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Effects of agroforestry on farm biodiversity in the UK

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Summary
One advantage claimed for agroforestry is that it can bring onto farmland some of the biodiversity benefits associated with woodlands. The aim of this paper is to review recent research in order to describe the potential impact of agroforestry systems on the diversity of plants and animals on British farms. The review suggests that the introduction of silvopastoral systems can lead to an increase in the diversity of invertebrates and perhaps birds on grassland farms. The introduction of silvoarable systems can also lead to an increase in the diversity of airborne arthropods, small mammals and possibly birds on arable farms; however the effects on arable pests are likely to be mixed.

Introduction
Biological diversity was defined at the 1992 Biodiversity Convention in Rio de Janeiro as 'the variability among living organisms from all sources and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems'. Following the convention, the British Government published the UK Biodiversity Action Plan which has a goal 'to conserve and enhance biological diversity within the UK' (Department of the Environment, 1994). As part of this plan, an assessment of UK habitats has identified the particular importance of broadleaf woodland as the principal habitat of 232 species of conservation concern (UK Biodiversity Steering Group, 1995a). The significance of ancient broadleaf woodland and wood pastures (a traditional form of agroforestry), relative to arable farmland and improved grassland, in the conservation of mammals, insects, flowering plants and lichens has also been identified by Wynne *et al.* (1995).

One advantage claimed for agroforestry is that it can bring onto farmland some of the biodiversity benefits associated with woodland (Stamps and Linit, 1998). Because trees are larger, live longer, and have a greater variety of tissues and structures than herbaceous plants, they can provide niches for a wide range of organisms. The aim of this paper is to review recent research in order to describe the potential impact of agroforestry on the diversity of plants and animals on British farms.

Biodiversity and agroforestry
The two major forms of agroforestry in the UK are silvopastoral (trees and pasture) and silvoarable systems (trees and arable crops). Because these have different arrangements and management strategies, their impact on biodiversity are considered separately.

Silvopastoral systems
Flora
During the initial years of a silvopastoral system, the changes in grassland flora, compared to an open pasture, appear to be small as both areas are regularly grazed (McAdam, 1998). However within a mature 35-year-old poplar stand, planted at a 6 x 6 m spacing into a grazed permanent pasture, changes in botanical composition have been observed. Some species (A*grostis capillaris*, *Holcus lanatus* and *Poa annua)* were more common under the tree canopy, and some (*Lolium perenne*, *Poa trivialis*, *Trifolium repens* and *Cirsium arvense*) were less common compared to an adjacent open sward (Crowe and McAdam, 1993) (Figure 1).

Fauna
Within silvopastoral systems, an increase in invertebrate species and numbers when moving from open grassland through agroforestry systems to typical woodland conditions has been recorded for carabid beetles in Northern Ireland (Cuthbertson and McAdam, 1996) and for four arthropod groups in Scotland (Dennis *et al*., 1996). So far the experimental data are limited but Toal and McAdam (1995) reported a greater number of birds, although not bird species, within the silvopastoral plots than the agricultural and forestry control areas at two sites in Northern Ireland. Although the difference was not statistically significant, Agnew and

Sibbald (1996) also reported a higher number of bird species in the agroforestry plots than the agricultural control at a site in Scotland. Such research should be continued.

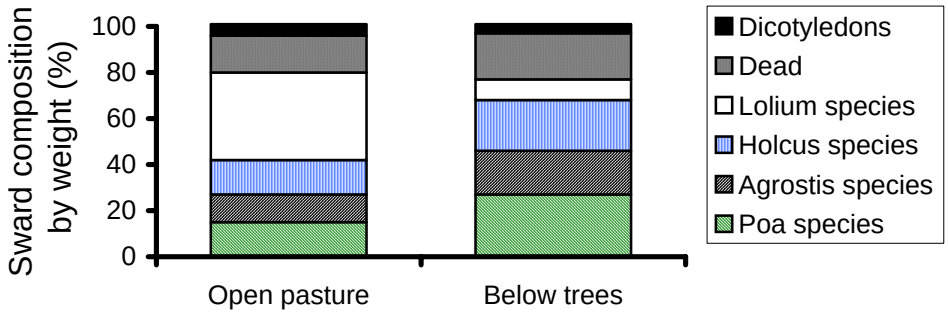

Figure 1. *Effect of poplar trees, planted in 1960 at a spacing of 6 x 6 m, on the mean botanical composition of a sward (May, July and October 1991) in Northern Ireland (Crowe and McAdam, 1993).*

Silvoarable systems

Silvoarable agroforestry systems can be regarded as a method of increasing the species diversity in monocultural arable land. In this respect, the objective is similar to that specified in the costed habitat action plan for cereal field margins (UK Biodiversity Steering Group, 1995b).

Flora

At three silvoarable sites, established in 1992 at Cirencester in Gloucestershire, Leeds, and Silsoe in Bedfordshire, vegetation around the base of the trees was initially suppressed by the use of a one-metre-wide plastic mulch. However, as the plastic has disintegrated, so the area at the base of the trees at Silsoe has become colonised by common arable weeds such as barren brome (*Bromus sterilis*), blackgrass (*Alopecurus myosuroides*) and common couch (*Elymus repens*). Species such as groundsel (*Senecio vulgaris*), charlock (*Sinapis arvensis*), and meadow-grasses (*Poa* spp) have been reported at the Leeds site (Peng *et al*., 1993). Some of these species, such as barren brome, can act as a major seed source for re-infestation of the field (Theaker *et al*., 1995). Although these can be controlled by herbicides, this is only likely to perpetuate a species-poor weed community. In one of the experiments at Leeds, in an attempt to control such weeds, the tree row understorey was sown with a set-aside grass mixture which has tended to a red fescue monoculture. The development of such low-maintenance and non-competitive vegetation within the tree strip requires further investigation.

Fauna

The diversity of plants along the tree rows of a silvoarable system is likely to attract a more diverse and abundant fauna than traditional agriculture (Stamps and Linit, 1998). Research at Leeds (Peng *et al*., 1993), has shown that both the number of individuals and the number of airborne arthropod species within an agroforestry system (both in the hedge and the arable alley) were greater than in an arable control. By contrast, the effects on the distribution of ground beetles was more varied. Some were more common in the arable control; some were most common in the agroforestry system (Phillips *et al*., 1994).

In terms of birds and mammals, the benefits of silvoarable agroforestry over traditional agriculture are more clear-cut. At Leeds, the silvoarable system with a grass understorey increased the number of bank voles (*Clethrionomys glareolus*), wood mice (*Apodemus sylvaticus*), field voles (*Microtus agrestis*) and common shrews (*Sorex araneus*) compared to an arable control area (Wright, 1994) (Figure 2). In turn these can be useful predators of insect pests and are themselves the prey of hawks and owls. Other reports have shown that the creation of a non-cultivated area of wild flowers and grass can provide a beneficial habitat for farm birds (Clarke *et al*., 1997; Sotherton and Rands, 1986).

Pest control

The effects of a silvoarable system on pest control are mixed. In an analysis of five airborne arthropod pests within a system at Leeds containing a pea crop (*Pisum sativum* L. var. Solara), the numbers of pea and bean weevil (*Sitona* spp) and pea midge (*Contarinia pisi*) were less within the silvoarable plots than the agricultural control (Figure 3). In part this could be related to the substantial increase in the numbers of those

species identified as predators of insect pests. Even so, within the same trial, the number of thrips (*Thysanoptera*) was greatest in the silvoarable system. There was no significant effect on the number of pea aphids (*Acyrthosiphon pisum*) and leaf miners (*Agromyzidae*) (Peng *et al*., 1993).

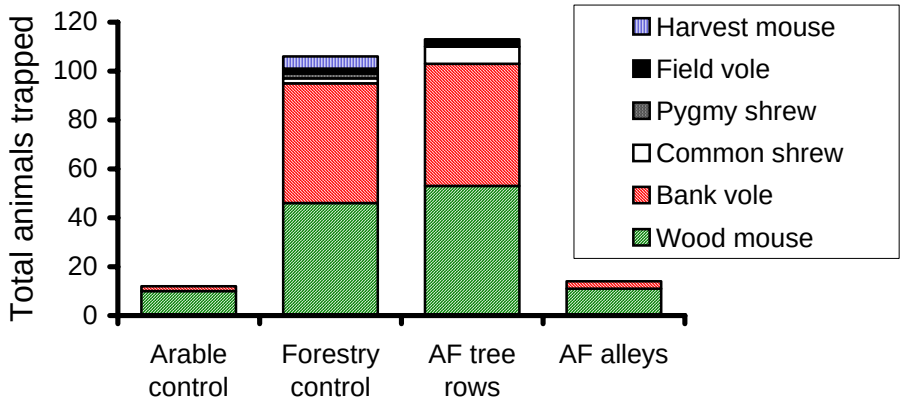

Figure 2. *The number of mammals caught in each treatment area of a silvoarable agroforestry system at Leeds University Farm (Wright. 1994) (AF= agroforestry).*

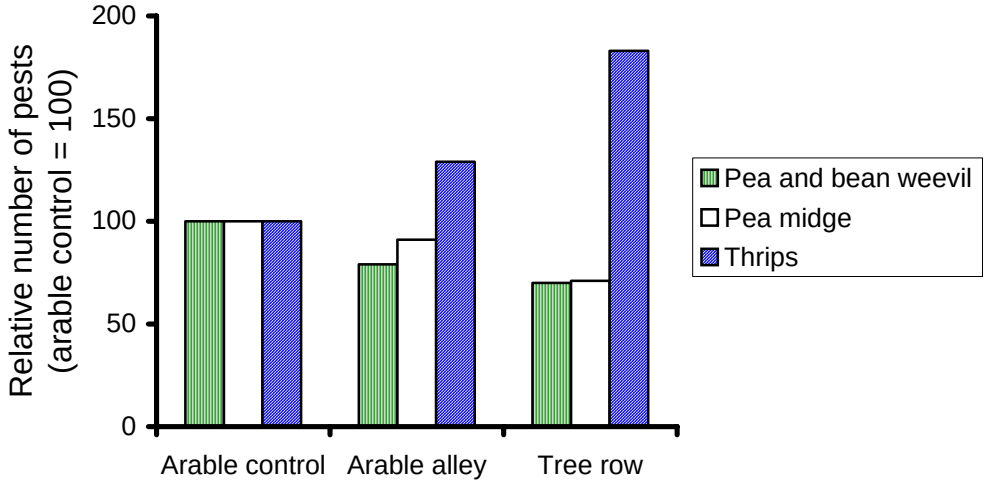

Figure 3. *The relative number of insect pests, caught using water traps, within each of three treatment areas of a silvoarable agroforestry system, with a pea crop, at the Leeds University Farm (Peng et al., 1993).*

During the same experiment in the Summer of 1993, when the arable crop was winter barley, the number of grain aphids (*Sitobion avenae*), which formed over 90% of the total aphid population, within the silvoarable system was approximately half that found in the arable control (Naeem *et al*., 1994). This was attributed to the tree-strips acting as a refuge for natural enemies, such as hoverfly (Diptera: Syrphidae) (Phillips *et al*., 1994). A similar effect of lower densities of insect pests, due to high densities of beneficial arthropods, has also been reported near to wild flower strips (Frank, 1998).

Although silvoarable agroforestry appears to offer benefits for the control of some arthropod pests, the vegetation at the base of the trees has been reported to lead to a greater density of slugs and therefore poorer crop emergence than in arable control plots (Griffiths *et al*., 1994). Such slug damage can cause complete crop failure and it can necessitate the use of a molluscicide (Frank, 1998).

Conclusion

This review demonstrates that silvopastoral agroforestry can offer a viable way to increase the diversity of invertebrates and perhaps birds in grassland systems. Silvoarable agroforestry can also provide opportunities for increasing the diversity of airborne arthropods, small mammals and possibly birds within arable agriculture. The increased numbers of some pest predators or changes in microclimate can also lead to reduced numbers of some pests, such as grain aphids. Nevertheless additional provision may be required to control slugs and further research is required to develop low maintenance understoreys of non-weedy species for the tree row.

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