Agri-Environment Scheme design: the importance of landscape scale

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Background

Since the mid twentieth century, agriculture in Europe has sought to increase agricultural production to meet the food demands of an increasing population. Agricultural management has employed new technologies to manage crops and improve agricultural production, resulting in significant increases in yields e.g. global grain production doubled in only 40 years (Tilman et al., 2001). The increase in agricultural production has resulted in an intensification of agricultural management (e.g. monocultures, increase in fertiliser and pesticide application) and the simplification of agricultural systems (Altieri, 1999). However, such changes have often compromised the environmental quality of agro-ecosystems, giving rise to significant impacts on water quality, soil erosion, increases in greenhouse gas emissions and also biodiversity loss (Tilman et al., 2001, 2002; Tscharntke et al., 2005).

Agricultural landscapes are no longer viewed as merely farmed land, but are widely recognised as providing multiple goods and services such as biodiversity, water and soil quality, along with public good *per se* e.g. aesthetical, recreational and cultural value (Lefebvre, Espinosa, and Gomez y Paloma, 2012; Sayer et al. 2013). Approximately 50% of all European species are dependent on agricultural practices (Stoate et al., 2009), therefore efforts to preserve biodiversity (and associated ecosystem services) in these systems are now a main focus in conservation programmes worldwide. Additionally, studies have highlighted the importance of the conservation of biodiversity and ecosystem services provisioning to guarantee the resilience and sustainability of agronomic systems (Bommarco, Kleijn, & Potts, 2013; Foley et al., 2005; Macdonald & Service, 2007; Tscharntke et al., 2005).

Tackling the loss of farmland biodiversity

The European Union (EU) has focused attention on reducing and reversing the impacts of intensive agriculture on environmental quality and biodiversity conservation. Agri-environmental schemes (AES) were established (EU Agri-environmental Regulation [90/20788/EEC]) to promote management practices that are more ecological and environmentally beneficial (Kleijn and Sutherland, 2003). A significant amount of resources (i.e. € 34.5 billion for 2007-2013, IEEP, 2008) have been directed to incentive-based mechanisms for farmers to adopt more sustainable measures, the majority of which is through AES, settled by each member state but based on the Common Agricultural Policy (CAP) dictated by the EU. AES are a key policy mechanism for encouraging farmers to adopt environmentally friendly practices aimed at reducing the impact of farming on the environment (and biodiversity), compensating them for the costs incurred (Evans & Green, 2007).

From an Irish perspective, agricultural systems represent the dominant land-use in the country and, thus, shape its landscape and its biodiversity (Boyle & Keena, 2009). Hence, agri-ecosystems and the associated semi-natural habitats are key for the conservation of biodiversity in Ireland and have also been the focus of conservation efforts. The Republic of Ireland has implemented a variety of different programmes of AES over the last few decades, starting with the Rural Development Protection Scheme (REPS), first introduced in 1994 until the on-going Green Low Carbon Agri-Environment Scheme (GLAS). Maintaining and protecting the environment and enhancing biodiversity in farmed systems are primary objectives for all of these schemes.

Effectiveness of AES at preserving biodiversity and ecosystem services

AES have been widely implemented throughout Europe over the last number of decades. As part of their implementation, EU Member States are obliged to monitor and evaluate the environmental, agricultural and socioeconomic performance of their agri-environmental programmes (EC Regulation No. 746/96). Evaluation is necessary to assess effectiveness, but also to demonstrate value for money to taxpayers, as well as to avoid accusations of trade distortion (Ó hUallacháin et al., 2016). There has been some research regarding the effectiveness of AE measures and schemes at conserving biodiversity, and also on the ecological processes determining the conservation of biodiversity and ecosystem services. (e.g. Batáry et al., 2011, 2015; Finn and Ó hUallacháin, 2012; Herzog et al., 2005; Kleijn et al., 2011, 2006; Kleijn and Sutherland, 2003; Whittingham, 2011). However, results on the effectiveness of many AES on conserving biodiversity and ecosystem services are inconsistent (Batáry et al., 2015; Finn & Ó hUallacháin, 2012; Kleijn et al., 2011). Some studies recognise an overall positive effect of AES at enhancing species richness and diversity of different organisms (Batáry et al., 2011; Scheper et al., 2013). However, several national and international studies have found no significant changes in biodiversity as a result of AES (Kleijn et al., 2004).

Where there are reservations over the effectiveness of AES there is a need for an improvement in the design, management and implementation of such agri-environmental measures to guarantee the effectiveness in the conservation of biodiversity and in the ecosystem services provisioning. For this reason, here we aim to review national and international literature to 1) assess some of the factors influencing effectiveness of AES at preserving biodiversity and ecosystem services delivery; 2) evaluate the extent at which the ecological processes act for biodiversity conservation; and 3) identify novel practices and measures that are able to address the significant ecological processes for biodiversity conservation and ecosystem services provisioning under AES and 4) how such measures can be implemented in Ireland.

Factors influencing the effectiveness of AES

The effectiveness of AES at preserving biodiversity in agricultural systems is found to be influenced by landscape structure and land use intensity (Batáry et al., 2011; Kleijn et al., 2011; Scheper et al., 2013; Wrbka, Schindler, Pollheimer, Schmitzberger, & Peterseil, 2008). Importance of landscape structure at modulating the effectiveness of AES on biodiversity and ecosystem services conservation has been widely highlighted (Batáry et al., 2015; Concepción, Díaz, & Baquero, 2008; Scheper et al., 2013), but has frequently been overlooked in the design of many AES.

Several studies report that the lack of effectiveness of AES is due to their local focus (field/farm), which aim to conserve small proportion of biodiversity targeted at local scale (Batáry et al., 2015; Lewis et al., 2011) and is not yet possible to scale up the effects of locally implemented conservation actions to larger spatial scales (Kleijn et al., 2011). Current AES can create high-quality habitats to support biodiversity, but often such areas are too small or too isolated to support much of the biodiversity and ecosystem services for which they were intended (Baker, Freeman, Grice, & Siriwardena, 2012; Mckenzie, Emery, Franks, & Whittingham, 2013). The effectiveness of patches created for biodiversity conservation will depend on their size and quality of the habitats, but also on the distance from, and connectivity to, other habitats in the landscape (Mckenzie et al., 2013). Therefore, the farm-scale and fragmented approach to conservation within AES, reduces the effectiveness and the final efficiency of the main schemes (Emery & Franks, 2012). There is, thus, a mismatch in scale between the scale of management (typically at the field or farm scale) and the scale at which the ecological processes being managed (species mobility, ecosystem services, etc.) take place (Cumming, Cumming, & Redman, 2006).

Ecological processes impacting on the conservation of biodiversity and on the delivery of ecosystem services

Landscape complexity may compensate for biodiversity loss due to local management intensity (Merckx et al., 2009). Complex landscapes consist of a mosaic of different habitats in which species and populations of different organisms are balanced, overall supporting high levels of biodiversity (Kleijn et al., 2011; Tscharntke et al., 2005). In farmland, mosaic structured agricultural landscapes allow good movement of organisms in between patches, particularly if habitats are structurally similar (Eycott et al., 2008). Therefore, the diversity of habitats and the landscape heterogeneity are widely recognised as key for biodiversity conservation, particularly when involving a gradient from natural to agricultural habitats (Santana et al., 2017). Conservation of semi-natural features and patches scattered across the agricultural landscape are a prominent target in AES design to protect the remaining refuges for biodiversity conservation and better enhance ecological processes (Bengtsson et al., 2003).

However, fragmentation and isolation of habitats, for example due to agricultural intensification at a larger spatial scales (Tscharntke et al., 2005), cause major ecosystem perturbation and their effects are generally unpredictable and eclectic (Donald & Evans, 2006). Small and isolated patches tend to contain fewer species and the populations living there are more likely to experience extinctions than more connected habitats (Hendrickx et al., 2007; Perfecto & Vandermeer, 2010). Dynamics of single populations might depend on neighbouring populations, so migrations of individuals from one habitat patch to another are critical for their persistence (Macdonald & Service, 2007; Perfecto & Vandermeer, 2010). Therefore, connected habitats are more valuable for the conservation of species than isolated ones (Bennett, 2003). Connectivity and habitat corridors can thus increase dispersal and the rate of colonisation if the landscape matrix offers limited options of dispersal (Macdonald & Service, 2007). Scientific evidence gathered in Tzilivakis et al. (2016) also highlights that habitat quality and conservation of species and populations can only be maximised if there is good connectivity between habitats and the landscape structure is heterogeneous. Therefore, the consideration of the availability of corridors and connectivity in between habitat patches within a mosaic of different habitats is crucial to guarantee effectiveness of conservation (Concepción et al., 2008).

However, habitat connectivity and permeability is well recognised to be species and landscape-specific (Eycott et al., 2008). Species with different mobility may interact with the environment at different spatial scales (Concepción et al., 2008), making it difficult to design general landscape oriented conservation measures. However, such landscape-scale consideration is required to enhance conservation of biodiversity and ecosystem services. Both the amount and the spatial configuration of suitable habitats act as determinants of biodiversity preservation at large spatial scales; but even local scale diversity is highly determined by landscape structure. Management, restoration and creation of suitable habitats, provision of corridors and stepping stones to improve connectivity and improving the permeability of the surrounding landscape are, thus, key targets for successful ecological networks and conservation (Eycott et al., 2008).

The negative effects of fragmentation and isolation are reduced as the quality of the surrounding landscape increases, particularly if the connectivity and permeability function of the system are enhanced (Donald & Evans, 2006; Eycott et al., 2008). There is increasing evidence that communities in fragments, even in large fragments, are significantly influenced by the quality of the surrounding matrix (Donald & Evans, 2006). Therefore, land management at a landscape scale should reduce fragmentation through improving connectivity, but should also recognise the importance of the landscape-scale mosaic of habitats to support dynamic ecological processes such as dispersal and migration that maintain metapopulation structures viable (Jeremy R. Franks & Emery, 2013; Manning, Gibbons, & Lindenmayer, 2009; Perfecto & Vandermeer, 2010; Stoeckli et al., 2017). Targeting spatially explicit landscape-scale ecological concepts such as fragmentation, corridors and metapopulation functions would provide more effective means of enhancing biodiversity (Dutton, Edwards-Jones, Strachan, & Macdonald, 2008).

Furthermore, the landscape-scale focus of conservation is crucial not only for the conservation of biodiversity but also for the long-term sustainability of ecosystems and the functions and services they generate. Spatial exchanges among local systems provide spatial insurance of functions and services when species may complement each other and better occupy spatial and temporal gradients (Tscharntke et al., 2005). Therefore, the functional significance of biodiversity and the ecosystem services provided (e.g. pollination service, pest control, flood mitigation, carbon sequestration) tend to be spatially extensive at a landscape scale and not limited to single farms (Mckenzie et al., 2013; Tscharntke et al., 2005). The persistence of structurally diverse agricultural landscapes is hence a prerequisite for the conservation of a significant part of Europe’s biodiversity and ecosystem services delivery. More specified and targeted schemes at a landscape perspective and regional context might lead to higher effectiveness at preserving biodiversity (Wrbka et al., 2008) but also, simultaneously, at improving other ecosystem functions such as water quality or prevention erosion (Galler, von Haaren, & Albert, 2015).

AES –a landscape approach

Several studies highlight that conservation of biodiversity and ecosystem services in agricultural systems requires a landscape perspective (Donald & Evans, 2006; Gabriel et al., 2010; Galler et al., 2015; Manning et al., 2009; Tscharntke et al., 2005; Wrbka et al., 2008), and the consideration of adjacent habitats and their structure to tackle wider environmental problems and guarantee the preservation of the maximum number of species (Donald and Evans, 2006; Manning et al., 2009). Therefore, a stronger focus on landscape-context measures, maintenance and improvement of landscape diversity and connectivity, and improvement of the participation of farmers in specific conservation measures targeting the landscape-scale focus could be one approach to achieve higher effectiveness of AES and enhance the long-term viability and resilience of species (Concepción et al., 2008; Emery & Franks, 2012; Lewis et al., 2011; Wrbka et al., 2008).

However, limitations exist with the implementation of conservation actions at larger scales, given that land management is typically conducted at the field and farm scale. A question then arises on how management at a landscape level can be implemented among many particular landowners (Bengtsson et al., 2003). To address such limitations, different approaches have been implemented to incentivise landowners to collaborate and organise their actions for conservation and to select spatially connected areas for conservation (Drechsler, Wätzold, Johst, & Shogren, 2010; Prager, 2015).

Landscape management requires integrative instruments to coordinate scattered actions of different landowners (Lefebvre et al., 2015), which involves complex forms of collaborative governance with individual owners, users, stakeholders and government (Dedeurwaerdere, Polard, & Melindi-Ghidi, 2015). Such approach adds extra costs to the planning operation, but might improve the outcomes and effectiveness in the long term (Dutton et al., 2008; Swales, 2009). Therefore, institutions need to promote the stakeholder co-ordination and the support from the administration on such groups, as well as the establishment of incentives for land-owners to enrol in collaboration actions and the provisioning of training (Hodge & Adams, 2013; Swales, 2009).

Some countries have already considered the landscape scale focus in the design and implementation of some AES aiming at conserving biodiversity (e.g. Australia (Wilson, 2004); Germany (Prager & Vanclay, 2010; Schomers, Sattler, & Matzdorf, 2015), Denmark (J. R. Franks & Mc Gloin, 2007), The Netherlands (Swales, 2009), Wales in UK (Swales, 2009), some states in USA (Swales, 2009), Table 1). Overall, such schemes implemented and designed at a landscape scale, are successful at promoting collaborative actions among farmers, at involving landscape scale changes or at delivering public goods (Swales, 2009). There is still room however to improve the outcomes of landscape scale AES, but such examples may act as the basis upon which we can get the good practices and propose appropriate changes that might lead to improve the design of AES at landscape scale and, therefore, their effectiveness (Swales, 2009).

Table 1: Some examples of AES implemented at landscape

AES at landscape scale	Country	Type
Australian Landcare Programme	Australia	Farmer / community groups (co-operative)
German Landschaftspflegeverbände groups	Germany	Farmer / community groups (co-operative)
Dutch environmental cooperatives	Denmark	Farmer / community groups (co-operative)
Environmental cooperatives (VEL and VANLA)	Netherlands	Farmer / community groups (co-operative)
Pumlumon Large Areas Conservation Project	UK (Wales)	Multi-partner co-operative (collective groups)
Malpai Borderlands Group	USA (Arizona & New Mexico)	Farmer / community groups (co-operative)

Collaborative AES

If conservation measures are to be carried out on spatially connected land from different landowners, then coordination of actions is required. Collaborative AES could be based on the cooperation of farmers and other stakeholders and agencies working in close collaboration to integrate a sustainable management focused on environmental protection and conservation into farming practices by adopting an approach based on a regional perspective (J. R. Franks & Mc Gloin, 2007). Collaborative AES allow planning measures according to the landscape context, which are likely to benefit small but key groups of species more than farm-scale schemes, while not disadvantaging species operating at smaller scales (Mckenzie et al., 2013). The examples in Table 1 include collaborative AES, which require joint submissions with neighbouring farmers (Jeremy R. Franks & Emery, 2013).

The idea of the collaborative schemes would involve a direct entry dependent on groups of farmers and stakeholders joining together. Such level of integration and entry to the schemes can be achieved through the establishment of an organisation, such as a co-operative in which the individual landowners can participate and implement collective actions. The individual landowners can collectively apply for funding and agree subcontracts within the co-operative (Hodge & Adams, 2013). Another approach to the collaborative schemes could be the collective actions conducted through an external organisation that bridges the group of farmers and the government. This type of approach has been implemented in some regions such as Wales (Hodge & Adams, 2013). Such collective actions enable conservation to be implemented at a larger scale under a collective body agreement, from which funding is allocated to individual contracts (Hodge & Adams, 2013). Local actors questioned by Prager (2015) considered best suitable the option of the external organisation rather than farmer-led proposals.

The idea is that collaborative AES involve a large number of partners that can bring different skills and resources to the project, potentially offering scientific advice, support for monitoring, voluntary labour or land. This level of organisation may involve different requirements for funding, but might guarantee the effectiveness of the practices at conserving biodiversity and enhancing habitat quality (J. R. Franks & Mc Gloin, 2007; Hodge & Adams, 2013). Moreover, it can help to improve the challenge of fragmented land ownership and target conservation at a landscape level (Metzner et al., 2013; Schomers et al., 2015). In general, collaborative AES have good acceptance among farmers (van Dijk et al. 2015; Dutton et al., 2008; Franks and Mc Gloin, 2007; Mckenzie et al., 2013; Prager, 2015; Uthes and Matzdorf, 2013), who see the advantages and the environmental benefits of these schemes. When properly designed and implemented, such collaborative approaches offer flexibility and adaptability for farmers and are subject to adequate compensation payments. The role of an intermediary organisation in bringing farmers together, in providing information, in building trust and in acting as mediator between local actors and the policy is recognised to be of main importance for farmers to rely and enrol in such collaborative schemes (Lastra-Bravo et al., 2015; Metzner et al., 2013; Prager, 2015). Besides, participatory approaches seem they can increase acceptance among farmers (Lastra-Bravo et al., 2015; Uthes and Matzdorf, 2013).

Agglomeration payments or bonus

A different approach to achieve landscape scale conservation could be through agglomeration payments or bonus, which envisages the payment of or the additional bonus on top of spatially homogeneous payment if the spatial allocation of land where conservation measures take place is part of a connected habitat network and thus benefits biodiversity (Wätzold & Drechsler, 2014). Agglomeration payments or bonus are meant to incentivise landowners to select spatially connected areas for conservation. Such compensation payment schemes are more likely to account for the spatial configuration of habitat patches and reunite fragmented habitat for conservation than regular AES (Drechsler et al., 2010; Parkhurst et al., 2002).

One way to implement such schemes would be through agglomeration payments, considered by Drechsler et al. (2010), in which payments are made only if certain level of spatial connectivity in the land where conservation actions are applied is reached. Another way would be the agglomeration bonus, proposed by Parkhurst et al. (2002), which envisages the payment of an additional bonus over the regular payment if the spatial allocation of land on which land users carry out conservation benefits the connectivity and the landscape structure of the habitat or species distribution. Wätzold and Drechsler (2014) found that agglomeration payments might perform much better than the agglomeration bonuses.

Landscape-scale targeting of whole areas in terms of actively encouraging farmers to take up general AES, as opposed to specific AES measures is currently seen as a key issue in enhancing the wider ecological benefits of AES (Eycott et al., 2008; Whittingham, 2007). A good coordination and implementation structure, as well as addressing specific environmental issues and a long-term orientation of the measures and areas seem to be key for successful actions (Metzner et al., 2013; Swales, 2009). However, very little empirical evidence of the effectiveness of such landscape oriented measures exist (Dutton et al., 2008).

Novel approach of AES implementation in Ireland

The implementation of schemes for conservation with a landscape scale focus could help Ireland meet its objectives for habitat and biodiversity preservation. There are already some examples of cooperative working among farmers in Ireland (e.g. farmer discussion groups, commonages). And also some cases of collaborative management for biodiversity conservation through specific projects (e.g. LIFE projects) and through the implementation of the European Innovation Partnership (EIP) initiative, proposed under the RDP 2014-2020, which seeks proposals from groups to address environmental and climate related problems. However, the consideration of a landscape-scale focus for the implementation of AES is not the main way of AES appliance in Ireland.

The effectiveness of current Irish AES aimed at enhancing the quality of habitats and at preserving the biodiversity could be improved if implemented with a landscape-scale focus. Thus, for example, if planting of new hedgerows is done where it improves the connectivity between existing habitats, the effectiveness of such measure at conserving biodiversity in these habitats is more likely to be higher. Actually, previous studies have already pointed out that conventional AES measures if applied at larger spatial scale lead to better success (Carvell, Bourke, Osborne, & Heard, 2015). The same idea can be applicable to other measures, such that we considered 16 measures out of 23 that can improve its outcomes for biodiversity conservation if designed according to a landscape perspective (Table 2).

Taking into account some already established structures of farmer discussion groups and cooperative working through common advisors in Ireland, the implementation of landscape oriented AES could be feasible. However, there may be need to allocate more resources to promote the coordination of such groups and an appropriate landscape oriented design of AES. The higher investment in such collaborative structures, however, might better ensure the effectiveness of the measures implemented.

Table 2: Current AES implemented in Ireland under the GLAS programme and the indication (asterisks) if such measures could improve its effectiveness and the outcomes in terms of biodiversity conservation if designed and implemented considering a landscape scale focus (e.g. improving connectivity or increasing the habitat patches in between current patches)

GLAS	Name	Description	
GLAS 1	Arable Margins	Create different types of conservation crop margins offering an opportunity for more characteristic plants and animals associated with arable farms to live and feed on the working farm. Maintain a 3, 4 or 6-metre margin along a full LPIS parcel boundaries.	*
GLAS 2	Bat boxes	Improve biodiversity in the farming landscape and replace habitats lost through changes in farming practice. Bats also play an important role in farm pest management as they feed on midges, flies and other potential pest species.	*
GLAS 3	Bird boxes	Improve biodiversity in the farming landscape and replace habitats lost through changes in farming practice.	*
GLAS 4	Conservation of solitary bees (boxes or sand)	Improve biodiversity in the farming landscape and replace habitats lost through changes in farming practice.	*
GLAS 5	Conservation of farmland birds	Maintain and increase the breeding success of breeding waders by halting habitat loss and enhancing habitat availability and suitability. 1) Breeding waders; 2) Chough; 3) Corncrake; 4) Geese and swans; 5) Grey partridge; 6) Hen harrier; 7) Twitter	*
GLAS 6	Catch crops	Establish catch crop that will absorb nutrients and prevent leaching in the autumn/winter period.	
GLAS 7	Coppicing hedgerows	Enhance and increase the length of hedgerows and stonewalls in the interest of stock control and scenic appearance of the farm. The additional works will also increase the wildlife habitat area on the farm. Rejuvenate hedgerows where the tree stems are cut back to 10cm from ground level. Dormant buds will regrow and eventually develop into reinvigorated hedgerow.	*
GLAS 8	Environmental management of fallow land	To provide food and habitat for ground nesting birds, other fauna and insects throughout the nesting season.	*
GLAS 9	Laying hedgerows	Cutting part of the way through selected stems, bending them over at an angle of 70-80 degrees and fishing the branches and stems to stakes driven into the hedgerow bank. Enhance and increase the length of hedgerows and stonewalls in the interest of stock control and scenic appearance of the farm. The additional works will also increase the wildlife habitat area on the farm.	*
GLAS 10	Low-emission slurry spreading	To improve the recycling of organic fertiliser and to contribute to reduced nitrous oxide emissions, ammonia emissions and odours.	
GLAS 11	Low-input permanent pasture	To promote grassland management system that through appropriate grazing levels and restriction on fertiliser and pesticide use results in a more diverse sward with an increase in flora and fauna.	*
GLAS 12	Minimum tillage	Sowing crops without inverting the soil, soil cannot be ploughed.	
GLAS 13	Planting a grove of native trees	To encourage the planting of small groups of trees to provide a valuable pocket habitat and opportunity for carbon sequestration.	*
GLAS 14	Planting new hedgerows	Plant new hedgerows on the land. Establish new hedgerows on farms to increase biodiversity, to enhance the visual landscape and to help protect water quality. Enhance and increase the length of hedgerows and stonewalls in the interest of stock control and scenic appearance of the farm. The additional works will also increase the wildlife habitat area on the farm.	*
GLAS 15	Protect features of historical & archaeological interest	Increase in Buffer Margins for Archaeological and Historical Features and manage publicly accessible archaeological sites. Enhance the protection of these features and also to assist farmers maintain public access to archaeological sites on their land where such rights are currently in existence.	
GLAS 16	Protect and maintain watercourses, water bodies and wells	The specific objective is to avoid physical damage to the watercourse by preventing bovine access at drinking points and to improve water quality by protecting the river margin from poaching increasing the watercourse margin.	**
GLAS 17	Riparian margins	Establish and maintain a fenced-off margin of a set width along the watercourses chosen	**
GLAS 18	Traditional hay meadows	Whole grassland LPIS with at least 3 grass species other that Ryegrass / To promote the maintenance of a traditional method of forage conservation that is beneficial to grassland flora and fauna. Ensure that farm management allows these flowers and grasses the opportunity to produce seed.	*
GLAS 19	Traditional Irish orchards	Create and maintain apple orchards with specific varieties traditional to Ireland to ensure the survival of this unique resource.	
GLAS 20	Traditional dry stone wall maintenance	To maintain and enhance the network of traditional freestanding dry walls, increase biodiversity and enhance the visual landscape.	*
GLAS 21	Wild bird cover	Grassland farmers that grow specific wild bird cover crop seed mix in a whole LPIS plot	*
GLAS 22	Conservation of animal genetic resources (rare breeds)	Encourage farmers to rear animals of specific breeds traditional to Ireland, that are in danger of being lost to farming	
GLAS 23	Commonage Management Plan (CMP) and Commonage Farm Plan (CFP)	To ensure that commonage lands are appropriately grazed and managed to ensure they remain in good agricultural and environmental conditions (GAEC) and are compliant with eligibility criteria.	*
GLAS 24	Farmland habitat (Private Natura sites)	To avoid farming practices that cause environmental damage and protect vulnerable habitats such as wetlands, which in turn helps to safeguard animals and plants which occupy them.	*

*	Possible improvement of the effectiveness of the measure at conserving biodiversity if planned considering the landscape structure and implementing it to improve connectivity of the habitat or conducting the measure where it increases patches of habitat in between current patches.
**	Might improve its outcomes for water quality enhancement if planned at a landscape scale.

Conclusions

One of the main reasons cited for the lack of effect of current AES is the mismatch between the scale of implementation (usually at the field or farm scale) and the scale at which the ecological process take place (typically at larger spatial scales). Therefore, a stronger focus on landscape-context specific measures could be incorporated in the design of AES to improve their effectiveness on the preservation of biodiversity at a landscape scale. Enhancement of landscape diversity, maintenance and improvement of the quality of the habitat matrix and ensuring an appropriate connectivity between habitat patches should be the main targets of AES design to guarantee, in this way, better biodiversity conservation and an appropriate ecosystem services delivery at a long term. Agricultural landscapes should be conceived as a mosaic of well-connected early and late successional habitats both with farmed and natural patches to support high diversity and ecosystem services delivery and, thereby, to enhance the resilience of the agroecosystems.

Given that the agricultural landscape is usually fragmented into small owned properties, to achieve such goal, there is the need to incentivise the participation of farmers in spatially connected conservation measures. Agglomeration payments and bonuses are approaches to target conservation at a landscape scale that have been proved to perform well, particularly the agglomeration payments, i.e. when payments are given only if actions are undertaken in spatially connected areas. Collaborative AES, either as a co-operation group among farmers or through an external bridging organisation, seem to be a good option to implement conservation at larger scales. Although associated costs of collaborative AES with an external organisation involved acting as mediator between the group of local farmers and policy makers might be higher, the acceptance among farmers is likely to be better and the outcomes of the actions in terms of conservation successful. Such collaborative bridging organisations might allow to improve the level of provisioning of environmental public goods and to facilitate the process of social learning (Dedeurwaerdere et al., 2015), which are crucial elements to ensure trust, long-term participation and effectiveness of the measures implemented.

The already existing structures of grouping and cooperation among farmers in Ireland would facilitate the establishment of AES focused on the landscape scale planning. However, there would be the need to allocate more resources to incentive the cooperation among farmers and to promote the coordination of the actions, beside the investment for the implementation of such practices at a landscape scale. But it seems that such design of AES could give higher effectiveness of management for biodiversity conservation and for the provisioning of ecosystem services in Ireland.

However, further studies assessing the cost-effectiveness of landscape oriented AES such as collaborative AES or agglomeration payments or bonuses would help appraise the most appropriate actions to improve the conservation outcomes. More empirical evidence of the effectiveness of landscape oriented measures is also needed to proof the outcomes and help allocate more resources into such measures to ensure the benefit for the conservation of landscape-scale biodiversity and the provisioning of ecosystem service in agricultural landscapes.

References

Altieri, M. a. (1999). The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems & Environment*, *74*(1–3), 19–31.

Baker, D. J., Freeman, S. N., Grice, P. V., & Siriwardena, G. M. (2012). Landscape-scale responses of birds to agri-environment management: A test of the English Environmental Stewardship scheme. *Journal of Applied Ecology*, *49*(4), 871–882.

Batáry, P., Báldi, A., Kleijn, D., & Tscharntke, T. (2011). Landscape-moderated biodiversity effects of agri-environmental management: a meta-analysis. *Proceedings of the Royal Society of London B: Biological Sciences*, *278*, 1894–1902.

Batáry, P., Dicks, L. V., Kleijn, D., & Sutherland, W. J. (2015). The role of agri-environment schemes in conservation and environmental management. *Conservation Biology*, *29*(4), 1006–1016.

Bengtsson, J., Angelstam, P., Elmqvist, T., Emanuelsson, U., Folke, C., Ihse, M., … Nyström, M. (2003). Reserves, Resilience and Dynamic Landscapes. *AMBIO: A Journal of the Human Environment*, *32*(6), 389–396.

Bennett, A. F. (2003). *Linkages in the landscape. The role of corridors and connectivity in wildlife conservation*. *IUCN Forest Conservation Programme* (Vol. 24).

Bommarco, R., Kleijn, D., & Potts, S. G. (2013). Ecological intensification: Harnessing ecosystem services for food security. *Trends in Ecology and Evolution*, *28*(4), 230–238.

Boyle, G., & Keena, C. (2009). The Irish agricultural landscape. In *The Heritage Council 2009 Landscape Conference* (pp. 1–8).

Carvell, C., Bourke, A. F. G., Osborne, J. L., & Heard, M. S. (2015). Effects of an agri-environment scheme on bumblebee reproduction at local and landscape scales. *Basic and Applied Ecology*, *16*(6), 519–530.

Concepción, E. D., Díaz, M., & Baquero, R. A. (2008). Effects of landscape complexity on the ecological effectiveness of agri-environment schemes. *Landscape Ecology*, *23*, 135–148.

Cumming, G. S., Cumming, D. H. M., & Redman, C. L. (2006). Scale Mismatches in Social-Ecological Systems : Causes , Consequences , and Solutions. *Ecology And Society*, *11*(1), 20.

Dedeurwaerdere, T., Polard, A., & Melindi-Ghidi, P. (2015). The role of network bridging organisations in compensation payments for agri-environmental services under the EU Common Agricultural Policy. *Ecological Economics*, *119*, 24–38.

Donald, P. F., & Evans, A. D. (2006). Habitat connectivity and matrix restoration: The wider implications of agri-environment schemes. *Journal of Applied Ecology*, *43*(2), 209–218.

Drechsler, M., Wätzold, F., Johst, K., & Shogren, J. F. (2010). An agglomeration payment for cost-effective biodiversity conservation in spatially structured landscapes. *Resource and Energy Economics*, *32*(2), 261–275.

Dutton, A., Edwards-Jones, G., Strachan, R., & Macdonald, D. W. (2008). Ecological and social challenges to biodiversity conservation on farmland: Reconnecting habitats on a landscape scale. *Mammal Review*, *38*(2–3), 205–219.

Emery, S. B., & Franks, J. R. (2012). The potential for collaborative agri-environment schemes in England: Can a well-designed collaborative approach address farmers' concerns with current schemes? *Journal of Rural Studies*, *28*(3), 218–231.

Evans, A. D., & Green, R. E. (2007). An example of a two-tiered agri-environment scheme designed to deliver effectively the ecological requirements of both localised and widespread bird species in England. *Journal of Ornithology*, *148*(SUPLL. 2), 279–286.

Eycott, A., Watts, K., Brandt, G., Buyung-ali, L., Bowler, D., Stewart, G., & Pullin, A. (2008). *Which landscape features affect species movement? A systematic review in the context of climate change*. *Forest Research & Centre for Evidence-Based Conservation*.

Finn, J. A., & Ó hUallacháin, D. (2012). A review of evidence on the environmental impact of Ireland's Rural Environment Protection Scheme (REPS). *Biology and Environment: Proceedings of the Royal Irish Academy*, *112*(B), 1–24.

Foley, J. a, Defries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., … Snyder, P. K. (2005). Global consequences of land use. *Science*, *309*(5734), 570–574.

Franks, J. R., & Emery, S. B. (2013). Incentivising collaborative conservation: Lessons from existing environmental Stewardship Scheme options. *Land Use Policy*, *30*(1), 847–862.

Franks, J. R., & Mc Gloin, A. (2007). Environmental co-operatives as instruments for delivering across-farm environmental and rural policy objectives: Lessons for the UK. *Journal of Rural Studies*, *23*(4), 472–489.

Gabriel, D., Sait, S. M., Hodgson, J. A., Schmutz, U., Kunin, W. E., & Benton, T. G. (2010). Scale matters: the impact of organic farming on biodiversity at different spatial scales. *Ecology Letters*, *13*(7), 858–869.

Galler, C., von Haaren, C., & Albert, C. (2015). Optimizing environmental measures for landscape multifunctionality: Effectiveness, efficiency and recommendations for agri-environmental programs.

Journal of Environmental Management, *151*, 243–257.
Hendrickx, F., Maelfait, J. P., Van Wingerden, W., Schweiger, O., Speelmans, M., Aviron, S., … Bugter, R. (2007). How landscape structure, land-use intensity and habitat diversity affect components of total arthropod diversity in agricultural landscapes. *Journal of Applied Ecology*, *44*(2), 340–351.
Herzog, F., Dreier, S., Hofer, G., Marfurt, C., Schüpbach, B., Spiess, M., & Walter, T. (2005). Effect of ecological compensation areas on floristic and breeding bird diversity in Swiss agricultural landscapes. *Agriculture, Ecosystems and Environment*, *108*(3), 189–204.
Hodge, I., & Adams, W. M. (2013). The role of agri-environment measures in promoting co-ordinated land management in large conservation areas. *14th Global Conference of the International Association for the Study of the Commons*, 1–17.
IEEP. (2008). *Funding for Farmland Biodiversity in the EU: Gaining Evidence for the EU Budget Review*. *Case Study Reports*. *A report for the RSPB*.
Kleijn, D., Baquero, R. A., Clough, Y., Díaz, M., De Esteban, J., Fernández, F., … Yela, J. L. (2006). Mixed biodiversity benefits of agri-environment schemes in five European countries. *Ecology Letters*, *9*(3), 243–254.
Kleijn, D., Berendse, F., Smit, R., Gilissen, N., Smit, J., Brak, B., & Groeneveld, R. (2004). Ecological effectiveness of agri-environment schemes in different agricultural landscapes in the Netherlands. *Conservation Biology*, *18*(3), 775–786.
Kleijn, D., Rundlöf, M., Scheper, J., Smith, H. G., & Tscharntke, T. (2011). Does conservation on farmland contribute to halting the biodiversity decline? *Trends in Ecology and Evolution*, *26*(9), 474–481.
Kleijn, D., & Sutherland, W. J. (2003). How effective are European agri-environment schemes in conserving and promoting biodiversity? *Journal of Applied Ecology*, *40*(6), 947–969.
Lastra-Bravo, X. B., Hubbard, C., Garrod, G., & Tolón-Becerra, A. (2015). What drives farmers' participation in EU agri-environmental schemes?: Results from a qualitative meta-analysis. *Environmental Science and Policy*, *54*, 1–9.
Lefebvre, M., Espinosa, M., & Gomez y Paloma, S. (2012). *The influence of the Common Agricultural Policy on agricultural landscapes*.
Lefebvre, M., Espinosa, M., Gomez y Paloma, S., Paracchini, M. L., Piorr, A., & Zasada, I. (2015). Agricultural landscapes as multi-scale public good and the role of the Common Agricultural Policy. *Journal of Environmental Planning and Management*, *58*(12), 2088–2112.
Lewis, D. J., Plantinga, A. J., Nelson, E., & Polasky, S. (2011). The efficiency of voluntary incentive policies for preventing biodiversity loss. *Resource and Energy Economics*, *33*(1), 192–211.
Macdonald, D., & Service, K. (2007). *Key topics in Conservation Biology*. (D. Macdonald & K. Service, Eds.). Pondicherry, India: Blackwell Publishing Ltd.
Manning, A. D., Gibbons, P., & Lindenmayer, D. B. (2009). Scattered trees: A complementary strategy for facilitating adaptive responses to climate change in modified landscapes? *Journal of Applied Ecology*, *46*(4), 915–919.
Mckenzie, A. J., Emery, S. B., Franks, J. R., & Whittingham, M. J. (2013). Landscape-scale conservation: Collaborative agri-environment schemes could benefit both biodiversity and ecosystem services, but will farmers be willing to participate? *Journal of Applied Ecology*, *50*(5), 1274–1280.
Merckx, T., Feber, R. E., Riordan, P., Townsend, M. C., Bourn, N. A. D., Parsons, M. S., & Macdonald, D. W. (2009). Optimizing the biodiversity gain from agri-environment schemes. *Agriculture, Ecosystems and Environment*, *130*(3–4), 177–182.
Metzner, J., Keller, P., Kretschmar, C., Krettinger, Be., Liebig, N., Mäck, U., & Orlich, I. (2013). Kooperativer Naturschutz in der Praxis. *Naturschutz Und Landschaftsplanung*, *10*(11), 315–321.
Ó hUallacháin, D., Finn, J. A., Keogh, B., Fritch, R., & Sheridan, H. (2016). A comparison of grassland vegetation from three agri-environment conservation measures. *Irish Journal of Agricultural and Food Research*, *55*(2), 176–191.
Parkhurst, G. M., Shogren, J. F., Bastian, C., Kivi, P., Donner, J., & Smith, R. B. W. (2002). Agglomeration bonus: an incentive mechanism to reunite fragmented habitat for biodiversity conservation. *Ecological Economics*, *41*, 305–328.
Perfecto, I., & Vandermeer, J. (2010). The agroecological matrix as alternative to the land-sparing/agriculture intensification model. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(13), 5786–5791.
Prager, K. (2015). Agri-environmental collaboratives as bridging organisations in landscape management. *Journal of Environmental Management*, *161*, 375–384. https://doi.org/10.1016/j.jenvman.2015.07.027
Prager, K., & Vanclay, F. (2010). Landcare in Australia and Germany: Comparing structures and policies for community engagement in natural resource management. *Ecological Management and Restoration*, *11*(3), 187–193.
Santana, J., Porto, M., Reino, L., Moreira, F., Ribeiro, P. F., Santos, J. L., … Beja, P. (2017). Using beta

diversity to inform agricultural policies and conservation actions on Mediterranean farmland. *Journal of Applied Ecology*, *54*(6), 1825–1835.

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., … Buck, L. E. (2013). Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proceedings of the National Academy of Sciences*, *110*(21), 8349–8356.

Scheper, J., Holzschuh, A., Kuussaari, M., Potts, S. G., Rundlöf, M., Smith, H. G., & Kleijn, D. (2013). Environmental factors driving the effectiveness of European agri-environmental measures in mitigating pollinator loss - a meta-analysis. *Ecology Letters*, *16*(7), 912–920.

Schomers, S., Sattler, C., & Matzdorf, B. (2015). An analytical framework for assessing the potential of intermediaries to improve the performance of payments for ecosystem services. *Land Use Policy*, *42*, 58–70.

Stoate, C., Báldi, A., Beja, P., Boatman, N. D., Herzon, I., van Doorn, A., … Baldi, A. (2009). Ecological impacts of early 21st century agricultural change in Europe - A review. *Journal of Environmental Management*, *91*(1), 22–46.

Stoeckli, S., Birrer, S., Zellweger-Fischer, J., Balmer, O., Jenny, M., & Pfiffner, L. (2017). Quantifying the extent to which farmers can influence biodiversity on their farms. *Agriculture, Ecosystems and Environment*, *237*, 224–233.

Swales, V. (2009). *Realising Agricultural Landscape-Scale Conservation A Report for the RSPB*.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature*, *418*(6898), 671–677.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., … Swackhamer, D. (2001). Forecasting agriculturally driven global environmental change. *Science*, *292*(5515), 281–284.

Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I., & Thies, C. (2005). Landscape perspectives on agricultural intensification and biodiversity - Ecosystem service management. *Ecology Letters*, *8*(8), 857–874.

Tzilivakis, J., Warner, D. J., Green, A., Lewis, K. A., & Angileri, V. (2016). An indicator framework to help maximise potential benefits for ecosystem services and biodiversity from ecological focus areas. *Ecological Indicators*, *69*, 859–872.

Uthes, S., & Matzdorf, B. (2013). Studies on agri-environmental measures: A survey of the literature. *Environmental Management*, *51*(1), 251–266.

van Dijk, W. F. A., Lokhorst, A. M., Berendse, F., & de Snoo, G. R. (2015). Collective agri-environment schemes: How can regional environmental cooperatives enhance farmers' intentions for agri-environment schemes? *Land Use Policy*, *42*, 759–766.

Wätzold, F., & Drechsler, M. (2014). Agglomeration payment, agglomeration bonus or homogeneous payment? *Resource and Energy Economics*, *37*, 85–101.

Whittingham, M. J. (2007). Will agri-environment schemes deliver substantial biodiversity gain, and if not why not? *Journal of Applied Ecology*, *44*(1), 1–5.

Whittingham, M. J. (2011). The future of agri-environment schemes: Biodiversity gains and ecosystem service delivery? *Journal of Applied Ecology*, *48*(3), 509–513.

Wilson, G. A. (2004). The Australian Landcare movement: Towards "post-productivist" rural governance? *Journal of Rural Studies*, *20*(4), 461–484.

Wrbka, T., Schindler, S., Pollheimer, M., Schmitzberger, I., & Peterseil, J. (2008). Impact of the Austrian Agri-environmental scheme on diversity of landscapes, plants and birds. *Community Ecology*, *9*(2), 217–227.