

Sustainability and Environmental Burdens in Agriculture

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Contents

- ***Sustainability – a view***
- ***Analysis of production systems***
- ***Environmental Life Cycle Assessment***
- ***Methodology***
- ***Crops***
- ***Animals***
 - ***Industry Structures***
 - ***“Hot spots”***
- ***Alternatives***

Sustainability – What is it?

- **The Second Law of Thermodynamics.**
- **Is anything sustainable?**
- **Few absolutes**
- **Easier to show what is not than what is.**
- **Superficial factors, e.g. the time to next election.**

Three Pillars of Sustainability

- **Economic**
- **Social**
- **Environmental**
 - **Pollution**
 - **Resource use**

- **Conflict**

Drivers of Change

- **Market Forces**
 - UK, EU and World
- **Political**
 - National and international + **environmental**
- **Continued Rationalisation within Agriculture**
- **Consumer Led Supply Chain**
 - Food quality, safety, welfare, **environmental**
- **Technological Change**
 - new breeds, seeds, GM
- **Macroeconomic Factors**
 - growth rates, exchange rates

Projections in Livestock Trends for England 2006 to 2015 (without WFD)

Stock Type	Change, %	Regional Variations Assumed
Dairy Herd	-20	Concentration in the west
Beef Herd	-15	No
Pigs	-10	Concentration in arable areas
Sheep	-6	No
Laying Fowls *	5	No
Table Fowls	10	No

* from 2000

Source: Business as Usual Projections of Agricultural Outputs in 2015
Final report to the Environment Agency, Centre for Rural Economics Research,
University of Cambridge, July 2004

Environmental (socio-political) pressures of change on livestock production

- **Water Framework Directive (WFD)**
 - Nitrate, Phosphate, Faecal Indicators
- **Global Warming**
 - Methane, nitrous oxide, (CO₂)
- **Acidification (and eutrophication)**
 - Ammonia

Social Sustainability

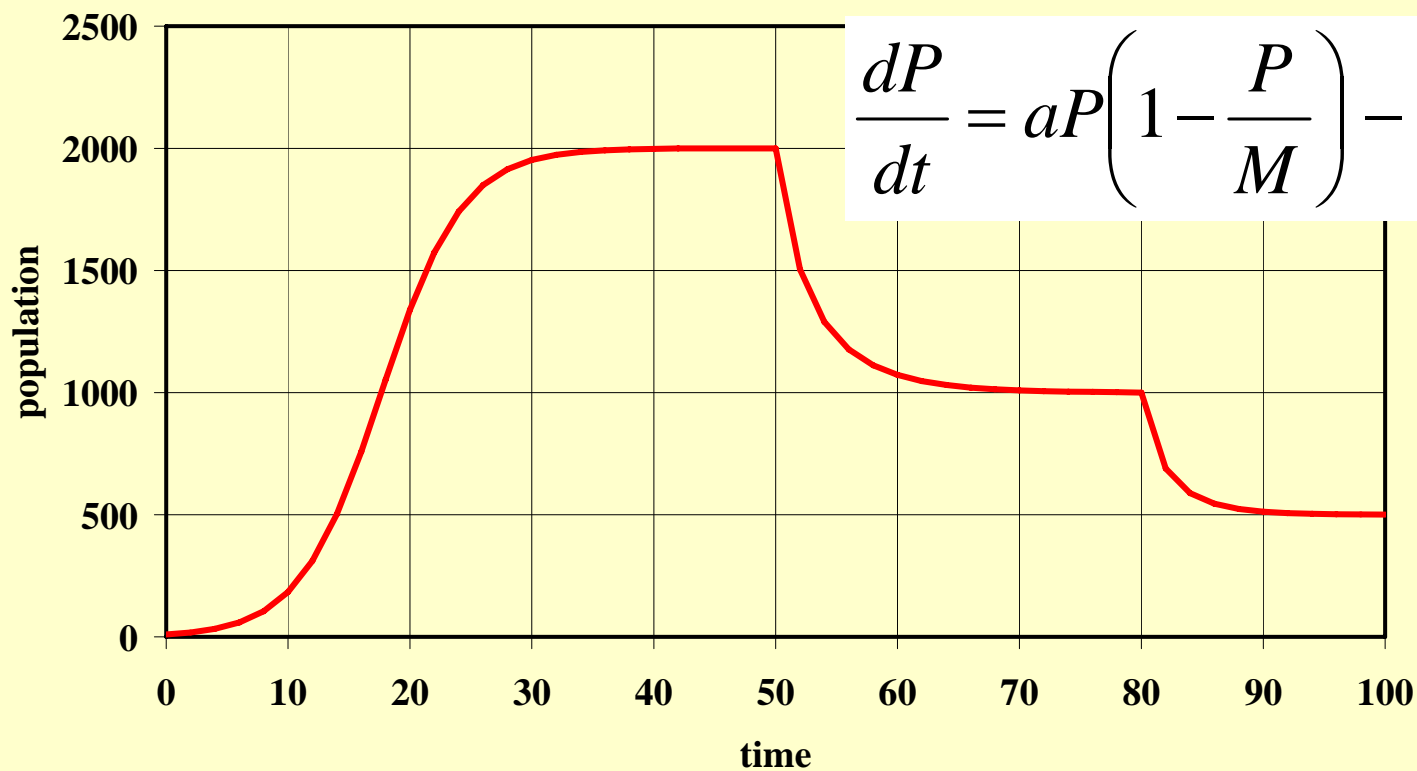
Jilly Hall, Countryside Agency

Rebuilding social capital

http://www.nottingham.ac.uk/geography/general/news-events/RF%20seminars/programme%20of%20events_rev5.phtml

Sustainable Populations and Conflict

Logistic growth model: Exploitation and sustainability



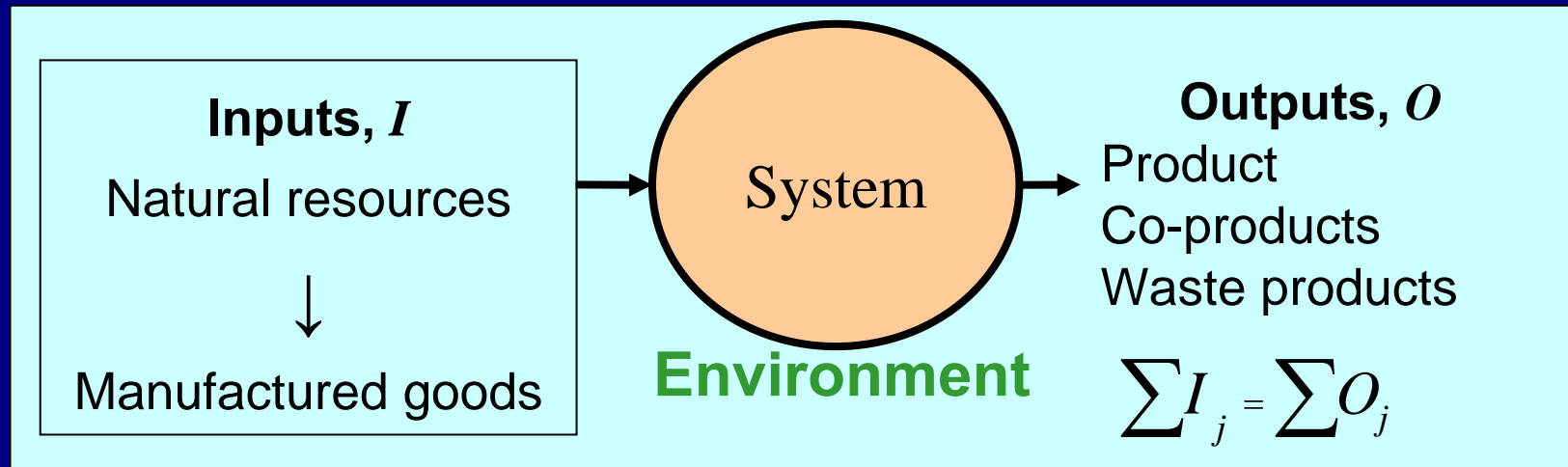
Environmental Life Cycle Assessment (LCA)



- Bread wheat, oilseed, potatoes, tomatoes, Sheep meat, beef, pig meat, poultry meat, milk and eggs.
- To quantify the effects of choice or change
- To inform science based policy
- To enable stakeholders or LCA analysts to quantify the burdens of speculative ideas

LCA concepts

Environmental LCA calculates burdens per unit of product



- **System boundary is the farm gate**
- **Functional unit 1 t of edible carcass weight**
- **Inputs and outputs = a set of burdens to the natural environment**
- **System A vs System B if Product A \equiv Product B**

Environmental burdens Cranfield UNIVERSITY

- **Emissions to the environment**
 - Methane, ammonia, nitrous oxide, nitrate
- **Weighted potential impacts**
 - Global Warming Potential (100 years)
 - 1 kg CH₄ = 22 kg CO₂ equiv
 - Eutrophication and acidification
- **Natural resource use (abiotic)**
 - Fossil energy, minerals
 - Antimony
- **Land use**
 - Grades 1 to 5, (arable 3a)

Generic Crop Production

- **Seedbed establishment**
 - Plough, reduced till, direct drill
- **Fertilisation**
 - Rotational transfer, bag, residues
- **Crop protection**
 - Pesticide, mechanical, rotational
- **Harvest**
 - Proportion baled
- **Cool & store**
 - Harvest moisture, store type



Elements of Animal production

■ Productivity

- Fecundity, longevity, FCR, yields

■ Feeds

- Concentrates
 - Arable + transport + processing
- Forages
 - Field husbandry and conservation

■ Housing and land

- Structures, heating and ventilation
- Land for nutrition and welfare (ranging)

■ Transport between production centres

■ Manure management

- Debits and credits

The diversity of sheep



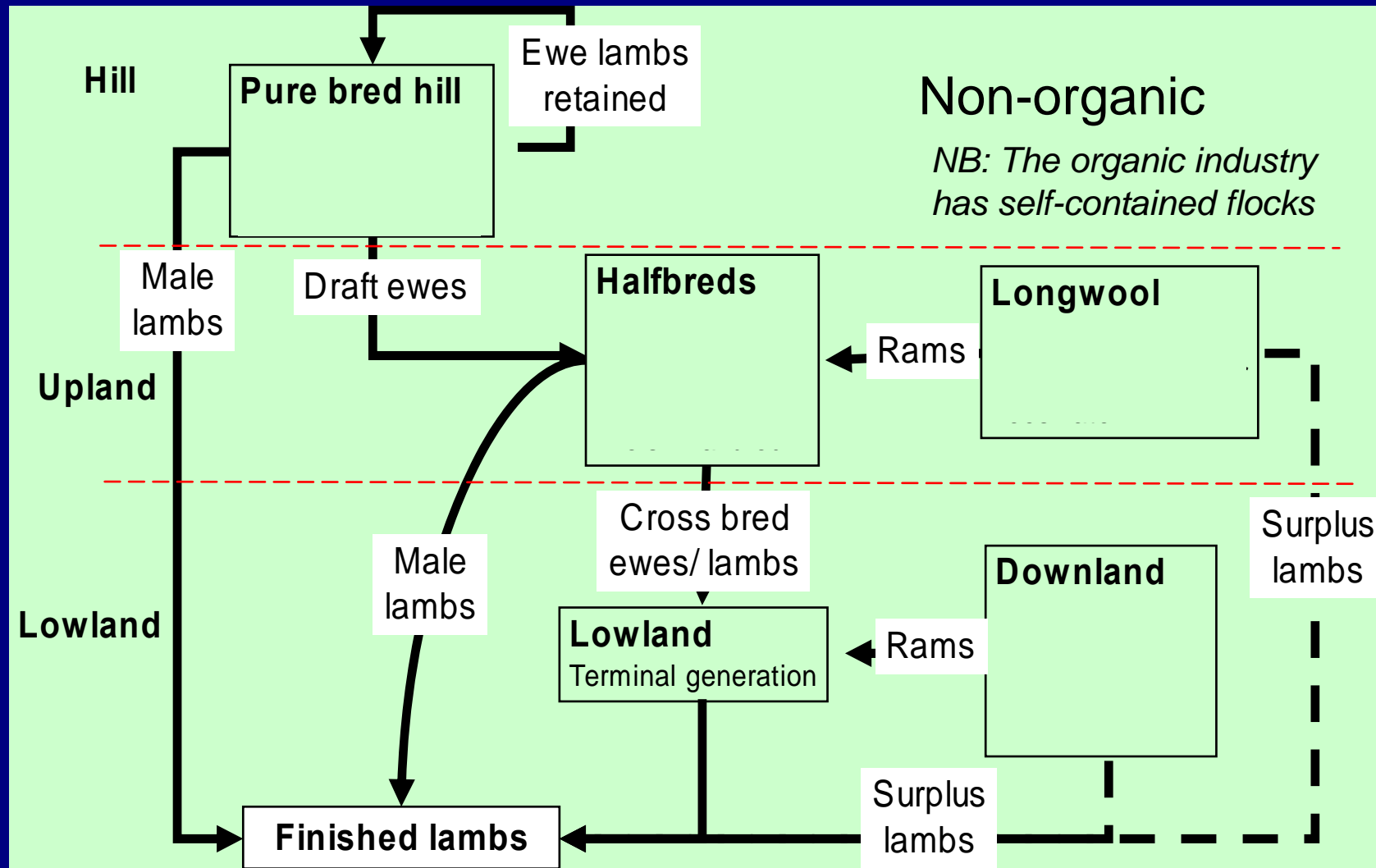
**Hill / mountain, 1 ewe & 0.9 lamb
needs 5-10 ha**



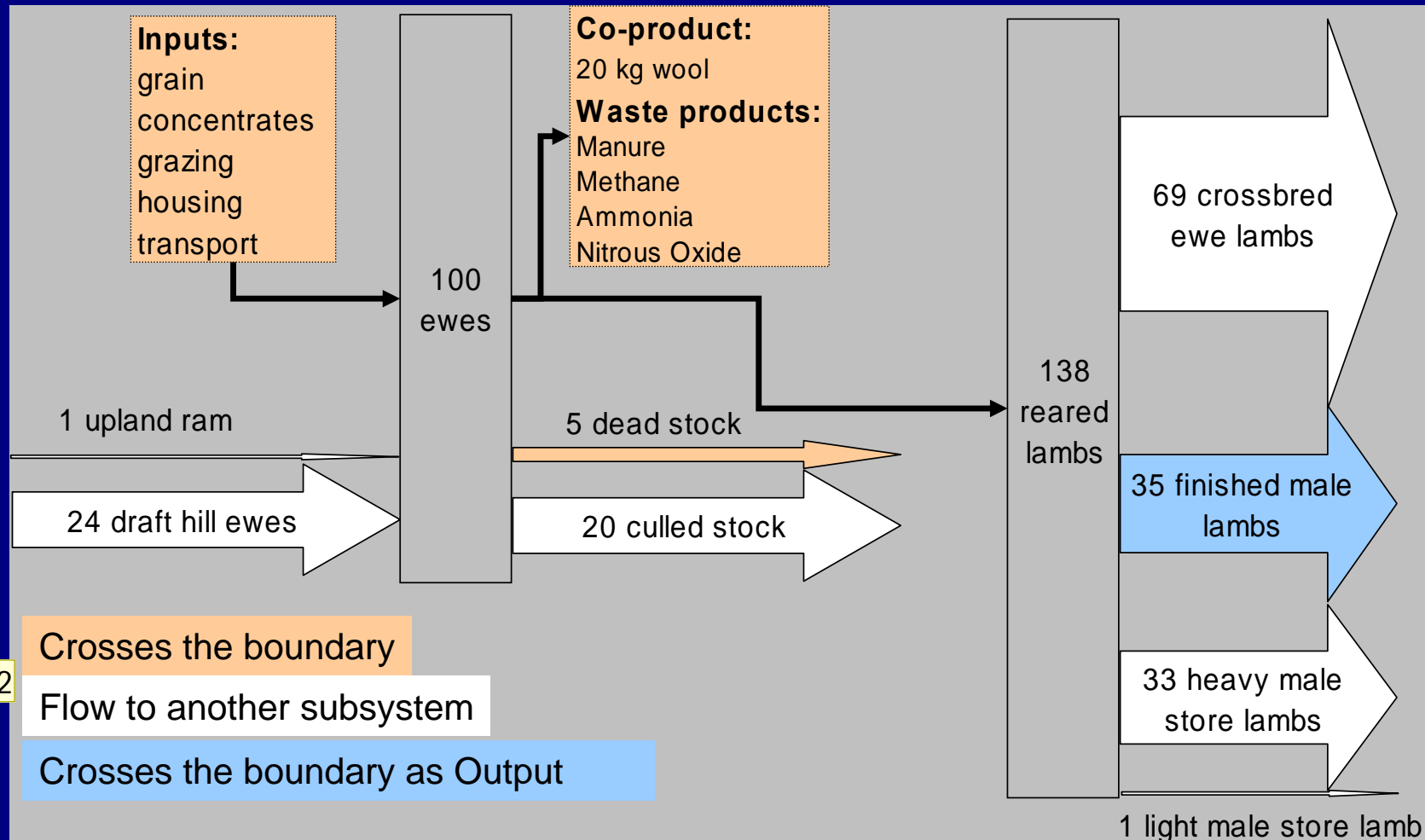
**Lowland, 1 ewe & lambs
needs 0.1 ha**



Lamb production (simplified)



An upland cross bred flock



Slide 17

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Sources: National emission inventories, Farm costings books, June census, Farm business surveys, literature, simulation models, and experts
Daniel Sandars, 29/06/2006

Main burdens in crop production

Impacts & resources used per t	Bread wheat	Oilseed rape	Potatoes	Tomatoes
Primary Energy used, GJ	2.5	5.4	1.4	130
GWP ₁₀₀ , t CO ₂ (1)	0.80	1.7	0.24	9.4
Eutrophication pot'l kg PO ₄	3.1	8.4	1.3	1.5
Acidification pot'l, kg SO ₂	3.2	9.2	2.2	12
Pesticides used, dose-ha	2.0	4.5	0.6	0.5
Abiotic resource used, kg antimony	1.5	2.9	0.9	100
Land use (Grade 3a), ha	0.15	0.33	0.030	0.0030

Main burdens in animal production

Impacts & resources *	Beef	Pig meat	Poultry meat	Sheep meat	Eggs	Milk
Primary Energy used, GJ	28	17	15	23	14	25
GWP ₁₀₀ , t CO ₂	16	6.4	4.6	17	5.5	11
Eutrophication pot'l, kg PO ₄	160	100	49	200	77	64
Acidification pot'l, kg SO ₂	470	390	170	380	310	160
Pesticides used, dose ha	7.1	8.8	7.7	3	7.7	3.5
Abiotic resource use, kg antimony	36	35	30	27	38	28

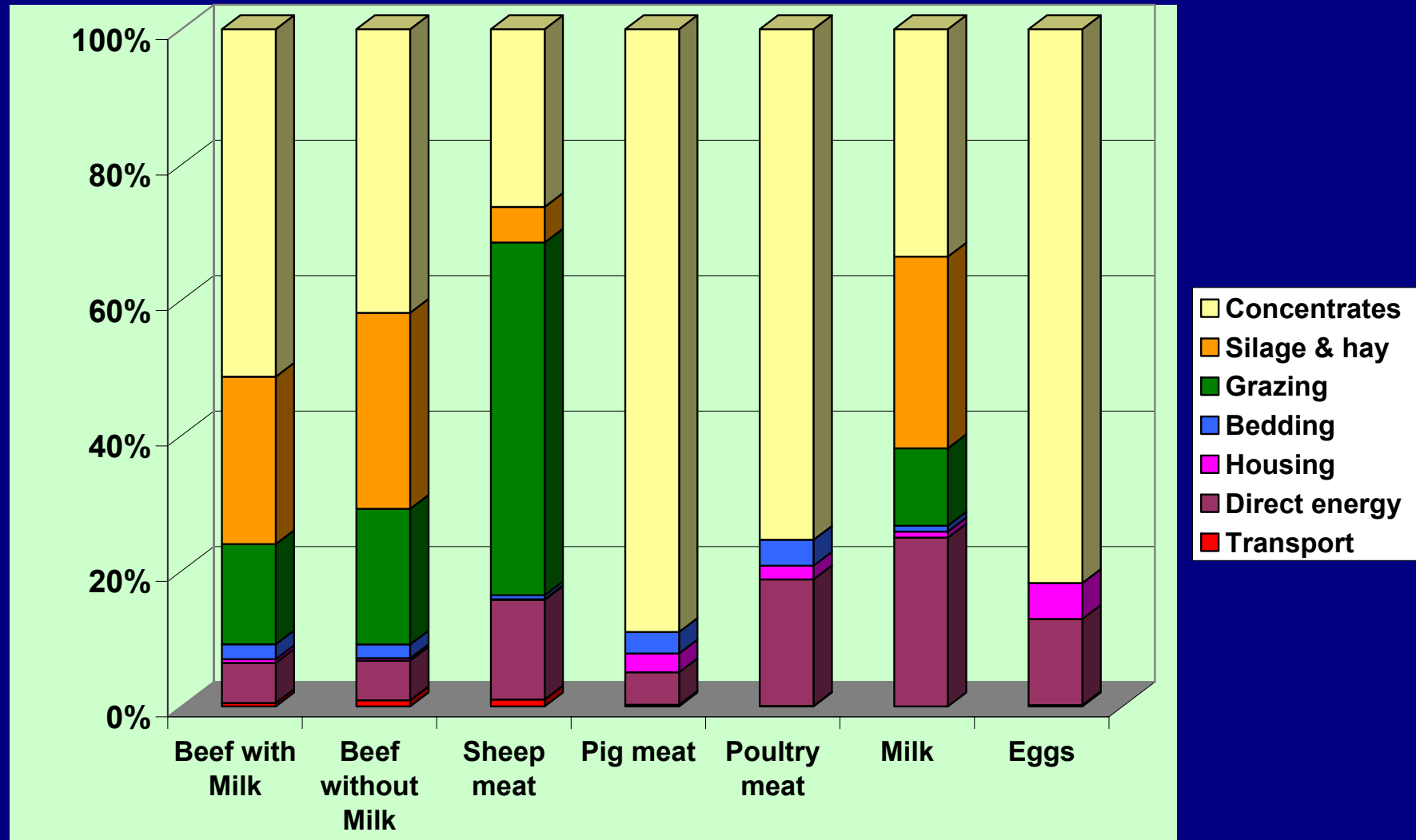
* Per t carcass, 10 m³ milk (c. 1 t d.m.) or 20 000 eggs (c. 1 t)

Land use in animal production

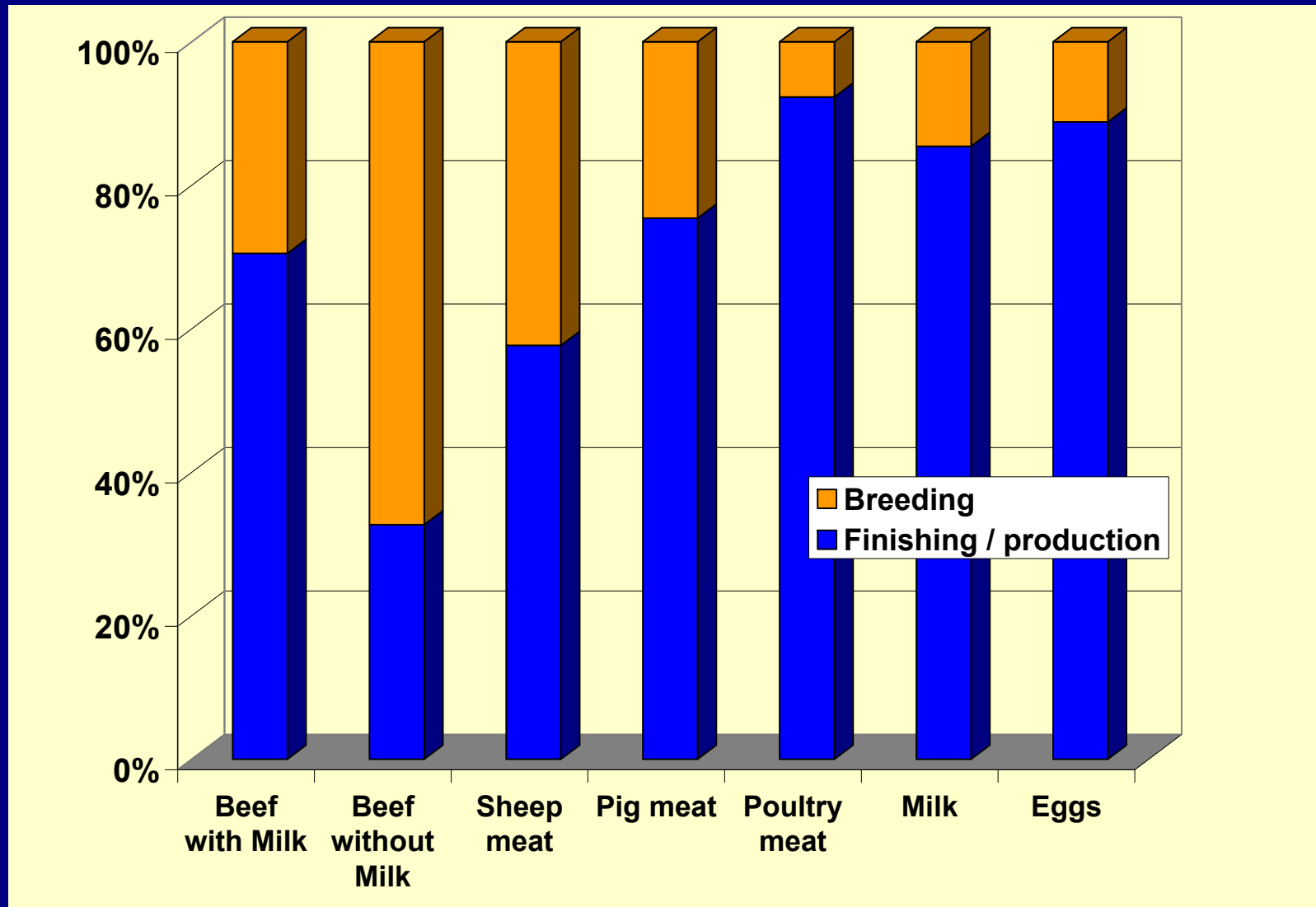
Impacts & resources *	Beef	Pig meat	Poultry meat	Sheep meat	Eggs	Milk
Land use ⁽¹⁾						
Grade 2, ha	0.04			0.05		0.22
Grade 3a, ha	0.79	0.74	0.64	0.49	0.67	0.98
Grade 3b, ha	0.83			0.48		
Grade 4, ha	0.67			0.38		

* Per t carcass, 10 m³ milk (c. 1 t d.m.) or 20 000 eggs (c. 1 t)

Distributions of energy by activity



Distributions of energy by function



Feed Crops

Feed crop production (per t)

Impacts & resources used	Feed wheat	Barley	Field beans	Soya beans	Grain maize	Forage maize
Primary Energy used, GJ	2.3	2.4	2.5	3.0	2.0	1.9
GWP ₁₀₀ , kg CO ₂ equiv.	730	720	1,000	1,300	650	580

Processed feed crops (per t)

Impacts & resources used	Wheat-feed (Non-org)	Wheat-feed (Org)	Maize gluten feed	Soya meal (no hulls)	Soya meal (with hulls)	Rape meal
Primary Energy used, GJ	0.8	0.58	3.8	6.6	6.0	3.5
GWP ₁₀₀ , kg CO ₂ equiv.	130	110	340	940	850	550

Organic and Non-Organic Feeds

Ratios of burdens of Org / Non-Org

	Primary energy	GWP	Eutro- pication pot'l	Acid- ification pot'l	Pest- icides	ARU
Feed wheat	77%	100%	280%	100%	0%	110%
Feed beans	93%	110%	93%	73%	0%	100%
Barley	85%	110%	260%	85%	0%	120%
Maize grain	91%	110%	200%	130%	0%	120%
Maize Silage	83%	89%	250%	140%	0%	120%
Wheatfeed	79%	100%	290%	100%	0%	88%

Alternative Ruminant Meat Production Systems

Beef	Non-organic	Organic	100% suckler	Lowland	Hill & upland
Primary energy	100%	65%	146%	96%	107%
GWP_{100'}	100%	115%	160%	99%	104%
Land use	100%	183%	167%	99%	105%

Sheep meat	Non-organic	Organic	Higher valuation of mutton
Primary energy	100%	80%	84%
GWP_{100'}	100%	58%	83%
Land use	100%	226%	86%

Alternative Pig Meat Production Systems

Pig meat	Non-organic	Organic	Heavier finishing	Indoor breeding	Outdoor breeding
Primary energy	100%	87%	93%	100%	100%
GWP _{100'}	100%	89%	96%	101%	100%
Land use	100%	173%	93%	99%	101%

Alternative Milk Production Systems

Milk	Non-organic	Organic	More fodder as maize	60% High yielders	20% autumn calving
Primary energy	100%	62%	94%	96%	93%
GWP_{100'}	100%	116%	92%	96%	97%
Land use	100%	166%	99%	96%	102%

Increasing sustainability

- Increase technical efficiency
- Feed dominates
 - Crop production
 - Animal performance
 - FCR
 - Growth rate
 - Fecundity
 - Productivity
 - **NUE**
 - Lower energy housing

Conclusions

- **Sustainability is relative**
- **Pressures on animal production will increase**
- **Aspects of sustainability can be quantified with LCA**
- **Complex agriculture modelled in LCA framework.**
- **Feed burdens dominates resource use**
- **Animals exacerbate impacts**
- **Increase technical efficiency increases sustainability**

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