# The Dehesas: a study of a Mediterranean silvopastoral system. Implications for temperate silvopastoral systems in Northern Ireland

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## Abstract

There has been a resurgence of interest in silvopastoral systems (widely spaced trees growing on grazed pasture) in the United Kingdom and Ireland in recent years. Potential benefits of these combined land-use systems over simple pasture or woodland can include an increase in diversity of flora and fauna, increased financial returns and more efficient nutrient cycling amongst others.

The tradition of these systems in other parts of Europe has been particularly strong and much can be gained from studying the ecological interactions within these established systems. The Dehesas of Spain and Portugal are perhaps the best-known example of an established silvopastoral system in Europe.

Both market and non-market advantages of temperate agroforestry are discussed based on results from a continuing National Network Experiment (NNE) in Great Britain and Northern Ireland and findings from the dehesa system of western Spain.

## Keywords

Dehesas, agroforestry, silvopastoral systems, woodland grazing.

## Introduction

The dehesas are an example of a silvopastoral system (widely spaced trees on grazed pasture) with extensive (both diverse and low intensity) utilisation. They occur in semi-arid, Mediterranean regions of Spain and Portugal with a seasonal climate on poor acid soils.

They present a unique example of nature conservation combined with optimal land use and as such are considered one of the best examples of environmentally sound traditional agricultural practices in Europe. They also offer a unique habitat for protected plants and animals (Ruiz 2000). The survival of the Dehesas depends on a delicate balance between grazing pressure, pasture quality and tree growth (Gómez-Gutiérrez et al. 1998).

There is little tradition of silvopastoral systems in the United Kingdom or Ireland (Sibbald et al. 2001). However, a resurgence of interest in agroforestry became evident in the mid 1980s as a result of pressures to:

1. reduce agricultural production following changes in the Common Agricultural Policy (CAP),
2. increase diversity of rural production,

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3. maintain rural employment and infrastructure,
4. reduce imports of wood products and
5. enhance the rural environment.

Silvopastoral systems are capable of satisfying these multiple objectives (McAdam et al. 1999a) and are suited to implementation on small livestock farms in Northern Ireland (Crowe and McAdam 1998). Although, as experience of practical and experimental systems is limited, there is merit in learning from longer established systems elsewhere.

The aim of this paper is to outline how the Dehesas, as a silvopastoral system, are more beneficial environmentally and has more efficient production than more recent land use practices adopted in Mediterranean areas and to apply relevant findings to assist silvopastoral research in Northern Ireland, both in an agroforestry and woodland grazing context.

## Background

Pasture woodlands were once common throughout Europe and they may well have dominated the landscape for over 1000 years (Rackham 1998). Today in north-western Europe, only a few remnants remain. However, with recent EU policy developments there is a renewed interest in silvopastoral systems. Yet, at present, few examples of such systems exist. But in the Mediterranean area large pasture-woodlands still exist. One of the richest systems is the Dehesas of central and southern Spain (Ruiz and Ruiz 1986).

Dehesas are normally privately-owned farms ranging from 300 to 2000 ha (Pulido et al. 2001). They form an important land-use alternative to more complex and dense forests and contain more annual plant species. The wide spacing of the trees and reduction of scrub through grazing decreases the risk of wildfires.

Ancient in origin (a relict of Roman land management), they were developed by progressive selection of the best acorn producing trees, which are used to feed livestock. They have a particular value in making meat production compatible with the maintenance of a high quality landscape and biodiversity (Pineda et al. 1981). High value food products such as *Jamón serrano*, the typical cured legs of ham seen hanging in restaurants and bars in Spain, are a product of acorn-fattened Iberian pigs raised on the Dehesas.

The fragile ecological balance provided by the Dehesas is under threat from modern intensive agricultural systems, partly encouraged by CAP reforms and the intensification of agriculture since World War II. Over the last three decades, 2 m ha of the Dehesas has been significantly altered or destroyed (Gómez-Gutiérrez and Pérez-Fernández 1996), with estimates of the remaining area varying between 2.5 and 8 m ha (Gómez-Gutiérrez and Pérez-Fernández 1996, Goncalves 2000, Diaz et al. 1997). Many of the areas lost have been converted from their system of optimum production of livestock and wood products to intensively managed crops such as sunflower and cereals. These result in soil erosion and require irrigation and fertilisation, resulting in lowered water tables and ground water contamination (Gómez-Gutiérrez and Pérez-Fernández 1996).

Livestock raising up until the age of industrialisation/emigration in the 1950s and 60s, was highly diversified, incorporating *bravo* (fighting bulls), *retinta* and *morucho* cattle, sheep, goats, pigs and horses (Gómez-Gutiérrez et al. 1998). Recent trends have seen a change from the more traditional breeds towards animals with more efficient milk and meat production. These animals are not compatible with the dehesa system, requiring more attention, supplementary feed and being more susceptible to heat stress, disease and injury. The traditional breeds of the Dehesas have been selected over many hundreds of

years, in some cases through natural selection due to the vast areas they can range over and the little contact they have with man. This also allows the animals to become semi-feral, and consequently they are harder to handle than more conventional breeds. As these rural areas depopulate, the number of people with the specific animal handling and husbandry skills required are also lost, thus preventing the return of the indigenous livestock breeds.

In Northern Ireland, farms are small (average 32 ha), family-owned and there is a predominance of livestock farming with the emphasis on grazed pasture and conserved forage. Tree cover is low (approximately 6%) and there is a heavy reliance on imported wood products (only 13% self-sufficiency). Current agricultural policy is strongly influenced by the Common Agricultural Policy (CAP) where the emphasis is on reduction in agricultural production and the encouragement of systems which encourage biodiversity, enhancement of the landscape, embrace high animal welfare values, yet remain economically viable. It was felt that silvopastoral systems could combine these objectives and align with recent agri-environment support measures, which encourage wildlife conservation through structural heterogeneity of habitat.

Trials were established in 1989 at a lowland site at Loughgall, Co Armagh (Sibbald et al. 2001), and in 1991 at an upland site at Broughshane, Co Antrim (McAdam and Mulholland 1990). These trials were part of a National Network Experiment (NNE), where a common set of treatments was used to investigate all aspects of the output of the system and some of the ecological interactions which occurred within the system (Sibbald et al. 2001).

It is clear from the two trial sites in Northern Ireland that up to 9 years after planting of the trees, livestock production and quality (carcass composition) of output are unaffected by the presence of trees at spacings of up to 400 trees $ha^{-1}$ (McAdam and Hoppé 1997). Clear environmental benefits have been shown (McAdam 2000) and the economic predictions for the system have been favourable (McAdam et al. 1999b). However, experience of the long-term implications of the systems on livestock farms and their incorporation in the conventionally farmed landscape and the economy of Northern Ireland is almost non-existent.

## Conservation

The Dehesas form an important habitat for many rare or endangered species. There are 40 important bird areas (IBAS) in Extremedura province alone (Sears 1991). Two threatened endemic Iberian species, the Imperial eagle *Aquila heliaca adalberti* and the Iberian lynx *Linx pardina* inhabit the dehesa regions almost exclusively, thus demonstrating the close link with the natural climax flora and fauna that the Dehesas must have to support these large, native predator species. The European Habitats Directive affords designated areas of dehesa special protection from damage or intensification (Pulido et al. 2001), thus helping to safeguard the future of many of the species reliant on the unique habitat.

Plant diversity is amongst the highest in the world, the average pasture was found to contain about 150 higher plant species in a survey in 1993 (Baldock and Beaufoy 1993). This diversity is intimately linked with the traditional grazing regimes (González-Bernáldez 1991, Pineda and Montalvo 1995).

## Soils

In Mediterranean regions with a highly seasonal semi-arid climate, soil organic matter rarely exceeds 1% (Garcia-Rodriguez et al. 1979). The tree component of the system can

enhance the organic content, and thus fertility of the soil by cycling nutrients from the lower soil horizons and enriching the surface layers via leaf litter and other residues from the woodland system (Escudero-Berian et al. 1985).

Traditionally, this system of enrichment is exploited by obtaining one or two crops of cereal. The soil is then returned to pasture before it becomes too impoverished (Gómez-Gutiérrez and Pérez-Fernández 1996).

Weeds and shrubs are also controlled by this periodic ploughing and by sowing with cereals or foliage such as clover.

## Tree species

The most commonly encountered tree species in the dehesa system are two evergreen oaks: holm oak (*Quercus ilex*) in the north (the more common) and cork oak (*Q. suber*) in the more southerly, drier areas (Blanco et al. 1997). In the north *Q. pyrenaica* forms the natural climax vegetation with holm oak but the latter is more resistant to grazing pressure and is the dominant species.

## Forest products

The trees serve multiple purposes: shade in summer, shelter in winter, fuel and forage for livestock thorough leaf-litter, pruned branches and high-energy feed from acorns (Gómez-Gutiérrez et al. 1998). They are not normally managed for timber as growth is too slow to be economically viable (Rupérez 1957), although small craft items such as furniture may be manufactured (Gómez-Gutiérrez and Pérez-Fernández 1996).

The shredding and pollarding carried out to increase leaf and acorn production also make the trees unsuitable for timber, but tend to prolong their lives, giving rise to the occurrence of ancient trees (Rackham 1976).

Cork oak is highly valued in the wine industry for producing bottle corks. Cork can be harvested by stripping the bark from the tree every 9-11 years. It is the only species that can so regenerate its cambium. However, the value of natural cork has decreased significantly over the last 5 years due to the increased use of plastic corks and screw-top bottles, thus reducing the profitability and as a consequence, viability of large areas of dehesa (Goncalves 2000). Some extra income can be gained by charcoaling pruned branches (Gómez-Gutiérrez et al. 1998, Pulido et al. 2001).

## Beneficial microclimatic effects

Trees have an important role in buffering climatic limitations and are an integral feature of many rural Spanish areas (Gómez-Sal 2000). Provision of shade is the most beneficial physical aspect of trees on both the associated flora and fauna of the Dehesas.

In Mediterranean silvopastoral systems a certain amount of tree cover can enhance sward production, especially with leguminous trees e.g. *Acacia* spp, with approximately 40 trees $ha^{-1}$ being considered the optimum density to ensure maximum returns on pasture and cereal production (Pulido et al. 2001).

Holm oak has been shown to prolong the growing period of the sward by 15-20 days (Puerto et al. 1994). Presence of trees also delays the effects of drought on pasture species, which can extend the period of available green forage by 10-15 days (Acciaresi et al. 1993).

Excessive heat is one of the main constraints to animal production, particularly to lamb

growth and milk production (Ani et al. 1985), shade in summer can also ameliorate heat stress.

In Northern Ireland silvopastoral systems, canopy cover is unlikely to enhance sward growth due to the more overcast conditions resulting in reduced light intensities compared to Mediterranean areas. However, in the National Network Experiment (NNE) sward production was maintained for 12 years following planting before yields started to decline (McAdam and Sibbald 2000). Although having a tree component introduced in the conventional pasture system does not enhance sward production, sheep production has benefited from the shade and shelter cast by the trees (McArthur 1991, Hoppé et al. 1997).

## Management and regeneration

In some areas of Spain the dehesas may be seen as an example of a forage dominant production system in which tree management aims exclusively at producing as much forage as possible when the herb layer is dry. This has also been defined as pastoral silviculture (Etienne 1996). The trees of the Dehesas are more drought resistant, and have good leaf and acorn production in the dry months contributing significantly to the forage production of the system.

Normally canopy cover does not exceed 65% (Figure 1). Five types of pruning are carried out to ensure this:

1. form pruning which facilitates cork production and acorn harvesting (Figure 2),
2. maintenance pruning: which ensures steady acorn production,
3. production pruning for firewood and browse during hard years (Figure 3),
4. renewal pruning which restores foliage production and tree vitality and
5. lopping, a more drastic pruning leaving only 4-6 thick branches per tree (Figure 4).

Pruning is generally carried out every 7-10 years, with lopping every 15-20 years (Gómez-Gutiérrez and Pérez-Fernández 1996). Skilled workers are usually hired to carry out these operations.

Regeneration is difficult, if not almost impossible, in some instances due to the presence of large domestic herbivores. They browse leaves and shoots and break the young trees (Pérez-Fernández and Gómez-Gutiérrez 1995). However regeneration usually occurs without artificial planting. It is normally encouraged by one of three methods:

1. low animal stocking densities, which allow the regeneration of new seedlings, browsing will delay growth without significantly affecting mortality,
2. pruning to accelerate development by encouraging greater terminal shoot growth than lateral growth, thus ensuring trees grow as tall as possible as quickly as possible. This reduces the risk of terminal leader browsing by livestock.
3. seasonal exclosure to allow regeneration if livestock numbers are not reduced, this can be carried out on a rotational system ensuring that stock carrying capacity is kept constant.

Recent research has however, suggested that the only long-term sustainable management of the dehesas may be to exclude livestock for 20 years or more, either continually, or rotationally to ensure regeneration (Pulido et al. 2001).

**Figure 1.** *Normal canopy cover does not exceed 65% in the Dehesas.*

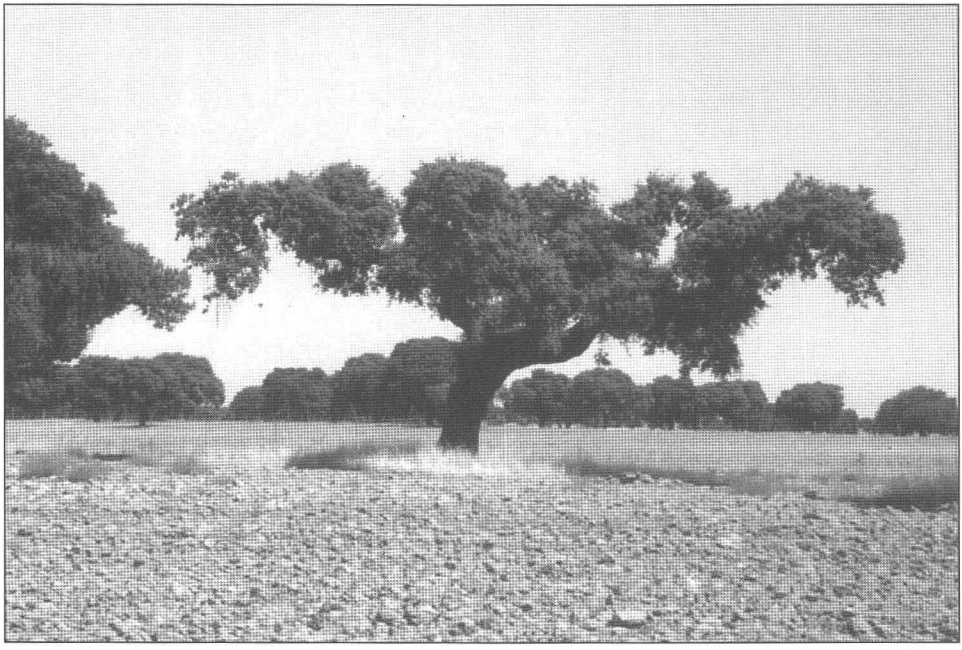

**Figure 2.** *Form pruning facilitates cork production and acorn harvesting.*

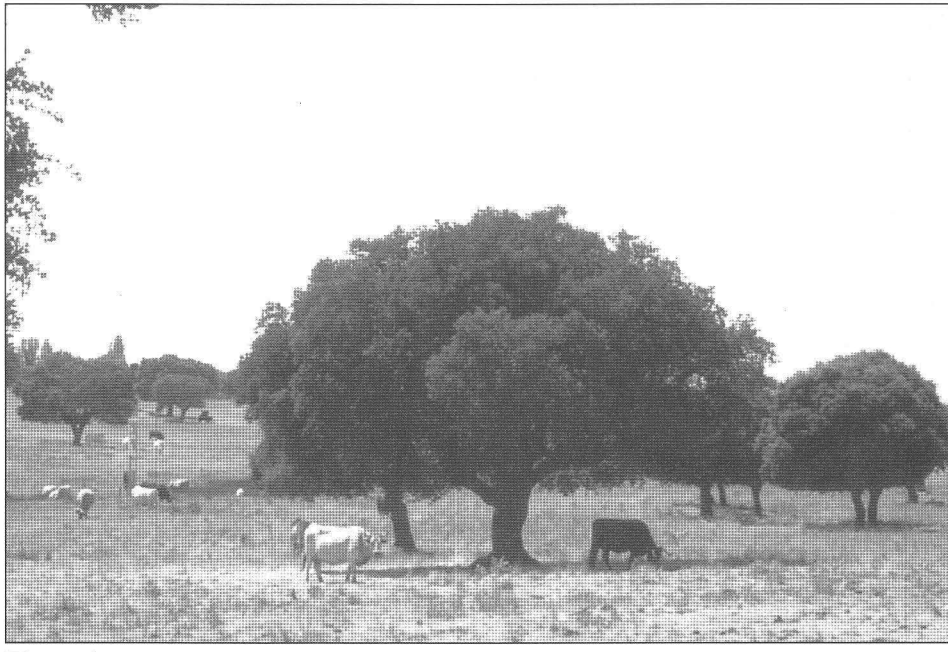

**Figure 3.** *Dehesa tree with full crown, trees are ready for production pruning.*

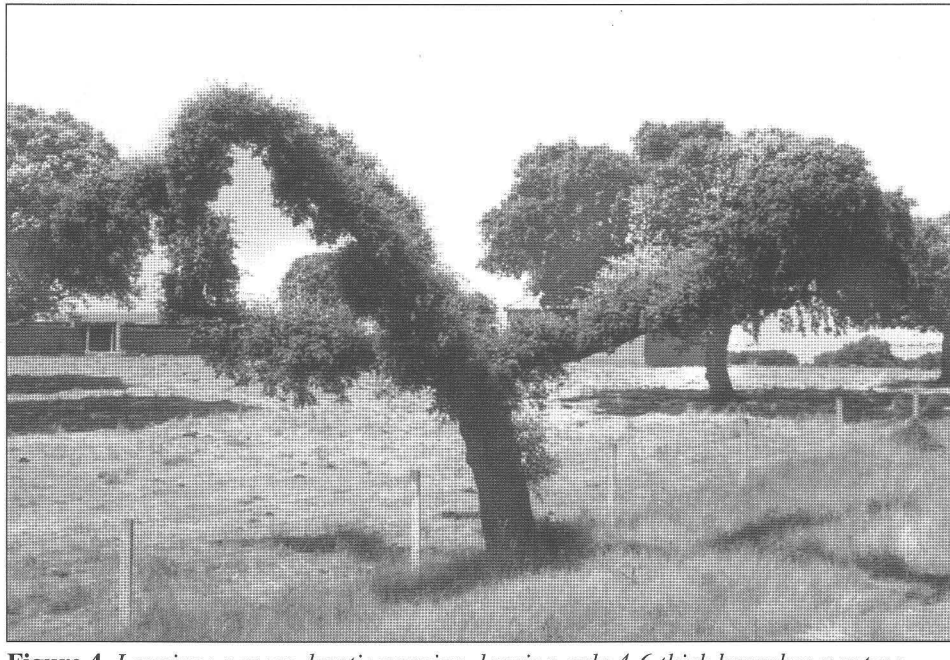

**Figure 4.** *Lopping; a more drastic pruning, leaving only 4-6 thick branches per tree.*

In Britain in similar cases regeneration can be sporadic, rather than continuous (Rackham 1998), especially when periods of browsing fall below critical limits. (Work carried out by Tubbs (1986) in the New Forest, England has shown such an effect.) Due to the long-lived nature of trees in silvopastoral systems, sporadic periods of regeneration can be sufficient to ensure continuity of tree cover.

Holm oak is resistant to high herbivore grazing pressure (Gómez-Gutiérrez and Pérez-Fernández 1996) but the trees remain dwarfed under heavy browsing. However, while the outer leaves are consumed, the terminal shoots become more lignified, dense and dry. These form spike-like barriers, which defend the innermost leaves. The tree does not increase in height but it builds up reserves for future growth and will increase in height when grazing pressure is reduced. It is only when herbivore pressure is very high and persistent that it eventually dies.

Regeneration has suffered in the last few decades due to higher livestock densities, increased mechanisation and abandonment of traditional forestry practices (Diaz et al. 1997).

Tree density is controlled to ensure optimum returns on pasture and cereal production; it is usually around 40 trees $ha^{-1}$ (Pulido et al. 2001).

## Implications for silvopastoral systems in NI

*Agroforestry systems*

There is a need for integrated management, with early and multiple returns to make agroforestry systems economically viable. Timber trees could be planted with inter-spaced fruit and nut producing bushes to encourage both biodiversity and generate some early income. Non-timber crops have the added advantage of requiring less protection from livestock as tree form and leader damage are not as important as for trees grown for timber, reducing one of the main costs of agroforestry.

Pruning is important at all stages for optimum output from tree and pasture systems. The specialised pruning used in the dehesa system requires skilled workers. Pruning is especially important in silvopastoral systems when timber is an end product as the wide-spacing of trees results in the formation of heavy lateral branching (Figure 5). Branches from pruning and early thinnings could be used for firewood/charcoal and fodder for livestock.

Although weather conditions are less extreme than the dehesa region, animal welfare also benefits from the shade and shelter provided by the tree canopy, through reduction in wind-speed, precipitation and irradiance.

While soil conservation and nutrient cycling are of obvious benefit in the dehesa system, in the past these issues have never been of great importance in Northern Ireland. However, recent policies relating to sustainable land management have encouraged greater awareness of soil conservation and the excessive use of both organic and inorganic fertilisers. Agri-environment schemes pay subsidies for reduction in fertiliser applications. Planting of agroforestry systems can increase the natural fertility of pasture through efficient nutrient cycling, ameliorate the problems of erosion caused by livestock and water and decrease the amount of fertiliser runoff into water courses.

The value of the livestock could be increased through eco-labelling it as a product from a silvopastoral system, much like the labels carried by organic and regional food products.

**Figure 5.** *Form pruned ash* (fraxinus excelsior) *trees in the national network Experiment, Loughgoll, Co Antrim.*

## Woodland grazing management

The Dehesas provides examples of how, on the one hand, natural regeneration can be achieved in a semi-natural silvopastoral system, and, on the other, of the problems associated with achieving it.

Recent concerns of both over and under-grazing of semi-natural woods have created interest in understanding the effects of large herbivores on natural regeneration (Mitchell and Kirby 1990, Kirby et al. 1994). While the full range of effects is unclear, some conjectures can be made based on observations of the dehesa system:

1. trees can regenerate under low grazing pressures, but the species assemblage may be altered depending on species browse tolerance, in extreme cases this can lead to a mono-specific stand of climax trees,
2. tree regeneration in the dehesas is also encouraged by exclosing stock from areas of land for a number of years to allow regeneration to occur, this will allow some browse-sensitive species to regenerate from seed and permit the leaders of the more browse-resistant species that have survived as shrubs to grow above browsing height[3],

[3] Research is currently underway at The Queen's University of Belfast, in conjunction with the agri-environment section of the Department of Agriculture and Rural Development, to ascertain the approximate age of some common woodland tree species that this critical height occurs at. This estimation is critical as many tree species will not survive prolonged periods of leader browsing and defoliation

3. natural regeneration without the direct influence of man may rely on natural catastrophes, such as disease outbreak (e.g. Foot and Mouth Disease, or bovine tuberculosis) or drought in order to reduce herbivore levels sufficiently to allow sporadic episodes of tree regeneration,
4. the dehesa system, as a converted woodland system, has more floral and faunal diversity than either woodland or pasture systems alone.

It would seem that it is more feasible to graze woods on a rotational basis, rather than continuously at low densities, to ensure sufficient tree regeneration. This would also allow graze-sensitive species (both trees and forbs) to regenerate, given the longer periods of exclusion (approximately 10 years for temperate systems). The problems associated with ensuring correct animal stocking densities and grazing pressure are not as important in a rotational system as the tree regeneration occurs in the absence of livestock. Post and wire fencing is used to fence woodlands in existing agri-environment schemes in Northern Ireland.

## Conclusion

These observations suggest that a system of woodland grazing, or agroforestry is potentially more beneficial than either a woodland, or system of pasture alone, much in keeping with the historical practices of pannage and wood-pasture in historic parkland-type environments in northern Europe.

These findings however, must be applied with caution due to the climatic differences between the Mediterranean dehesa system and the temperate Atlantic climate of Britain and Ireland. Environmental benefits of a relatively young silvopastoral system have already been shown, but more needs to be known about the long-term effects.

In the Mediterranean systems, the tree component can ameliorate problems associated with nutrient cycling, heat stress, evaporation and scorching of grass, but in temperate systems, light will eventually become the limiting factor for herbage production under a silvopastoral system, even with a regime of pruning and thinning. Thus the number of useful applications of the tree component of the system would be reduced, consequently reducing the viability and profitability of the system.

There are however enough non-market advantages of temperate agroforestry to sustain interest in its use, such as biodiversity (McAdam 2000), carbon fixation and increasing tree cover in areas of low cover. These can also be financially compensated through agri-environment schemes and woodland planting grants making the system more financially viable for the landowner (Thomas and Willis 2000). Any future increases in timber values relative to livestock, no matter how small, could make agroforestry a much more attractive option to farmers. The current uncertainties in the meat market with BSE, Foot and Mouth disease and the continuing EU policies towards extensification and biodiversity in farming may further enhance the attractiveness of agroforestry (Thomas and Willis 2000).

Currently, experimental, temperate silvopastoral systems are under investigation, in addition to on-farm trials (Hoppé et al. 1996). Silvopastoral systems could become a more familiar part of the landscape in the future, just as they were in the past. Lessons can be learnt from other countries, which have managed to preserve their traditional silvopastoral systems despite modernisation and intensification of farming practices.

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