School of Biology

# AGROFORESTRY RESEARCH GROUP

## Rationale for Agroforestry

## Agroforestry Experiment AF1 - Silvoarable with Furniture Timber Trees

Revised: April 2005

**University of Leeds**
**School of Biology**

## Rationale for Silvoarable Agroforestry

While the justification for this form of agroforestry is less obvious for grade 2 land than for marginal areas, it nonetheless offers a number of possible benefits.

1) Reduction of demand for chemical pest control due to increased diversity of plants, animals and habitats. This applies particularly to silvoarable systems, where, after the trees are established, the herbaceous vegetation in the tree rows may provide additional niches to those in silvopastoral agroforestry.

2) A possible increase in total production of dry matter per unit area because of better seasonal exploitation of above- and below-ground environments for growth of annual and perennial crops.

3) Protection of topsoil in areas prone to erosion by wind or water, an acute problem in some arable areas in England - notably on the sandy soils of Nottinghamshire and Norfolk.

4) Production of food (nuts) from woody species more likely than herbaceous crops to be resistant to the droughts that the greenhouse effect may bring.

5) Reduction of windspeeds; something that could also be directly relevant to the consequences of the greenhouse effect, one of which is said to be an increase in mean wind speeds.

6) Recycling of nutrients such as nitrogen, due to interception by tree roots. Apart from its resource implications, this would also be relevant to the protection of aquifers.

7) Reduction in the shorter term of the area under crops currently in surplus.

8) Production of quality timber, a commodity for which an increasing world scarcity is forseen, or in the case of fast growing poplar

In addition, this form of agroforestry could facilitate the transition of marginal arable land to full forest because much smaller numbers of trees are planted and tended, and because agricultural crops should provide an income from most of the land during the early years.

There are also possible disadvantages such as:

1) Harbouring of pests in tree rows, e.g. slugs and aphids, which could either cause direct crop damage or transmit virus diseases of crops.

2) Long tree rotation for slower growing species - up to 60 years.

3) Concentrated soil compaction because the tramlines are in the same position every year.

Many of the possible advantages listed above are directly relevant to current and possible future environmental and resource problems. Alleviation of these problems may in the long term turn out to be more important than taking land out of agricultural production to counter a temporary food surplus.

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## Agroforestry Experiment AF1 - Silvoarable with Furniture Timber Trees

This agroforestry system was designed as a series of rows of trees separated by arable alleys. The tree rows consist of four species of high-quality timber trees (sycamore, ash, wild cherry and walnut) at 4 m intervals with an intermediate storey of Kentish Cob hazel bushes, one between each pair of timber trees, which was hoped would be sufficiently shade-tolerant to produce nuts (see plan overleaf). The timber trees have been high pruned to improve timber quality and to remove branches that might interfere with farm machinery. The arable alleys are 12 m wide (a width chosen partly for convenience of cultivation and partly to ensure a reasonable density of trees) and are being cropped with a rotation of cereals and pulses. Potatoes, sugar beet or rotational grass may be introduced into the rotation later. For the first two years after planting in 1988, the 2-m wide tree rows were maintained free of herbaceous vegetation. During autumn 1990 the tree row understoreys were sown with a grass set-aside mixture of timothy and red fescue.

Abutting onto the agroforestry treatment areas are three "forestry control" plots of three of the four tree species (not walnut) planted at 2 m x 2 m spacing, plus a hazel orchard plot planted at 4 m x 4 m spacing. The areas under these trees and bushes have been treated similarly to those under the tree rows.

Surrounding the whole of the above there is a windbreak hedge of willows and poplars to simulate the likely microclimate in an extensive area of this system of agroforestry.

In the experimental phase until 1999, the above design was replicated four times. Near to each, but far enough away to minimise the microclimatic interactions, were areas of the same arable crop as in the alleys as a control treatment.

**Investigations completed**

1) Comparison of arable crop yield in the control areas with that in the arable alleys at various distances from the various species in the tree rows. All these areas receive a uniform agronomic treatment equivalent to standard current commercial practice but without insecticide sprays.

2) Comparison of growth of trees in girth and height in the forestry control and tree rows.

3) Measurements of soil moisture content by neutron probe in forestry control, agroforestry and arable control areas.

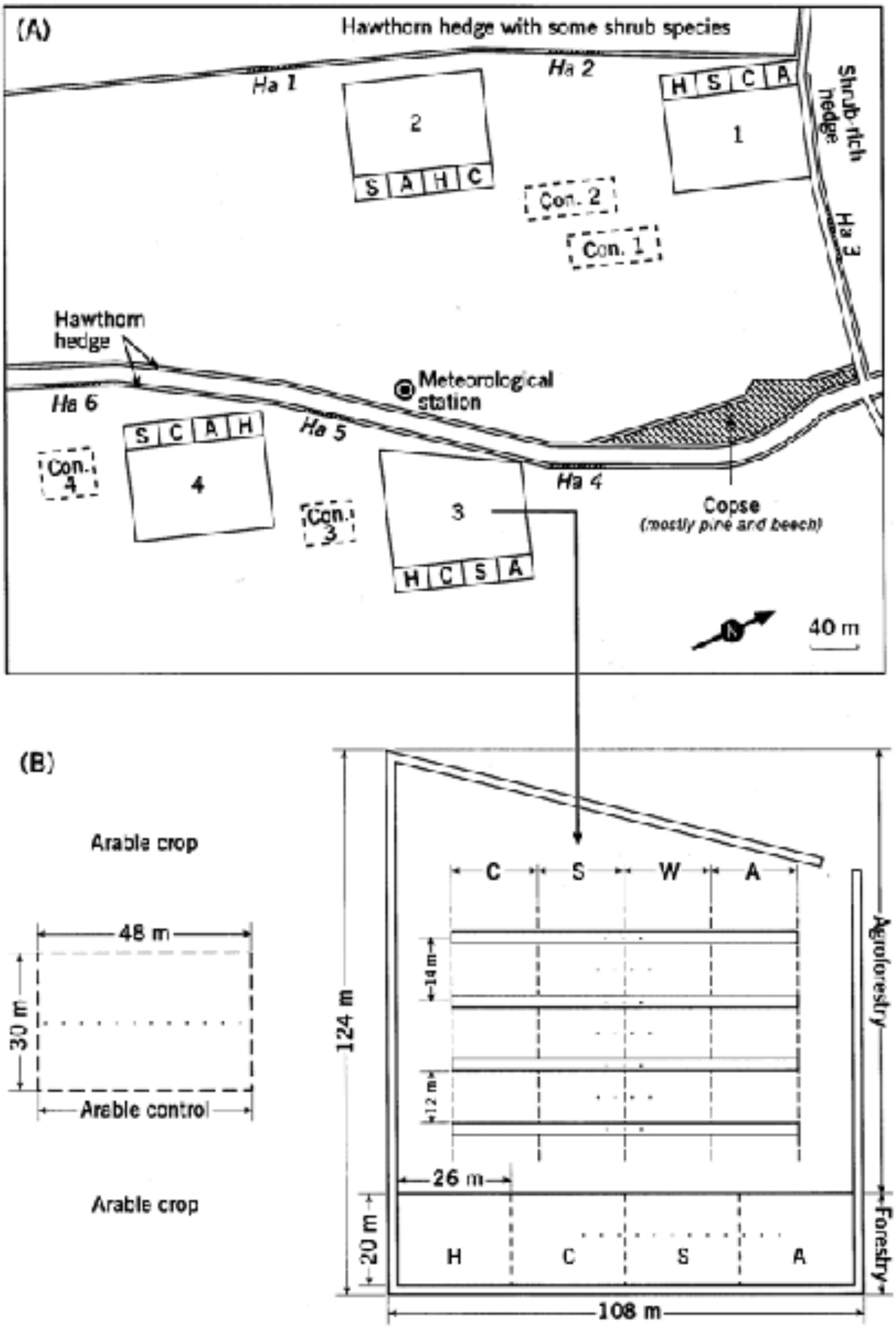
4) Monitoring of fauna in the three treatments, using water traps, pitfall traps and vacuum sampling for invertebrates, periodic bird counts, and mammal trapping.

In addition we are now monitoring the practical difficulties of running a silvoarable system, which at the moment appear to be wind damage to trees, rabbit and hare damage and pernicious weeds.

We would like to use the experiment for a silvopastoral experiment with laying hens.

## EXPERIMENTAL DESIGN

Fig. 1



## SOME RESULTS

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### 1. Tree growth in height

*Table 1. The mean[1] height (m) and diameter (cm) at breast height of trees in agroforestry tree rows and forestry control plots since the winter of 1990/91. Figures in brackets are heights and diameters as a percentage of the forestry control.*

| | ***a) Height / m*** | | ***b) Diameter / cm*** | |
|---|---|---|---|---|
| | Treatment | | Treatment | |
| Year | Forestry control | Agroforestry tree rows | Forestry control | Agroforestry tree rows |
| 1990/91 | 2.8 (100) | 2.6 (93) | 2.6 (100) | 2.4 (92) |
| 1991/92 | 3.4 (100) | 3.0 (89) | 3.5 (100) | 3.0 (86) |
| 1992/93 | 3.9 (100) | 3.3 (86) | 4.4 (100) | 3.7 (85) |
| 1993/94 | 4.4 (100) | 3.7 (82) | 5.1 (100) | 4.4 (87) |
| 1994/95 | 4.8 (100) | 4.0 (83) | 5.7 (100) | 5.3 (94) |
| 1995/96 | 5.1 (100) | 4.3 (84) | 6.2 (100) | 6.1 (98) |
| 1996/97 | 5.6 (100) | 4.7 (85) | 7.1 (100) | 7.4 (105) |
| 1997/98 | 6.2 (100) | 5.4 (87) | 7.7 (100) | 8.6 (112) |

[1] Mean of three species - ash, cherry and sycamore

### 2. Yield of crops

*Table 2. Mean yields (t ha$^{-1}$) of arable crops in the arable control areas, and the arable alleys of the silvoarable system since 1990, expressed per unit cropped area. Figures in brackets are yields as a percentage of the arable control.*

| | | Treatment | |
|---|---|---|---|
| Year | Crop | Arable control | Arable alley |
| 1990 | Threshing peas | 5.9 (100) | 5.3 (90.8) |
| 1991 | Winter wheat | 7.6 (100) | 8.3 (108.4) |

| | | | |
|---|---|---|---|
| 1992 | Winter wheat | 6.6 (100) | 6.8 (103.4) |
| 1993 | Winter barley | 5.1 (100) | 6.3 (122.7) |
| 1994 | Threshing peas | 4.5 (100) | 4.2 (94.2) |
| 1995 | Winter wheat | 9.3 (100) | 8.8 (95.0) |
| 1996 | Winter wheat | 10.4 (100) | 8.1 (78.1) |
| 1997 | Winter barley | 5.7 (100) | 5.6 (98.0) |
| 1998 | Spring barley | 4.7 (100) | 3.8 (80.0) |
| 1999 | Set-aside | - | - |
| 2000 | Spring barley | Not sown | Not measured |

**3. Spatial distribution of yield and slugs**

Fig. 2. The effect of position within the arable alley (a) and across a 12-m strip of arable control crop (b) on yield of winter wheat in 1995. Positions 1 and 6 in the arable alley are next to the tree rows. The tramline is between positions 3 and 4 in each treatment. Values with the same letter are not significantly different.

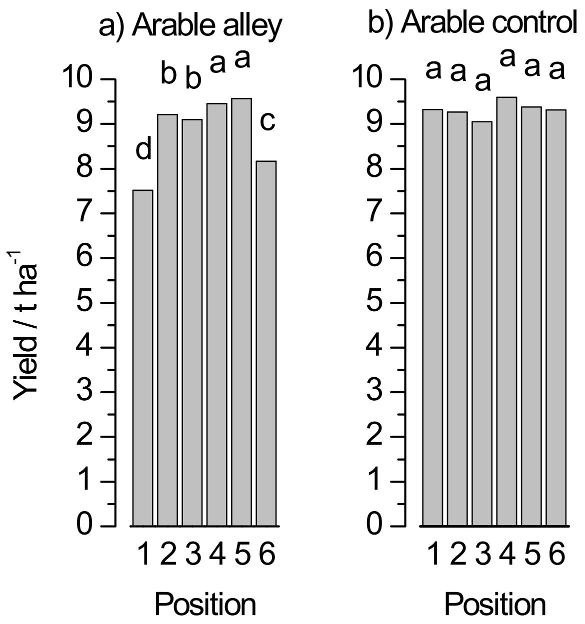
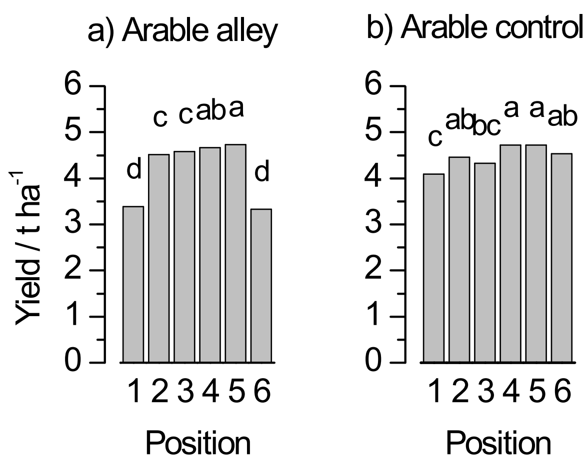


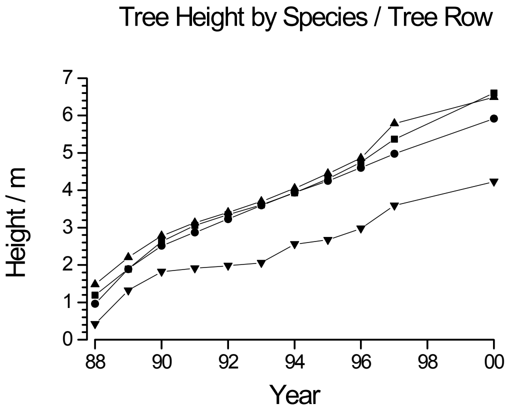

Fig. 2. The effect of position within the arable alley (a) and across a 12-m strip of arable control crop (b) on yield of spring peas in 1994. Positions 1 and 6 in the arable alley are next to the tree rows.

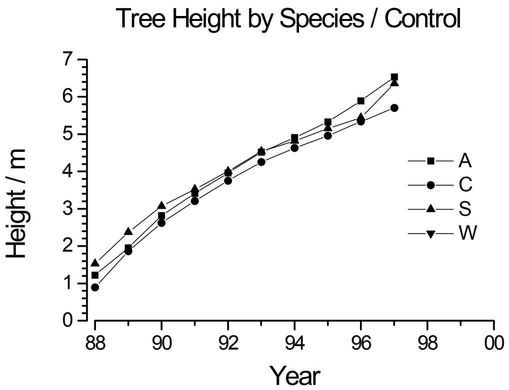


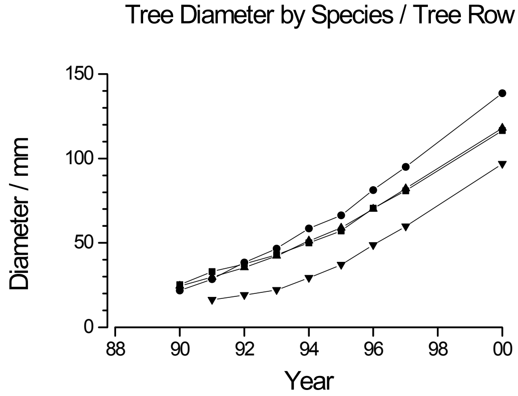

Our measurements of slug numbers in the pea crop and in the tree rows in 1994 have shown that there are larger numbers of slugs in the tree rows than in the arable control crop at the critical time in late March and early April when the peas were emerging. Densities of slugs were 28 m$^{-2}$ in the tree rows and 5 m$^{-2}$ in the arable treatments in 1994. Furthermore there were more slugs in the first 3 m of the alley closest to the tree row. The numbers of slugs were inversely related to the number of surviving plants and directly related to the proportion of damaged plants.

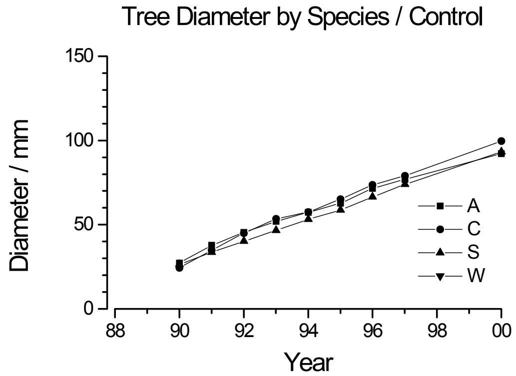
**TREES IN MORE DETAIL**

Fig. 2 a) The effect of treatment and species on the growth of trees

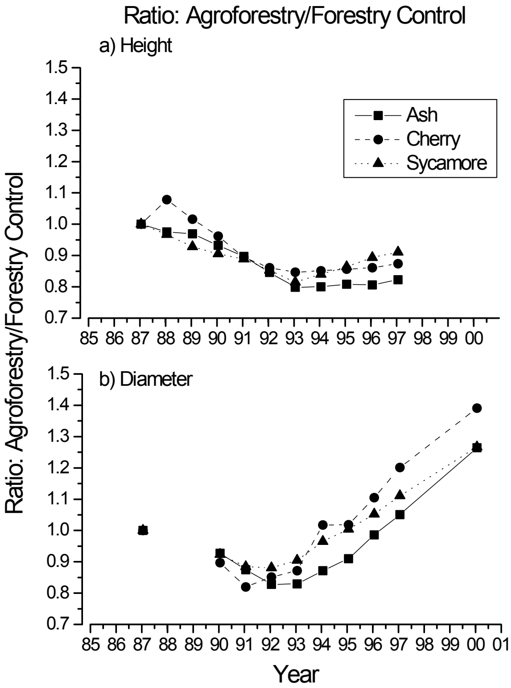


b) The ratio of agroforestry to forestry control with time

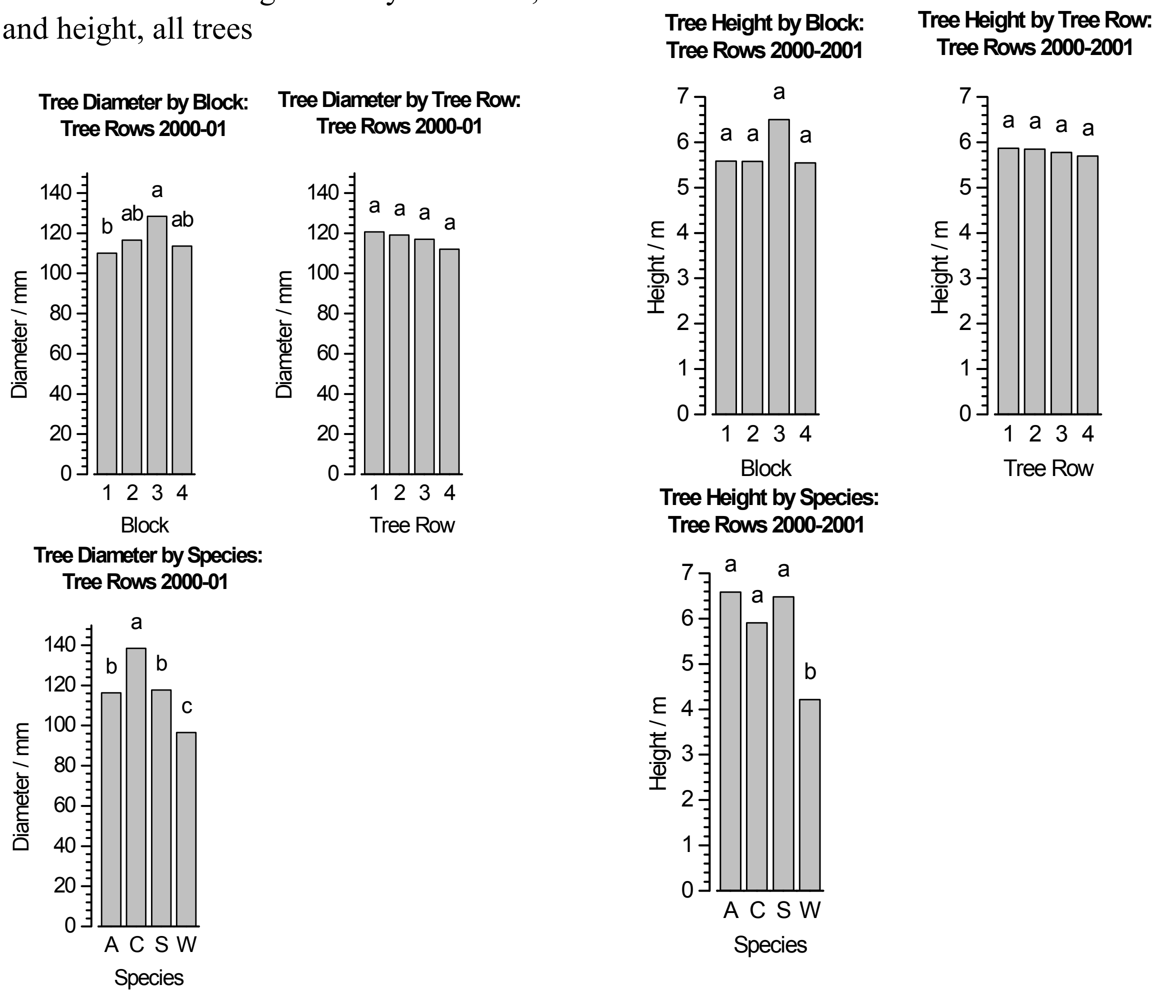



It will be apparent from these first three pairs of graphs that there are no measurements of height in the forestry control treatment at the end of the 2000 growing season before the major thinning of trees in the late 2000-2001 winter. We did not have the time or the labour to measure the heights of 1560 closely spaced trees in sets of 130 trees (13 x 10 at 2 m x 2 m).

This will explain the incomplete comparisons in some of the following figures. For example, the comparison in the second pair of graphs in d) lacks forestry control heights for 2000-2001. So that plot illustrates instead the fact the agroforestry trees at the end of the growing season in 2000 had only reached the height of the forestry control trees three years earlier at the end of the 1997 growing season.

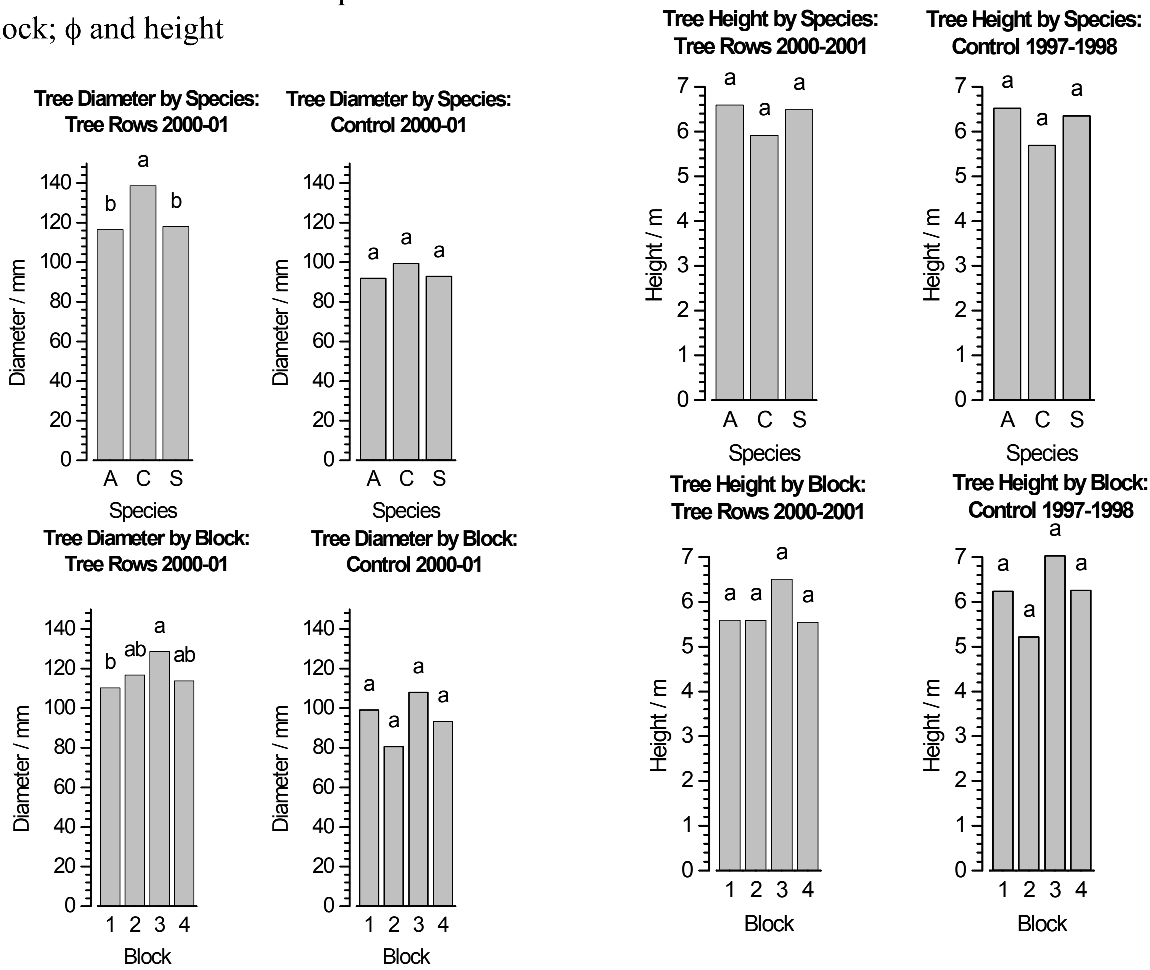
Note: The heading "2000-2001" means winter 2000-2001 and is equivalent to "2000" which means measurements at the end of the growing season in 2000.

c) Effects within the agroforestry treatment;
ϕ and height, all trees



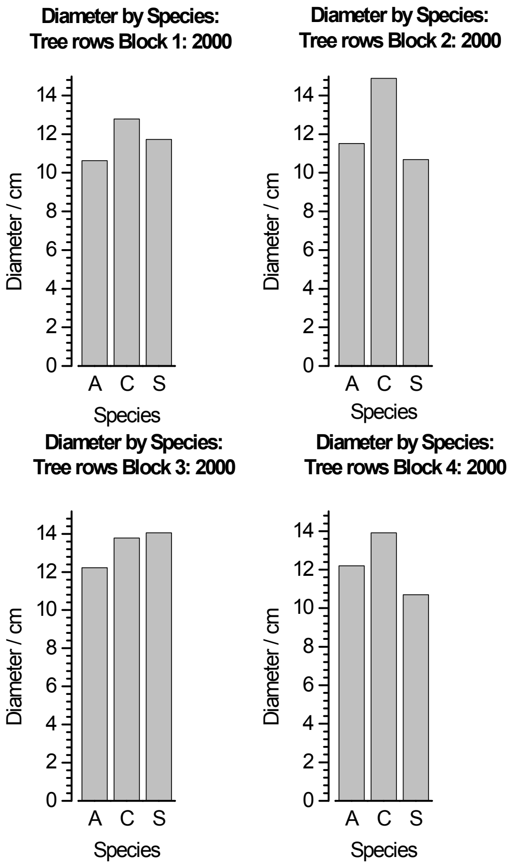

*Columns with same letter are not statistically different at P = 0.05*

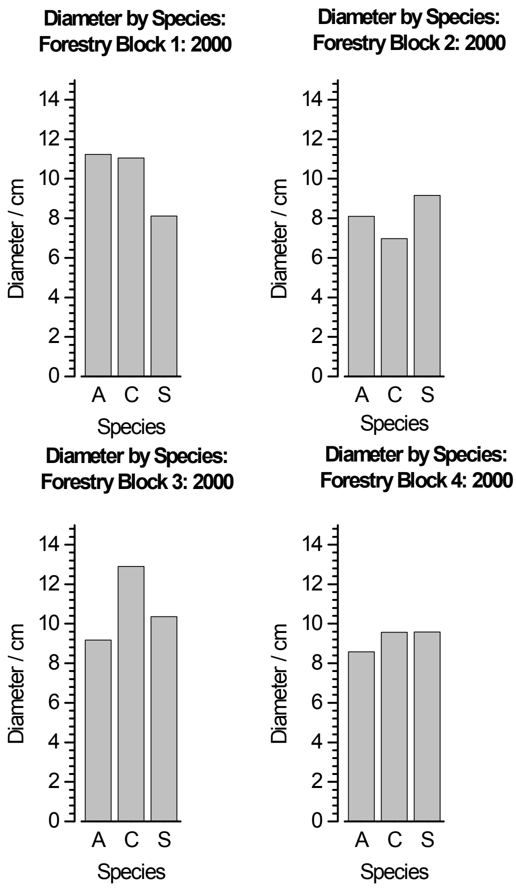
d) Effect of treatment with species and block; ϕ and height




*Comparisons between and within years.*

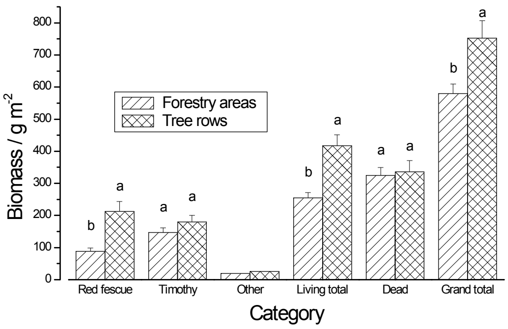
e) Within experiment comparisons; ϕ, between species



## FAUNA: APHIDS

Fig. 2. Biomass (g m-2 dry matter) of plant material sampled in summer 1994 in 0.5-m2 quadrats thrown in the understoreys of the sycamore trees in agroforestry tree rows and forestry areas. Living total biomass = timothy biomass + red fescue biomass + other biomass. Pairs of values (means + 1 SE, n = 96) with the same letter are not significantly different at P = 0.05.




The biomass of red fescue is significantly greater in the understoreys of the agroforestry tree rows and causes the significant differences in the 'total living' and 'grand total' biomasses.

However in 1993, although the greatest density of cereal and grass aphids was in the arable alleys, there was a greater density in the understorey of the agroforestry tree rows than under the forestry trees (Fig. 3). It is clear that the grassed understoreys are not a source of infestation of the arable alley crop.

Fig. 3. The change in density of aphids (m–2; all species) with time of year based on visual surveys. (Note different scales of a and b.)

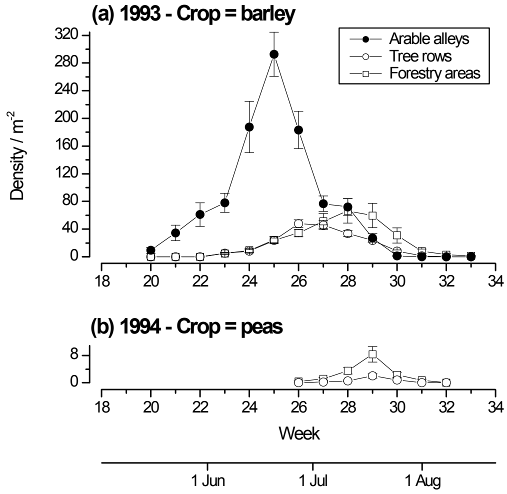


*Table 3. Density of captures (number per 100 trap nights) of all small mammals (woodmouse, voles, shrews and other mice) in relation to habitat between December 1994 and August 1997. Measured by Longworth trapping (mark, release, recapture).*

| Habitat | Density of captures |
|---|---|
| 1. Agroforestry tree rows | 15.0 |
| 2. Arable alleys (arable crop between tree rows) | 9.1 |
| 3. Forestry control trees | 9.2 |
| 4. Arable control areas (open arable crop) | 4.3 |

*Fig. 3. Distribution of core ranges of both sexes of the woodmouse, **Apodemus sylvaticus**, in Block 3 as established by radiotracking at night. The diagram shows four tree rows (long thin rectangles) separated by three arable alleys and one forestry control area (large long rectangle at the bottom of the diagram). Female ranges (n = 3 animals) are dark shaded and male ranges (n = 9 animals) are light shaded.*

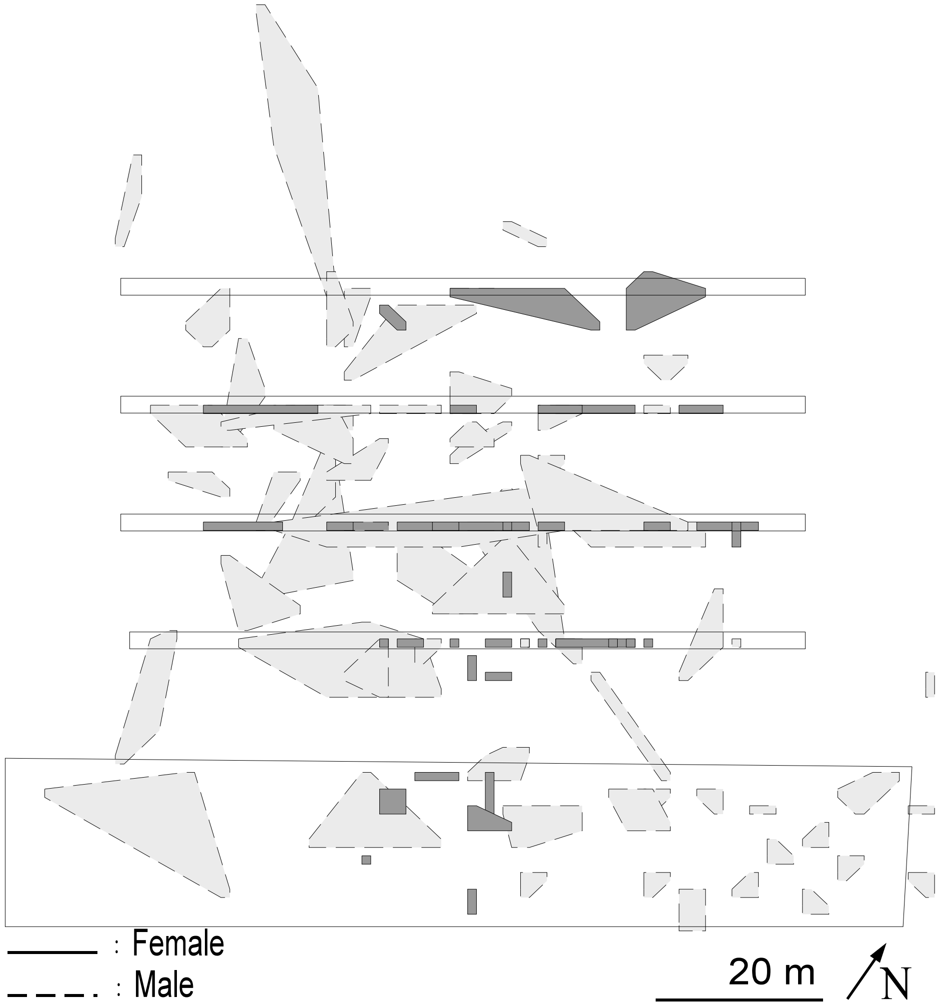

: Female
: Male
20 m
N

*Table 4. Comparison of published ranges of estimates of density of* ***A. sylvaticus*** *populations (mice/ha)*

| | Habitat | | | | |
|---|---|---|---|---|---|
| Source of data in order of publication | Woodland | Farmland | Set-aside | Sand dune | Agroforestry system |
| Gurnell (1978) | 75-225 | | | | |
| Green (1979) | | 0.46-17.54 | | | |
| Flowerdew (1985) | 0.25-100 | | | | |
| Akbar & Gorman (1993) | | | | 1-13 | |
| Rogers & Gorman (1995) | | 0-36 | 0-11 | | |
| Klaa (1999) – this project | | | | | 1-36 |

## REFERENCES


1. Incoll, L.D., Corry, D.T., Wright, C., Klaa, K. & Mill, P.J. (2000) Temperate silvoarable agroforestry with quality timber trees - report for 1997-2000. *UK Agroforestry Forum Newsletter* Number 1, December 2000, pp 9-12.

2. Incoll, L.D. and Newman, S.M. (2000) Arable crops in agroforestry systems. In "Agroforestry in the UK". Forestry Commission Bulletin 122. (eds M. Hislop and J. Claridge. Edinburgh: Forestry Commission. pp 71-80.


## ACKNOWLEDGEMENTS


**1. Members of the Agroforestry Research Group:**

The Group was formed in late 1989 - early 1990 to capitalise on a silvoarable agroforestry experiment which had been established in 1988 by D.T. Corry with financial support from the Leeds Philosophical and Literary Society. The foundation members of the group were

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| * | L.D.Incoll | | D.Hardy | | J.G.Lockwood | | S.C.Clark |
| * | D.J.Pilbeam | | J.E.Oughton | | G.M.Whiteley | | S.L.Sutton |
| * | C.Wright | | J.S.Bale | | K.Rushton | | |
| | D.T.Corry | | J.Altringham | † | P. Field | | |

(D. Colquhoun in attendance at meetings)
New members are

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| * | P.J.Mill | | S.G.A.Compton | | N.Callow | | R.Peng |
| * | F.H. Reynolds | | | | J.Griffiths | | M.Naeem |
| | | | | | D.Phillips | | A.Bolton |
| * | = actively involved at present | | | | K.Klaa | | |

D.J. Pilbeam leads the Agroforestry Research Group and is formally in charge of the agroforestry experiments. C. Wright is responsible for the day-to-day management.

**2. Summer and winter assistants**

There have been many people, too numerous to list, who have helped to make the Group's success, British, French, Danish, students and researchers.