Chapter 17
The Potential for Silvopastoralism to Enhance Biodiversity on Grassland Farms in Ireland

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Abstract In the western British Isles, pastoral agriculture with sheep and cattle is the dominant land use. Current changes in EU policy, specifically the implementation of farm decoupling through the Single Farm Payment, enforcing the Nitrates Directive, environmental cross-compliance measures and other initiatives within the Rural Development Plan have driven the need to find alternative land use systems which can enhance biodiversity on grassland farms. Ireland has a moist, temperate climate which suits intensive livestock production systems, and these have negatively impacted on the region's biodiversity. This represents a microcosm of the general problems facing such systems in the British Isles and north western Europe. The integration of farm woodlands and trees onto farmland can address these issues. Silvopastoral systems, where wide spaced trees are planted into grassland have been shown to be compatible with conventional grassland systems, increase biodiversity and enhance the farmed landscape. Research in Ireland with sheep on upland vegetation and sheep and cattle on lowland pastures has shown that such systems can reduce nutrient leakage, increase some invertebrates, birds and flora and create spatial heterogeneity in the canopy and soil. This delivers much more sustainable agroecosystems while still allowing the combination of farming and rural economic development. Such systems should be targeted to and adapted for farmers who wish to develop conservation, amenity, recreation and environmental 'goods' on their farms, be compatible with current agri-environment measures, the organic farming sector and rural community group objectives. These objectives are common to the British Isles and the example of their applicability in Ireland should encourage others to apply them more widely in the region.

Keywords Rural development, silvopastoral systems, agri-environment policy, forestry

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Introduction

In north-western areas of Europe and the west of the British Isles, a moist, wet climate has best suited pastoral agriculture with sheep and cattle. The island of Ireland exemplifies this scenario and represents a microcosm of the region where the enhancement of biodiversity on grassland is a prime agri-environment objective (McAdam 2005).

Over the past 50 years, livestock production from grassland in Ireland has been intensified substantially (Moss 1997; Connolly et al. 2002; Feehan 2003) creating serious environmental problems such as reduced biodiversity and nutrient leakage into water courses. Nowadays, EU policy aims to reduce the levels of output from grassland systems through implementation of fertiliser restrictions under, e.g. the Nitrates Directive and to promote sustainable farming practices which attempt to address some of the damage caused by previous intensive agricultural practices (Finn 2003). Such a policy is to be implemented through decreasing levels of livestock output, tightening nutrient management on farms, enhancing biodiversity through a more sustainable and lower input agriculture, increasing tree cover to contribute to habitat heterogeneity and increased stabilisation of rural communities as is happening in other EU countries.

Tree cover in Northern Ireland (6%) is the lowest in Europe (mean 31%) (Cooper and McCann 2002) and in Ireland is approximately 10% (Bulfin 1999; Short et al. 2005).

Agri-environment Policy

It is widely accepted that agriculture has a multifunctional role, delivering not just food but other public goods such as the protection of habitats and biodiversity and enhancement of the countryside (DARD 2003). The increasing need to integrate food production with responsible countryside management is reflected in the changing emphasis of agricultural policy. The need was originally addressed through EU regulation 797/85 which stated that member states could introduce agri-environment measures in order to ameliorate some of the long-term environmental damage caused by intensive agriculture. Subsequently, as part of the reform of the Common Agricultural Policy, regulation 2078/92 stated that member states should introduce agri-environment measures (Finn 2003). Agri-environment measures became compulsory in 1999 in the EU (under regulation 1275/99) and are now an integral element of Rural Development Plans. The underlying concept behind these measures is the encouragement of producers to farm in an environmentally friendly way through active management of the countryside and reduced inputs, especially of pesticides and fertilisers.

The aim of establishing these schemes is to help safeguard areas of the countryside where the landscape, wildlife or historic interest is of particular importance and where that interest would benefit through farmers continuing with, or engaging in, environmentally sensitive farming practices. These programmes, with their direct and tangible commitment to such farming practices, marked a significant departure from agricultural policy. Farmers are effectively being paid by Governments to 'produce' countryside (Baldock et al. 1990). The additional financial support received by farmers also contributes towards rural development and ensuring the stability of rural populations.

Where agroforestry aligns with EU policy is much less well defined. Silvopastoral systems can contribute to reduction of livestock grazing pressure, better nutrient management and amelioration of animal living conditions if introduced to intensive or semi-intensive farming systems. Animal welfare is now a key element of cross-compliance measures for the Single Farm Payment. Silvopastoralism aligns closely with current EU policy for intensively managed pasturelands which will be decoupled from subsidies based on headage payments for production to a system of payment based on stewardship of land with strict environmental and other cross-compliance measures attached.

In a more global context, silvopastoralism can be a mechanism to create land use systems with levels of carbon sequestration which are higher than those from pastureland and which can buffer the more adverse effects of climate change (Mosquera-Losada et al. 2005).

Agricultural officials in Northern Ireland are regarding silvopastoral systems as eligible forage area for Single Farm Payment (SFP) as long as agriculture remains the primary land use. Within the current Rural Development Regulation support is provided for agroforestry (EC, 2004).

It is proposed that silvopastoral systems, where wide spaced, protected trees are planted into grassland and managed as a multi-functional system to realise significant ecological, social and economic benefits, represents one option to introduce trees to the farmed landscape. This paper will analyse the background to the evolution of practice and thinking and the current research on silvopastoral systems in Ireland will be reviewed to demonstrate the validity of this proposal. The opportunity for Ireland and Northern Ireland offered under increased modulation proposals within the Rural Development Plan will contribute to this proposal.

Climate, Soils and Land Use in Ireland

The island of Ireland consists of a large central lowland of limestone with a relief of hills and several coastal mountain ranges and is situated in the extreme north west of Europe between 51.5 and 55.5 degrees north latitude and 5.5 and 10.5 degrees west longitude. The Irish Sea to the east, which separates Ireland from Britain, is 17.6–192 km wide. The total land area is 84,421 km^2 (70,282 km^2 in the Republic of Ireland and 14,139 km^2 in Northern Ireland).

Topography is varied, a high proportion of the land is undulating, hilly or mountainous. Approximately 30% of the region is above 150 m altitude. Soil cover is very varied, alluvial sands, clay and heavily gleyed soils, reflecting a diverse parent geology several periods of glaciation and relatively high rainfall. There are extensive areas of peat bogs and underlying drainage is a key determinant of soil fertility and land use (Wilcock 1997).

The cool maritime climate is ameliorated by the Gulf Stream and temperatures are fairly uniform over the country. The coldest months are January and February which have mean daily air temperatures between 4°C and 7°C while July and August are the warmest months (14–16°C). Extremes of temperature below −10°C or above 30°C are very rare. May and June average 5–7 hours of sunshine per day. In low-lying areas mean annual rainfall is 800–1,200 mm and in upland areas can exceed 2,000 mm. Rainfall is well distributed throughout the year but about 60% of the total falls between August and January. Cloud cover is high, mean total hours of sunshine per year is 1,300 (Betts 1997).

Agriculture and Land Use

In Northern Ireland 78% of the area is in agriculture (1.1×10^6 ha) and 70% of the farmed use is classified as Less Favoured Area (LFA). Agriculture is based on livestock production from grassland and approximately 2.3×10^6 sheep and 1.7×10^6 cattle graze 78% of the land area (MLC 2003). Of this area, 54% is grassland which has been improved by cultivation reseeding (usually with *Lolium* spp.) fertilising and more intensive management; 36% is unimproved and semi-natural grassland (i.e. native grassland or degraded previously improved grassland or grassland, which has been man-modified at some stage in the past but is now unmanaged) and 5.5% is in arable production (Cooper and McCann 2002). There are approximately 30,000 farms, mean farm size is 35.5 ha and 92% of farms are either owned or owned and rented (DARD 2003). In the Republic of Ireland, there are 144,000 farms in a total farmed area of 4.4×10^6 ha (63% of the area), mean farm size is 29.3 ha, most farms are cattle or sheep based (MLC 2003) and the proportion of LFA is 67%. Tree cover over the whole island is 9.3% and approximately 80% of this area is with exotic conifer species (mainly *Picea sitchensis* Bong. Carr and *Pinus contorta*) planted on wetter, heavier or more acidic soils.

Biodiversity

Ireland has typically only about 50% of the British Isles total biodiversity, a very low level of endemism and a small proportion of the world total for most species groups (Anon 2000). This is largely because: Ireland was glaciated until only 12,000 years ago; recolonisation since the ice age has been slow due to rising sea levels and the resulting sea barriers; isolation from continental Europe; habitats are restricted by size; northerly latitudes have fewer species. However, the naturally impoverished fauna and flora is significant because: Ireland contains several important subspecies and variants as a result of post glacial isolation; there is less interspecific completion; the warm, wet, oceanic climate benefits some groups such as cryophytes and pteridophytes; valuable overwintering habitat for wetland birds (Anon 2000). The main issues affecting biodiversity in Ireland include policy and activities in the fields of: agricultural systems and support, forestry and woodland management, coastal and marine management, water use and management, construction and development, tourism and recreation, peatland management, introduced species, protecting special areas for biodiversity, protecting priority species and habitats and conserving genetic biodiversity. For the purposes of this paper, only agricultural systems and support will be considered.

The effects of post-war agricultural intensification in Europe and the resultant reduction in semi-natural habitats have been well documented (McCracken 1993).

In Ireland, state-funded programmes of drainage, land reclamation and the change from hay production to conserving grass as silage has led to major increases in intensively managed grassland with low species diversity at the expense of more natural habitats such as wetlands, boglands and species-rich grassland. Concomitant with an increase in areas of intensively managed grassland was a substantial increase in stocking rate and its associated problems of high volume slurry production. Agricultural-related pollution incidents from slurry and silage effluent increased to a maximum in the mid 1990s and then declined. This trend was fuelled by the Common Agricultural Policy which encouraged increased food production up until the early 1990s.

Trees and Biodiversity on Farms

Woodlands and Biodiversity

Semi-natural Woodlands

Northern Ireland is the least wooded region of Europe, with an approximate total tree cover of 6%. Only 1% consists of mixed species broadleaf semi-natural woodland (i.e. woodland which had some form of human modification in the past) and the remaining 5% of total land area is introduced, exotic conifers.

Remaining areas of semi-natural woodland occur on steep slopes or other areas inaccessible to forestry practices (Mitchell and Kirby 1990; Cooper and McCann 2000). These remaining fragments of semi-natural woodland usually survive adjacent to grazing land and include many woods which have been grazed by deer and domestic stock for many hundreds of years (McCracken 1971; Mitchell and Kirby 1990; Kirby et al. 1994). Such woodlands make an important contribution to upland agriculture by providing shelter and grazing for domestic stock (Blyth et al. 1987; Mitchell and Kirby 1990), in addition to their importance as conservation and landscape features (Kirby et al. 1994).

Despite this long history of grazing in woods, the practice has been considered one of the main threats to present-day ancient woodland (Rackham 1990).

Concerns over lack of tree regeneration in many woodlands in Northern Ireland have resulted in all grazing activity being excluded from many woodlands under agri-environment agreement (McEvoy and McAdam 2005).

However, a number of changes to the woodland ground flora have been observed under a regime of grazing that may increase botanical diversity:

(1) A reduction or total elimination of palatable species, thus reducing diversity, driving the community towards a species-poor assemblage of a few hardy and resistant species (Putman 1996; Tubbs 1997).
(2) An expansion in numbers of species resistant to grazing pressure, by virtue of prostrate growth form, or through possession of physical or chemical defences against herbivory (Putman 1996).
(3) A reduction in dominant species, such as *Rubus fruticosus* agg. (bramble), *Pteridium aquilinum* L. Kuhn (bracken) and rank grasses may enhance diversity by providing a release from competition for the lower growing, less vigorous forbs, thus increasing diversity (McEvoy and McAdam 2002).
(4) Grazing may facilitate the co-existence of potential competitors by preventing dominance of the more vigorous species.
(5) Herbivores may introduce new species to the woodland on their bodies, in hair, wool, between propagules of hooves, etc., or by dunging. These processes are known as epi- and endozoochory (Gill and Beardall 2001). Plants with small hard seeds are most likely to survive digestion. Most of the species known to be dispersed in this way are grasses and small herbs.

To evaluate the impact of livestock on the vegetation of semi-natural woodlands in Northern Ireland, a programme of surveying was undertaken between April 2002 and June 2003 (McEvoy et al. 2006a). One hundred and five areas of broadleaf woodland areas were sampled.

Significantly more species of higher plant ($p < 0.01$) were found in grazed woods than ungrazed woods. Additional species found in grazed woods tended to be ruderals such as *Cardamine flexuosa* With. and *Cerastium fontanum* Baumg. Ungrazed woods were found to have significantly more leaf litter and deadwood than grazed woods ($p < 0.01$) with approximately twice the ground cover of leaf-litter.

No significant difference ($p > 0.1$) was observed in percentage cover of bryophytes.

Grazed woods were found to have significantly more grass cover (approximately twice as much) than ungrazed woods ($p < 0.01$).

Ungrazed woods were found to have significantly more bramble (*Rubus fruticosus* agg.) cover than grazed woods ($p < 0.05$). Bluebell (*Hyacinthoides non-scripta* L. Chouard ex Rothm.), a typical woodland indicator species, had significantly less ($p < 0.05$) cover in grazed woods compared to ungrazed woods.

Grazing has also been shown to have positive association with tree regeneration. An investigation on seedling and sapling density of oak *Quercus robur* in a range of habitats in a grazed wood in Galicia, NW Spain found significantly more seedlings and saplings inhabiting open, grazed areas, compared to areas of taller ungrazed vegetation and scrub (McEvoy et al. 2006b). Stocking rate is an important factor. The absence of grazing allows tall shrubs grow up, which avoid significantly tree regeneration due to the lack of light input to the soil (McEvoy et al. (2006a).

Plantation Woodlands

Current trends in tree planting favour slow-growing broadleaves which require fertile conditions. The introduction of grants and premia by the Government to the private sector in Britain, i.e. the Woodland Grant Scheme (WGS) has vitalised interest in forestry among farmers and the choice of land available for tree planting has widened significantly. There is a considerable interest now in planting broadleaves on good quality lowland that was previously used for intensive pastoral agriculture. Any future increases in the area covered by trees is likely to come from such areas of farmland which are released from pastoral grazing by farmers wishing to destock or reduce their stock under the single farm payment (SFP).

Forests established on intensively managed, species-poor grassland habitats can often create greater opportunity for wildlife as the variety of habitats increase. Forests in such areas also contribute to reductions in fertiliser and pesticide applications, as unlike modern agriculture, sustainable forests do not require large quantities of these chemicals on a continual basis.

However herbicide applications are still required as ex-agricultural and improved grassland sites are normally much more fertile than the unimproved grassland sites that have been the subject of forestry planting in the past and competition is a major establishment issue.

Competition by grasses and herbaceous weeds in young plantations can seriously reduce the survival and early growth of the trees and lead to an extended establishment period. Grasses especially can compete vigorously for light, nutrients and water (Williamson and Lane 1989). Culleton and Bulfin (1992) found considerable amounts of apical bud death and dieback in young plantations with no weed control.

One way of fulfilling all of the above requirements may be the use of livestock to graze the unwanted herbage as a form of biological control. Forest grazing has had a revival, following an initial interest in the 1970s (Adams 1975). This has most likely arisen from the research carried out on agroforestry systems since the early 1990s (Sibbald et al. 2001) in the UK. In silvopastoral systems created by planting trees into pasture, some form of tree protection maybe necessary for up to 5 years for sheep (depending on tree species) and 12 years for cattle. This usually involves plastic tree guards or netting.

Many silviculturalists are reluctant to support prescribed livestock grazing because of fears of browsing damage to young trees (Sharrow et al. 1992).

However, this method of weed control in forest plantations has been successfully carried out in a number of countries including; Greece (Papanastis et al. 1995), New Zealand (Breach 1986; Brown 1986; Dale and Todd 1986; Hansen 1986), the United States (Sharrow et al. 1992), Spain (Silva-Pando and González-Hernández 1992; Silva-Pando et al. 1998; Rigueiro-Rodríguez et al. 1997), Japan (Shibata 1970; Ide 2001) and the Netherlands (Kuiters et al. 1996; Kuiters 1998). These systems differ from conventional agroforestry systems, which incorporate trees into a livestock/pasture system, where the livestock forms the basis of the system. In the forest grazing systems mentioned above, the livestock is used purely as a silvicultural tool, with the trees the principal component of the system.

An experiment was carried out where sheep were grazed in temporary fenced paddocks at a stocking rate of 178 Livestock Units LSU ha^{-1} in a 5-year old broadleaf plantation of oak *Quercus* spp. and ash *Fraxinus excelsior* L. (1.5 m spacings) on fertile ex-lowland pasture in Northern Ireland (McEvoy 2004). The grazing regime was rotational and intensive, with two grazing periods of 5 days in February and October 2001.

Results showed that a significant proportion of the rank herbage height was removed in the first 24 hours of livestock introduction. Herbage biomass was reduced by approximately half after 5 days. Sward height in grazed plots remained significantly lower than control plots for over 6 months after cessation of grazing, whilst biomass remained significantly lower for over 4 months after cessation of grazing.

No significant tree damage to either oak or ash was measured during the February grazing period, however significant damage to the lateral branches of both oak and ash was observed in the October grazing period. Ash was more commonly browsed than oak. Terminal leader damage did not occur on trees greater than 152 cm. Annual height increment of both tree species was unaffected by grazing, but annual stem diameter increment was significantly reduced in both oak and ash in February grazed plots and not in October grazed plots. The reduction in rank herbage by grazing and trampling may also encourage colonization of typical shade and woodland species form the dense network of species-rich hedgerows and banks which occur on the site. Further research is required to assess the potential of such a resource to colonise broadleaf plantations to create a species-rich woodland understorey.

From a series of six co-ordinated trials (the UK National Network Silvopastoral Experiment, Sibbald et al. 2001) across pastoral areas in the UK, protected trees – Sycamore *Acer pseudoplatanus* L. (at all sites) and Ash, *Fraxinus exelsior* L. Hybrid Larch Larix decidua, Red Alder *Alnus rubra* and Scots pine, *Pinus sylvestris* L. were planted at woodland (2,500 per ha) and two silvopastoral spacings (5 × 5 m – 400 trees per hectare; 10 × 10 m – 100 trees per hectare) unto pasture grazed by sheep to a predetermined sward height profile and compared with a pasture-only system.

Silvopasture and Biodiversity

A review of the effects of silvopasture on biodiversity is presented by McAdam (2000). Broadly, it was concluded that invertebrates (especially spiders) were encouraged to grassland sites by the presence of trees. Most of the work reported was on the effects of silvopasture on some invertebrate groups, birds and grasses and broadleaved plants typically invading sown, *Lolium*-based grassland (e.g. Cuthbertson and McAdam 1996). This, in turn will provide more food for birds (McAdam 2000). Dennis et al. (1996) and McAdam et al. (2007) found that spiders and staphylinid beetles appeared to respond more rapidly to the introduction of silvopastoral systems than carabid beetles. Silvopastoral systems appear to encourage birds normally associated with hedgerow and woodland onto grassland, creating a dynamic assemblage of species unique to silvopastoral systems and creating a more diverse farmed landscape where birds can have access to cover and food in a series of wildlife corridors (McAdam et al. 2007). From the silvopastoral National Network Experiment in the UK (Sibbald et al. 2001) it was found that the presence of trees tended to speed up the natural process of succession from a diverse soil seed bank and create pasture with greater floral richness (McAdam 2000).

Silvopasture in Ireland

Research on silvopastoral systems to date has been concentrated on quantifying production (eg Mcadam et al. 1999b) and fewer resources have been directed towards the investigations of ecological interactions (Crowe and McAdam 1999; McAdam 2000; McAdam et al. 2006). In 12 year old silvopastoral systems (at the Agri-Food and Biosciences Institute (AFBI)) lowland grassland field station at Loughgall, output was only marginally reduced 11 years after planting ash at 400 stem per hectare as part of the National Network Experiment (Sibbald et al. 2001). The impact of the system on aspects of biodiversity (carabid beetles, spiders, birds and flora) was investigated when trees had been established for up to 8 years. More spiders were collected from silvopasture than either pasture or woodland treatments and within the agroforestry, at the higher density of planting (400 stems per hectare vs. 100 stems hectare) (Johnston 1996). Carabid beetles were more numerous and from a wider range of species in the silvopasture than open pasture (Cuthbertson and McAdam 1996; Whiteside et al. 1998). Toal and McAdam (1995) found that, generally significantly more birds were recorded on lowland and upland silvopasture in summer and winter than either open pasture or woodland. In establishing silvopasture at Loughgall, plant diversity was slightly greater (but not significantly so) near trees than in open pasture (McAdam 1996; McAdam and Hoppé 1996) but in a mature, 35 year old poplar stand at 8 × 8 m spacings, Crowe and McAdam (1992) found that plant diversity was significantly greater than in the open sward. This work showed that over the life history of silvopastoral systems in Ireland, changes in biodiversity will occur and this will likely result in systems which have significantly greater levels of biodiversity than conventional grassland.

In the Republic of Ireland Short et al. (2005) established a silvopastoral experiment at Johnstown Castle in County Wexford (Teagasc Research Station) in 2002 with oak (*Quercus robur*) in an alley design and grazed by cattle. Trees were successfully established and cattle managed in the system. The establishment of an alley silvopastoral system (in this case with electric fencing) into existing pasture increased ground beetle abundance relative to a plantation being introduced. The study also showed that there may be potential for silvopastoral systems to be used as a tool in the prevention of non-point source pollution from overland flow originating from pasture (Short et al. 2005).

Integration of Systems

Under the arrangements set in place following decoupling with SFP, the agricultural industry might develop in two groups of agricultural production: 'competitive pillar' – a relatively intensive agriculture industry competing on world markets in a strictly business-orientated method of raw material/food production; 're-creational pillar' – conservation, amenity, recreation and environment (CARE goods) – state subsidy aimed at producing CARE goods through funding to farmers/landowners. The 'bridge' between these two pillars is rural development policy, which can provide benefits in both areas. The integration of trees onto farms and into livestock systems (silvopasture) at a range of scales and levels offers a strategic policy option to realize some of these goals.

Agriculture has come through a series of crises recently and farm incomes are currently severely depressed. In difficult times farmers generally concentrate on short-term goals and needs, longer term needs being much less attractive. This tends to severely limit the opportunity for innovative long-term planning. The needs which can be justifiably met by planting trees tend to be longer term. However, currently farmers are by necessity concentrating on the short- to medium-term goals. Although this fact has always been recognized as major drawback to farmer investment in woodland-related enterprises, it would appear that this limitation is particularly strong at present. The position of trees in silvopasture becomes even more difficult as it is viewed as an unproven technology in a range of woodland options which are already considered as limited in achieving short- to medium-term goals. Speculating on the potential for agroforestry planting in Northern Ireland, given the current state of the industry, it is likely that silvopasture should not attempt to substitute for current or proposed woodland planting (McAdam and Crowe 2002) but be targeted to those farmers and landowners included in the recreational pillar (of the CAP) category, all farmers interested in agri-environment measures, and increasing levels of biodiversity in grassland; conservation bodies and community groups; farmers with specific nutrient management problems, e.g. riverside and general bioremediation scenarios and the organic sector (McAdam and Crowe 2002, McAdam 2005; McAdam et al. 2006).

Conclusions

The climate, soils and biodiversity on grassland farms and their associated environmental problems and production goals within a 'decoupled scenario' found in Ireland represent a microcosm of a much larger area of livestock production from grassland found in north west Europe.

In the light of current policy directions in areas such as part-time farming, broader environmental issues, need to diversity farming systems in sympathy with the environment, decoupling and the review of the CAP and the need for environmental cross-compliance to qualify for the SFP, there is a need to increase the utilisation of trees in the rural landscape.

In Ireland silvopastoral systems have been shown to have potential to enhance biodiversity and still be compatible with livestock farming at a range of scales of intensity.

It is likely that silvopastoral systems will be able to offer added value in terms of sustainability (McAdam et al. 1999a), environmental benefits or CARE goods. Any tree planting strategy should include a range of options which highlight the short- medium-term outputs possible, should highlight the environmental benefits and animal welfare generated, must align with requirements of agri-environment schemes and be attractive to rural community groups and the organic farming sector.

These objectives apply across the whole of north west Europe and the example of their applicability to Ireland should be applied on a wider scale in the region.

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