Grassland Intensification And Inevitable Tradeoffs Between Multiple Ecosystem Services

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Challenges and Opportunities

Production Targets
• 2025: Global food production up 50%
• 2020: N. Ireland production up 60%

EU Legislation Commitments
• 2030: EU GHG emissions down 40%

29% of Northern Ireland’s GHG from agriculture in 2012
92% of Northern Ireland’s agricultural land is grassland

Sustainable intensification is required to meet demand
Sustainable Intensification

Grasslands are multi-functional & provide key ecosystem services:

- Food and Forage
- Pollination
- Soil Fertility
- Climate Change Regulation

But, ability to do so is influenced by management ...

Questions

1) How many ecosystem services can be delivered by agricultural grasslands?
2) What kind of trade-offs exist between these services?
3) What are the ecological mechanisms behind these trade-offs?
Long-Term Slurry Experiment
Hillsborough, Northern Ireland

Established in 1970

Treatments:
- Control
- NPK 200 kg N/ha/yr
- Pig slurry at 50, 100, 200 m³/ha/yr
- Cattle slurry at 50, 100, 200 m³/ha/yr
Ecosystem Services - DM Yield

Above-ground

Below-ground
Ecosystem Services: Off-take & Diversity

**Nitrogen Off-take**

- Control
- NPK
- Cattle (L)
- Cattle (M)
- Cattle (H)
- Pig (L)
- Pig (M)
- Pig (H)

**Plant Species Diversity**

- Control
- NPK
- Cattle (L)
- Cattle (M)
- Cattle (H)
- Pig (L)
- Pig (M)
- Pig (H)
Ecosystem Services: Sequestration

Soil C sequestration

Soil N Retention
**CO₂-e emissions from:**
1. Liming applications
2. Liming production & transport
3. Enteric fermentation-ruminant (CH₄)
4. Manure management (CH₄ & N₂O)
5. Managed soils (CH₄ & N₂O)
6. Feed concentrate production/transport
7. Milk yields
8. Production of NPK
9. Fertilizer transport and application
10. Machinery use

**CO₂-e sequestration in soils**

Assumptions:
1. 2 LU (2 animals/hectare); 2. No animal age specifications; 3. IPCC EF CH₄; 4. No fodder purchased
It depends on how long-term management influences key functions and processes between above-ground and below-ground compartments ...
Trade-offs ...

Relative to Control Treatment, i.e. “No Management”

<table>
<thead>
<tr>
<th></th>
<th>NPK only</th>
<th>Cattle (L)</th>
<th>Pig (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant Diversity</strong></td>
<td>30% ↓</td>
<td>33% ↓</td>
<td>10% ↓</td>
</tr>
<tr>
<td><strong>DM Yield</strong></td>
<td>380% ↑</td>
<td>260% ↑</td>
<td>220% ↑</td>
</tr>
<tr>
<td><strong>N Off-take</strong></td>
<td>160% ↑</td>
<td>110% ↑</td>
<td>140% ↑</td>
</tr>
<tr>
<td><strong>Root Biomass</strong></td>
<td>16% ↓</td>
<td>22% ↓</td>
<td>3% ↓</td>
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<tr>
<td><strong>Carbon Seq.</strong></td>
<td>9% ↓</td>
<td>17% ↑</td>
<td>8% ↑</td>
</tr>
<tr>
<td><strong>Nitrogen Seq.</strong></td>
<td>2% ↓</td>
<td>10% ↑</td>
<td>8% ↑</td>
</tr>
</tbody>
</table>
Conclusions

- Finding the balance between increased productivity and environmental trade-offs is complex but essential
- Further research on GHGs, microbes, soil fauna etc. required
- Do we need to move beyond the grassland scale?
- Is Land Sharing / Land Sparing an option?

From Fischer et al, 2012
Acknowledgements

We gratefully acknowledge funding provided by:
DAERA, Northern Ireland

With thanks to field and lab staff at:
AFBI Newforge Lane
AFBI Hillsborough

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