearl mussel
- Enhance awareness and understanding of the mussel among stakeholders
- Demonstrate sustainable management techniques for farming and forestry in pearl mussel catchments
- Provide guidance for farming and forest practitioners to support the conservation of the freshwater pearl mussel.

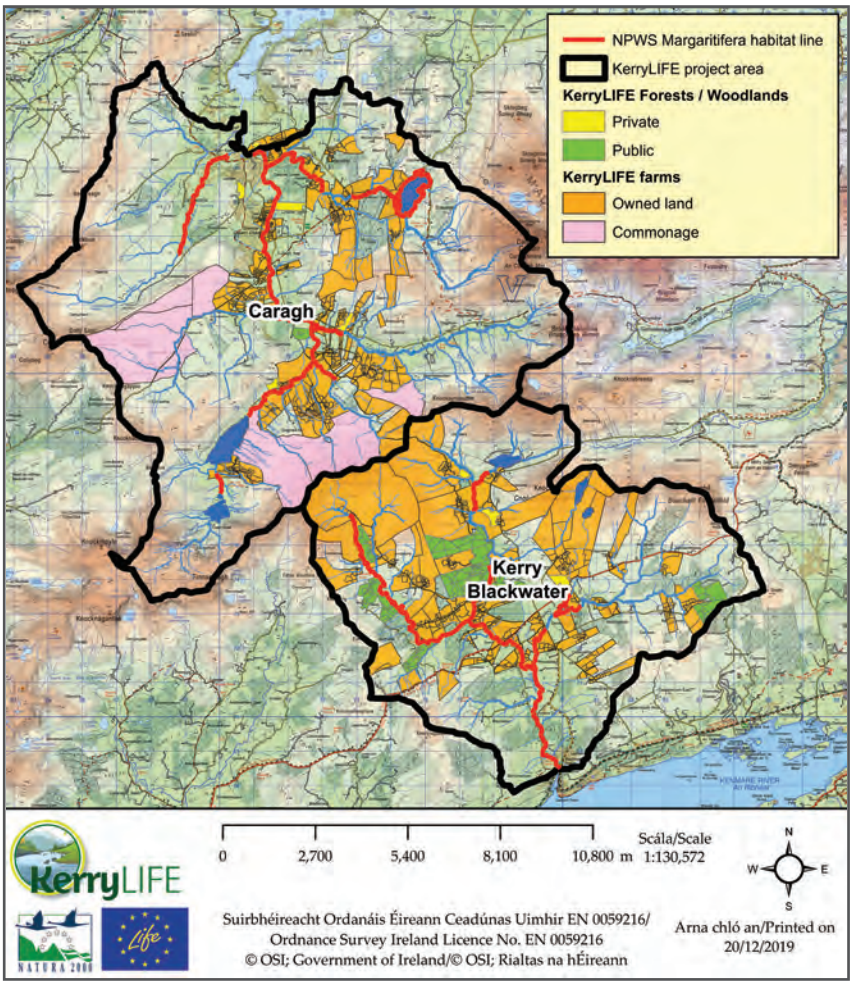

Figure 5.3
Map of KerryLIFE project area showing project farms and forest properties

Figure 5.4
Owenroe Tributary of the Caragh River with the MacGillycuddy Reeks Mountains in the background

The project specifically aims to improve the habitat quality for adults across 20% of the recorded habitat and improve 5% of the juvenile habitat through a reduction in siltation and eutrophication and an increased recruitment of juvenile mussels to the population to support the achievement of the favourable conservation condition.

The KerryLIFE project operates in the Blackwater and the Caragh catchments situated on the Iveragh Peninsula in Co. Kerry in south west Ireland (Figures 5.3 and 5.4). Both river systems support very large freshwater pearl mussel populations with a wide distribution within their respective river networks (Ross, 1999). It is estimated that the total population within

the Caragh is approximately 2.8 million individuals, while the estimated total population within the Blackwater is approximately 2.75 million individuals (Ross, 1999).

The Caragh and Blackwater populations have a good distribution of mussel size classes, although the number of juveniles and younger mussels are below the required criteria (Table 5.1). Water quality within the Caragh failed three of the five Environmental Quality Objectives (EQOs) specified in Schedule 4 of the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations, S.I. 296 of 2009, while all five were failed in the Blackwater. Both rivers are in unfavourable conservation condition (Moorkens, 2019).

Table 5.1

CRITERIA FOR THE ASSESSMENT OF THE CONSERVATION STATUS OF FRESHWATER PEAR MUSSEL POPULATION AND THEIR HABITAT IN THE CARAGH AND BLACKWATER RIVERS 2019

CRITERIA	TARGET TO PASS	STATUS IN CARAGH	STATUS IN BLACKWATER
Number of live adults	No recent decline	Pass	Pass
Number of dead shells	<1% of population and scatted distribution)	Pass	Pass
Mussel shell length <65 mm	At least 20% of population ≤65 mm in length	12.77% Fail	19.47% Fail
Mussel shell length <30 mm	At least 5% of population ≤30 mm in length	3.04% Fail	2.83% Fail

ECOLOGICAL QUALITY OBJECTIVES FOR THE FRESHWATER PEAR MUSSEL HABITAT AND THE RESULTS FROM THE CARAGH AND BLACKWATER RIVER 2019

ELEMENT	OBJECTIVE	STATUS IN CARAGH	STATUS IN BLACKWATER
Macroinvertebrates	EQR ≥ 0.90	Pass	Fail
Filamentous algae	Absent or present <5%	Fail	Fail
Phytobenthos (Diatoms)	EQR ≥ 0.90	Fail	Fail
Macrophyte cover	Absent or present <5%	Pass	Fail
Siltation level	No artificially elevated levels of siltation	Pass	Pass

Farming is dominated by extensive cattle and sheep rearing enterprises. The average farm size in the project is 131 ha ranging from 10 ha to 464 ha. While the holding is typically centred on the farm house, many farms also contain a number of separate land blocks, usually reflecting the inheritance of farms or amalgamation of adjoining or nearby farms.

Of the 40 farms participating in the KerryLIFE project, 32 are mixed cattle and sheep enterprises, 4 are sheep only farms and 4 are cattle only. The average number of cattle per farm is 21 animals (range 2 to 62). Larger continental or continental crosses such as Limousin, Charolais, and Simmental account for 71% of the cattle on project farms. Traditional breeds such as Hereford, Angus and Shorthorn accounted for 15%, 8% and 6% respectively. In the past, the herd was dominated by these smaller and hardier traditional breeds which would have been kept outdoors all year round except for the very worst of conditions.

Since the 1980's onwards there has been a shift towards specialised beef systems with larger continental breeds. This has lead simultaneously to the intensification of lowland portions of farms and an extensification and ultimately abandonment of upland and remote portions of farms across the catchments. The shift has been driven not only by competitive market conditions and increased mechanisation but also by a trend towards more off-farm work. The specialisation has been facilitated by the drainage of land in combination with the construction of animal housing units (i.e. slatted sheds), many of which were grant aided under various Department of Agriculture schemes. Today, the majority of KerryLIFE farmers house their animals for between 16 and 26 weeks, storing up nutrients that are spread on a small number of fields that would previously have been more evenly dispersed across a wider portion of the farm over the calendar year.

The presence of animal housing units with slurry storage in a catchment is generally regarded as a positive water quality protection measure; however there can be unforeseen consequences in high status water bodies such as freshwater pearl mussel catchments. This is largely explained by the limited availability of suitable land for the spreading of stored slurry on farms. In many cases the quantity of slurry has also driven farmers to create more land for spreading through land reclamation of semi-natural grassland and peatland habitats. In-field and surface drainage have been installed, the land ploughed and reseeded, or the bog would be turned over and topsoil

imported. Despite this there is still relative little spreadland amounting to about 5-6% of the farmland.

In terms of feed, cattle graze on pasture or rough grazing. Silage is made from the improved grassland with farmers typically achieving a single cut of silage in mid to late summer. This is well below those of more intensive grazing systems. Fertiliser (organic and inorganic) is applied in spring and again following the cutting of silage. Some farms have also been restructured to create a single block of extensive farmland in which livestock are free to roam for the majority of the year. Only small areas of improved grassland are fenced to exclude cattle and sheep, except for lambing or silage production. This has resulted in some portions of the farm being overgrazed while other portions are under grazed with livestock loitering in preferred locations resulting in poaching and sediment mobilisation.

Sheep production systems are typically based on robust mountain breeds which can survive the harsh upland environment while grazing poorer quality herbage (Kilcline, 2018). The dominant sheep breed is the Scottish Blackface hill ewe which is a very hardy and resilient breed. The average flock size is 200 (range 20-600). Sheep are kept out all year round. They are brought down from the hills or commonage lands to the better ground for lambing in order to reduce casualty rates which can otherwise be high if lambed on the hill. Lambs are kept as replacements or are sold as store lambs from August onwards due to limited areas of improved grassland to profitably finish them without adversely affecting the performance of the breeding ewe flock. A significant proportion of the store lambs produced are sold to finishers in the midland and east of the country and finished on these lowland farms.

The Central Statistic Office's (CSO) Agricultural Census data for the Loughbrin, Caraghbeg and Lickeen electoral divisions which cover the KerryLIFE project area and adjoining areas, reveal a trend since 1991 of increasing farm size areas and decreasing labour availability (CSO, 2010). This is coupled with a trend of decreasing livestock numbers and a switch from rough grazing to pasture and silage crop areas. Farmers are not in a position to finish their animals, which are sold as weanlings after 6-8 months or as yearlings. Replacement heifers are bred on the farm and calving takes place throughout the year. Other than livestock output, these farms also produce a range of ecological services and public goods, including landscape management, preservation of biodiversity, traditional farming systems and cultural heritage (Plieninger et al., 2006), such as the tourist industry.

The major causes of the unfavourable conservation condition of both the Caragh and Blackwater freshwater pearl mussel populations are regarded as diffuse sediment, nutrient enrichment and hydro-morphological change. The Caragh and Blackwater Freshwater Pearl Mussel Sub-basin Management Plans (DEHLG, 2010a and b) identified the pressures impacting on the species in the two catchments and were used to provide the following detail on threats.

Restructuring and drainage of agricultural land is the most significant threat to the freshwater pearl mussel in the project area. Restructuring involves changing the layout of farms by removal of field boundaries (e.g. hedgerows), re-contouring of land (e.g. levelling off hills), clearance of vegetation (e.g. scrub) and commencing to use uncultivated land for agriculture. Land drainage is the excavation of drainage channels to decrease the capacity of land to retain water and to increase its productivity. These activities result in increased erosion and transport of sediment and nutrients from land to the river. Restructuring and reclamation have occurred on low-lying land close to the main rivers, around farmsteads and on the moderately steep uplands. Drainage is widespread throughout the catchments. These activities can have complex direct and indirect impacts on the freshwater pearl mussel, causing hydrological and morphological changes in rivers, increasing loads, providing a direct pathway for sediment and nutrients and resulting in siltation and nutrient enrichment of the mussel's habitat.

Riverbank erosion is the second most significant pressures in both catchments, and a significant contributor to siltation and erosion of the habitat of the freshwater pearl mussel and to direct damage on its habitat. Bank erosion is a natural process; however changes in land use intensity have acted to significantly increase the rate of erosion. It occurs along the main Caragh and Blackwater rivers and their tributaries. It is closely associated with land reclamation works and land drainage. It leads to direct and indirect impacts to freshwater pearl mussels, including erosion and loss of habitat and increased siltation of the river bed.

Changes to traditional farm practices have led to an increase in nutrient inputs to farms. There has been specialisation of farm enterprises, particularly grazing regimes, and movement from traditional mixed farm systems (relying on native breeds of sheep and cattle) to the (continental-cross dominated) suckler cow systems. Pregnant suckler cows are usually less

mobile in the challenging hill terrain and require supplementary feeding. Nutrient inputs on farms have been concentrated in the low-lying areas that have been reclaimed. Typically, animal wastes (slurry) generated during housing are spread on these fields. Chemical fertiliser is also applied to achieve nutrient balance and increase productivity, particularly when re-seeding. Increased importation of chemical fertilisers onto farms, increased production of slurry and changing livestock management have resulted in increased losses of nutrients (nitrogen and especially phosphorus) in particulate and dissolved forms to rivers. These lead to damage to mussels from increased macroalgal and macrophyte production. The increased plant life also reduces oxygen levels during night time as plants respire.

Vegetation damage and soil erosion (i.e. poaching, tussocks, etc.) has resulted from changes in the livestock types and their management. Vegetation damage increases soil exposure and weathering, resulting in increased losses of sediment from land to rivers. Localised vegetation damage and soil erosion can occur on any part of the farm however, it is most strongly associated with supplementary feeding stations, access points and upland and peatland areas. Vegetation damage and soil erosion contribute significantly to siltation of freshwater pearl mussel habitat. They can also result in enrichment, through losses of soil-bound nutrients. Bare soil can generate faster runoff and contribute to hydrological and morphological changes in rivers.

Conifer plantations typically occur on peaty, erodible soils and often on steep slopes or close to rivers. These forests are managed under the clearfell silviculture system, with a crop cycle of approximately 40 years involving ground preparation, drainage, planting, fertiliser application, road construction, firebreak management, thinning, clearfell harvesting, further ground preparations and replanting. Many of these operations can result in significant sediment and/or nutrient losses. Erosion risks are especially high during drainage, ground preparations, crop establishment, road construction and clearfell harvesting, when soils are exposed or damaged. Nutrient losses are high at planting/reestablishment (fertiliser applications) and after harvesting (decay of brash-small diameter wood). Inappropriately sited conifer plantations are located throughout the catchments and can result in siltation and nutrient enrichment of freshwater pearl mussel habitat. They also contribute to hydrological and morphological changes in rivers.

In addition to the above, other threats include a lack of host fish for the larval glochidia; there is currently no evidence that a lack of host fish is a

threat to mussels in these rivers. Additional threats include non-agricultural/forestry pollution sources namely peat-cutting, infrastructure and septic tanks.

FARMER ENGAGEMENT AND SELECTION, AND DRAFTING THE FARM MANAGEMENT PLANS

Early engagement with farmers at the outset of the project was crucial to securing their buy-in. This was achieved through requesting expressions of interest at public information meetings, advertisements in local media (radio shows, radio advertisements and newspaper advertisements), putting up posters in the project area, attendance at local livestock marts and calling to farm yards and houses. This latter approach was by far the most effective method and it aided the project team in making direct contact with the farmers. A total of 125 of 288 expressions of interests were received through the whole process. As the available spaces were over-subscribed, it was necessary to develop a selection process. This process aimed to balance the ability of the project to improve the condition of the freshwater pearl mussel population and habitat, and the ability to demonstrate the measures across the two catchments.

The selection process assumed that every farm in the catchment had the potential to positively contribute irrespective of the farm's position within the catchment. There were seven selection criteria, five of which were based on information available from existing sources (reflecting the area of land and proximity to pearl mussel watercourses, and a risk assessment), one criterion required a field survey and another was based on a farmer's interest in participating in the project.

The Caragh and Blackwater rivers contain approximately 45 km of freshwater pearl mussel habitat (NPWS Margaritifera Geodatabase) and the project committed to improving the condition of 20% or 10 km of freshwater pearl mussel habitat across the two river networks (Figure 5.5). Following a scientific review of the pearl mussel monitoring reports (Ross, 1999; Ross, 2004a and b; Ross, 2009a and b; Ross, 2011a and b; and Moorkens, 2014) and the Caragh and Blackwater Sub-basin Management Plans (DEHLG, 2010a and b) stretches of habitat were prioritised. In addition, important watercourses connected to this priority habitat were categorised as (i) large streams (streams equal or greater than Strahler Order 3) and (ii) small

Figure 5.5
Targeted freshwater pearl mussel habitat in the KerryLIFE project area, showing a) poached area with cattle access to stream, and high sediment load and b) the same stream after fencing, revegetation and control of sediment

streams feeding into pearl mussel habitat (streams of Strahler Order 1 or 2) as these have the greatest potential to influence the freshwater pearl mussel population.

Using GIS tools and available data on land use, watercourses, mussel habitats and farm distribution (with permissions) each farm was ranked according to the total area of land within (criterion 1) 200 m of priority pearl mussel habitat, (criterion 2) 200 m of other pearl mussel habitat, (criterion 3) 100 m of principal tributaries and (criterion 4) 50 m of low order streams.

A rapid catchment-level agricultural risk assessment (criterion 5) was conducted to identify potential pressures in the project area that posed a threat to the freshwater pearl mussel. Agricultural activities were identified through a desk study and field investigations and were related to Land Parcel Identification System (LPIS) parcels. A weighting based on the three key issues identified for freshwater pearl mussel conservation was assigned to each activity based on its potential to give rise to negative impacts if the activity was implemented inappropriately. The number of activities and their corresponding weightings were then summed for each farm.

As the project committed to demonstrating six broad types of conservation actions on farms, a qualitatively assessment based on farmer's interest in the types of measures and the potential to implement them on their farm was conducted (criterion 6). Farms were assigned a value of one for each conservation action and the results were summed to give a total for each farm.

With the above information, the following selection method best balanced the needs of the Kerry LIFE project:

- Each value within criteria 1 to 6 was normalised to a value between 0 and 1 by dividing it by the maximum value for that criteria. Farms were ranked according to the sum of normalised values.
- Any remaining farms that did not have LPIS land within 200 m of targeted FPM habitat were ranked according to potential for implementing a range of KerryLIFE conservation actions. Where more than one farm had the same value, random values were assigned to each farm and farms were thereby ranked randomly within values for this criteria.
- Farmers were then separated into two categories, those who expressed an interest in participating and those who did not (criterion 7). The highest ranking farmers from both catchments who had expressed an interest in participating in the project were then offered a place.

Allocation of places between the Blackwater and Caragh catchments was based on the relative size of the catchment (km^2). The Project Team wrote to all farmers who expressed interest in the project explaining the selection criteria and invited 50 farmers, 22 in Blackwater and 28 in Glencar to participate in the project. Once the farmer confirmed their continued interest the Project Team (Manager, Scientist, Farm Advisor and Administrator), commenced surveying farms. The preparation of the farm management plan involved documenting current farm management practices and carrying out comprehensive plot by plot surveys to conduct more detailed risk assessments and inform the best selection of management practices.

Current farm management practices were documented through a questionnaire. Information such as stocking rates, stock types, grazing periods, feeding regimes, forage utilisation patterns and fertiliser application were assessed. This assessment took into account relevant farm operations, such as silage production, animal housing infrastructure, slurry and fertiliser use, the availability of spread-lands, drainage history, drain maintenance and land reclamation works, e.g. ploughing, re-seeding and re-contouring. This gave an insight into how the farm was being managed before any management changes were proposed. A survey card ensured that information was collected in a standardised way.

A whole farm approach was used as the management of sediment and nutrients from critical source areas is dependent on the availability of support areas (e.g. alternative spread lands or grazing land) on other parts of the farm. The field survey was completed on a plot by plot basis designed to map sources of sediment, nutrients (soil sample analysis) and hydrology (streams, rivers, field drains, overland surface flows were mapped) on the farm. Source mapping identified critical source areas for sediment and nutrients on the farm and worked with the assumption that typically 80% of losses are associated with 20% of the area. Other potential sources not evident at the time of the field survey that were identified during the desk-based surveys were also incorporated into the risk assessment. In many cases the farmer accompanied the surveyor during the initial survey.

The source – pathway – receptor (S-P-R) model for environmental management was used to determine which pressures would be acted on. A source only becomes a pressure if the pollutant e.g. nutrients can reach the receptor i.e. the habitat with a freshwater pearl mussel population. The pathway is the link between the source of pollution and the receptor e.g. drains or overland run off. For each identified pressure, the risk was assessed taking into account the severity, scale, slope, soil type, presence of a pathway and proximity to pearl mussel habitat. Three categories of relative risk are used: low, moderate, and high. Measures were proposed in order of risk, starting with the high risk pressures that posed the highest risk to pearl mussels and their habitat.

Once the surveys were completed a farm management plan was drafted, which detailed the proposed concrete conservation actions to be implemented by the farmer. The conservation measures designed to support the conservation objectives for freshwater pearl mussel can be grouped into six broad measure types: drain management; stabilizing riparian sediments through broadleaf planting; buffers and hedgerows; grazing and livestock management; nutrient management planning, and; drinking water facilities for livestock. These are described in further detail below. Measures which had the greatest potential to deliver the desired improvement e.g. reduction of nutrients or sediment on a given farm were then proposed. For each of the measures, there were various alternatives, and associated payment rates. Details on selected examples only are provided here; full details are available on the KerryLIFE website http://kerrylife.ie/.

C1 Drain management. The project area has a dense network of field drains to improve productivity on wet soils and in an area of high precipitation. Agricultural drains are one of the most critical sources of sediment loss. The drainage systems accelerate the delivery of sediment and nutrients from land to watercourses, by acting as a preferential flow routes. Field drainage results in the soils and sub-soils of the drainage channels being opened up to erosion, increasing the load of fine and coarse sediments to surface waters. By causing changes to the hydrological regime, drainage also increases the erosive power of rivers, causing further changes in the hydrological regime. This leads to erosion of the freshwater pearl mussel habitat and of river banks, resulting in further sedimentation. Once installed, drains require on-going maintenance, including the removal of silt, vegetation and other obstructions, and the repair of damaged banks.

The KerryLIFE project used a series of measures to reduce the hydrological connectivity between source areas of sediment and freshwater pearl mussel populations, and minimise erosion and sedimentation in rivers. These include the re-vegetation of drains, the creation of effective and functioning buffers designed to reduce sediment losses to watercourses, and installation of peat plugs. The project has also worked to make farmers aware that much of the damage results from unnecessary maintenance which can inadvertently lead to the deepening and widening of drains. There is a perception that water must be seen flowing otherwise the drain is not functioning. This is often inaccurate and the hydrological function of vegetated drains is maintained.

C2 Stabilising riparian sediments using native broadleaf planting. Strategic, targeted tree planting at vulnerable locations along channels was proposed to reduce undercutting and slumping of the banks. The re-vegetation of riverbanks will help to dissipate the energy during moderate to high flow events, further reducing in-channel erosion. This action was delivered through the native woodland scheme funded by the Forest Service. The scope to implement small scale strategic planting through the scheme was challenging as in-built requirements of the scheme ruled out many locations e.g. set back distances from water-courses, minimum planting areas and minimum planting widths. Farmer's willingness to plant their more agriculturally productive land was also a factor in using trees to

stabilise riparian sediments. In light of these the project adapted and instead identified larger sites (>6 ha) through the running of a demonstration event and trialled alternative planting scenarios, including birch pioneer woodland, together with measures to contribute to the restoration of the hydrology on site.

C3 In-field buffers and hedgerows. Restructuring of land for agriculture has created long paths for overland flow on farms. These increase the risk of sediment and nutrient transport to rivers, as well as contributing to negative hydrological changes. In-field grass buffers (€11.70 per m length for 5m wide buffers, and €24.65 for 30 m buffers) and hedgerows were proposed to intercept, interrupt and disperse overland flows and at the same time, promote infiltration in the soil. Division of the landscape into smaller constituent parcels will also aid livestock management on the farm and contribute to the implementation of grazing and supplementary feeding strategies. The opportunity to demonstrate the efficacy of the in-field buffers was limited due to the farms that ultimately participated in the project. However the project established over 3 km of hedgerows.

C4 Grazing and livestock management. Changes to traditional farm practices has, in particular, changed grazing regimes, from the traditionally diverse range of mixed farm systems (relying largely on native breeds of sheep and cattle) to the suckler cow based systems that prevail today (continental-cross dominated). The larger cattle breeds are usually less mobile, especially in the challenging terrain of the Caragh and Blackwater catchments. This has resulted in a concentration of more intensive farming activities in the relatively more fertile, low-lying parts of farms closest to the river.

The project implemented a wide range of measures including fencing of watercourse, installation of cattle crossing bridges, introduction of grazing strategies, conversion to traditional breeds of cattle and reducing stock number (Table 5.2). These continental crosses are also less hardy and require housing and/or supplementary feeding if out-wintered. Farmers were incentivised to reduce the number of cattle on their farm by payments for phosphorus reduction that offset the anticipated loss in margin from reduced cattle sales. The payment was linked to the quantity of phosphorus produced per animal type. The greater the reduction in phosphorus achieved by reducing or converting from continental to traditional breed of cattle, the higher the payment. The reduced level of stocking density could not

be increased for the lifetime of the project. In addition, the project also endeavoured to develop a beef initiative to add value to smaller traditional brands of cattle with the view that a premium price would be paid for environmentally friendly produced products

During the initial farm surveys, all farmland plots were risk assessed and assigned a condition score. Areas identified through the risk assessment were categorised as a critical source and transport areas for sediment and/or nutrients. These areas or plots were mapped and assessed using a five point objective scoring system (see Table 5.2) at the beginning of the project and each year during the farm plan. A farmer who reduced sediment losses (as estimated and assessed by percentage bare ground and/or maintained optimal condition) was paid when a score of 3 and above was achieved for land parcels. This results-based payment was implemented across 437 ha of farmland focusing on plots adjoining the main pearl mussel habitat.

Table 5.2

LIVESTOCK AND GRAZING MEASURES, UNITS AND PAYMENT RATES.

C4 MEASURE	UNIT	PRICE PER UNIT (€)
Critical source area score = 1 (>20% bare soil)	ha	0
Critical source area score = 2 (10 - 20% bare soil)	ha	0
Critical source area score = 3 (8 - 10% bare soil)	ha	50
Critical source area score = 4 (3 - 7% bare soil)	ha	80
Critical source area score = 5 (<3% bare soil)	ha	100
Fencing – stockproof	m	5.40
Fencing – single strand barbed wire	m	3.00
Fencing – double strand barbed wire	m	3.85
Fencing – electric	m	1.00
Fencing – A frame	m	8.40
Footbridge		50 - 100
Gates		120 - 180

Note the results-based payment for reduction of bare soil (associated with sediment and phosphorus transfer to watercourses) in critical source areas identified in the farm risk assessment

Figure 5.6
Example of a) critical source area with a score of 1 in Year 1 (2015) and b) score of 4 in Year 3 (2017)

'A'-FRAME FENCING: CASE-STUDY

Michael O'Neill farms along the bank of the Kealduff and Blackwater rivers adjoining some of the most important stretches of pearl mussel habitat. Before the project commenced there was evidence of cattle accessing the river for drinking and crossing to the opposite bank for grazing. This resulted in trampling of mussels and disturbance of the mussel's habitat. Cattle also defecated and urinated in the river.

The team proposed fencing the cattle out of the river and establishing a 10 m wide set back area. The standard fencing procedure for cattle involves driving timber posts 0.5 m into the ground with spacing between each post of 5 m. Wire is then put up along the full length. Due to the wetness of the site and sensitive location along mussel habitat, a standard stockproof fence was considered unsuitable mainly due to the potential for ground disturbance during installation or the risk of the stakes breaching the iron pan and releasing iron rich water which can give rise to iron bacteria colonies.

Michael was approached to come up with a solution and through discussions with the project team, it was decided to trial using A-frame fencing. Michael agreed to do this and visited the nearby Killarney National Park to see how a similar fence used for controlling deer in native woodland

was designed and constructed. Michael used strainer posts secured to the ground at both ends, where the fence changed direction and at either side of a gap. Light poles of 1.8 m in length were nailed in 'A' shape formation and stood on top of the ground every 5 m. Sheep wire was nailed to the timber posts and a single strand of thorny wire was run at the top to add tensile strength. The fence was priced at €8.40 per metre.

The erection of the fence has had multiple benefits. Cattle are excluded from the river which immediately stopped mussel trampling. The river bank vegetation at former cattle access points has recovered, reducing erosion and destabilisation of the bank. The protected riparian margin is dominated by rushes and sedges, and will supply detritus-rich water to the river for mussels to feed on. If a standard fence was used, approximately 50 posts would have been driven into the ground. The A-frame fence rests on the ground, is temporary, and can be moved by hand if necessary e.g. moved away from the river during flooding. A gap was retained to allow access for management and maintenance.

Figure 5.7
There were multiple benefits of cattle exclusion: A (facing page) innovative use of A-frame fence and 10 m wide buffer zone along the Kealduff river: B (left) cattle access point for drinking along river before erection of the fence and C (below) the same location three years after cattle were excluded.

C5 Nutrient management planning

Changes to traditional farm practices have led to specialisation of farm enterprises. This has been achieved through the re-cycling of organic fertilisers and the application of imported inorganic, chemical fertilisers on farmland. Investment in farm infrastructure (e.g. slatted houses) has facilitated intensification of farm management practices, generating increased volumes of animal waste from livestock housing. Nutrient loss from farmland is high owing to high rainfall and poor nutrient retention of many soils. A bespoke nutrient management planning system was developed specifically for the project. Many nutrient management plans calculate nutrients at a whole farm level; however in the KerryLIFE farms this is not appropriate as very little of the farm is suitable for the disposal of stored slurry due to wetness, slopes or trafficability of farm machinery. The net result is that the nutrients are applied on a very small proportion of the farm, 5-10 ha, therefore increasing the potential for run-off. Building on the work of Magette et

Table 5.3
NUTRIENT MANAGEMENT MEASURES, UNITS AND RATES

ACTION	MEASURE	UNIT	PRICE (€)
C05	Annual Nutrient Management Plan	Farm	200
	Single application – summer only	ha	40
	Split applications – summer only	ha	80
	Split applications- spreading period	ha	80
	Reduction – suckler cow	per animal	400
	Reduction ->2 year old cattle	per animal	320
	Reduction – 1-2 year old cattle	per animal	250
	Conversion to Dexter	per animal	160
	Conversion to Shorthorn	per animal	100
	Conversion to Kerry cattle	per animal	100
	Conversion to Galloway	per animal	60
	Conversion to Aberdeen Angus	per animal	60
	Conversion to Hereford	per animal	40
	Conversion to Mountain ewe	per animal	25
	Conversion to Mountain hogget	per animal	15

al. (2007), the modified Phosphorus Risk Score (mPRS) risk assessment was adapted for the make-up of the farms and local conditions. In the first instance, measures to reduce the nutrient inputs (source) were adopted as intercepting nutrients along pathways is less effective. Measures included reduction in cattle numbers, conversion to smaller cattle breeds, switching to low or zero P concentration fertilisers and out-wintering period to reduce the quantity of stored slurry (Table 5.3). Secondly, measures aimed to reduce the risk of nutrient losses arising when the stored slurry was applied. This was achieved by: recommending the quantity to be applied for each plot; splitting nutrient applications across two applications to increase the potential uptake by the grass crop, and; changing the timing of applications to summer months with drier ground conditions.

C6 Alternative drinking water facilities. Livestock typically had access to rivers, streams and drains for drinking purposes on farms in the project area. Livestock (especially cattle) entering watercourses result in the destabilisation of the bank channel, bank collapse, fouling of water from animal excreta, trampling of freshwater pearl mussels and disturbance of their habitat. Alternative supplies were provided where livestock were excluded from the watercourses. To this end, the project trialled three main types of water troughs: gravity fed troughs, nosepumps and solar-pumps. Variations of the size and type (plastic or concrete) were used to adapt to the circumstances or preference of the farmer.

Working together to finalise and implement the farm management plans

Before the farmer was asked to sign up to the plan, the Farm Advisor walked each farm with the farmer, explaining to him/her the issues identified and the measures proposed to resolve them. These one-to-one farm walks proved invaluable, as the farmer was able to input into their farm plan, often offering alternative solutions to the Project Team in solving technical issues based on their knowledge of their own farm. The Farm Advisor updated the plan accordingly following the farm walk. The Manager reviewed it before it was finalised. The farmer was responsible for the implementation of the farm actions; however, several farmers worked together to implement a measure, while other farmers paid contractors do the work. The Farm Advisor provided technical information on how the measure was to be implemented while maintaining flexibility for the farmer to adapt the measure to suit their own circumstances or the local conditions. Each spring, the Farm Advisor carried

out the Annual Review to determine what measures had been completed, to score the critical source areas and to assess how the measures were working.

To best design the farm plan to communicate aims and be a useful tool to inform farm management, KerryLIFE built on the experience of the Burren Programme, AranLIFE and other projects. The farm plan comprised a series of maps and associated tables, containing information on the individual measures to be implemented. Farm plans contained three maps displaying the following:

1 **The farm overview map** displays the farm plots, the external farm boundary, the Special Area of Conservation and the freshwater pearl mussel habitat. A plot was defined as a field or recognisable management unit identified during the farm survey and utilised by the farmer. Plot was assigned in sequence with 1 attributed to the most north and western plot on the farm, moving eastwards, and then south with the highest number plot being the most south-easterly plot on the farm.

2 **The sediment and drain measures map** displays the location and extent of sediment reduction, drain management measures and the farmland woodland measures to be implemented on the farm as part of the farm plan. Measures were displayed as a point, polyline or polygon depending on the nature of the measure. Each measure was assigned a unique code e.g. 'C1a' comprised of the Action Number followed by a letter and each action was assigned a colour to help distinguish the measures in each action. The same colour was used on the associated tables. This resulted in a colour coding system which was repeated on the tables.

3 **The nutrient management plan map** displays the location and extent of nutrient measures to be implemented on the farm as part of the farm plan.

A series of tables accompany the farm maps. The first table lists the farmer details, the KerryLIFE farm plots, the associated Land Parcel Identification System (LPIS) and the Agri-environmental Option Scheme (AEOS) / Green Low-carbon Agri-environment Scheme (GLAS) plots, to avoid double payments.

There was one page per each of the six actions (C1-C6). All table followed the same format. At the top of each table a brief description of the action and the reason why it was been proposed was provided. Below this, there

was a series of columns containing, the plot the measure was to be carried out, the measure code (e.g. C1a comprised of the Action code and letter), the number of units (length, area or number), a brief description of the measures, the total payment or the payment rate each the measure and the annual payment due each year. The final two pages of the plan provided a payment summary and the farmer's declaration. The farm plan was accompanied by a written contract which sets out all the relevant terms and conditions. An example of a complete farm plan (including payment rates and calculations is available from the KerryLIFE website: http://kerrylife.ie/destination/publications/.

PAYMENTS, IMPLEMENTATION AND ONGOING ADVICE

On signing their farm plan, each farmer was paid a pre-payment amounting to 30% of their first year payment. All subsequent payments were linked to the completion of the measures contained in their farm plan which was assessed during the Annual Review. At the end of the plan year, the second 70% payment was issued for completed works only. Each individual measure type had a fixed price. The core elements considered in the payment rate were the cost of any equipment or materials, the management cost, labour, income foregone, environmental benefit and an element of reward. The payment rate had to be acceptable to the farmers in order for them to see the benefit to them in undertaking the measure. Payment rates were realistic and broadly in line with payment rates associated with contemporary schemes. The payment rates were also driven in part by the project-scale commitments and the budget available in the project e.g. install drain measures at 1,000 locations, or implement nutrient measures across 375 ha.

KerryLIFE operated a hybrid payment model with a mixture of capital payments (non-productive investments), action-based payments and results-based payments. Capital costs included the erection of a fence to exclude livestock from freshwater pearl mussel habitat or the installation of a water trough. These measures accounted for 55% of the farm plan payments. Action-based payments (such as the split applications of slurry) accounted for 20% of farm plan payments. Result-based payments consisted of the achievement of improvements of habitat condition, and accounted for 25% of the payments. The high proportion of capital payments tend to be associated with one-off supporting actions that would not need to

Figure 5.8
Open door policy in action - KerryLIFE Farm Advisor leaning out of the office window to give advice to one of the project's participants

be undertaken in subsequent farm plan cycles; however, the maintenance of the capital works may need to be taken into account in future programmes.

As the total value of each farm plan was directly linked to the measures outlined in their farm plan there was a wide range of payments with the higher payments typically being made to the farmer who had the most measures to implement. The project did not set a minimum payment per plan but did apply a maximum payment. The average payment was very variable between farms ranging from €1,500 to €10,000 per annum over the 3½ year term of the farm plan.

The timing of the payment was important as the majority of farm payments e.g. Area of Natural Constraint, Basic Payment Scheme and Greening Payment, Young Farmers Scheme, AEOS, GLAS and the Beef Data and Genomics payment occur between September and December each year. This payment profile can present many farmers with unfavourable cash flow mid-way between the main payment periods. In recognition of this, the KerryLIFE payment was paid in June of each year following the Annual Review which was carried out in late spring.

Once the plans were in place, there was still a need to have a strong interaction with the farmers. In the first year, the Farm Advisor or Manager would call out to the farmers to ensure everything was going according to plan. These visits provided an excellent opportunity to troubleshoot with the farmer to solve a technical issue that might have arisen or which might be preventing a measure from being implemented. It also afforded the farmer an opportunity to discuss alternative approaches to those initially agreed. This informal learning between farmer and project team was very important as it highlighted practical considerations that can sometimes be overlooked or not clearly explained in the first instance. The meetings also allowed the project team to explain the importance of the measure, the benefit to the environment and the mussel and the benefit to the farmer. The on-going support available to the farmers was critical in underpinning the success of the project because it allowed time for trust to build between the farmer and the project team. In the initial stage of the farm planning process, the majority of farmers would have consulted their own independent Farm Advisor about what was proposed. As trust began to be developed, it became increasingly clear that the farmers would come direct to the project team with project issues (Figure 5.8).

KerryLIFE entered farm plan contracts with 40 farmer participants covering 3,658 ha or 27% of the Caragh catchment and 1,429 ha or 16% of the Blackwater catchment. Drainage measures have been implemented at 863 locations across the project farms, 341 locations in the Caragh and 522 locations in the Blackwater. These measures have commenced the process of re-wetting critical areas of the catchments to support the freshwater pearl mussels in the adjoining river reaches. Many of the drains have rapidly re-vegetated, intercepting sediment and increasing the retention of water in the catchment. Riparian buffers and/or set back areas have been implemented along approximately 5 km of freshwater pearl mussel habitat. Eliminating livestock access to the pearl mussel habitat prevents trampling of mussels that can cause mussel mortality, reduces bank destabilisation and erosion and protects fringing habitats. Implementation of grazing and livestock management in critical source areas covering 256 ha or 7% of KerryLIFE farmland in the Caragh and 181 ha or 12% of the KerryLIFE farmland in the Blackwater, has resulted in a reduction in the percentage of bare soil adjacent to freshwater pearl mussel habitat. The condition of the critical source areas in the two lowest scores (88 ha) decreased by 50% between year 1 and year 3 of the farm plans, while the area with the highest score increased from 36 ha to 229 ha in the same period (Figure 5.9).

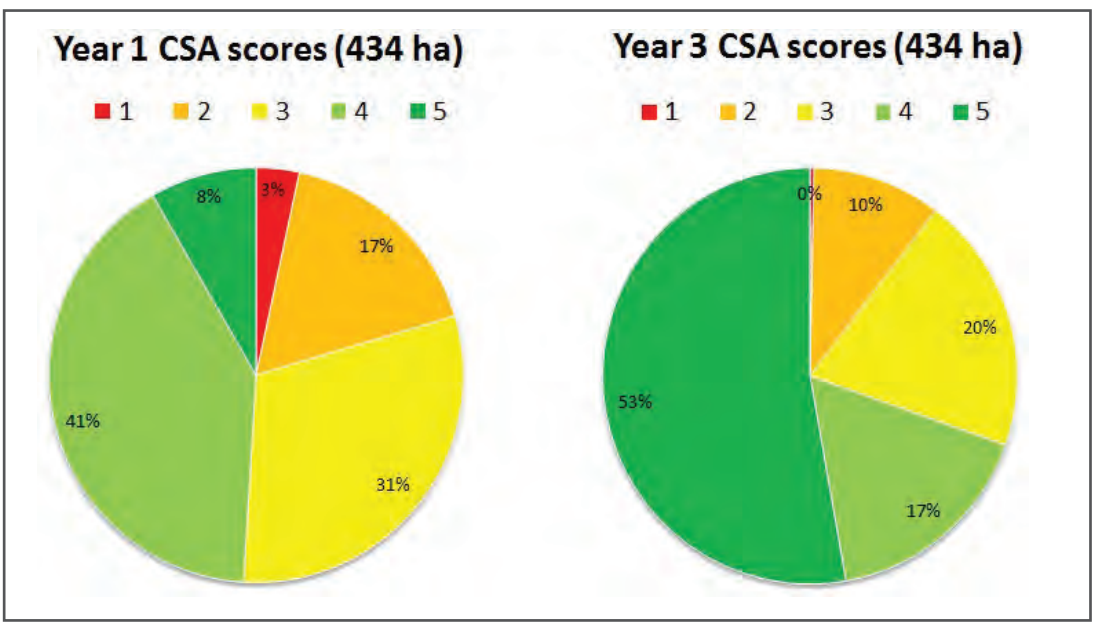

Figure 5.9
Changes in critical source and transport areas from year 1 to year 3 of implementation of the farm plans

Nutrient management planning has been implemented across 40 farms with measures implemented across 501 ha or 10% of KerryLIFE farmland. Farm level measures include stock reduction, conversion to traditional cattle breeds, switching to non-phosphorus containing chemical fertiliser and alteration of grazing patterns. Across the participating farms, 61 cattle have been removed from the herds for the duration of the project. This equates to an 18% reduction in slurry generated on farms. The switch away from phosphorus-containing compounds achieved an 83% reduction in phosphorus inputs at a farm level.

A total of 262 alternative drinking water facilities for livestock have been installed by the project. It is estimated that 1,040 cattle have been excluded from entering freshwater pearl mussel habitat or tributaries discharging to the watercourses. This measure has resulted in a 100% reduction in livestock damage to mussels and their habitat and a 100% reduction in cattle urination and defecation on pearl mussels in locations where the measure has been implemented.

KerryLIFE aimed to restructure 175 ha of commercial plantation to long-term retention woodland using several bespoke conservation measures including halo-thinning, a restructuring technique that aims to increase the proportion of broadleaf trees through manually felling or ring-barking conifer trees in a circle to release the broadleaf tree from competition from surround conifers; sensitive harvesting of conifer plantations and the demonstration of over 15 different mitigation measures designed to reduce sediment and nutrient losses associated with the harvesting. Novel measures such as sediment trapping 'in the dry' designed to intercept sediment before it reaches the main drains were trialled. High risk areas vulnerable to sediment and nutrient losses were seeded with Yorkshire fog (*Holcus lanatus*) and common bent (*Agrostis capilliaris*). Other measures included use of long-top (all woody material less than 7 cm in diameter) brash mats, brash removal from near watercourses, brash export from the catchment, drain management, log dams, pollarding, reduced timber product range (e.g. lengths of pulp wood, pallet wood, saw long etc.), and willow planting. A total of 90 ha of native broadleaf woodland was established or conserved on project forests.

The prospect of continuing the conservation measures after the lifetime of the project is very positive. In 2018, the Department of Agriculture, Food and the Marine (DAFM) funded a €10 million European Innovation Partnership (EIP) project called the Pearl Mussel Project under the Rural

Development Programme 2014 – 2020. The measures developed and demonstrated in the KerryLIFE project have been incorporated into a whole farm results-based agri-environment programme that recognizes and financially rewards farmers for delivering environmental benefits. The Pearl Mussel Project operates in the two KerryLIFE catchment plus six other catchments located in Counties Donegal, Mayo, Galway, Kerry and Cork. KerryLIFE has worked closely with DAFM in the development of this EIP. Since the project has become operational, KerryLIFE participates on the Steering Group of the Pearl Mussel Project, has provided training to the Pearl Mussel Project team, supported the identification of pilot farmers, and provided technical specification for measures. The two projects have worked closely to ensure that the KerryLIFE participants transition across to the Pearl Mussel Project EIP.

Woodland sites created through the project will continue to be managed under a continuous cover forestry model, and the measures demonstrated by the project have direct relevance to operations throughout the forest cycle for the protection and conservation of freshwater pearl mussels and other high status water bodies.

Even in the very short lifetime of the project there has been a noticeable change in the behaviours of the participants. There was initially a low level of awareness of the freshwater pearl mussel or what role farmer's activities were having on the river and water quality. Farmers have become more aware of their role and the role of others in managing the environment. Some farmers question the value of their contribution if pressures arise elsewhere in the catchment from some of their neighbours who were not able to join the project or who didn't want to join. There is increased awareness of how vital it is that all farmers work together to deliver water quality improvements.

Farmers are also more willing to challenge certain aspects of their own farming practices that they previously took for granted. Many farmers are quick to explain that they are only doing what their parents did before them. They often overlook the reality that there have been significant advances in the mechanisation that is available to them today; when a drain was maintained in the past it was done by hand and was a relatively low-intensity operation. Today, the same operation would be done with a digger in a far shorter time and may inadvertently deepen and widen the drain. Farmers have begun to question why they are doing what they were doing over the years. For example, many farmers would have applied the same

amount of fertiliser every year, often in the absence of soil sample analysis results, as they believed it was necessary to achieve grass growth. As part of their nutrient management plans, soil samples showed that many of the soils were in excess of their nutrient requirements. Soil sampling results showed that the addition of expensive chemical fertiliser was not needed every year and, due to the very high rainfall together with low nutrient retention in peaty soils, much of the nutrients were being lost to the river or groundwater. As the project has progressed, farmers are slower now to apply fertiliser without soil testing, which is both more environmentally and financially beneficial.

KEY LESSONS

The experience of the KerryLIFE project provides some key lessons for the development and operation of an agri-environment scheme for a high nature value farming community, as follows:

Locally-led: The freshwater pearl mussel is the local priority for biodiversity conservation, and KerryLIFE addressed the local need to enhance conservation of this species. The Locally-led approach was evident in how the project consulted widely with local farmers and local stakeholders, and included them in the governance of the project. The prior knowledge from previous research projects and reports was a crucial support for the targeting of efforts and farmer selection criteria. The project works out of the local community centre, and the rental payment directly benefits the community. Having a local physical presence has been crucial in building trust between the project and the community.

On-going support: The access and availability of the project team to the farmers and forest-owners was essential in solving technical issues that might have arisen or which might be preventing a measure from being implemented. It also fostered continual dialogue and exchange of knowledge between the farmer and the team not only on aspects of farm management but also the history of the farm, the river and wider societal nuances. Annual monitoring of the condition of the CSA allowed farmers to track changes on their farm and encouraged adjustments to management to further improve their scores.

Figure 5.10
The 'Pearl Shield' challenge match was an enjoyable community event that also helped to build trust with the project team, and awareness about the project

Engagement: The project has been very proactive in engaging with not just the farmers but also the whole community. One of the more creative ways we embedded the project into the community was the setting up of the 'Pearl Shield' football competition which embraced the strong sporting tradition in the area (Figure 5.10). This event brings together the two communities that make up the project area but which play in separate divisions for an under 10s and 12s Gaelic Athletic Association football competition. The match also provided an excellent opportunity for the project team to meet the locals and explain the work they are doing and how it benefits the local environment.

Awareness and education: The project hosted public events to raise awareness of the freshwater pearl mussel, the very rare White Prominent Moth, and the Lesser Horseshoe Bat. The project has also worked with the community to develop two walking trails that benefit not only the local community but also visitors to the area.

Flexibility: The project enabled farmers to develop their own solutions to the pressures identified on their farms, which strongly aligns with a locally-led approach. This gave farmers ownership of their farm plan and farmer took pride in delivering their work to a very high standard. Another aspect of flexibility was the project's approach to the delivery timelines. While all farmers were asked to implement their full farm plan in the first year, this was not always possible. This may have been due to unsuitable weather, ill-health or limited availability of family members to help complete the

task. Payments associated with measures not completed by the time of the Annual Review were withheld until they were completed. When the measure was completed, the intervening payments were paid. This non-punitive approach proved very effective and the longer a measure went undone the greater the financial incentive there was for the farmer to undertake the outstanding measure.

Policy alignment: The project has endeavoured to work through a complex policy and legal framework that farmer and forest owners operate under. In complying with one policy, a farmer may run counter to another. It would benefit the farmers and the environmental outcomes to have greater alignment across policies and a clear hierarchy where two or more policies apply.

A whole catchment approach is really needed to achieve the very high requirements of the freshwater pearl mussel for water quality and habitat condition. As a pilot project, KerryLIFE worked with only 20% of the farmland and 20% forest land within the catchments. It is still too early to determine whether the project's actions have improved the conservation condition of the pearl mussel populations and their habitat in the Caragh and Blackwater catchments. Although some early signs of a recovery have been observed in the condition of farm habitats, riparian corridors and water quality, it may take a much higher rate of participation and time to detect the desired outcome in the pearl mussel populations.

Definitive improvements in habitat condition and water quality may take many years due to lag time (the time elapsed between adoption of management changes and the detection of measurable improvement in water quality in the target water body). The UK's Catchment Sensitive Farming predicted a best-case scenario of approximately 3 years if a programme of measures had an immediately beneficial effect (Environment Agency, 2019). A Belgian case study reported additional young pearl mussels as a consequence of improved water quality ten years after their project ended and through continued targeting of conservation efforts (Becerra, 2019). The freshwater pearl mussel is a long-lived, slow-growing species that requires clean sand/fine gravel throughout its whole life in addition to water quality improvements.

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Agricultural habitats cover approximately half the European Union (EU) and an estimated 50% of all species and several habitats of conservation concern in the EU depend on agricultural management. Reversing the loss of European biodiversity is clearly dependent on the conservation of farmland biodiversity.

Results-based approaches are the focus of a growing discussion about improved biodiversity conservation and environmental performance of EU agri-environmental policies. This book outlines lessons learned from a collection of Irish case studies that have implemented results-based approaches and payments for the conservation of farmland habitats and species. The case studies include prominent projects and programmes: the Burren Programme, AranLIFE, KerryLIFE, the NPWS Farm Plan Scheme and Result-Based Agri-environmental Payment Schemes (RBAPS) project.

This work is intended for an international audience of practitioners, policymakers and academics interested in results-based approaches for the conservation of biodiversity and the provision of ecosystem services.

FARMING FOR NATURE
THE ROLE OF RESULTS-BASED PAYMENTS

Teagasc
Agriculture and Food Development Authority

An Roinn Cultúir, Oidhreachta agus Gaeltachta
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