Agroforestry: A land-use system with potential on Irish farms

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Definition

- **Agroforestry**
  - A dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels
  
  (ICRAF, 2002)

- **Agroforestry is a new name for old practices**

History

- First defined in 1978 in the context of the Tropics
- Agroforestry as a land-use system is ancient
- Majority of research based in the Tropics
- Interest increased in Temperate regions
Types of agroforestry

- Silvoarable
  - Trees and crops
    - Alley cropping
    - Orchard intercropping

Cocoa under coconut, Malaysia
Types of agroforestry

- Silvoarable
  - Trees and crops
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    - Orchard intercropping

Rubber and tea, China
Types of agroforestry

- Silvoarable
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    - Orchard intercropping

Arable crops and poplar, Uni. Leeds experiment
Types of agroforestry

- Silvoarable
  - Trees and crops
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    - Orchard intercropping

Intercropping with strawberries in an immature peach orchard, Ontario
Types of agroforestry

- Silvopastoral
  - Trees and livestock
    - Forest grazing
    - Pannage

Forest grazing, B.C., Canada
Types of agroforestry

- Silvopastoral
  - Trees and livestock
    - Forest grazing
    - Pannage

Dehesa, S.W. Spain
Types of agroforestry

- **Agrisilvopastoral**
  - Trees with crops and livestock

- **Others**
  - Shelterbelt
  - Riparian zones
  - Fodder banks
  - Home gardens

Shelterbelt, New Zealand
Arrangement of components

- Spatial arrangement
- Temporal arrangement
<table>
<thead>
<tr>
<th>TEMPORAL ARRANGEMENT</th>
<th>SCHEMATIC ILLUSTRATION</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>COINCIDENT</td>
<td></td>
<td>Coffee under shade trees; pasture under trees</td>
</tr>
<tr>
<td>CONCOMITANT</td>
<td></td>
<td>Taungya</td>
</tr>
<tr>
<td>INTERMITTENT (space dominant)</td>
<td></td>
<td>Annual crops under coconut; Seasonal grazing of cattle in pastures under trees</td>
</tr>
<tr>
<td>INTERPOLATED (space- and time-dominant)</td>
<td></td>
<td>Homegarden</td>
</tr>
<tr>
<td>OVERLAPPING</td>
<td></td>
<td>Black pepper and rubber</td>
</tr>
<tr>
<td>SEPARATE (time-dominant)</td>
<td></td>
<td>Improved &quot;fallow&quot; species in shifting cultivation</td>
</tr>
</tbody>
</table>

(time scale will vary for each combination)

woody component nonwoody component

*Figure 3.2. Arrangement of components in agroforestry systems. Source: Nair (1985a).*
Component interactions

Species A
causes a response in
The environment
Species B
has an effect on
causes a response in

- Micro-climate
- Resources
Shared above-ground space

Possible facilitation

✓ +ve shade and shelter for crops and livestock
✓ Litter and mulch effects
✓ Improved topsoil water status
✓ Fodder

Possible competition

✗ For light, depending on canopy structure and relative times of canopy activity
✗ Soil compaction
Shared rooting zone

Possible facilitation

- Improved resource capture
- Improved soil physical and chemical properties
- Mycorrhizas
- N-fixation
- Enhanced numbers and activity of soil biota

Possible competition

- For nutrients, depending relative times of root activity and niche requirements
Deep rooting zone occupied by one plant component

Possible facilitation
- Improved resource capture
- Nutrient ‘pumping’

Possible competition
- None apparent
Publications
European Extension
Context

- EU agricultural policy
  - Sustainability
  - Environment
  - Decoupling
Context

  - Article 8
    - A parcel that contains trees shall be considered an agricultural parcel for the purposes of the area-related aid schemes provided that the agricultural activities ... or the production envisaged can be carried out in a similar way as on parcels without trees in the same area.
Context

- EU agricultural policy
  - Sustainability
  - Environment
  - Decoupling
- Government forest strategy
  - 9%-17% land area by 2030
- Kyoto agreement
Afforestation

- Private > Public since introduction of Annual Premia (1987)
Private afforestation

- Majority by farmers

![Graph showing private afforestation with data points for different categories over years from 1990 to 1998. The categories include total private afforestation, afforestation by full-time farmers, afforestation by part-time farmers, and afforestation by non-farmers.](image)
Farming systems

- Majority of Irish farms have cattle

- Cattle: 81%
- Dairying: 29%
- Cattle rearing: 19%
- Dairying + other: 16%
- Mainly tillage: 8%
- Mainly sheep: 11%
- Cattle other: 17%

8th Institutes of Technology, Science and Computing Research Colloquium, WIT, 26-28 May, 2004
Model

Inputs

Systems
- Forestry
- Pasture
- Agroforestry

Economics
- Timber price-size data
- Grants and subsidies
- Discount rate

Whiteman poplar price-size curve

Log volume (m$^3$)

£/m$^3$
Model

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Model
- Agroforestry interaction
- Sensitivity
  - Prices, costs, yields, subsidy, discount rate

Economics
- Actual values
- Discounted values
Model - Agroforestry interaction

\[ Y = Y_m \times (1 - (2.18 \times 10^{-4} \times GCL)) \]

Where:

- \( Y = \) intercrop yield t.ha\(^{-1}\)
- \( Y_m = \) monocrop yield t.ha\(^{-1}\)
- \( GCL = \) green crown length m.ha\(^{-1}\)

Sibbald \textit{et al}., 1994
Model

Inputs
- Systems
  - Forestry
  - Pasture
  - Agroforestry
- Economics
  - Timber price-size data
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Model
- Agroforestry interaction
- Sensitivity
  - Prices, costs, yields, subsidy, discount rate
- Economics
  - Actual values
  - Discounted values

Outputs
- Data
  - Cash flows
  - Net present values
- Graphical
  - Net present values
  - Yields etc
Bio-economic model
**Bio-economic model**

### Crop enterprise
- **Winter wheat (Feed Wheat)**
  - Output (tonnes/hectare): 8.6

### Poplar agroforestry file
- File: 88uh14
- Stems/ha: 156
- Yield class: 14

### Grants and subsidies
- **Area Aid payable?**
  - Current or User defined?: Current
  - Current Area Aid
    - Area Aid (£): 290
  - User Defined Area Aid
    - Area Aid (£): 280

### Livestock enterprise
- **Early for lamb**
  - Stocking per hectare: 10.4
  - Output per Ewe: 1.4

### Poplar plantation
- File: 88uh14
- Stems/ha: 625
- Yield class: 14

### Grants
- **Afforestation Grant payable for agroforestry?**
  - Afforestation grant (£): 917.50
- **Maintenance Grant payable for agroforestry?**
  - Maintenance grant (£): 312.50
- **Premium payable for agroforestry?**
  - Annual Premium (£): 86.86
  - Premium (no. of years): 12
- **Second formative shaping grant payable?**
  - Formative shaping (£): 200
  - Formative shaping (year): 3
- **Grants for pruning available for agroforestry?**

### Forest service or User Defined?
- Afforestation grant (£): 1875
- Maintenance grant (£): 625
- Premium payable?
- Annual Premium (£): 348
- Premium (no. of years): 12
- Second formative shaping grant payable?
- Formative shaping (£): 200
- Formative shaping (year): 3

### Grants for pruning available for poplar?
- Afforestation grant (£): 1875
- Maintenance grant (£): 625
- Premium payable?
- Annual Premium (£): 348
- Premium (no. of years): 12
- Second formative shaping grant payable?
- Formative shaping (£): 200
- Formative shaping (year): 3

### Forest Service high pruning grants
- Value (£)
  - Year 4: 550
  - Year 6: 650

### User defined pruning grants
- Value (£)
  - Year 5: 125
  - Year 7: 138

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### Bio-economic model - sensitivity

#### Discount rate
- Sensitivity: 0.0%
- New discount rate: 5.0%

#### Agricultural costs and revenues
<table>
<thead>
<tr>
<th>Factor</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural subsidies (total)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Annual or total agri-costs change? (a/t)</td>
<td></td>
</tr>
<tr>
<td>Agricultural costs (annual)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Agricultural costs (total)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Annual or total crop price change? (a/t)</td>
<td></td>
</tr>
<tr>
<td>Crop price (annual)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Crop price (total)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Annual or total livestock price change? (a/t)</td>
<td></td>
</tr>
<tr>
<td>Livestock price change (annual)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Livestock price change (total)</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

#### Poplar agroforestry costs and revenues
<table>
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<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poplar agroforestry subsidies (total)</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

#### Silvoarable Tree/Crop interaction
<table>
<thead>
<tr>
<th>Factor</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop yield (total)</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

#### Silvopastoral Tree/Livestock interaction
<table>
<thead>
<tr>
<th>Factor</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield change (total)</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

#### Agrisilvopastoral
- Earliest year of livestock introduction: 7
- Cost of pasture establishment (£/ha): 100

#### Poplar plantation costs and revenues
<table>
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</tr>
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<tr>
<td>Poplar subsidies (total)</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

#### Poplar yield and price
<table>
<thead>
<tr>
<th>Factor</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poplar yield (total)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Poplar price (total)</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

#### Poplar costs
<table>
<thead>
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<th>Factor</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual or total poplar cost change? (a/t)</td>
<td></td>
</tr>
<tr>
<td>Poplar costs change (annual)</td>
<td>0.00%</td>
</tr>
<tr>
<td>Poplar costs change (total)</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
Results - livestock

[Graph showing net present value £/ha over years for different systems: Single suckler 1.7/ha, Poplar 4x4, Poplar 8x8, Silvopastoral.]
Results – Winter wheat

- Winter wheat 8.6 t/ha
- Poplar 4x4
- Poplar 8x8
- Silvoarable
Results – Sensitivity to product price

<table>
<thead>
<tr>
<th>% change in product price</th>
<th>Cattle</th>
<th>Silvopasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 20</td>
<td>+ 27.1</td>
<td>+ 20.9</td>
</tr>
<tr>
<td>- 20</td>
<td>- 27.2</td>
<td>- 20.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% change in product price</th>
<th>Winter wheat</th>
<th>Silvoarable</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 20</td>
<td>+ 30.4</td>
<td>+ 25.2</td>
</tr>
<tr>
<td>- 20</td>
<td>- 30.4</td>
<td>- 24.5</td>
</tr>
</tbody>
</table>
## Results – Sensitivity to input costs

<table>
<thead>
<tr>
<th>% change</th>
<th>Winter wheat</th>
<th>Cattle</th>
<th>Silvoarable</th>
<th>Silvopastoral</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 20</td>
<td>- 22.4</td>
<td>- 22.0</td>
<td>- 23.2</td>
<td>- 17.0</td>
</tr>
<tr>
<td>- 20</td>
<td>+ 22.4</td>
<td>+ 22.0</td>
<td>+ 26.7</td>
<td>+ 17.0</td>
</tr>
</tbody>
</table>
Results – Sensitivity to interaction equation

![Graph showing the sensitivity of net present value to interaction equation. The x-axis represents the year, ranging from 0 to 40, and the y-axis represents net present value (£/ha), ranging from -2000 to 10000. Three curves are shown: Livestock, Silvopastoral, and +10%.](image-url)
Results – Sensitivity

- The silvopastoral system is less sensitive to price changes than the monocultural system.
- The interaction equation can have an affect on conclusions derived from the model.
Conclusions

- Silvopastoral system shows economic potential
- Model verification is required
- Real data required for model improvements
  - Experiments
  - Field trials