# Silvopastoral Agroforestry in Upland and Lowland UK Grassland: Tree Growth and Animal Performance

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## Presenter Information

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# SILVOPASTORAL AGROFORESTRY IN UPLAND AND LOWLAND UK GRASSLAND: TREE GROWTH AND ANIMAL PERFORMANCE

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## ABSTRACT

Trees, individually protected from herbivore damage using plastic shelters, were planted at two densities (100 and 400 stems/ha) into sheep-grazed pasture in upland and lowland UK grassland sites in 1988. Tree and animal performance were compared with conventional forestry (no sheep) and pasture (no tree) systems. Effects on tree growth and survival are highly species and site dependent although some treatment effects did emerge. Tree shelters encouraged rapid early height growth compared to forestry controls although in some cases tree form was also adversely affected. Generally tree performance within agroforestry treatments was better at the higher planting density. Eight years after planting there has been no reduction in animal production despite interception of up to 10% of total photosynthetically active radiation by the developing tree canopy.

## KEYWORDS

Silvopastoral agroforestry, sheep, trees, animal performance, light interception

## INTRODUCTION

Silvopastoral agroforestry systems, in which forestry production systems are integrated into livestock rearing systems, offer considerable potential as a productive land use system (Eason *et al*, 1994), with potentially equal or higher economic returns compared to conventional agriculture (Doyle *et al*, 1986; Sibbald *et al*, 1987; Bullock *et al*, 1994). Such systems have also been shown to have significant environmental benefits, with for example increases in avian and invertebrate diversity (Jones and Eason, 1995; Eason *et al*, 1994). Agroforestry offers considerable potential within the European Community where there is pressure to find forms of land use which address production and environmental concerns (Rabbinge *et al*, 1994). In the UK research on silvopastoral agroforestry systems has focused on the UK National Network Experiment. Common treatments, management and recording protocols were applied at a number of sites thought the UK, covering a range of soil and climatic conditions (Sibbald and Sinclair, 1990). The work described here is from two of these sites run by the Institute of Grassland and Environmental Research and reports on eight years of growth following establishment in 1988.

## METHOD

**Sites.** The sites represent upland (Bronydd Mawr) and lowland (North Wyke) UK grassland and differ primarily with respect to altitude and climate (Eason, 1994).

**Treatments.** Trees have been planted at 100 and 400 stems/ha (T100 and T400) into sheep-grazed pasture in a regular grid pattern (10m and 5m spacing) with no-sheep forestry controls at 2500 stems/ha (2m spacing), and no-tree agricultural controls (Eason *et al*, 1994). *Acer pseudoplatanus* (sycamore) was planted at both sites with, additionally, *Larix eurolepis* (hybrid larch) at the upland site and *Fraxinus excelsior* (ash) at the lowland site. Each treatment is replicated three times. Plot size is approx. 0.6 ha for grazed treatments and 0.2 ha for forestry controls. Trees were originally established in weed-free conditions and were individually protected with 1.2m high narrow plastic guards (diam. 8.4-11.4 cm; Tubex Ltd, UK) which, at the upland site, were replaced with larger, mesh guards in 1991 (height. 1.5 m; diam. 35 cm; Netlon Ltd, UK) (Eason *et al*, 1994). The pasture receives 160 kg/N/ha/yr. Forestry controls receive no fertiliser.

**Tree performance.** Height, stem diameter (20 cm above the bole) and survival are recorded annually.

**Animal production**. Livestock carrying capacity is determined on the ryegrass-based pasture. This is grazed by a core group of sheep (with additional stock weighed on and off as required) to a sward height of 4-6 cm.

**Photosynthetically active radiation (PAR).** Assessment of PAR received by the pasture was determined using a total of nine sensors placed under a group of four trees with a control sensor placed away from the influence of the tree canopy. The nine recording sensors were placed in a 3x3 grid between each set of measurement trees (Sibbald, 1993). T100 and T400 treatments only were assessed for *Fraxinus* and *Larix* during 1995. A minimum of four recording cycles were made for each replicate plot during the grazing season (April-October).

## RESULTS AND DISCUSSION

**Tree performance.** Lowland (North Wyke): Sycamore and ash in agroforestry treatments exhibited good height growth in the first 2-3 years after establishment (Figs 1a and 1d), although this apparently at the expense of later stem diameter increases (Figs 1b and 1e), when compared to the free-grown forestry controls. Furthermore the early advantages in height growth in agroforestry treatments were lost approximately five years after establishment. Sycamore T100 treatments generally performed worse than T400 treatments although survival rates for all treatments were generally poor (Fig 1c). The site is subject to periods of water logging in winter months, to which the sycamore appears particularly vulnerable. In contrast ash survival approaches 100% in all treatments, apparently tolerant of these conditions (Fig 1f). The periods of water stress experienced by the site may help to explain the relatively poorer growth of trees in agroforestry treatments compared to forestry controls. In the close spaced forestry controls there has been a recorded reduction in water logging stress in ash treatments (M. Penn. pers. obs), this possibly as a result of effects of tree roots on drainage and water use. In time, similar improvements might also be expected in agroforestry treatments. Upland (Bronydd Mawr): Again, early tree height was favoured by the use of tree shelters (Figs 2a and 2d). On emergence from the shelter the leader was subject to significant wind damage however. At this point growth rates in most agroforestry treatments are clearly slowed. In contrast trees in forestry controls appeared to be better adapted to the exposed site conditions demonstrating relatively accelerated rates of growth in the later part of the study. Larch growing in shelters were not self-supporting and in 1991 shelter design was changed to allow more lateral stem movement (to assist in the development of better form and stability), and on more sheltered plots this approach appeared to be relatively successful with development of comparable height and girth compared to free-grown forestry controls (Fig 2e). Apparent in both species is the relatively poor performance of the T100 compared to the T400 treatments, with survival rates approaching only 50-60% in both species (Fig 2c and 2d). The poorer performance of T100 treatments, also observed in sycamore treatments at North Wyke, may be partly attributable to effects of the grazing animal (e.g. rubbing and soil compaction) where sheep:tree ratio is higher in these plots (Eason *et al*, 1994).

**PAR transmission.** Altered microclimate: The development of the hybrid larch canopy at Bronydd Mawr T400 treatments in 1995 (Mean width 2.84 m; S.E 48.5) resulted in a mean reduction of 10.5% (S.E. 3.0) of PAR received by the pasture. In contrast the T400 ash treatments at North Wyke resulted in only a 2.19% (S.E. 0.18) reduction. This is due in part to the smaller canopy of ash (Mean width 1.26 m; S.E. 34.1) but also to a lower leaf area index in ash than larch (F. Sinclair. pers. comm.). In all T100 treatments reductions in light transmission were less than 2%.

**Animal production**. Despite the reductions in light transmission in larch T400 treatments eight years after tree planting there have been no reduction in livestock carrying capacity (agricultural controls: 239.4 t/d/ha; S.E. 12.8; T100: 281.4; S.E. 5.8; T400: 261.6; S.E. 45.6). This was not anticipated by the early agroforestry models (Doyle *et al*, 1986). The results although variable are encouraging. More research needs to focus on the critical establishment phase, and in particular the design and use of tree shelters. Where good tree growth has occurred it is encouraging that there still has been no reduction in agricultural returns.

**ACKNOWLEDGEMENTS**
This work is supported by the Ministry of Agriculture, Fisheries and Food, the European Union and the Forestry Commission.

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**Figure 1**

Mean height, stem diameter (20cm from bole), and annual survival of sycamore (a-c) and ash (e-f) planted at 100 and 400 stems/ha in sheep-grazed agroforestry and at 2500 stems/ha in forestry controls at the lowland grassland site, North Wyke. Annual means (with standard error bars on 1989, 1992 and 1994 data). Where no data supplied this was either not recorded or treatments have terminated.

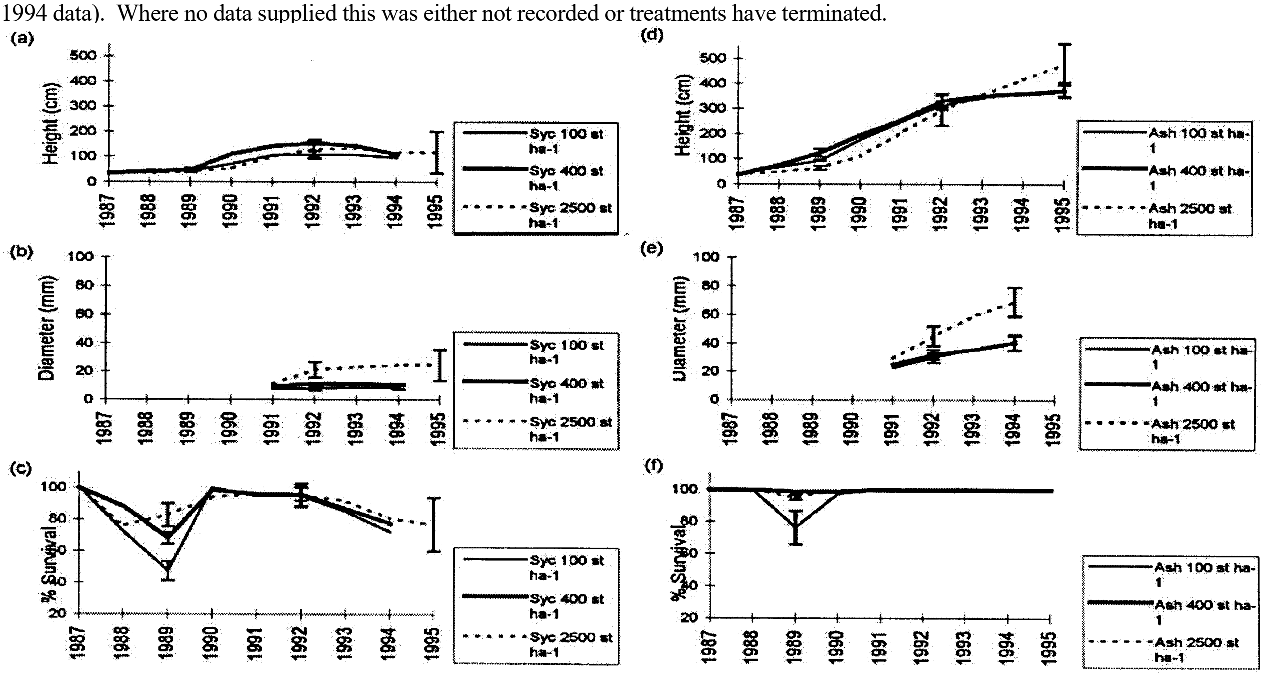


**Figure 2**

Mean height, stem diameter (20 cm from bole), and annual survival of sycamore (a-c) and hybrid larch (e-f) planted at 100 and 400 stems/ha in sheep-grazed agroforestry and at 2500 stems/ha in forestry controls at the upland grassland site, Bronydd Mawr. Annual means (with standard error bars on 1989, 1992 and 1994 data). Where no data supplied this was either not recorded or treatments have terminated.