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Green Food Project Dairy Subgroup Report

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Chairman’s introduction

Firstly I’d like to thank the members of the Dairy Subgroup, who by contributing their specialist expertise and valuable time, allowed us to explore the important and challenging objectives as set out in the Green Food Project’s Steering Group Terms of Reference; to consider the implications of achieving an increase in food production and protecting and enhancing the natural environment in England, and the relationship between these objectives. Our conclusions set out a number of practices and behaviours that can help the dairy industry achieve these twin objectives. However the group identified a number of tensions, trade-offs and areas where further research is required to understand the interrelationship between production and the environment.

This document is written and owned by members of the dairy subgroup. The content does not necessarily reflect the views of Green Food Project Steering Group members. This is a discussion paper by representatives from the following organisations:

National Farmers Union (Chair), Agriculture and Horticulture Development Board - DairyCo, Royal Society for the Protection of Birds (RSPB), WWF, Royal Society for the Prevention of Cruelty to Animals (RSPCA), Milk Link, Volac, Dairy UK, National Federation of Young Farmers Clubs (NFYFC), Natural England, AB Agri, Technology and Strategy Board (TSB), Tesco, and Department for Environment Food and Rural Affairs (Defra).

Summary

The subgroup examined the potential for increasing productivity in the dairy sector and for enhancing the environment; teasing out some of the tensions and challenges of meeting both outcomes and identifying any potential trade-offs that may need to be made. A two-pronged parallel approach was taken to examine the potential to maximise efficiency and improve environmental impacts in the sector.

Production, Productivity and Efficiency

The analysis of MilkBench+[1] (an analysis of benchmarking data on the efficiency of dairy production in Britain) highlighted a wide range in efficiency (as measured by net margin p/l) of farms within the three categories, ‘cows at grass’, ‘composite’ and ‘high-output cows’. MilkBench+ data suggest that neither system of production nor scale (within certain parameters) were a barrier to efficiency[2] and profitability – although further analysis is needed. However, because the range in efficiency is so great, the group did conclude that better uptake of existing recognised best management practices could significantly improve productivity.

MilkBench+ data suggests that bringing the efficiency of the bottom quarter up to the average would result in a 7% increase in milk production, furthermore by bringing the efficiency of all the sample farms to that of the top performers would result in a 35% increase in milk production. The environmental impact of this was not fully considered given the time constraints.

Looking at the longer term, the group recognised that novel and emerging technologies are in existence and being developed that can drive productivity gains in the dairy industry. The advances in genomics will enable more rapid and effective selection for desired traits in both plants and animals. This could allow producers to deliver more robust, healthy and resource efficient crops and livestock. This has the potential to drive productivity gains, potentially in a more sustainable way than previous breeding strategies that have tended to select for production traits in isolation.

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[1] DairyCo Milkbench+ Report 2012, published January 2012, available at http://www.dairyco.org.uk/library/market-information/milkbenchplus/milkbench-report-2012.aspx.

[2] The definitions of the terms ‘efficiency’ and ‘productivity’, that are used throughout the report, are provided in Annex 1.

The emergence of new technologies in both the crop and livestock fields, from precision farming to animal telemetry and monitoring, will enable better management decisions to be made and more efficient use of inputs again driving resource efficiency gains and potentially minimising adverse effects on the environment. These new technologies, could target productivity indicators and potentially address some environmental indicators.

Environment and social implications

Analysis of the environmental impact of dairy farming, and how this could be improved highlighted loss of biodiversity from intensive forage production, greenhouse gas emissions, local/catchment water pollution, remote biodiversity loss/greenhouse gas emissions from imported crop production (soy/palm), local soil structure and impact of reactive nitrogen, remote depletion and pollution of ground waters[3] as significant impacts of UK dairy production. In addition to these environmental impacts, it was noted that the dairy industry raises a range of issues of significant social concern, for instance the (remote) cultivation of GM crops[4] used in feed and animal welfare issues and influence the dairy sector has on the landscape.

To address a number of these environmental concerns, a system change should be considered. If appropriately managed, an increase in cropping diversity and vegetation structure would yield a range of environmental benefits. Polarisation/specialisation of livestock and arable production has contributed to negative impacts on biodiversity and problems of nutrient loading in intensive grassland 'hotspots' (expanded further in Annex 4). Redistribution of livestock and their manures through more integration of arable and pastoral production could reduce nutrient load in current hotspots, and could bring soil and nutrient cycling benefits. A decision tree is proposed (as described in Annex 5) as an appropriate framework for considering existing features and constraints, and then choosing the most appropriate ways of increasing cropping/sward diversity on a given farm.

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[3] There are potential risks from a major catastrophe, such as a slurry store failure, that would have resulted from the groundwater potable supply source. This also relates to the pollution of waters due to the production of soy.

[4] It is considered that the use of GM crops may have wider implications than just social.

To assess the environmental footprint of dairy production, less direct, 'second order' impacts must be considered (such as land-use change associated with imported soy) and the cattle industry should be viewed as a whole, including both beef and dairy products. Considering the period to 2050, the environmental representatives on the group believe that continued specialisation or separation of beef and dairy may be undesirable when considered according to the range of outcomes that society requires. The group agreed that a proper assessment of the interrelationship between beef and dairy production would be beneficial, to assess the relative merits of techniques such as sexed semen, use of dual purpose breeds or more breeding programs that make a greater consideration of dual functionality. Beyond the indications of effects of specific management practices, it has not been possible to analyse the implications of improving the environmental impact of dairy systems on production and profitability. The impact will vary for different mitigation measures and systems. However, considerable previous research has been identified which should be drawn on[5].

Integrated conclusions

Based on the opinions of the group and analysis undertaken by DairyCo, looking at the relationship between output per hectare and technical efficiency as defined by indicators from Milkbench+, the group recognised there are environmental impacts that can be reduced by optimising efficiency, resource use and reducing waste. A number of these efficiency-related management practices were found to result potentially in win-win outcomes; for instance by reducing mortality and endemic disease in the herd, inputs such as feed/energy/water/land use, per unit of (milk) production, would be reduced.

In other instances, clear tensions exist, specifically around the efficient utilisation of land for forage crop production. MilkBench+ suggests that litres milk per hectare[6] is clearly related to farm business efficiency and directly related to farm business profitability. Sample farms achieving profitability would typically achieve optimum dry matter intake (DMI), by a function of feeding an optimum nutritional balanced diet and produced forage

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[5] An example of such research is a Defra funded project on 'New integrated dairy production systems: specification, practical feasibility and ways of implementation', completed in 2007 and the final report is available here. Supporting this is a published scientific paper looking at 'A modelling framework to identify sustainable dairy farms in the UK. Framework description and test for organic systems and N fertiliser optimisation.', A. Del Prado *et al,* Science of Total Environment. Volume 409, Issue 19, 1 September 2011, Pages 3993-4009.

[6] Annex 1 – Theoretical Land Requirement for Milkbench+ analysed dairy herds, an analysis undertaken by DairyCo.

(grazed or harvested) of optimum dry matter per ha of an optimum nutritional value. Traditionally grass varieties are grown in monoculture and harvested before seeding to optimise DM and energy yield. This is counterproductive to the provision of habitats for certain wildlife species that require structural heterogeneity and feed resources. The group did however agree that in certain instances forms of mixed cropping can achieve dual objectives, for instance the use of traditional species appropriate to certain geographical/topographic locations or grass and clover swards. But, the uncertainties raised highlight the need for further analysis to examine the extent to which this is a productivity/biodiversity tension and, if so, how it could be addressed.

A policy recommendation with regards to productivity was the establishment of a common set of 'key performance indicators' (KPIs) that dairy farmers, research providers, advisers and those involved in allied/ancillary industries were aware of and working to address. Some environmental indicators are already being addressed through the Dairy Roadmap, but further analysis of the interactions with wider environmental indicators would need to be considered. KPIs, such as calving interval or involuntary culling, would first have to be agreed by industry and effectively communicated and benchmarked.

It was also noted by members of the group that by developing a system for measuring, recording and benchmarking DM yield from grassland, through grazing and silage production, it would be possible to assess the productivity implications of environmental practices like sward diversity and also drive productivity gains linked with DM yield and DMI. Such systems exist and are widely used in other dairy producing countries such as New Zealand, but not currently in the UK.

Note

The environmental representatives on the group do not accept the premise that growing global demand for dairy products, or food security issues, mean that an increase in production is currently necessary or desirable in the UK dairy sector. The social impacts of an increase in UK dairy production on the livelihoods of farmers in developing countries also require consideration. But it should be noted that other members of the group differ from this view.

Approach

In the Natural Environment White Paper[7], a commitment was made to '*bring together government, industry and environmental partners to reconcile how we will achieve our goals of improving the environment and increasing food production*'. In response to this, the Green Food Project aims to work jointly with organisations from across the food, farming, environment and consumer sectors to reconcile the needs of food production and the environment up to 2050.

The mandate for this subgroup was therefore to examine the potential for increasing productivity in the dairy sector and for enhancing the environment; teasing out some of the tensions and challenges of meeting both outcomes and identifying any potential tradeoffs that may need to be made.

The subgroup agreed to approach this work by first developing a baseline of how the dairy sector currently operates and then considering the potential for maximising efficiency and improving environmental impacts in the sector. The subgroup would then consider the impacts as we push the potential/frontier for the industry forward.

A two-pronged parallel approach was taken to examine the potential to maximise efficiency and improve environmental impacts in the sector, which is as follows:

a) assessing the potential for the dairy industry to maximise productivity and the consequent impact that this has on the environment

This group set out looking at the potential to maximise productivity based on data and information derived from the Milkbench+ Report (Annex 2). This report is an analysis of benchmarking data, collected from 330 dairy farms, providing an insight and a good indication of the efficiency of dairy production in Britain. It was acknowledged that while this represented a cross section of farms, those likely to be involved in the survey are potentially already or considering ways to be more efficient. The analysis on the data also identified that there are three key dairy farming types:

[7] The Natural Choice: Securing the Value of Nature, HMG, 2011

- Cows at grass – generally grass based systems, operating at lower yield levels
- Composite – mixed based approach to feeding and housing
- High-output cows –generally housed system with intensive use of inputs

b) examining the potential for the sector to improve its environmental performance and the consequent impact on productivity

This group initially identified a set of key environmental impacts of the dairy sector, and for all of these impacts the measures that can be taken to mitigate the current negative impacts of dairy farming or improve their environmental performance. It was considered, however, that given the time constraints, the best approach would be to focus on the key factors of a dairy system design that would be optimal for the environment in 2050. These factors focused more on issues where it is considered that least progress is being made by the sector; around improving biodiversity outcomes and fully accounting for the indirect footprint (as described in Annex 4).

Limitations to the work undertaken

The subgroup highlighted a number of limitations to the work that was undertaken:

- The relationship between increasing production/productivity and the consequent environmental impact is complex and more work is needed to understand this in key areas;
- The environmental impacts on productivity (and vice versa) are difficult to quantify, and a full analysis was not possible given the time constraints;
- Resource use efficiency, expressed in economic terms, is a proxy for some, but not all, environmental impacts – e.g. tensions exists between biodiversity and productivity at a field level;
- The impact of on-farm actions taken will vary between farming systems, geographical regions, etc. There is not a ‘one-size fits all’ solution;
- Improving biodiversity and identifying the indirect footprint of dairy production are key challenges;
- The role of the taxpayer and consumers in understanding the dairy farming systems, and the propensity to pay for systems and products with a more positive environmental profile is an issue which has not been examined;

- The analysis undertaken did not include an examination of the desirable level of consumption of dairy products between now and 2050;
- Consideration was not given to the physical inputs to the dairy sector that are likely to be limiting over the next 40 years, such as fossil energy or phosphorus, and how the industry could become less dependent on these finite natural resources.

Given these limitations, a series of hypotheses were developed that will require further testing. These hypothesis are outlined further under the relevant questions that were posed by the Synthesis Group.

Potential to increase productivity and improve environmental performance at farm gate

Hypothesis 1: There is potential to narrow the range of performance in milk production

Following the initial examination of the data generated for the Milkbench+ Report, the group then undertook further analysis and identified the following preliminary findings:

- Profitability, efficiency and productivity can be achieved across each of the farming types, therefore it is not considered that a radical shift into one of these systems is an optimum solution.
- The variation of performance does occur largely within each of the three defined farming types. Therefore, the potential for the industry to improve their efficiency should be examined within each system type. Furthermore, for the reason set out in the previous point, the group did not make recommendations for a shift to any specific system, or analyse the impact of doing so.
- A set of key measures for technical efficiency that would optimise the potential to maximise productivity (output per ha of land used, local and remote) within each system type was initially identified. Subsequently, a set of key indicators that achieve an increase in productivity was derived and used for further analysis. These are:

Overall production	**Grass/forage production and utilisation**
Feed efficiency	Herd fertility
Herd replacement rate	Herd health

- Annex 3 presents the productivity framework that was developed to present the findings of the assessment of the potential capacity of increasing milk production.

Overall, if the bottom half of performing farms achieve the level of efficiency achieved by average farms, then production could increase by around 7% (as defined by net margin in pence per litre).

Due to time and resource constraints, an analysis of the impact that this increase in productivity has on the environment was not explored.

Hypothesis 2: A number of measures could have a big impact on the environment

Following the work undertaken to examine the potential for the dairy sector to improve environmental outcomes, some of the key findings are as follows:

- A set of eight key environmental issues were identified as part of the work to assess the potential for the dairy sector to maximise improvement in environmental impacts. These are:

Biodiversity	**Diffuse pollution impacts – local**
Soil structure (including reducing sediment loss)	Diffuse pollution impacts – remote
Ammonia emissions	Greenhouse gas emissions
Water use	Deforestation due to feed from tropical crops

- Increasing heterogeneity of cropping/grassland and other forage species, and better integration of dairy, beef and arable production could be a universal measure that is integral to the dairy farm design. This approach should improve biodiversity, nutrient use efficiency, soil structure and other environmental benefits. Annex 4 provide further information and the analysis undertaken by the group.
- It was noted by some in the group that some conventional approaches to assessing the environmental footprint of dairy farms (and other livestock production) tend to overlook the indirect 'second order' impacts of the sector. This is particularly relevant to animal feed; where the impact on greenhouse gas emissions and land use change are driven

by the use of soy in feedstuffs, derived from South America. Annex 4 provides further information and the analysis undertaken by the group. It has also been noted that the UK dairy industry accounts for 0.2% of global soya production, and the environmental impact must be taken into account.

- There is no ‘one-size-fits-all’ solution; this would depend on the farm’s soil type, landscape and other environmental features. It is therefore proposed that a decision framework would be developed to enable a farmer to prioritise the environmental issues and action that are appropriate on their farm. Annex 5 provides a possible framework for this decision tool to improve a farm’s overall environmental performance.
- Increased efforts are needed to reduce the impact on the environment and society of imported soy, (for example, by increasing cropping of home grown forage legumes) and to ensure soy used by the dairy sector comes from more sustainable sources. Consideration should also be given to the greater use of home-produced co-products in feed.
- Reductions in nutrient loading are also needed, for example, to reduce the negative environmental, economic and human health impacts of reactive nitrogen as outlined in the European Nitrogen Assessment.
- Improving building designs, and better slurry management, handling and storage capacity would also be beneficial from the environmental perspective; including on animal health and welfare. It is acknowledged that this would require significant investment and steps are already being taken to achieve this in the areas most at risk of pollution through the NVZ action programme.

Due to time and resource constraints, an analysis of the impact that these improvements in environmental performance on farm productivity was not explored.

Presentation of key findings

To bring the analysis of both the production and environment groups together, the subgroup agreed a methodology to analyse the impact of the on-farm actions on increasing productivity and improving the environment. The subgroup identified a series of key management practices (although not exhaustive), that a dairy system could consider to either improve the environment, increase productivity or deliver both. These management practices were grouped under the following areas:

- **herd management** – e.g. reducing feed wastage
- **grazing and crop management** – e.g. greater use of precision farming methods
- **cattle breeding** – e.g. making use of improved genetic resources in livestock, where appropriate
- **crop breeding** – e.g. using plants with improved nitrogen use efficiency
- **land use** – e.g. reducing reliance on imported soy
- **soil management** – e.g. improved soil fertility management
- **fertiliser management** – e.g. optimising manufactured fertiliser application rates
- **manure management** – e.g. increasing the capacity of farm slurry stores to improve timing of applications
- **infrastructure** – e.g. improving building design
- **water use** – e.g. improved water storage and management
- **biodiversity** – e.g. retaining any existing unimproved or long-term uncultivated habitats

Each identified management practice was then assessed against the set of environmental and productivity indicators (as listed under hypothesis 1 and 2), including a social indicator around public perception (around e.g. technology and welfare), to consider the potential win-wins, tensions and tradeoffs.

The report now presented the conclusions of the subgroup, derived from the analysis described above.

Case Studies

The case studies presented below demonstrates that some farms are already taking actions that lead to an increase in productivity and environmental performance.

ABAgri's Compass Farms

The Compass programme aims to develop and validate new/innovative farming models, supporting farms on their journey towards a more profitable farming – more information is available at http://www.kwalternativefeeds.co.uk/resource-centre/the-compass-programme/. The Compass strategy covers herd health, nutrition and improved management capability. A summary of the actions taken on a Compass Farm that demonstrates some of the win-wins are:

Reduce calving-related problems:	❖ Dry cow feeding management adjusted ❖ Target Dry period of 42 days implemented
Move to proactive veterinary input:	❖ Increased veterinary input introduced ❖ Focus on prevention rather than cure ❖ Started weekly fertility visits ❖ Implemented new hers health protocols
Increase dry mater intake:	❖ Dry cows primed for lactation ❖ Ration balance improved (both palatability and physical structure) ❖ Fresh cow comfort improved and lameness reduced
Increase use of co-products	❖ Use of distillery liquids ❖ Use of food industry co-products ❖ Feeding a 'protected' rape meal to replace soya
Change to labour structure:	❖ Unskilled labour removed ❖ Knowledgeable herd manager employed ❖ Application of strict health and hygiene routines

The culmination of the actions taken, as described above, has resulted in an increase in the daily milk yield by 8 litres per cow and the annual milk yield increased from 8000 litres to over 10500 litres, per cow per year. In addition, the herd calving interval has been cut from 454 to 418 days, the average somatic cell counts have been cut from 300 to under 150, and clinical mastitis cases have reduced by 50%.

Tesco Sustainable Dairy Group & Dairy Centre of Excellence

The **Tesco Sustainable Dairy Group** was formed in 2007. This group of 700 farmers provides Tesco with all its liquid milk via contracts with processors Dairy Crest, Arla and Robert Wiseman. The farmers supply Tesco exclusively with all the milk they can produce; giving us quality assurance and stability of supply. In return the farmers are guaranteed a fair price for their milk, a guaranteed market and support with issues such as herd health, increasing the sustainability of their farms, and increasing yield.

Members of the Group must meet rigorous quality and welfare standards:

- Farm hygiene and management programmes, such as vaccination, appropriate animal husbandry and care, should be used to reduce disease and the need for therapeutic intervention.
- All of Tesco's dairy producers must have a written health and welfare plan.
- The Livestock Code of Practice (which goes further than the Red Tractor standards) enables us to monitor closely the welfare of the animals in our supply chain – we also audit our farmers independently every year.
- Most TSDG farmers have farm business accounts, which enables them to watch their costs more easily, as does feeding data into the Promar tracker.
- All TSDG farmer milk record, which enables them to manage their yields, fertility and costs, and work to improve them.

A biodiversity pilot is being developed for the Tesco Supply Dairy Group (TSDG) in collaboration with the RSPB, which will take place over the coming year with the 12 TSDG panel farmers and Liverpool University. This programme will seek to assess the existing nature value of producer/farmer landholdings within the TSDG, and support the group to monitor bird populations and implement best practice actions to maintain and improve nature.

The **Tesco Dairy Centre of Excellence** was established in 2009 is based at Liverpool University's dairy farm. Current research at the TDCE includes:

- <u>Reassessing the best way to feed calves.</u> A study is being co-sponsored by Tesco and the Technology Strategy Board and BBSRC under the Knowledge Transfer Partnership Scheme. Automatic feeding of calves with as much milk as they want will be compared to industry-typical restricted feeding. The metabolism of the animal will be studied and they will be followed until they join the milking herd. The ability to sponsor projects for longer than the usual 3 year PhD type project is an important part of Tesco's long-term commitment to the Centre.
- <u>Footbath trial to tackle lameness and project on calves</u>

Win-wins, Tensions and Tradeoffs

Hypothesis 3: There are a number of key potential win-wins with a positive impact on environmental and productivity measures

Following the analysis undertaken, a number of key potential win-wins were identified:

- improving herd health and management/eradication of endemic diseases and better resource efficiency including those relating to cow nutrition;
- improved building stock/infrastructure for ‘cow comfort’, having a positive impact on animal health and welfare;
- better integration of arable and pastoral production could improve nutrient use efficiency, where current hotspots exist, and bring soil and nutrient cycling benefits – e.g. reduced risk of diffuse pollution of water and air, improving soil organic matter of arable land and hence better soil structure potentially leading to improvements in crop performance and water holding capacity; reduced need for inorganic fertiliser on cropped land.
- reducing greenhouse gas emissions by employing mitigation options that do not have other negative environmental impacts and energy inputs;
- improved utilisation of genomic selection to breed the animal most appropriate for more sustainable systems.

Hypothesis 4: Constraints to progress being made

The subgroup members identified some tensions and constraints to achieving the environmental and productivity improvements that can be made by farmers:

- succession planning, access to capital, business structures and stability to allow farmers to access resources, e.g. land, infrastructure, technology;
- public awareness of possible future changes and understanding of what dairy production involves;
- planning regulations need to be more inclusive in relation to things such as animal welfare;

- there is a lack of strategic research and development and better knowledge transfer across the whole food supply chain;
- awareness of best practice and implementing these particularly in the hard to reach farms;
- there are difficulties in establishing an adequate bio-security framework;
- ensuring the processing capacity to sufficient to meet market demand;
- effective implementation and enforcement of existing regulation and cross-compliance is needed (in a way that is proportionate, consistent and transparent);
- awareness of biodiversity impacts and how these can be mitigated (particularly in industry knowledge transfer initiatives/programmes);
- there is a lack of research on grassland options in agri-environment schemes and voluntary initiatives to develop a package of measures to provide the key resources on a sufficient scale to meet biodiversity needs;
- adequate funding of agri-environment schemes and better uptake of high quality agri-environment options by dairy farmers is necessary to allow mitigation of negative environmental impacts;
- increased productivity should not achieved at the cost of animal welfare.

Hypothesis 5: Some longer term developments could push the boundary and move the frontier forward

The subgourp highlighted the potential longer term developments that could push the frontier forward for both productivity and environmental performance:

- plant and animal genomics, and associated disciplines;
- redistribution and integration of systems, including potentially some rebalancing between systems on a regional or national basis, allowing for adaptation to changing pressures for resources – e.g. feed, water and land;
- better communication with farmers and ensuring that action takes place is essential.

Radical development

The subgroup identified a list of more radical developments that could affect dairy farming over the next 40 year period. These were divided into those that farmers could actively take action on and those that they may need to respond to.

Actions that farmers can actively do:	Actions that farmers may need to respond to:
Infrastructure	GMO and other genomic technologies
Redistribution of dairy farming – in UK and globally	Changes in water availability in UK
Adoption of technological development	Major endemic disease patterns
Feed – growing different crops for feed (specifically protein crops, but also feed energy crops) in UK with improved technology/R&D	Changes in public perception of food production and nutrition
Farm restructuring /rationalisation of holdings	Competition for land – in UK and globally
Collaborate more effectively between businesses within dairy and between farming types	Food manufacturing – e.g. artificial milk
	Removing farm subsidies
	Domestic and global demand drivers
	Limited resources – e.g. water, oil, phosphorus
	Recognition of the value of the natural environment - markets develop for payment for Ecosystem Services
	Rationalisation of the industry, fewer larger farms will be a continuing trend in the future

Areas for further work

The subgroup recognised that more work is needed before sound recommendations can be made on the options for the future shape of dairy production in the context of the agricultural and food industries as a whole. This includes:

- Quantifying not only the financial but the physical inputs, outputs and impacts of current dairy farm systems.
- Using the results together with computer models, currently existing and further developed, to examine the options for sustainable systems. This will enable quantification of the impact of increased productivity on the environment, and vice versa.
- Further exploration on the potential for integrating the dairy, beef, arable and other sectors.
- Further developing the decision support tool, outlined in Annex 5, allowing farmers to prioritise environmental issues in context of soil, landscape and environmental features.
- Exploring land sparing versus land sharing in a UK dairy production context to deliver further environmental and economic benefits.
- Take a more strategic overview of the dairy sector, encouraging better joined up thinking with common indicators of success across the food chain and academia.
- Further analysis could be conducted by the synthesis group to identify the most sustainable options in relation to physical inputs, e.g. fossil energy and phosphorus, for the future.
- Further work is required to fully explore the cultural constraints, i.e. behaviour change, to achieving more consistent standards of farm business efficiency across dairy farming business in the UK. This also needs to take into account of the environmental impacts.
- The barriers to uptake of best practice needs further exploration. Initial recommendations made in the report, include the establishment of efficiency KPIs, that are well communicated and understood, that the dairy sector can work to.
- Proper assessment is needed of the role that the processing sector has to reacting to a potential increase in the dairy production in the UK.

Annex 1: Glossary of terms used

Efficiency:	Producing more effectively with minimum waste, expense and use of inputs.
Productivity:	Increasing output relative to the inputs used
Production:	The total output in quantitative terms

Annex 2a: Analysis on the theoretical land requirement for Milkbench+ analysed dairy herds

Feed quantities per herd - Data collected and validated through Milkbench+

Type of feed	Cows at grass			Composite			High-output cows		
(t FW/herd/year)	Average	Top 25%	Bottom 25%	Average	Top 25%	Bottom 25%	Average	Top 25%	Bottom 25%
Home-grown cereals	21.9	49.3	14.2	16.8	13.1	28.0	48.7	40.5	51.1
Home-grown protein feeds	2.7	2.1	4.8	0.3	0.7	0.5	1.7	0.0	5.6
Home-grown arable by-products	2.3	0.0	0.0	0.0	0.0	0.0	1.9	7.5	0.0
Purchased compound feeds	195.7	225.0	87.9	291.5	323.3	227.5	466.8	594.3	357.7
Purchased cereals	5.7	1.5	11.0	16.6	21.1	20.1	31.3	20.8	37.9
Purchased protein feeds	13.7	21.5	21.7	8.0	3.4	19.1	88.3	100.5	62.6
Purchased by-products	41.1	68.4	25.3	71.4	107.4	57.4	261.8	332.2	219.7

Using co-efficients calculated by Cranfield University, the quantities of non-forage feed has been converted in to the area required to grow the estimated quantities fed to each herd. This calculation was then, along with forage areas, converted to estimate the area required per one million litres of milk produced under each system type.

Theoretical land requirements for producing one million litres of milk using assumptions on land requirements of different feedstuffs

Land requirement for 1 milion litres of milk produced	Cows at grass			Composite			High-output cows		
(ha/1'000'000 l/year)	Average	Top 25%	Bottom 25%	Average	Top 25%	Bottom 25%	Average	Top 25%	Bottom 25%
Area for grazing	86.85	74.53	115.55	66.06	54.27	77.36	38.22	35.14	45.79
Area for conserved forage	15.55	8.02	22.21	18.05	14.02	18.69	22.46	16.76	29.04
Area for feed production	22.49	19.68	27.57	30.80	28.05	36.72	43.46	39.54	46.92
Area for home-grown feed	*3.18*	*4.41*	*3.71*	2.43	1.59	3.96	*4.20*	*2.67*	*6.25*
Area for purchased feed	*19.31*	*15.27*	*23.85*	*28.38*	*26.47*	*32.76*	*39.26*	*36.87*	*40.68*
Total land area required	**124.89**	**102.23**	**165.33**	**114.92**	**96.34**	**132.77**	**104.14**	**91.44**	**121.76**
Notes:									
The above does not include land for dairy buildings, parlour, farm house, tracks, hedges, manure storage etc.									

The analysis shows the top 25% use less land than the bottom 25% for the same number of litres of milk produced. What cannot be confirmed from this analysis is whether there are geographical factors that influence this trend or whether the top producers are generally better at utilising feed and forage resources. Although the latter must be a strong possibility due to the strength of the trend.

Annex 2b: Analysis on land requirement for production

	ha/t	
Compounds	0.078	(UK)
Cereals	0.14	
Mixture of these crops		
Wheat	67%	
Winter Barley	17%	
Spring Barley	13%	
Oats	3%	
By-products (equal weighting)	0.052	
Molasses		
Brewers grains		
Beet pulp		
Biscuit Blend		
Malt Culms		
Rice bran non-org USA		
Proteins purchased (equal weighting)	0.27	
Sunflower meal weighted non-org		
Soy meal weighted non-org		
Rape meal non-org		
Wheatfeed weighted org		
Feed Beans		
Proteins home grown		
Field beans (very similar to peas)	0.31	

Annex 3 - Dairy Productivity Framework

Table 1. Current performance (as single variables)

Sentinel productivity indicator (as single variables)	Production system								
	Cows at grass			Composite			High-output cows		
	Average	Top 25%	Bottom 25%	Average	Top 25%	Bottom 25%	Average	Top 25%	Bottom 25%
Forage output									
Stocking rate (LU / adjusted ha)	2.0	3.0	1.1	1.8	2.4	1.2	2.2	3.0	1.5
Grass silage production (t/dm/ha)	4.4	5.2	1.9	4.0	5.4	2.8	4.2	6.1	2.7
Other forage production (t/dm/ha)*	9.1	14.4	4.0	9.8	13.1	6.8	11.4	15.0	7.6
Forage utilisation									
Milk from forage**	2951	4127	1742	2023	3430	568	1237	3033	-1033
Feed conversion									
Feed conversion efficiency (kg milk/kg feed DM)***	1.9	2.7	1.3	1.5	1.8	1.2	1.4	1.7	1.1
Herd fertility									
% calved in year	74	88	56	71	84	57	71	79	62
Cow longevity									
Herd replacement rate	23	13	35	25	15	36	26	18	36

Notes:
The ranking into bottom ¼, average and top ¼ based on individual variables, rather than on net margin.
*Includes maize, wholecrop and other non-grass forage
**Milk from forage = Average yield (l/cow/year) – (Energy from feed (ME/cow/year)/Energy content of 1 l of milk)
*** Energy corrected milk (ECM) (kg) = (milk production (l/year)*1.033*(0.383*butterfat (%) + 0.242*protein (%) + 0.7832)/3.1138)
Source DLG (2001), IFCN (2011
Feed conversion efficiency (FCE) = ECM (kg)/ feed and forage fed excl. grazed grass (kg DM)

Table 2. Current performance (aggregate data by farm type, ranked by net margin)

Sentinel productivity indicator (aggregate margin, p/l)	Production system					
	Cows at grass		Composite		High-output cows	
	Bottom ¼	*Top ¼*	*Bottom ¼*	*Top ¼*	*Bottom ¼*	*Top ¼*
Forage output						
Stocking rate (LU / adjusted ha)	1.6	2.3	1.7	2.4	1.9	2.5
Grass silage production (t/dm/ha)	3.2	3.6	3.8	4.4	4.0	4.5
Other forage production (t/dm/ha)*	9.4	11.0	8.6	11.2	10.9	11.8
Forage utilisation						
Milk from forage**	2597	3502	1544	2414	711	1710
Feed conversion						
Feed conversion efficiency (kg milk/kg feed DM)***	1.5	2.3	1.3	1.7	1.3	1.5
Herd fertility						
% calved in year	69	78	68	75	71	71
Cow longevity						
Herd replacement rate	23	21	29	22	27	24

Notes:
Ranking into bottom ¼ and top ¼ based net margin in p/l.
*Includes maize, wholecrop and other non-grass forage
**Milk from forage = Average yield (l/cow/year) – (Energy from feed (ME/cow/year)/Energy content of 1 l of milk)
** *Energy corrected milk (ECM) (kg) = (milk production (l/year)*1.033*(0.383*butterfat (%) + 0.242*protein (%) + 0.7832)/3.1138)
Feed conversion efficiency (FCE) = ECM (kg)/ feed and forage fed excl. grazed grass (kg DM)

Table 3. Impact on production of bringing below average farms up to the average (Source Milkbench+ data)

	Cows at grass	Composite	High-output cows
Average l/ha for top 10 farms based on net margin p/l	13,359	17,242	24,008
Average l/ha for average 10 farms based on net margin p/l	13,012	12,571	18,772
Average l/ha for bottom 10 farms based on net margin p/l	6,330	9,453	14,305
Total hectares currently used for dairy production	8,547	10,696	14,633
Number of farms with below median net margin	39	61	65
Total hectares used by below median dairy enterprise	3,477	4,990	6,903
Current milk production by below median (1000's l)	32,526	58,715	112,532
Current MB+ milk production (1000's l) by system	92,305	132,779	257,593
Total	482,677		
Theoretical production by below median dairy enterprises if brought to the average level (1000's l)	45,249	62,733	129,584
Theoretical additional production for the MB+ sample (1000's l) through improved efficiency	12,723	4,017	17,052
Total	33,793		
Potential theoretical milk production if below median farms achieve average farm's level of efficiency (1000's l) for the Milkbench+ sample	105,028	136,796	274,645
Total	516,470		
% change in milk production	7%		

ANNEX 4 - Discussion Paper: How can the dairy industry improve environmental outcomes?

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Summary

This paper proposes an approach to improving the environmental impact of dairy farms in England, in the period up to 2050, based primarily on increasing cropping diversity and/or within sward diversity. Given the time constraints of the Green Food Project, it is unrealistic to produce a comprehensive analysis of how impact can be improved across all environmental aspects. Instead, the authors argue that increasing heterogeneity of grassland and other forage species, and better integration of dairy, beef and arable production, could be universal measures which should improve biodiversity, nutrient use efficiency, soil structure and other environmental benefits. Two case studies are given of how this could be achieved, along with likely environmental impacts. There can be no blueprint applicable to all farms; rather a decision framework is proposed with which individual farmers could prioritise environmental issues and deliver an increase in cropping/sward diversity in the context of their own soils, landscape and environmental features.

Background

At the outset of this project, the authors identified nine key environmental impacts of the UK dairy sector, which are outlined in Appendix 1. For all these impacts, measures can be implemented to, at least partly, mitigate current negative impacts of the dairy sector. However, given the time and resource constraints associated with the current Project, the authors have particularly focused on issues where they consider least progress is being made by the dairy industry – improving biodiversity outcomes and fully accounting for the indirect environmental footprint of the sector (such as land-use change associated with imported soy). Improving biodiversity outcomes was considered to be particularly challenging and therefore the authors propose this issue should be designed into the system first. The environmental component of industry Knowledge Transfer initiatives is based heavily on resource use efficiency – in particular, on measures which will reduce cost. Such approaches are not covered here in detail as the authors consider that best value will be added by examining the issues which receive little attention in existing programmes.

Impacts of ‘intensification’ on biodiversity

Agricultural intensification has been a major contributor to a widespread decline in farmland biodiversity across many taxa. In the UK, major declines in farmland birds are well documented and similar patterns have been shown for other groups including mammals, arthropods and flowering plants. While there has been more focus on arable areas, changes in livestock farming practice are considered a major cause of biodiversity declines in the lowlands. For example, there is evidence of severe declines in the abundance and range of farmland birds in lowland pastoral areas[8], particularly seed-eaters[9] and those reliant on sward-dwelling invertebrates to feed their chicks. Indeed, for bird species, local extinctions have been more common in grass-dominated areas compared to arable areas[10]. A number of species which were widespread in lowland grassland a century ago have become very rare or extinct in these habitats.

The problem of uniformity and polarisation

Rather than any particular farming practice causing biodiversity decline, 'intensification' is multivariate[11] and the elements of agricultural intensification (reseeding and fertilisation of grassland, land drainage, increased livestock densities etc) interact very strongly. A universal consequence of agricultural intensification is the replacement of heterogeneity in habitat structure, in time and space, with homogeneity[12]. For example, failure to retain heterogeneity in agricultural land-use at the farm scale is likely to be an important reason for range contraction and local extinction of bird species in grassland areas[13]. Of particular importance is the loss of habitats that wildlife need for different purposes and at different times of year. The resources wildlife need must be present within their limited ranges, so localised habitat losses result in landscapes that can no longer support wildlife. For example, mixed-diet seed eating birds need different habitats in the breeding season (spring/summer) and winter (typically insect-rich grasslands and weedy cereal stubbles, respectively). The birds are unable to persist in homogeneous landscapes that do not have both habitats within the dispersal range of the birds. Polarisation into specialized livestock and arable regions has reduced variation at the landscape scale with larger contiguous areas becoming dominated by either tilled land or grassland[14].

There has thus been a tendency towards uniformity at different spatial scales from within the sward up to the landscape level, with negative impacts on biodiversity[15]. This has led to the conclusion that, rather than concentrating on particular farming practices, there is an identifiable management objective – promoting heterogeneity – that could be applied widely across agricultural systems to promote biodiversity across different taxa by making the necessary resources available for wildlife throughout the year [16]. This is particularly the case

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[8] For example, Chamberlain, D.E. & Fuller, R.J. (1999) Local extinctions and changes in species richness of lowland farmland birds in England and Wales in relation to recent changes in agricultural land use. Agriculture, Ecosystems and Environment, 78, 1-17; Chamberlain, D.E. & Fuller, R.J. (2000) Contrasting patterns of change in the distribution and abundance of farmland birds in relation to farming system in lowland Britain. Global Ecology & Biogeography, 10, 399-409.

[9] ibid

[10] ibid

[11] Chamberlain & Fuller (2000)

Benton, Vickery and Wilson (2003) Farmland biodiversity: is habitat heterogeneity the key. TRENDS in Ecology and Evolution vol 18 no 4;

Robinson, R., Wilson, J.D. & Crick, H.Q.P. (2001) The importance of arable habitat for farmland birds in grassland landscapes. Journal of Applied Ecology, 38, 1059-1069.

[14] Robinson, R.A. and Sutherland, W.J. (2002) Post-war changes in arable farming and biodiversity in Great Britain. J. Appl. Ecol. 39,157–176

[15] Benton, Vickery and Wilson (2003) Farmland biodiversity: is habitat heterogeneity the key. TRENDS in Ecology and Evolution vol 18 no 4; Wilson, Whittingham and Bradbury (2005) The management of crop structure: a general approach to reversing the impacts of agricultural intensification on birds. Ibis 147 453-463; and Robinson, R., Wilson, J.D. & Crick, H.Q.P. (2001) The importance of arable habitat for farmland birds in grassland landscapes. Journal of Applied Ecology, 38, 1059-1069.

[16] Benton, Vickery and Wilson (2003) Farmland biodiversity: is habitat heterogeneity the key. TRENDS in Ecology and Evolution vol 18 no 4

for high intensity agricultural landscapes[17] such as those found in areas of intensive grassland management. It is important to note that maize is far less beneficial than cereal crops for biodiversity so lacks the benefits of reintroducing other arable crops.

The authors consider that the polarization/specialization of livestock and arable production has also led to increased problems of nutrient loading in intensive grassland 'hotspots'. For example, ADAS recently reviewed the evidence base for assessing the impacts of the NVZ (Nitrate Vulnerable Zone) Action Programme on water quality in England.[18] They found that losses of nitrate from intensive grassland management, associated with intensive dairying, often exceeds 50 mg/l, even if farmers follow best practice and the 2008 NVZ measures are adopted (for example, livestock manure N farm limit of 170 kg/N/ha). Nitrate concentrations in excess of 150 mg/l are not unusual below intensively managed grassland, whereas nitrate leaching below permanent pasture that is grazed extensively or lightly fertilized is often well below 50mg/l.

The review concludes that: *'Losses of pollutants from grassland systems are correlated with numbers of livestock. Intensively stocked farms generate greater losses per hectare and per animal kept... Therefore, a reduction in stock numbers reduces the losses of all pollutants. ..In general, the countries with the highest excretion per unit area have the lowest nitrogen utilisation efficiency (NUE) figures. This is because livestock are inefficient users of N compared to arable crops and intensive livestock rearing concentrates manures in a small area. The greatest benefits of reducing stocking density would be felt if there was a reduction in total stock numbers.(page 18)'*

However, some redistribution of livestock and their manures through more integration of arable and pastoral production (where soil type or topography allows) could also reduce nutrient load in current hotspots. Furthermore, it could bring soil and nutrient cycling benefits – for example, by improving the level of soil organic matter in arable areas.

In considering how the dairy industry could improve environmental outcomes, the opinion of the authors is that promoting heterogeneity would be a widely applicable and flexible measure that would be likely to yield significant biodiversity benefits. It would also be compatible with reducing nutrient loading in intensive pastoral areas and thus reducing damaging emissions.

Homogeneity within the dairy sector and impacts on biodiversity

Within ruminant livestock systems, a trend towards homogeneity is particularly evident in the dairy sector. The authors consider that specialisation within the sector and the focus on meeting the modern dairy cow's nutritional requirements have been key drivers towards this uniformity of land use in dairy areas.

There has been a move away from grassland grazed or cut at a later stage of growth or containing less digestible species, and on a substantial proportion of dairy farms an increasing

[17] Batary et al (2011) Does habitat heterogeneity increase farmland biodiversity. Frontiers in ecology and the environment. Vol 9 issue 3

[18] ADAS December 2011 Nitrates Directive Consultation Document The evidence base for assessing the impacts of the NVZ Action Programme on water quality across England and Wales.

reliance on supplementary feeding with bought-in, or home grown, concentrates, in order to meet milk specifications and animal dietary needs[19]. Species-rich hay fields, unimproved grasslands and certain beneficial forms of arable cropping (especially spring sown cereals and Brassica/root forage crops) have been replaced in pastoral areas by ryegrass-dominated fields (sometimes with white clover) and fodder maize.

There has also been a tendency towards uniformity within the sward. The dairy industry places great emphasis on efficiency in grassland management because high yields of quality forage are seen as essential for silage to feed cows during winter, as well as summer grazing. Achieving high grassland utilization is a major focus of the industry's technical knowledge transfer programmes. Swards on dairy farms tend to be very intensively managed - typically receiving twice the rate of inorganic fertilisers used on grassland in the average beef or sheep farm (mean rates of c 120kg/N/ha on dairy swards, though this is nearly half the amount used in the mid-1990s) [20]. The authors have been unable to access up-to-date information on soil nutrient status on dairy farms but we recommend that such data would be valuable, for example, to allow better understanding of phosphorus balance in grassland systems.

Conventional (ie non-organic) dairy swards include both recently sown (ryegrass dominated) leys and older grassland which, because of its management, tends to resemble sown leys in terms of having a uniform structure and being dominated by perennial ryegrass[21]. These dense, heavily fertilised swards are cut early and sometimes repeatedly for silage or are grazed heavily.

Both intensively managed grassland and maize are challenging habitats for biodiversity, lacking suitable nesting environments and both invertebrate and seed food resources. Modern grassland management aims to prevent seed production and maize fields lack seed resources due to the intensive weed control associated with maize management. In addition, both conventionally cut grass silage and maize fields can act as ‘ecological traps’ for ground nesting birds – skylarks are attracted to silage fields and lapwings to maize stubbles but birds breeding in these habitats produce insufficient young to maintain their own populations. Birds are drawn into these fields from elsewhere in the landscape, so there must be sufficient suitable habitat nearby to compensate for this if populations are to survive. As intensively managed grassland and maize have become prevalent in dairying areas, such ‘donor’ habitats have become scarce.

Intensively grazed fields (grazed to relatively low target sward heights, to optimize livestock outputs) have relatively little value as foraging habitats for many farmland birds (particularly the suite of declining mixed-diet seed eating birds, including the buntings and skylarks). Swards grazed to higher average sward heights and not routinely topped, result in greater structural heterogeneity, greater invertebrate prey densities and greater utility to such birds.

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[19] Garnett (2007) Meat and dairy production and consumption. Exploring the livestock

sector’s contribution to the UK’s GHG emissions and assessing what less GHG intensive systems of production and consumption might look like. FCRN paper.
Section 2.2 Feeding the dairy herd

[20] Hopkins and Lobley, 2009 *A scientific review of the impact of UK ruminant livestock on greenhouse gas emissions.* University of Exeter CRPR Research Report 27.

[21] ibid

Structural heterogeneity is considered to be key to sustaining high biodiversity across different taxa as different groups (insects, plants etc) have varying requirements in relation to moisture, access to light, freedom from defoliation and so on, which are best promoted by heterogeneity.

A location-specific approach to increasing cropping/sward diversity

The authors propose that, appropriately managed, an increase in cropping diversity, and within sward diversity, would potentially yield a range of environmental benefits. To achieve optimum outcomes for different environmental aspects (biodiversity, resource protection etc) in a given situation, the approach to increasing cropping/sward diversity would need to be context specific and in particular, would depend on choosing an appropriate method of increasing diversity and appropriate siting (and of course, such decisions would have to complement the wider management of the farm). To give a couple of examples, if there is existing grassland of wildlife value, this should not be replaced by arable cropping or reseeded, and careful field selection is crucial if cropping diversity is increased through introduction of forage brassicas to prevent erosion and risk to water courses. Strategic introduction of small patches of suitable habitats to support biodiversity or resource protection (for example, through agri-environment measures for field margins/corners) can also provide considerable benefits. The authors propose a decision tree would be an appropriate framework for considering existing features and constraints, and then choosing the most appropriate ways of increasing cropping/sward diversity in the context of a given farm (see Annex 5 of the final Dairy Subgroup Report).

A word about scale

Habitat heterogeneity, at a range of spatial scales, has been greatly reduced wherever intensification has affected agricultural landscapes and is clearly important in maintaining biodiversity within these landscapes by providing resources throughout the year for species-rich communities. Enhancing heterogeneity at a variety of spatial and temporal scales will ensure that a range of taxa whose requirements may differ (for example, birds and plants) are accommodated[22]. It is recognized that farmers generally do not manage at the landscape level, but policy makers can consider whether different drivers are likely to enhance or impoverish heterogeneity at larger spatial scales. For example, targeted measures within agri-environment schemes and a broader uptake of a wider range of options, could lead to increased heterogeneity across farmed landscapes. The development of remedial agri-environment measures for livestock systems has lagged behind that for arable farmland, but has been the subject of increased research effort during the last 5 years[23]. Equally, the drivers likely to lead to yet further homogeneity in land use within the dairy sector should be identified. Sections 8 and 9 provide two case studies of how diversity could be increased – one at the field scale and one at the within-sward scale.

Other benefits of increasing cropping/sward diversity

While increasing cropping and/or grassland diversity was proposed initially to enhance biodiversity, the authors consider that, if appropriately managed, this approach could also bring other environmental benefits. For example, increasing the number of species , particularly legumes and herbs, in grassland for grazing and cutting could be anticipated to

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[22] Benton, Vickery and Wilson (2003) Farmland biodiversity: is habitat heterogeneity the key. TRENDS in Ecology and Evolution vol 18 no 4.

[23] Buckingham *et al*. 2010. New livestock measures for birds. *BOU Proceedings – Lowland Farmland Birds III*.

improve soil structure, water infiltration and gaseous exchange. Carbon benefits may also arise due to a reduction in use of inorganic nitrogen if leguminous species are incorporated.

A number of forage legumes have considerable potential in England, depending on soil type and location. All are high in protein, could increase biodiversity as well as benefitting soil structure and require no N fertiliser:

White clover. Already the key species on organic dairy farms and present at low levels on many conventional farms. Great potential for this to be increased.

Red clover. Higher yielding but less persistent than white clover. Particularly suitable for short-term silage leys on almost all soil types , and for rotational grazing.

Lucerne (alfalfa). The backbone of dairy farms in many countries worldwide. Very high-yielding and drought resistant so of increasing interest with climate change. Suitable for well-drained soils - particularly if calcareous but is very difficult to graze. Currently little-used in UK.

Sainfoin. Similar to lucerne, lower yielding but non-bloating. Almost non-existent on UK dairy farms.

Peas/beans/ lupins. Annual crops with high protein and potential to mix with cereals for wholecrop silage

Non-leguminous, non-cereal forage crops include kale and other brassicas which can be high-yielding and high in energy. If grazing careful site selection is needed to avoid soil damage/ runoff.

There is also potential for bi-cropping. Wholecrop cereals have been successfully grown in a base of white clover. Cereals and brassicas can be grown together.

The indirect footprint of the dairy sector – for example, due to land use change linked to importation of soy -could also potentially be reduced through greater on-farm cropping diversity. The impacts of introducing new cropping types would vary depending on the situation. For example, if Cereal Based Whole-Crop Silage (CBWCS) is introduced in place of maize, in addition to biodiversity benefits, there could be a reduced risk of resource protection problems given that maize is considered a high risk crop in terms of soil structural damage and run-off due to extensive periods of low ground cover and the need to harvest late in the year, often in sub-optimal weather conditions[24].

Case study 1- Cereal-Based Whole-Crop Silage[25]

Arable crops, particularly cereals, are disproportionately valuable for maintaining declining farmland bird populations in grass-dominated areas[26]. The production of combinable arable

[24] Natural England, 2009. Environmental impacts of land management. Report NERR030

[25] The following is based on Peach, W.J. 2007. *Cereal-based whole crop silages: a potential conservation mechanism for farmland birds in pastoral landscapes*. Final report

to Defra on Project BD1448. London: Defra,

http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=ProjectList&Completed=0&AUID=952 and Buckingham, D.L., Atkinson, P.W., Peel, S. & Peach, W. 2010. New conservation measures forbirds on grassland and livestock farms. *BOU Proceedings – Lowland Farmland Birds III*.

http://www.bou.org.uk/bouproc-net/lfb3/buckingham-etal.pdf crops has greatly declined in western Britain as part of the regional specialization into grass-based production. A wide range of crops may be grown to provide alternative sources of fodder for livestock, and could provide a mechanism for reintroducing heterogeneity to grass-dominated areas.

Cereal-based whole-crop silage (CBWCS) has become increasingly popular among UK livestock farmers in recent years and is notable for the substantial biodiversity benefits provided compared to both maize and grass silage. It is highly palatable to dairy cows, resulting in higher dry matter and energy intake than with grass silage alone, reduced rates of acidosis, and increased health and fertility of dairy cows[27]. Unlike grass, CBWCS provides feed of consistent quality giving predictable, high yields. Previous issues with aerobic spoilage of CBWCS can be overcome by additives[28] and there can be advantages when introducing CBWCS into maize-grass systems in that harvest and management operations take place at different times of year, spreading the workload. The following is taken from Defra project BD1448:

*'A key attraction of whole-crop cereals is flexibility and economic return. They can be fed to dairy cattle, beef cattle, young stock and sheep, up to 100% forage DM intake or in mixed rations with other silage. The production system is also flexible in that in some instances the decision on how much whole-crop is needed can be delayed until late in the cereal growth stage and after first grass silage cuts have been taken. If there is sufficient grass, then the cereal crop can be harvested as grain. If not, then it can be harvested as fermented whole-crop or left to a later stage and preserved as alkaline whole-crop with urea-based additives (*Note that the latter has a high-risk of ammonia emissions)*. Overall, farm profitability can be increased with better use of home-grown forages. Whole-crop has lower production costs than grass or maize silage…'*

Biodiversity benefits

The biodiversity and agronomic impacts of CBWCS have been assessed in a recent study (Defra/ Natural England project BD1448). This research compared the three standard commercial silage crops – grass, winter wheat and maize – with the arable crop predicted to provide the greatest benefits to farmland birds: spring barley, along with its associated winter stubbles.

Barley treatments (either sprayed with just a narrow-spectrum herbicide or also with a broad-spectrum herbicide) were strongly preferred by Red-Listed species including Yellowhammer, Tree Sparrow and Skylarks. In summer, barley crops were also used relatively heavily by a range of birds including granivores, Skylarks, gamebirds, insectivores and Hirundines - probably in response to a combination of high invertebrate biomass and the late summer grain resources. The impact of early-harvesting of CBWCS on ground-nesting species (notably corn bunting and skylark) has not been determined. Although the winter wheat crops were strongly avoided by most birds of conservation priority during winter, usage during summer was similar to that of barley fields. However, effective weed control rendered maize a relatively sterile crop

[26] Robinson, R., Wilson, J.D. & Crick, H.Q.P. (2001) The importance of arable habitat for farmland birds in grassland landscapes. Journal of Applied Ecology, 38, 1059-1069.

[27] Lewis, P. 2007. *Whole-Crop Cereals in UK Agriculture - a briefing document covering current practices and research findings*. Report by Harper Adams University College to Natural England and Defra under project BD1448.

[28] Ibid; personal communication Jonny Bax.

during both summer and winter. Invertebrate biomass was significantly lower in summer, while there was a lack of winter seed resources. Grass fields were little used by most farmland birds (particularly the conservation priority species) during summer or winter, probably due to a severe lack of invertebrate and seed food driven by the lack of forbs and reproductively active grasses.

Agronomic impacts

The production costs of CBWCS[29] , were £43–62/t DM, considerably lower than those of grass silage (*c*. £77/t DM) and similar to those of maize (*c*. £52/t DM). The high and predictable yields of winter wheat made this the most attractive whole-crop cereal option for livestock farmers (production costs *c*.£50/t DM); the equivalent costs for spring barley whole-crop were about 15% higher (*c*. £58/t DM).

Growing spring barley whole-crop without the use of a broad-spectrum herbicide reduced yield by 13% and increased production costs by 6% (*c*. £61/t DM). In some situations, farmers in England can now receive payments through the Entry Level Scheme (ELS) to grow up to 5 ha of CBWCS each year. No broad-spectrum herbicide can be used and following stubbles must be left *in situ* through the following winter. The payments available on these 5 ha of CBWCS make the production costs the lowest of all silage crops, reducing costs by approximately 40% for spring barley (from *c*. £61/t DM to *c*. £36/t DM) and by an estimated 33–37% for winter wheat (depending on the reduction in yield from not using broad-spectrum herbicide).

In conclusion, there are strong economic and biodiversity reasons for wider uptake of CBWCS in grassland-dominated regions (with one exception, CBWCS should not replace existing low-intensity arable cropping or high biodiversity-value grasslands). Note that it is proposed to remove the 5 hectare cap on CBWCS in Entry Level Scheme from 2013 which would further reduce obstacles to take up.

Case study 2 - The Wide-scale Enhancement of Biodiversity (WEB) project

The WEB project is testing legume- or legume plus forb mixtures compared with grass only swards with the following objectives:

- achieve modest plant diversity enhancement including robust herb and wildflower species thought able to compete in productive swards
- increase pollinators and other invertebrates
- improve soil structure
- reduce nutrient losses and C footprint
- improve agronomic value

This project is providing evidence that a moderate increase in plant diversity has the potential to deliver these multiple objectives. Previous research (Defra project BD1624) showed that more competitive legume species have a good chance of establishing and persisting in soils with a moderately high P Index (at least 2+), which would make them suitable for use in many agriculturally improved grassland soils.

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[29] Calculated at 2007 prices.

Environmental benefits

There is evidence that increases in plant diversity can deliver a range of benefits including grassland faunal diversity and abundance enhancement, soil structural amelioration and nutrient retention and agronomic value in terms of forage quality. Legume-rich swards are likely to provide significant benefits for insects and other fauna and provide landscape pathways that could aid their adaptation to climate change. Phase 1 of this project (Defra/ Natural England project BD1466, 2008-2011) established multi-factorial experiments on grasslands in Devon and Berkshire. Both sites had heavy soils and few plant species. The experimental aim was to develop simple, low cost management prescriptions to enhance biodiversity and ecosystem services. Factors investigated were low cost seed mixture composition (grass only, grass+legume, grass+legume+forb), seed bed preparation (minimal cultivation vs. conventional ploughing), and the type (cut vs. grazed) and intensity (typical vs. summer rested) of management.

The response of a wide range of biological, biophysical and agronomic variables were measured, including botanical composition, floral and seed resources, pollinator diversity, invertebrate abundance, soil nutrient concentration, bulk density, compaction and nutrient leaching losses, herbage productivity and quality, and liveweight gain.

The initial results are promising, confirming that a range of legumes and robust herbs can be established and maintained. Large differences were found in the composition of the plant community between different seed mixtures. Although all species could be oversown into existing swards, ploughing and reseeding resulted in better establishment. There is also evidence that restrictions to cutting and grazing management drive positive biotic responses of the floral resource, pollinator assemblage and biomass of invertebrates available for farmland birds. However, the effects of management are likely to take longer to fully emerge. Similarly, abiotic responses particularly those relating to soil structure and nutrients, will also take time to manifest themselves. For these reasons it has been agreed to extend the project for a further two years. Phase 2 (2011-2013) will enable a full, integrated assessment of the benefits of the different management prescriptions on biodiversity and ecosystem services.

Agronomic impacts

Legume-rich swards are of high nutritional value for livestock and require little or no nitrogen fertiliser. Previous research (Defra project BD1404) showed that increased plant diversity can also increase biomass production and nitrogen content of the forage, which was not just due to higher legume diversity, but to a greater diversity of forbs in general. There were significant differences in agronomic output between the different seed mixtures.

In conclusion, increases of plant diversity within grassland swards should provide win-wins in terms of landscape, agronomic and biodiversity benefits. This approach is also anticipated to contribute to resource protection by greater nutrient use efficiency and restructuring agriculturally damaged soils, which should in turn benefit soil biodiversity, and reduce erosion and flood risk. Reseeding is only appropriate for agriculturally improved grassland and should not be considered for semi-natural habitats.

Accounting for the indirect environmental footprint of the sector

In identifying the key environmental impacts of the dairy industry, the authors highlighted that analysis has shown that conventional approaches to assessing the environmental footprint of livestock production tend to ignore the less direct, but often considerable[30], 'second order' impacts of the sector (such as those relating to animal feed production). This issue is particularly pertinent to two of the impacts identified – greenhouse gas emissions and land use change in South America and elsewhere, driven by the use of soy derived feedstuffs. As mentioned, the authors believe that enhanced on-farm cropping and grassland diversity could go some way to ameliorating the sector's reliance on imported protein. However, two other issues were discussed in relation to this point. Firstly, could there be environmental benefits to systems based on more multifunctional dairy animals better suited to meat production?[31] Secondly, is there potential for further use of by-products and waste products for feed within the dairy sector and would this be environmentally beneficial?

Considering dairy and beef production as a whole

The objective of increasing milk yield in the dairy industry has led to a separation between the beef and dairy herds, with dairy cows bred to produce milk and beef herds meat. In a paper examining greenhouse gas emissions from dairy and meat production, Garnett[32] reviews the evidence relating to the effect of breeding for specialisation rather than multifunctionality in the dairy industry and notes that on-going specialisation may be environmentally questionable. For example, Cederberg and Stadig[33] observe that in Sweden, milk output was almost the same in the year 2000 as it was in 1990, but this was achieved with 25% fewer cows. This means that the meat which would have been produced as a by-product of the dairy system has had to be compensated for with a substantial increase in the number of beef cattle reared. Beef imports have also shown an increase. This highlights the importance of viewing the cattle industry as a whole, producing both beef and dairy products.

Garnett also points out that improvements in dairy productivity through breeding strategies have not been an unalloyed success. She concludes these higher yielding cows are more prone to lameness, infertility and illness; they also usually have shorter life spans than lower yielding breeds. Once these factors are taken into account, Garnett claims, the remarkable improvements in milk productivity (and concomitant decline in methane emissions per unit of output) are questionable.

Recently, a number of research papers have highlighted the importance of system boundary and impact categories when evaluating the carbon footprint of milk[34]. Brien et al. [35] found that the method of reporting greenhouse gas (GHG) emissions altered the ranking of dairy systems. This study found that GHG emissions were higher using the LCA method (life cycle analysis) rather than the IPCC (Intergovernmental Panel on Climate Change) method. The effect of feed system on emissions per unit of product was inconsistent between

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[30] Garnett (2007) Meat and dairy production and consumption. Exploring the livestock

sector's contribution to the UK's GHG emissions and assessing what less GHG intensive systems of production and consumption might look like. FCRN paper.

[31] Cederberg and Stadig, 2003. System expansion and allocation in life cycle assessment of milk and beef production Int J LCA 8 (6) 350-356; Casey and Holden, 2006. Quantification of GHG emissions from suckler-beef production in Ireland. Ag Sys 90 79-98

[32] Garnett (2007)ibid 23

[33] Cederberg C and Stadig M. (2003).ibid 24.

[34] For example, Yan et al (2011) An evaluation of life cycle assessment of European milk production Journal of Environmental Management 92, 3, 372-379

[35] Brien et al (2011) The effect of methodology on estimates of greenhouse gas emissions from grass-based dairy systems. Agriculture, Ecosystems and Environment Vol 141 pages 39-48

methodologies because the IPCC method excludes indirect GHG emissions from farm pre-chains, that is, concentrate production. However, both methodologies agreed that animals selected solely for milk production (high production North American strain Holsteins) had higher GHG emissions per unit of product relative to strains selected on a combination of traits.

Another paper[36] considers the importance of beef as a co-product of dairy production and discusses how land-related impacts can have a marked impact on carbon footprint in beef and dairy systems (the example of use of soybean meal is given, acknowledging that carbon emissions from land use change, especially deforestation, accounted for 20-25% of total anthropogenic emissions during the 1990s).

Multifunctionality can refer to both cross-breeding and within breed selection, but potential benefits could include hardier, more durable animals, better carcase quality of cull cows and offspring, and less reliance on imported protein given North American Holstein genotypes now require higher feed inputs[37].

Given that over half of prime carcase beef in England is sourced from the dairy herd[38], the authors propose that further research to examine the implications of breeding for more multifunctionality within the dairy herd would be extremely valuable. In order to ensure any conclusions about overall environmental impact are robust, it is crucial to consider both dairy and beef products. Examining meat and milk quality, rather than just quantity, from different systems is also important. For example, the potential for meat and milk quality advantages have been noted with more multifunctional animals[39].

We believe that it should not be assumed that the current separation of beef and dairy is preferable or that further ongoing specialisation is the most desirable course when considered according to the range of outcomes that Society requires. Frequently, short term market drivers do not lead to the optimum outcomes over the longer term. Given the Green Food Project is considering a time scale up to 2050, we recommend that more consideration is given to the potential benefits that cross-breeding, or within breed selection for robustness, could bring from an environmental, health, welfare or overall productivity perspective.

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[36] Hermansen and Kristensen (2011) Management options to reduce the carbon footprint of livestock products Animal Frontiers July 2011 vol 1 no 1 33-39
[37] Bluhm, W. Paper to British Cattle Breeders Conference.
[38] Eblex 2011 Testing the water
[39] ibid 22 and ibid 29

Key environmental issues for English dairy farming

Summary

1. Loss of biodiversity due to intensive grassland and maize management
2. Greenhouse Gas emissions - including methane, nitrous oxide, Carbon dioxide and carbon sequestration under grass.
3. Water pollution by nitrates, phosphates, coliform bacteria, silt, pesticides and veterinary residues.
4. Biodiversity loss and Greenhouse gas emissions arising from forest and savannah conversion driven by the use of soy and palm derived feedstuffs from the tropics and South America.
5. Soil structural degradation
6. Nitrification leading to biodiversity loss and acidification as a result of atmospheric ammonia emissions.
7. Water use in areas and periods of high water stress.
8. Depletion and pollution of ground and surface waters by remote feed and fodder production e.g. maize in Southern Europe
9. Use of GM crops in dairy feed

1. Loss of biodiversity due to intensive grassland and maize management

Both intensively managed grass and maize are challenging environments for biodiversity. Changes in livestock farming practice are considered a major cause of farmland bird declines in the lowlands[40], with local extinctions more common in grass-dominated areas compared to arable areas.[41]

Species-rich hay fields, unimproved grasslands and certain beneficial forms of arable cropping (especially spring sown cereals and Brassica/root forage crops) have been replaced in pastoral areas by uniform ryegrass-dominated fields (often with white clover) and maize silage, with a consequent loss of heterogeneity from the landscape to the sward scale.

The focus on greater grassland efficiency (utilisation) to produce high quality forage for modern dairy systems has led to dense swards containing very few species which are cut early and repeatedly for silage or heavily grazed, and this has led to a reduction in the abundance and diversity of invertebrate and seed food resources.

Silage fields are attractive to skylarks, which tend not to nest in grazed lowland grasslands, possibly because of grazing pressure and because of grass length in mown fields. They are attracted to the swards in growing silage crops, but a very high proportion of nests in silage fields fail because nests/fledglings are abandoned, predated or run-over during harvesting[42]. In addition to producing insufficient young to maintain their own populations, silage fields also draw in birds from elsewhere in the landscape thus acting as an ecological trap.

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[40] Eg Chamberlain & Fuller (2000) Local extinctions and changes in species richness of lowland farmland birds in England and Wales in relation to recent changes in agricultural landuse. *Agric. Ecosys. Environ*. 78: 1-17; Vickery *et al*. (2001) The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. *J. Appl. Ecol*. 38: 647-664

[41] Chamberlain and Fuller (2000)

[42] It is calculated that to maintain their population 100 pairs of skylarks must raise 179 fledglings to independence but on conventionally managed silage fields with 2/3 cuts, productivity is less than 3% of this replacement rate. RSPB Defra Research Project BD1454. Final Report.

Maize has extremely limited value for biodiversity which is particularly impacted by cultivations at establishment and the use of residuals sprays to avoid weed competition[43].

The RSPB has conducted considerable research on bird usage of maize fields.[44] While spilled grain is available for a short period following harvest, this seed does not last long and there is a lack of other seed resources due to the intensive weed control associated with maize management. Maize stubbles are therefore of little use by the second half of the winter, the so-called 'hungry gap'[45], when food is scare. There are rare occasions where maize stubbles retain a high weed burden due to a pre-existing weed seed bank in the soil. However, in general cereal stubbles greatly outperform maize stubbles, particularly in late winter.

Estimates of annual productivity suggest maize is an ecological trap for breeding lapwing, which find the maize stubbles highly attractive for nesting. The stubbles are not ploughed in until very late spring, allowing lapwing to nest, only to have their nests destroyed repeatedly by operations. They can re-nest successfully, if sowing operations take place quickly after ploughing. However, any chicks which hatch will have low survival in established maize crops and will need sufficient suitable habitat nearby to compensate for this.

2. Greenhouse Gas emissions - including methane, nitrous oxide, Carbon dioxide and carbon sequestration under grass.

This includes the greenhouse gas emissions associated with feed production, including land use change. These 'second order' impacts associated with animal feed production are frequently ignored[46] but can be considerable. For example, Europe is responsible for 94% of the global GHG emissions caused by land-use change related to soy use for the dairy sector[47]. Within the dairy sector, such 'second order' impacts are particularly associated with high input systems based on high genetic merit cows. Carbon footprinting – particularly for comparing different types of system – can be extremely misleading for livestock systems if second order impacts are not included. Greenhouse Gas Emissions arising from nitrogen fertilizer manufacture may also need to be considered here.

3. Water pollution by nitrates, phosphates, coliform bacteria, silt, pesticides and veterinary residues.

Swards on dairy farms tend to be very intensively managed - typically receiving twice the rate of inorganic fertiliser used on grassland on the average beef or sheep farm[48]. Pollution from

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[43] Natural England, 2009 Environmental impacts of land management

[44] Peach, W.J., Dodd, S., Westbury, D.B., Mortimer, S.R., Lewis, P., Brook, A.J., Harris, S.J., Kessock-Philip, R., Buckingham, D.L. & Chaney, K. (2011) Cereal-based wholecrop silages: A potential conservation measure for farmland birds in pastoral landscapes. Biological Conservation 144, 836-850.

Buckingham, D. L., Evans, A. D., Morris, A. J., Orsman, C. J. & Yaxley, R. (1999) Use of set-aside land in winter by declining farmland bird species in the UK. Bird Study, 46, 157-169.

[45] Loddington is currently undertaking research into wild bird seed mix which keeps seeds for longer, therefore providing food during this period.

[46] Garnett (2007) Meat and dairy production and consumption. Exploring the livestock

sector's contribution to the UK's GHG emissions and assessing what less GHG intensive systems of production and consumption might look like. FCRN paper.

[47] FAO (2010) Greenhouse Gas Emissions from the dairy sector. Rome.

[48] Mean rates of c 120kg/N/ha on dairy swards, though this is nearly half the amount used in the mid-1990s. Hopkins and Lobley, (2009) A scientific review of the impact of UK ruminant Livestock on Greenhouse Gas Emissions, University of Exeter CRPR research report.

manure produced during grazing and slurry spreading are a significant problem on some dairy farms, with the risk being related to stocking density, local conditions and slurry management practices[49]. A survey of dairy farms reported that typically less than a fifth of N entering the systems was recovered in milk and animal products, the remainder being either retained in the soil or lost as environmental pollution to air or water[50].

In addition to diffuse pollution, dairy farms also account for a significant number of pollution incidents[51]. For example, in 2008, dairy farms were the source of over half of serious (category 1 and 2) pollution incidents to water from agriculture in England[52]. However, such point source incidents are preventable with correct equipment, good management and risk assessment.

Maize is a high risk crop from the perspective of causing run-off and pollution following harvesting. Herbicide use in pastoral areas is likely to be particularly associated with maize.

4. Biodiversity loss and Greenhouse gas emissions arising from forest and savannah conversion driven by the use of soy and palm derived feedstuffs from the tropics and South America.

The metabolic requirements of high genetic-merit dairy cows[53] cannot be met from a forage-based diet alone (although all dairy cows need dietary protein to meet nutritional needs), and as the proportion of high yielding cows has increased so has the reliance on concentrates and compound feed. The dairy industry is the biggest user of compounded feed of all UK farming sectors[54] and the soy content in intensively reared dairy cow rations can be substantial[55].

As against this one group member has provided evidence that UK dairy is responsible for 18.5% of UK soya meal consumption. This is still significant, but not as dominant as the preceding paragraph suggests.

We suggest that it would be very helpful for the work of the whole group in this area if we could get clear figures on the quantity of soya consumed in concentrate feeds for the English or the UK dairy herds. Land use change in the UK for growing feed is also a potential concern, for example, if semi-natural habitats are improved.

5. Soil structural degradation

[49] ADAS (2008)The Environmental Impact of Livestock Production

[50] ibid

[51] Improving environmental performance. Environmental plan for dairy farming. EA/NFU/RABDF/MDC/DairyUK

[52] Environment agency data

[53] The question of permanently housed cows is an interesting one – there are pluses (consistency and uniformity of diet, potential to reduce ammonia) and minuses (expensive in terms of money and energy for extra forage harvesting/ storage and manure spreading, perception of poor welfare). At least one member of the group thinks that grazing should be the backbone of UK systems, enabling us to exploit our comparative advantage in grassland production.

[54] http://drduncansdigest.blogspot.com/2010/07/my-beef-with-soya.html

[55] Garnett, 2010 Livestock, feed and food security

Dairy farms pose significant risks of soil compaction due to high grazing stocking rates and machinery use, particularly for harvesting of silage and maize. The increased use of contractors for these operations means that there may be less scope for delaying harvest when soils are wet.

Poor soil structure can result in slow water infiltration and increased runoff of water and manures. It may also increase nitrous oxide emissions.
DairyCo Research Partnership has recently made available £5m for soils research and AHDB is engaged with a project with Catchment Sensitive Farming looking at soils.

The 2011 Defra farm practices survey shows that 78% of dairy farmers regularly test the nutrient content of their soils and 82% regularly pH test. However the authors have been unable to access up to date information on soil nutrient balance as discussed earlier.

6. Nitrification leading to biodiversity loss and acidification as a result of atmospheric ammonia emissions.

The vast majority of ammonia pollution comes from agricultural sources, with 'hot spots' found near intensive livestock farms. Cattle are responsible for the majority of these ammonia emissions[56] but cattle units are not currently covered by Integrated Pollution Prevention and Control (IPPC) regulations (which aim to reduce pollution from intensive livestock units).

Atmospheric ammonia results in N deposition on semi-natural habitats such as species-rich grassland, heathland, moorland and woodland, increasing the growth of competitive species and hence reducing species-richness. It directly damages lichens which are also an important feature as well as causing acidification of soils. . The European Nitrogen Assessment concluded air pollution is a 'major threat to human health and ecosystems in Europe', and found that there had been low success in controlling ammonia emissions from agriculture.

In the UK Ammonia emissions (excluding natural emissions from wild animals and humans) fell by 22% between 1990 and 2009 (Emissions of Ammonia Defra statistics). However, during this period ammonia emissions from cattle only fell by 15% showing relatively less progress than in the agricultural sector as a whole (27% reduction). Ammonia emissions from the category 'manure management' increased over this period.

7. Water use in areas and periods of high water stress.

It is critical to bear in mind that it is water use relative to its availability in space and time that determines where it is an important issue to manage.

The dairy industry uses large amounts of water, for washing down and cow drinking purposes. Around 50-75% of water use on dairy farms is for drinking water for cows and this usage is difficult to reduce with high yielding dairy cows[57]. 8% of dairy holdings have a high or very high water requirement[58].

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[56] Defra data.

[57] Thompson et al, 2006. Opportunities for Reducing Water Use in Agriculture. Report to Defra, project no. WU0101

[58] NFU water survey2011.

A beneficial focus area could be preventing rainfall from entering slurry stores and working on increasing the uptake of slurry separation technology, as well as considering overall water requirement in relation to location and system details (e.g. herd size).

8. Depletion and pollution of ground and surface waters by remote feed and fodder production e.g. maize in Southern Europe

We are not clear of the degree to which dairy feedstuffs in England are contributing to such impacts. It would be good to have data on the provenances of dairy feeds currently fed or likely to be fed to understand whether or not this is, or is likely to be a significant impact of English dairy farming,

9. Use of GM crops in dairy feed – particularly in jurisdictions where there is strong public opposition to GM crops

The other issues than this one are all direct observable impacts. This last is more related to the precautionary principle. It is certainly an issue of public concern.

ANNEX 5 - Possible framework for environmental decision support for dairy farms

We recommend that a decision support tool should be developed for use on existing or prospective dairy farms, comprising the following steps:

Step 1

Identify existing features on, or immediately adjacent to, the holding (semi-natural habitats[59] or longer term uncultivated land, hedgerows, watercourses or waterbodies, buried archaeology or other historic features).

Maintain and manage these appropriately; protect them from damage by cultivation, nutrient enrichment or other pollutants, using buffers as necessary.

Step 2

Identify soil type, rainfall, gradient, susceptibility to erosion and current soil structural condition. Use this to rank cropping options, considering risks to the wider geographical setting. Also consider:

- ways to improve soil management to reduce loss of sediment and benefit soil structure, water infiltration and gaseous exchange.
- greater use of legumes to benefit soil structure, reduce reliance on inorganic fertiliser and associated carbon emissions, and boost supply of protein and minerals for livestock.
- the whole footprint of inputs to the farm, for example, from use of imported soy, and reduce as far as possible.

Provisionally identify suitable land use - ‘The right crop, in the right place’.

Step 3

Identify landscape-scale biodiversity needs and opportunities. For example, are there local populations of scarce or declining invertebrates, birds, amphibians, mammals; are there sufficient resources for them on your own and neighbouring farms? If not, provide them – this could involve breeding habitat, nectar and seed sources in purpose-grown patches or by appropriate management of grassland or crops (as provisionally identified in step 2).

Add area required in steps 1 and 3, then calculate area remaining for grassland and crops.

Step 4

Plan to make full use of, and fully account for, inorganic manures, including appropriate legally required storage.

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[59] A broad definition should be taken of semi-natural to include less improved land that may not be very botanically rich but could still have considerable wildlife, carbon and resource protection benefits.

Identify emission limits, particularly for nitrate and phosphate (to comply with the Nitrates and Water Framework Directives) and ammonia to implement Best Available Techniques as far as possible[60].

Use nutrient cycle models (see note below), in order to determine maximum stocking rate and to guide final cropping choice.

Aim for diversity of cropping where possible, within emission limits.

Notes

This framework has been drawn together by representatives from NE, EA, RSPB and WWF.

Step 1

Maintenance of these features can often be funded under agri-environment schemes. In the future, it is expected that farmers would be able to quantify Ecosystem Service (ES) provision from these features and potentially receive payment for ES provision.

Step 2

We consider that there is insufficient support for a farmer to make decisions on cropping options currently. This is not about being prescriptive but having a user-friendly 'one stop shop' for assessing risk and making appropriate decisions in a farm-specific context.

Step 3

The siting of measures on the farm should be determined on the basis of maximising synergies between biodiversity, resource protection and production. For example, positioning uncultivated land to buffer water courses could be a win-win for wildlife, diffuse pollution and have production benefits such as improving livestock welfare.

There will be further decision support nested within step 3 to help farmers implement appropriate measures on the ground, along with signposting to existing organisations and initiatives. Options to provide resources for biodiversity are available under open-to-all agri-environment schemes. The area required will depend on the quality of the resource provided. 'Land sharing' measures will be needed over a larger area than measures that are 'land sparing' ie taking land out of production in order to provide specific habitat or other resource. It is proposed that a simple scoring system is devised for rating the quality of resource being provided in order to help farmers calculate the area over which a measure should be implemented.

Step 4

The nutrient planning model PLANET incorporates legal Nitrate Vulnerable Zone requirements but does not address all nutrient emissions. Nitrogen cycle models, such as NGauge and SIMS Dairy, do address this but need further development and refinement in order to become farmer-based tools incorporating production requirements.

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[60] and if relevant, to comply with any future requirements under the Directive on Industrial Emissions.

Annex 6 – Post-production analysis

It should be noted that, due to time constraints, this paper was not discussed, considered or agreed by the Dairy Subgroup members.

Introduction

Taking the assumption that by 'post-production' action we are to examine activity beyond the farm gate we can divide subsequent activity into processing, retailer and consumer actions.

Processing

In broad terms the environmental impact of the processing of milk can be attributed to the following;

• Transportation of raw milk & products from farm to dairies to retailers,

• Emissions arising from energy use at dairies,

• Water use on site,

• Discharge of effluent,

• Packaging of dairy products and

• Factory food and packaging waste

Retailer

The environmental impacts of the retailer arise broadly from:

• Retailer Transportation

• Emissions arising from energy use at retailers – in particular refrigeration

• Food and packaging waste

Consumer

The environmental impacts of the consumer arise broadly from:

• Transport of goods to and from retailer stores

• Energy used in preparation of food

• Food and packaging waste

Detail

For the purposes of this paper let us consider two core drivers for processors to decrease the environmental impact of their products; energy efficiency and reduction in food and packaging waste.

1. Energy Efficiency:

Last year the dairy processing sector used a total of 3,711,588 mWh of power which equates to 380 kWh per tonne of throughput which marks a 30% reduction in energy intensity since 1998.

The improvements in energy efficiency have been achieved chiefly by the implementation of best practise measures, the replacement of kit/equipment and significant degree of rationalisation causing the closure of older less efficient plants. Whilst rationalisation will continue to play a role in energy efficiency improvements in the future, its role is to be significantly less it has been in the past; as such the continued improvement of existing sites through best practise measures (so called ‘low hanging fruit’), the use of innovative technology solutions (many of which are outlined in the Carbon Trust’s – Industrial Energy Efficiency Accelerator – Guide to the Dairy Industry), continued transition from fuel oils to less carbon intensive fuels and the use of renewable electricity and heat.

As with the producer sector, the short term aim for the processing sector will be about improving the performance of the bottom 25% of sites in each subsector. Data collected last year show there still exists a great deal of disparity;

Subsector	Energy Efficiency Range
Liquid Milk	80 – 300 kWh/tonne throughput
Cheese	295 – 680 kWh/tonne throughput
Mixed Dairy (including powder production)	142 – 1100 kWh/tonne throughput

*NB – All kWh figures used are primary rather than delivered energy.

Improving the performance of the bottom 25% of each subsector will largely be dependent on the replacement of older kit and equipment and the implementation of best practise measures over the next ten year. The Climate Change Agreement (CCA) scheme will be a key driver for this and targets for the dairy sector will be set later this year which are likely to ask for a 20% plus improvement in energy efficiency over the next 10 years.

Pushing the boundaries of the current top 25% will be reliant on improvements in current technology, innovative new technology and the roll out of renewable heat and electricity generation. As mentioned above, the dairy processing sector is a participant in the Carbon Trust’s Industrial Energy Efficiency Accelerator programme – which has identified a number of innovative technology solutions that will help push the boundaries of energy efficiency on what is currently possible.

These can be summarised as:

Alternative Homogenisation Techniques: Move to wider use of partial, rather than full stream, homogenisation and possibly ultrasonic homogenisation.

Reduction of Clean in Place (CIP) Water and Heat Use:

Novel forms of CIP which reduce the temperature, water or heat required by CIP have the potential to create a step change in sector energy consumption. Two projects currently being trialled in the dairy sector are the lessons learnt from these will be disseminated through the industry.

Low Temperature or non-thermal Pasteurisation

Low temperature or non thermal pasteurisation techniques can play a significant role in the future, but cannot currently be used because of legislation in place governing milk processing; if changes can be made to regulations technology such as UV pasteurisation could significantly reduce the heat load required at dairies.

Fuel Switches and Renewable Energy

Where possible sites that still rely on fuel oil for their heat load will switch to gas use over the next decade or so – this will significantly lower the carbon intensity of the industry. Further to this there is potential for the use of renewable technology, particularly renewable heat where connecting to the gas grid is not possible - The Dairy Roadmap commits the sector to producing 10% of its energy from renewable sources by 2020.

2. Reduction in Food and Packaging Waste

Through the Dairy Roadmap, the processing sector has committed to sending zero factory waste to landfill by 2020, achieving this target will require both the minimisation of waste and finding solutions to deal with waste where it does arise. Key to this will be;

- Minimising the amount of waste that is incinerated rather than recycled – currently the technology and recycling infrastructure doesn't widely exist to deal with certain types of packaging such as contaminated plastics and cheese film.

- Where food waste does arise in the supply chain the industry must increase the amount that is used as animal feed or is sent to anaerobic digestion. A number of AD plants now exist on dairy sites (For example BV Dairy in Dorset) and the amount of waste being sent to larger units, such as Biffa's plant in Poplar, is increasing.

- Processors also have a role to play in minimising food waste once it reaches consumers and a great deal has already been done to extend the shelf life of goods, remove 'best before' dates on goods where possible and increase the range of product sizes available to ensure consumers are able to buy only what they need. The majority of major dairy processors in the UK have signed up to Courtauld agreement and the accompanying 'Love Food, Hate Waste' campaign.

- One possible trade off to note here is the improvement of shelf life in milk: pure filter milk lasts significantly longer than regular milk but does require more energy to produce. Data required to assess whether the extra shelf life outweighs the additional energy used in the filtration process.

• The dairy processing sector has also committed to reducing the environmental impact of its packaging – in the short term this will be done by the increased use of recycled material, the light weighting of packaging and increasing the quantity of their packaging that is recycled by the end user - largely done through the PRN system.

- The dairy processing sector has committed to having 50% recycled material in milk bottles by 2020; this will require technological improvements in how bottles are produced, a far higher quantity or rHDPE to be produced in the UK and a greater willingness from across industry to pay a premium for recycled material.

• In the long run packaging will be produced from bio-plastics rather than oil based plastics; a possible trade off to note here will be on land use change to grow plants from which to produce the plastics.

3. Transport

Transport of dairy products account for a very small amount of their environmental impact and as such isn't largely relevant for this subgroup.

However, Dairy processors have taken significant steps in the last decade to rationalise collection of milk and coordinate transportation between companies where possible. The Dairy Roadmap is also looking to include emissions from transport in its scope from next year.

Consumer

• By far the largest environmental impact from consumers with regards to dairy products is from food waste and as such step change is needed in consumer behaviour to drastically reduce the environmental impact of the food we consume. WRAP figures show that the UK throws away 15 million tonnes of food each year and that almost half of this comes from households, if we are able to drastically reducing this must be central to the Green Food Project. Reducing food waste will not only mean less food has to be produced per head of population but less food will end up at land fill where it rots and produce harmful GHGs.

• *What needs to be done to affect change in consumer behaviour?*

WRAP gives the various reasons for food waste arising from households as

Left on the plate after meal – 34%

Passed its date – 22%

Looked, smelt or tasted bad – 21%

Went mouldy – 13%

Left over from cooking – 10%

The break down for dairy products was:

Cheese:

Out of date - 37%

Went Mouldy – 23%

Milk:

Smelt or tasted bad – 38%

Out of date – 37%

There are clearly things that all both industry and government can do to affect change for each of these.

1) As mentioned before, technological improvements have already significantly increased the shelf life of products and will continue to do so in the future.

2) The removal of ‘best before’ dates on packaging will ensure consumers do not through away food early.

3) Improving consumer knowledge and packaging instructions on food storage and freezing

4) Increasing the range of product sizes will ensure consumers do not buy more than they need.

5) Retailers limiting offers on perishable foods again will stop consumers buying more food than they need that is likely to go off

6) Greater consumer education on; what to do with leftover food, portion sizes, the effect food waste has on the environment.

Again where food waste does arise it is vital that it is dealt with in the most sustainable manner. Industry is already diverting food waste from landfill by using AD plants, Food waste charities and composters – at present this is largely impossible at a consumer level as most local authorities do not collect food waste and as such government has a role to play in increasing the number of local authorities that collect food waste.