A guidance tool to support farmers with ecological focus areas – the benefits of agroforestry for ecosystem services and biodiversity

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EFA Calculator Project

• Project commissioned by JRC:
  – Title: Guidance and tool to support farmers in taking aware decisions on Ecological Focus Areas
  – Duration: January-September 2015
  – Aim: To develop a software tool that helps farmers identify the most ecologically sound and pragmatic solution for implementing Ecological Focus Areas (EFAs)
EFA Calculator Project

• Objectives/functions of the software:
  – Calculate the contribution of different farm features to meeting the 5% EFA target (including checking implementation rules)
  – Calculate (ex-ante) the potential impact of different features on ecosystem services, biodiversity and management
  – Guide farmers towards features which offer the greatest potential benefits (minimising burdens & maximising benefits)
The key challenges

• Calculating the potential impact of EFA features on ecosystem services and biodiversity
  – No established or common metrics
  – Accounting for relative functional value (rather than absolute impact)

• Numerous parameters and factors to be accounted including:
  – 15 to 20 different types of EFA features/land uses
  – Different implementation permutations:
    • Surrounding landscape factors
    • Physical and management factors
  – Different spatial and ecological contexts across the EU-28...
Approach

1. Literature review
   - State of the art evidence on the benefits and burdens of different EFA components (features)

2. Impact assessment
   - Assessment of the relative functional value of different EFA features under different circumstances based on the evidence

3. Indicator framework
   - Harmonised framework for evaluating the relative benefits and burdens of EFAs (scoring and aggregation)

4. EFA Calculator (software)
   - Knowledge transfer vehicle

Focus for today
# EFA elements & farm land and features

<table>
<thead>
<tr>
<th>EFA Element</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow land</td>
<td>Fallow land</td>
</tr>
<tr>
<td>Terraces</td>
<td>Terraces</td>
</tr>
<tr>
<td>Hedges or wooded strips</td>
<td>Hedges or wooded strips</td>
</tr>
<tr>
<td>Isolated trees</td>
<td>Isolated trees</td>
</tr>
<tr>
<td>Trees in line</td>
<td>Trees in line</td>
</tr>
<tr>
<td>Trees in groups and field copses</td>
<td>Woodland</td>
</tr>
<tr>
<td>Field margins</td>
<td>Land strips (adjacent/parallel to water)</td>
</tr>
<tr>
<td></td>
<td>Land strips (other)</td>
</tr>
<tr>
<td></td>
<td>Hedges or wooded strips</td>
</tr>
<tr>
<td></td>
<td>Ditches</td>
</tr>
<tr>
<td>Ponds</td>
<td>Ponds</td>
</tr>
<tr>
<td></td>
<td>Land strips (adjacent/parallel to water)</td>
</tr>
<tr>
<td>Ditches</td>
<td>Ditches</td>
</tr>
<tr>
<td>Traditional stone walls</td>
<td>Traditional stone walls</td>
</tr>
<tr>
<td>Other landscape features</td>
<td>Ancient monuments</td>
</tr>
<tr>
<td></td>
<td>Ancient stones</td>
</tr>
<tr>
<td></td>
<td>Archaeological sites</td>
</tr>
<tr>
<td></td>
<td>Garrigue</td>
</tr>
<tr>
<td></td>
<td>Hedges or wooded strips</td>
</tr>
<tr>
<td></td>
<td>Isolated trees</td>
</tr>
<tr>
<td></td>
<td>Natural monuments</td>
</tr>
<tr>
<td></td>
<td>Ponds</td>
</tr>
<tr>
<td></td>
<td>Terraces</td>
</tr>
<tr>
<td>Buffer strips (GAEC1, SMR1 or SMR10)</td>
<td>Land strips (adjacent/parallel to water)</td>
</tr>
<tr>
<td>Buffer strips (Other)</td>
<td>Land strips (other)</td>
</tr>
<tr>
<td><strong>Agroforestry</strong></td>
<td>Agroforestry</td>
</tr>
<tr>
<td>Strips along forest edges (NO PRODUCTION)</td>
<td>Land strips (other)</td>
</tr>
<tr>
<td>Strips along forest edges (WITH PRODUCTION)</td>
<td>Land strips (other)</td>
</tr>
<tr>
<td>Short rotation coppice</td>
<td>Short rotation coppice</td>
</tr>
<tr>
<td>Afforested areas</td>
<td>Woodland</td>
</tr>
<tr>
<td>Catch crops or green cover</td>
<td>Catch crops or green cover</td>
</tr>
<tr>
<td>Nitrogen fixing crops</td>
<td>Nitrogen fixing crops</td>
</tr>
</tbody>
</table>
Impact assessment

• First step was a structuring process
• For each EFA feature:
  – **Impact categories**: based on Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin, 2013) and European Nature Information System (EUNIS) habitat classification species groups (EEA, 2015)
  – **Parameters**: affect the potential impact of EFA features on ecosystem services, biodiversity & management (e.g. Soil texture)
  – **Classes**: within parameters that differentiate the impact of that parameter (e.g. Soil texture: Coarse, Medium, Medium fine, Fine, Very fine)

Impact assessment

• The structuring process resulted in 230 feature-impact combinations, characterised using 138 different parameters containing 708 parameter classes

• Each feature-impact required a score on a common scale, which is used to indicate/calculate the relative benefit or burden of a feature:

  – **Semi-quantitative** approach using meta-modelling (e.g. soil erosion to derive t/ha/yr (van der Knijff et al., 2000))
  
  – **Qualitative** approach (e.g. biodiversity) scored parameters and classes to derive a Habitat Suitability Index using literature and expert judgement
  
  – Differences identified between agroforestry and other EFA options; and between agroforestry species

Scores derived from the literature (qualitative approach)

- Biodiversity impact scores derived based on Habitat Suitability Index (HSI) approach (Oldham et al., 2000; ARG, 2010)

- Aims to broadly to assess the relative benefit (or burden) of an EFA feature with respect to ecosystem services and biodiversity based on:
  - The attributes of the feature itself; and
  - The attributes of features in the surrounding landscape

ARG (2010) Advice Note 5: Great Crested Newt Habitat Suitability Index. Amphibian and Reptile Groups (ARG) of the United Kingdom

HSI example: Great crested newt

- The great crested newt (*Triturus cristatus*)
- Protected under:
  - Bern Convention 1979
  - EC Habitats Directive 1992
- HSI has been subject ‘ground-truthing’ for *Triturus cristatus* populations...
Habitat Suitability Index (HSI)

- Poor (HSI < 0.5)
- Below average (HSI 0.5-0.59)
- Average (HSI 0.6-0.69)
- Good (HSI 0.7-0.79)
- Excellent (HSI >0.8)

Adapted from: ARG (2010) Advice Note 5: Great Crested Newt Habitat Suitability Index. Amphibian and Reptile Groups (ARG) of the United Kingdom
HSI: *Triturus cristatus*

- Uses 10 habitat feature specific variables indicative of habitat quality potential for *T. cristatus* populations
- Derived from multiple years field measurements and population monitoring
Application of the HSI – pond number

Score = 1
Score = 0.67
Score = 0

Ponds / km²

0.1 1 10

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

250 m radius
1 km radius

Pond
Extending the HSI

- Distribution density of adjacent water bodies
- Adjacent water bodies quality
- Adjacent vegetation structure
- Ground cover
- Adjacent wildlife corridors
HSI: *Triturus cristatus*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Type</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Geographic location</td>
<td>Zone with UK</td>
<td>Spatial</td>
<td>Region</td>
</tr>
<tr>
<td>2. Pond area</td>
<td>Surface area of the pond</td>
<td>Quantitative</td>
<td>Feature</td>
</tr>
<tr>
<td>3. Permanence</td>
<td>Frequency of when pond dries out</td>
<td>Quantitative</td>
<td>Feature</td>
</tr>
<tr>
<td>4. Water quality</td>
<td>Based on invertebrate diversity, the presence of submerged water plants and knowledge of the water sources feeding the pond</td>
<td>Qualitative/Quantitative</td>
<td>Feature</td>
</tr>
<tr>
<td>5. Shade</td>
<td>Percentage pond perimeter shaded</td>
<td>Quantitative</td>
<td>Feature</td>
</tr>
<tr>
<td>6. Waterfowl</td>
<td>Impact of waterfowl upon the pond and newts</td>
<td>Qualitative</td>
<td>Feature</td>
</tr>
<tr>
<td>7. Fish</td>
<td>Fish stocking</td>
<td>Qualitative</td>
<td>Feature</td>
</tr>
<tr>
<td>8. Pond count</td>
<td>Number of ponds occurring within 1 km</td>
<td>Quantitative</td>
<td>1km²</td>
</tr>
<tr>
<td>9. Terrestrial habitat</td>
<td>Quality of the terrestrial habitat</td>
<td>Qualitative</td>
<td>250m radius</td>
</tr>
<tr>
<td>10. Macrophytes</td>
<td>Percentage of the pond surface area occupied by macrophyte cover</td>
<td>Quantitative</td>
<td>Feature</td>
</tr>
</tbody>
</table>

- Applied to biodiversity – amphibians
- Principle adapted to other biodiversity groups
Pollinating insects (bees)

- Ecosystem Service: Pollination
- Forage preference (scale of 0 to 3) for four bee groups (Kirk and Howes, 2012):
  - honey bees
  - long or short tongued bumblebees
  - solitary bees
- EFA agroforestry tree species flower suitability (e.g. corolla tube length)
- Length of flowering period
- Difference between agroforestry species
Pollinating insects (bees)

- Flowering period (months)
- Honey bee
- Short-tongued bumblebee
- Long-tongued bumblebee
- Solitary bee

Based on Kirk and Howes, 2012
Pest control - beneficial insects

- Ecosystem Service: Pest control
- Carabid (ground) beetles
- Spring breeding species overwinter as adults in field boundaries
- Move into crop areas during spring
- Feed on crop pests (for example aphids)
- May be edge distributed (especially in larger fields)

Pest control - beneficial insects

- UK – ‘beetle banks’ or hedgerows
- Provide winter refugia and enhance populations in central crop areas
- Agroforestry potentially similar function
- No difference between agroforestry species at present, only with other EFA options
Meta-modelling (semi-quantitative approach)

- **Ecosystem Services:**
- **Mass stabilisation and control of soil erosion**
- **Water quality**
  - Nitrate leaching
  - Phosphate run-off

Table 2. C factor values of the different Corine land covers.

<table>
<thead>
<tr>
<th>CLC code</th>
<th>Land use</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>111</td>
<td>Continuous urban fabric</td>
<td>0</td>
<td>Märker et al., 2008</td>
</tr>
<tr>
<td>112</td>
<td>Discontinuous urban fabric</td>
<td>0</td>
<td>Märker et al., 2008</td>
</tr>
<tr>
<td>121</td>
<td>Industrial or commercial units</td>
<td>0</td>
<td>Märker et al., 2008</td>
</tr>
<tr>
<td>122</td>
<td>Road and rail networks and associated land</td>
<td>0</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>141</td>
<td>Green areas inside urban fabric</td>
<td>0</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>322</td>
<td>Bare rocks</td>
<td>0</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>311</td>
<td>Water courses</td>
<td>0</td>
<td>Märker et al., 2008</td>
</tr>
<tr>
<td>312</td>
<td>Coniferous forest</td>
<td>0.001</td>
<td>Angele, 2004</td>
</tr>
<tr>
<td>313</td>
<td>Mixed forest</td>
<td>0.002</td>
<td>Angele, 2004</td>
</tr>
<tr>
<td>314</td>
<td>Broad-leaved forest</td>
<td>0.003</td>
<td>Angele, 2004</td>
</tr>
<tr>
<td>231</td>
<td>Pastures</td>
<td>0.020</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>324</td>
<td>Transitional woodland shrub</td>
<td>0.040</td>
<td>Märker et al., 2008</td>
</tr>
<tr>
<td>321</td>
<td>Natural grassland</td>
<td>0.050</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>322</td>
<td>Moors and heathland</td>
<td>0.050</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>323</td>
<td>Sclerophyllous vegetation</td>
<td>0.050</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>244</td>
<td>Complex cultivation patterns</td>
<td>0.200</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>241</td>
<td>Arable crops associated with permanent crops</td>
<td>0.250</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>223</td>
<td>Fruit trees and berry plantations</td>
<td>0.300</td>
<td>Angele, 2004</td>
</tr>
<tr>
<td>223</td>
<td>Olive groves</td>
<td>0.300</td>
<td>Märker et al., 2008</td>
</tr>
<tr>
<td>211</td>
<td>Non-irrigated arable land</td>
<td>0.300</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>212</td>
<td>Irrigated arable land</td>
<td>0.300</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>243</td>
<td>Agriculture land, with significant areas of nat. vegetation</td>
<td>0.300</td>
<td>Bakker et al., 2008</td>
</tr>
<tr>
<td>323</td>
<td>Sparsely vegetated areas</td>
<td>0.360</td>
<td></td>
</tr>
<tr>
<td>221</td>
<td>Vineyards</td>
<td>0.450</td>
<td>Ml.</td>
</tr>
<tr>
<td>131</td>
<td>Mineral extraction sites</td>
<td>1.000</td>
<td>B</td>
</tr>
<tr>
<td>331</td>
<td>Beaches, dunes, sands</td>
<td>1.000</td>
<td>B</td>
</tr>
</tbody>
</table>

Results

• Firstly, important to state that it is not easy to provide a simple overview of the impact of a particular EFA

• The complexity of ecosystem services and biodiversity means that the answer to any questions on the impact of EFAs is usually: “it depends…”
  – For ecosystem services, impacts will depend on:
    • Regional parameters
    • Attributes of the EFA
  – For biodiversity, impacts will depend on:
    • Regional parameters
    • Attributes of the EFA
    • Attributes of the surrounding landscape

• Can also be broadly split into ‘Land area’ and ‘Landscape feature’ EFAs...
Regional parameters:
- Rainfall
- Soil type
- Slope
- Regional water stress
  Etc.

Ground cover:
- Catch crop species
- Fallow land
- Nitrogen fixing crop species
- Agroforestry species

Surrounding landscape:
- Adjacent vegetation structure
- Adjacent water bodies quality
- Adjacent wildlife corridors
- Distribution density of adjacent water bodies
- Old trees or buildings present within 1 km²

Ecosystem services:
- Mass stabilisation and control of soil erosion
- Nitrate leaching
- Pest control
- Phosphate run-off
- Pollination and seed dispersal

Biodiversity:
- Amphibians
- Bats
- Birds of prey
- Flowering plants
- Insectivorous birds
- Pollinating invertebrates
- Reptiles
- Seed eating birds
- Small mammals (mice, shrews, voles)
- Soil surface invertebrates

Land area
EFAs
Regional parameters:
- Rainfall
- Soil type
- Slope
- Regional water stress
  Etc.

Ecosystem services:
- Aesthetic services
- Chemical condition of freshwaters
- Flood protection
- Global climate regulation
- Soil erosion
- Pollination and seed dispersal
- Provision of water

Feature attributes:
- Porosity
- Presence of fruit and pollen bearing plants
- Mature trees with basal hollows

Surrounding landscape:
- Adjacent vegetation structure
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Landscape feature EFAs
Results: Application of the EFA calculator

• As mentioned in the notes & caveats outlined above, the results of the impact assessment are best explored using specific contexts

• As part of the project the EFA calculator was applied/tested on 25 hypothetical farms:
  – Based on real locations in 16 Member States including:
    • Croatia, Cyprus, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Romania, Slovenia, Spain, Sweden and the UK
  – Features identified and quantified using:
    • Aerial photos from Google Earth and Maps, supplemented with photographs of features in Google Earth and/or using Street View
    • Dimensions for features were derived using basic GIS functions Google My Maps¹
    • Local knowledge supplemented the information gathered in a few instances

Google My Maps: https://www.google.com/maps/d/?hl=en_US&app=mp (Last accessed: 16/05/16)
Accounting for ‘production displacement’ - land taken out of production
Ranking: Management (incl. land taken out of production), biodiversity & ecosystem services
Results: Important notes/caveats

• The impact assessment results are not absolute:
  – They are relative to the circumstances of a farm
  – The results, especially for biodiversity, do not necessarily indicate that one EFA element is ‘better’ overall than another, it depends on the circumstances (in this case the hypothetical farms)

• The evidence for EFA features and their impacts is variable in terms of quantity and robustness, and there is always scope for improvement in scientific understanding

• The indicator framework and EFA software are prototypes - there is scope for further refinement and development

• Some caution is needed when using the outputs any comparative purposes, accounting for the notes above
Further information

EFA Calculator software:

• Version 1.0.2.7 currently available
• http://sitem.herts.ac.uk/aeru/efa/
• Contact: aeru@herts.ac.uk

Related publications:
