DEVELOPING MODERN MULTIFUNCTIONAL AGROFORESTRY SYSTEMS FOR SUSTAINABLE INTENSIFICATION

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SUMMARY

Agroforestry is a land-use system that integrates trees and shrubs with crops and/or livestock production. It has been identified by the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2008) as a 'win-win' approach that balances the production of commodities (food, feed, fuel, fibre, etc.) with non-commodity outputs such as environmental protection and cultural and landscape amenities. This paper will review the potential of agroforestry as part of a multifunctional working landscape in temperate regions, and will consider management and policy implications of widespread adoption of this form of land-use.

INTRODUCTION

Trees have historically been part of the working landscape in Europe, evolving from systems of shifting cultivation towards more settled systems involving agriculture, woodland grazing and silvopasture, with fertility transfer from woodlands to cultivated land via manure (Von Maydell, 1995). Trees within the agricultural system were traditionally managed for three main products – fruits and nuts, fodder for livestock, and wood for fuel or timber. These systems declined as a number of factors led to increasing separation of agriculture, forestry and nature conservation into discrete activities. These factors included increased mechanisation with trees removed to facilitate operations; the adoption of monocultures to maximise productivity; a reduction in the agricultural labour force; and the development of separate policy regimes (Eichhorn *et al.*, 2006). Agroforestry systems are still, however, an important component of the agricultural landscape in the Mediterranean, where traditional systems such as the *dehesas* in Spain, *montados* in Portugal, olive tree systems in Greece and fruit tree systems in Sicily are widespread. In northern Europe, remnants of traditional agroforestry systems include parklands, grazed orchards, hedgerows and woodland pasture.

In recent years, there has been a revival of interest in re-establishing trees within the temperate agricultural ecosystem, in recognition of the range of ecosystem services that trees can support and deliver (Jose, 2009; Smith *et al.*, 2012b). The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2008) identified agroforestry as a 'win-win' approach that balances the production of commodities with non-commodity outputs such as environmental protection and cultural and landscape amenities. The challenge now is to design and develop novel agroforestry systems that provide the potential benefit of increased productivity balanced with resource and environmental conservation through sustainable intensification (Smith *et al.*, 2012a). Here we review the key management and policy implications of widespread adoption of temperate agroforestry.

Figure 1: Silvoarable system, Wakelyns Agroforestry, Suffolk, UK. Alleys of hardwood trees are grown amongst cereals and other arable crops

THE POTENTIAL OF AGROFORESTRY IN TEMPERATE REGIONS

In Europe, agroforestry has the potential to address the three key themes of the European Commission's Rural Development Policy (RDP) 2007-2013:

1. *Improving the competitiveness of the agricultural and forestry sector.* A central hypothesis of agroforestry research is that complementarity of resource capture by trees and crops should lead to increased yields in agroforestry systems compared to forestry or agricultural monocultures (Cannell *et al.*, 1996). By combining crops or livestock with a tree component, it is possible to generate income in the short-term from the agricultural element, during the course of the long-term investment in the trees, which should increase competitiveness over a forestry-only enterprise (Benjamin *et al.*, 2000; Rigueiro-Rodríguez *et al.*, 2008). Agroforestry can also bring marginal land into production, and by reducing reliance on synthetic inputs, could potentially improve production efficiency (Smith *et al.*, 2012a).

2. *Improving the environment and the countryside.* Integrating trees on farmland has many environmental benefits including enhancing soil fertility, reducing nutrient leaching, reducing soil and wind erosion, improving water quality and regulating hydrological cycles, enhancing biodiversity and landscape quality, increasing aesthetics, remediating polluted land, mitigating greenhouse gases and sequestering carbon (Jose, 2009). Agroforestry can also reduce resource-use pressure on native woodlands and rates of deforestation (Bhagwat *et al.*, 2008). As multi-functional biodiverse systems, agroforestry approaches are predicted to have greater resilience against the effects of climate change (Schoeneberger, 2009).

3. *Improving the quality of life in rural areas and encouraging diversification of the rural economy.* There are many perceived socio-economic benefits of agroforestry, including improved rural employment opportunities, diversification of local economies and

products, and non-market benefits associated with landscape, aesthetics, ecosystem services and recreation (Smith *et al.*, 2012b).

More specifically, the environmental benefits of integrating trees into agricultural systems can contribute to meeting the aims of a number of mandatory EU regulations, including the European Nitrates Directive, the Water Framework Directive, the Renewable Energy Strategy and the Soil Protection Strategy.

Where and to What Extent is Agroforestry Feasible?

Reisner *et al*. (2007) used a modelling approach to identify the potential for silvoarable agroforestry within 32 European countries. They concluded that one of five commercial tree species (*Prunus avium, Juglans* sp., *Populus* sp., *Pinus pinea* and *Quercus ilex*) could grow productively in an agroforestry system on 56% of utilised arable land, while providing ecosystem services such as reducing soil erosion and N leaching on 6 million and 30 million ha respectively.

MANAGEMENT IMPLICATIONS OF AGROFORESTRY

In agroforestry systems, there are both ecological and economic interactions between the trees and crops and livestock, with an emphasis on managing rather than reducing complexity (Lundgren, 1982). Due to this increased complexity and diversity, agroforestry systems present certain management challenges which must be taken into consideration from the initial design and establishment stage right through to securing markets for the variety of products. The productivity of each system is determined by the balance between positive and negative interactions between the tree and agricultural components, and so the design and management of agroforestry systems should aim to maximise positive interactions that lead to facilitation, and minimise negative interactions that result in competition for resources.

Designing Temperate Agroforestry Systems

Design considerations include the selection of appropriate species, based on a number of criteria, and the spatial arrangement of the system (Table 1).

Managing Temperate Agroforestry Systems

Within agroforestry systems, productivity of each component can be manipulated by management (Mosquera-Losada *et al.*, 2005). Thinning and branch and root pruning determine tree quality and production, but also influence crop and pasture production and thereby animal production (Beaton and Hislop, 2000). Fertilisation, as a further management tool, increases production, and alters tree/crop competition dynamics. Finally, stocking density impacts livestock production and tree productivity through reduced competition with pasture or negative impacts of soil compaction through trampling (Schroth, 1999).

Table 1: Design considerations for temperate agroforestry systems

Design factor	Considerations		
Species selection			
Site characteristics	Rainfall		
	Drainage		
	Soil type		
	Aspect		
Outputs/products	*Trees*	*Crops*	*Livestock*
	Top fruit/nuts	Arable	Dairy
	Fodder	Horticultural	Meat
	Timber		Eggs
	Woodfuel		Fibre
Species properties	*Trees*	*Crops*	*Livestock*
	Canopy structure, density and timing	Shade tolerance	Breed suitability for agroforestry
	Root structure	Growth periods	Browsing impact
	Growth periods	Harvest timings	
	Harvest timings		
	Allelopathic		
Spatial arrangement			
Tree distribution	Scattered		
	Rows and alleys		
	Shelterbelts		
	Small clumps		
	Farm woodlands		
Orientation	Rows north/south to reduce shading on crops		
	Shelterbelts orientated against prevailing winds		
	Contour planting to reduce soil erosion		
Tree density	Trade-off between high volume wood production and greater competition with neighbouring crops at high densities		

POLICY IMPLICATIONS OF AGROFORESTRY

A lack of policy support is seen as one of the main barriers to wider adoption of agroforestry, with the integration of trees at a low density into agricultural land challenging the conventional specialisation of forestry and agricultural policy mechanisms (Dupraz *et al.*, 2004). Within the UK, where subsidies can represent a significant proportion of farm income, agroforestry has a

limited future if it is ineligible for support payments. Changes to current UK and EU agricultural policies would be needed to fully support widespread uptake of agroforestry (Smith, 2010).

There is currently no direct support available for agroforestry in the UK within the RDP, except within Northern Ireland, where Article 44 has been implemented, which provides support for the first establishment of agroforestry. Under Pillar I, agroforestry needs to be recognised by the EU as a valid land use to be eligible for Single Farm Payments. Under Pillar II, adoption of Article 44 across the whole of the UK would support the first establishment of agroforestry.

It is less clear how agroforestry could fit within existing agri-environment schemes such as Environmental Stewardship, where the options available aim to enhance the environmental, biodiversity or cultural value of farmland through careful management of existing features such as hedgerows or the introduction of semi-natural habitats including grass buffers. As such, productivity is of secondary importance, and the management needed to maintain productivity in agroforestry systems may conflict with management requirements specified by the schemes.

To promote agroforestry as a sustainable approach to production, there is a need to identify clear market and policy reasons for providing support, by collating, managing and, through research, providing evidence on the benefits (and limitations) of agroforestry to balance production with delivery of ecosystem services. Raising awareness of the potential benefits of agroforestry among policy makers is essential for promoting agroforestry as a mainstream land-use system.

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