A GUIDANCE TOOL TO SUPPORT FARMERS WITH ECOLOGICAL FOCUS AREAS – THE BENEFITS OF AGROFORESTRY FOR ECOSYSTEM SERVICES AND BIODIVERSITY

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Introduction

Farming has a significant role to play in the delivery of a number of desirable outcomes, including ecosystem services and biodiversity. Regardless of past agri-environmental policy and its intentions, there are still ongoing ecological problems that need attention, as demonstrated by the decline in populations of birds and mammals across the EU. Ecological Focus Areas (EFAs) have been introduced as part of the so called 'greening' measures of the Common Agricultural Policy (CAP). Member States can select (activate) the elements that they wish to be applicable within the area for which they are the competent authority. Agroforestry (intercropping) has been activated in 12 MSs. Eligible farms, those with an arable area 15ha or more, select from the EFAs activated in their Member State. They need to account for 5% by area of the total arable land declared, including fallow land, temporary grassland and crop land. It does not include permanent grassland or permanent crops.

The introduction of Ecological Focus Areas (EFAs) on the farm has potential to deliver tangible environmental improvements. It is also recognised however, that the extent of such improvements, and so the success of the policy, will ultimately depend on the specific EFA elements selected in addition to farm specific factors. To address this issue, the Joint Research Centre (JRC) commissioned a project to develop a software tool to help farmers select EFA elements that can deliver the optimal environmental benefits. It needed to consider the site specific characteristics of individual farms, and the pragmatic requirements of ensuring that the EFA solution overall was realistic in terms of farm management.

The software developed, the EFA calculator, is a standalone Windows application freely available to download from https://sitem.herts.ac.uk/aeru/efa/. The calculator determines the potential impact of each EFA feature on ecosystem services, biodiversity and farm management. For each feature-impact, a set of parameters (and classes within those parameters) are derived and then used to determine the relative significance of the impact of that feature on the specified impact. A bespoke scoring system has been developed, which although relatively simple, distils complex and data intensive parameters into a readily interpretable and user friendly format. This extended abstract reports on the ecosystem services provided by agroforestry, as highlighted by the EFA calculator tool.

Material

The EFA calculator assesses the impact of EFA elements on ecosystem services, biodiversity and farm management (albeit the latter was limited with respect to the impact assessment and thus was not applied to agroforestry). Ecosystem services are structured using the Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin, 2013), with the addition of 'Nitrate leaching' and 'Phosphate run-off' as sub-classes under 'Chemical condition of freshwaters', to account for the different nature of these effects. Biodiversity utilises the European Nature Information System (EUNIS) species groups (EEA, 2015) as a baseline for interpretation in the software. The impact of EFA elements were scored on a scale of -100 to +100 (to reflect positive and negative impacts) and varied based on a number of spatial and management parameters, using different classes within those parameters (e.g. the parameter 'distribution density of adjacent water bodies' has 5 classes: >1.3, 1, 0.5, 0.1 and 0 km^{-2}, each of which attains a different score with respect to potential impacts).

Two approaches to scoring impacts have been used. Firstly, a quantitative approach, which draws upon meta-modelling, in which a score is awarded for each possible combination of parameters. The impacts for which this approach has been taken include provision of water for as a material and for nutrition, flood protection, global climate regulation, nitrate leaching and phosphate run-off, and mass stabilisation and control of soil erosion. Existing models or quantified data were used to derive quantities of water, carbon, nitrate, phosphate and soil for all the possible combinations of the relevant associated parameters. These were then converted onto the scale of -100 to +100 using a calibration table. The second (qualitative) approach is similar to a risk factor approach. The scores are instead assigned for each class, then the scores for the classes selected are summed and weighted for each parameter.

Results

The impact matrix, and parameters within the EFA calculator that affect the impact on various ecosystem service and biodiversity categories within agroforestry, are summarised in Table 1.

Table 1: Basic impact matrix for agroforestry

	Ecosystem services					**Biodiversity**									
Parameters	Mass stabilisation and control of soil erosion	Nitrate leaching	Pest control	Phosphate run-off	Pollination and seed dispersal	Amphibians	Bats	Birds of prey	Flowering plants	Insectivorous birds	Pollinating invertebrates	Reptiles	Seed eating birds	Small mammals (mice, shrews, voles)	Soil surface invertebrates
Adjacent vegetation structure			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjacent water bodies quality						✓									
Adjacent wildlife corridors			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Agroforestry species	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Annual rainfall	✓	✓		✓											
Distribution density of adjacent water bodies						✓	✓								
Field size			✓												
Old trees or buildings present within 1 km²							✓								
Slope	✓			✓											
Soil texture	✓	✓		✓											
South aspect												✓			
Topography												✓			

Scores are not shown due to variation associated with different classes for each parameter. The rationale behind their allocation is discussed in the following section.

Discussion

The benefit offered by agroforestry to ecosystem services and biodiversity varies with species selected within the EFA calculator. The flowers of deciduous agroforestry species may provide a source of nectar and pollen for insects, especially *Salix* spp. (willow) and *Tilia* spp. (lime) (Kirk & Howes, 2012). This is beneficial for pollinators (ecosystem service) and biodiversity, since these insects are a source of food for bats (BCT, 2013) and insectivorous birds. These species groups are favoured by inclusion of agroforestry, for which the calculator allocates a corresponding higher ranking. Natural regeneration of wildflowers in the understory of deciduous plantations may increase wildflower diversity (Langeveld *et al*., 2012) and also favour pollinating invertebrates. Where the development of tussocky grasses occurs, it will provide potential nest sites for some species of bumblebee, or potentially increase the presence of small mammal nests that may also be utilised by bumblebees (Lye *et al*., 2009). The fruit of species such as holly (*Ilex* spp), crab apple (*Malus* spp), wild cherry (*Prunus* spp) and yew (*Taxus* spp) are a potential food source for seed and fruit eating birds.

The EFA calculator tool accounts for key benefits to biodiversity, provided by tree within areas dominated by cultivation, including structural diversity enhancement at the field scale, and creation of a habitat mosaic and improved connectivity of habitat fragments at the landscape scale (Langeveld *et al*., 2012). The implementation of agroforestry areas as linear features (Dix *et al*., 1995) offers a potential role as wildlife corridors, allowing movement of populations between what would otherwise be isolated habitats (Hilty *et al*., 2006). A number of species are known to utilise corridors within agricultural landscapes., The Red Data Book listed great crested newt (*Triturus cristatus*) exist as meta-populations, and require dispersal between multiple ponds and habitat fragments to ensure population survival (Oldham et al. 2000).

The enhancement by agroforestry of surface active predatory invertebrates may contribute to pest control (Holland & Luff, 2000). Dix *et al*. (1995) report that although beneficial insects are enhanced by the presence of trees within cultivated areas, suitable hibernation areas (tussocky grass) need to be present at the base of the tree lines. Further, because such species utilise both the crop and the tree planted area to exert an impact on crop pests, they are essentially ecotone species and benefit from a high edge to area ratio i.e. thin tree lines.

In terms of soil and water protection, the EFA tool calculates that nitrate leaching is reduced compared to arable cropping (Langeveld *et al*., 2012) because supplementary nitrogen is not applied and tillage frequency is reduced. This decreases the rate of mineralisation and release of nitrogen from organic matter. A permanent and deeper rooting system utilises soil nitrogen more effectively than an arable crop, rendering it unavailable to leaching (Nair & Graetz, 2004). Both coniferous and deciduous agroforestry species significantly reduce the risk of soil erosion and surface run-off of phosphate (Langeveld *et al*., 2012). This increases with increased maturity and ground cover. Schroth and McNeely (2011) highlight the need to consider appropriate tree mixtures, with different rooting strategies and temporal nutrient requirements that maximise the complementarity effect (coexistence of species exploiting different resources). Where planted as a line of trees perpendicular to prevailing winds, agroforestry areas may function as shelterbelts (Brandle & Kort, 1991) that reduce the risk of wind erosion, especially during stages in the cropping cycle when there is limited ground cover (López *et al*., 2002). Pesticide drift may also be intercepted in more mature stands with a higher canopy.

In summary, many benefits to ecosystem services and biodiversity are realised by the presence of the agroforestry EFA element, as illustrated by testing of the EFA calculator on multiple case study farms. This benefit is enhanced further by the integration with crop production that agroforestry achieves, such that productivity is not impacted.

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