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Ways to achieve protein autonomy in cattle feeding

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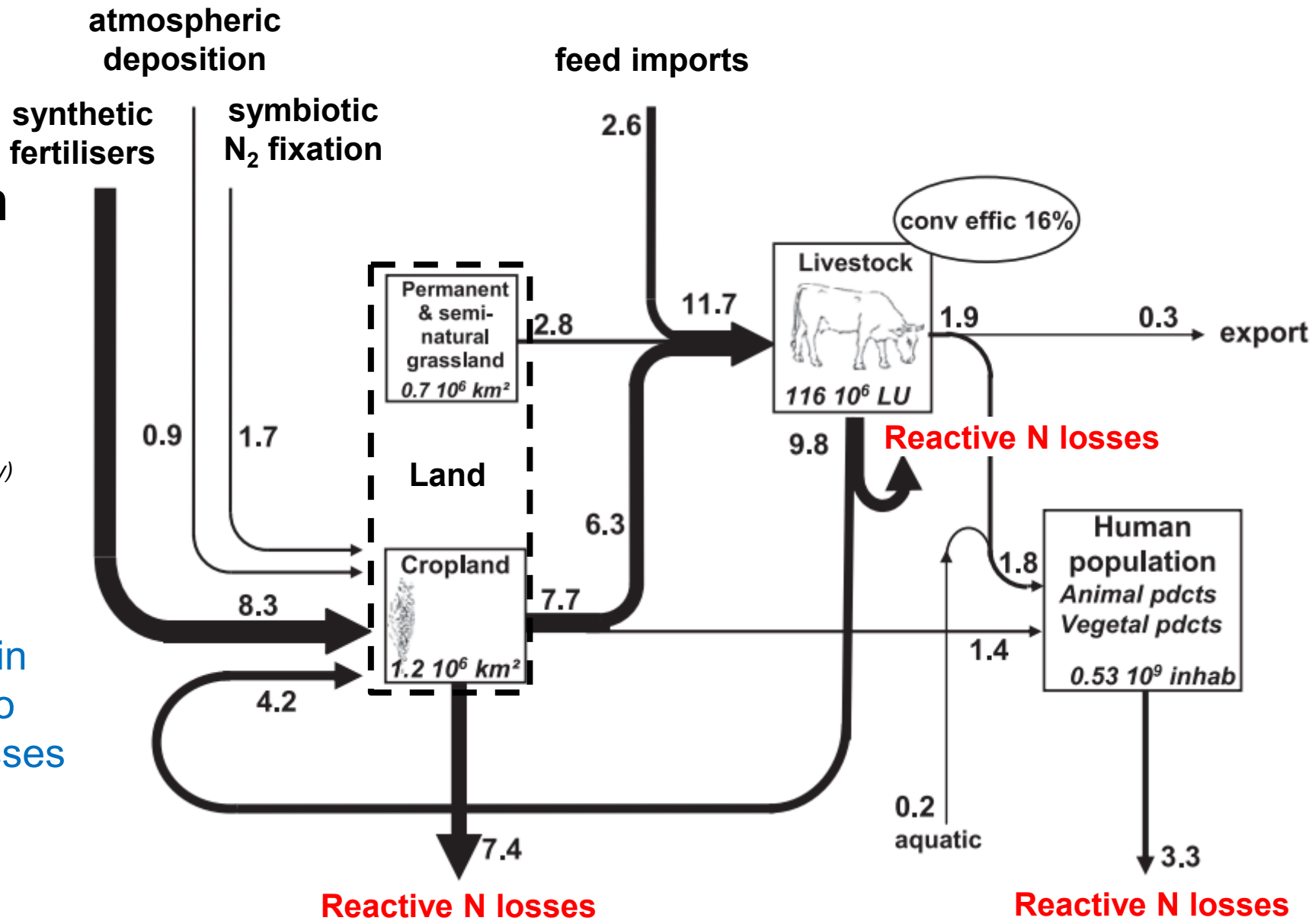
N transfers through the agro-food system in Europe 2009 (TgN/yr)

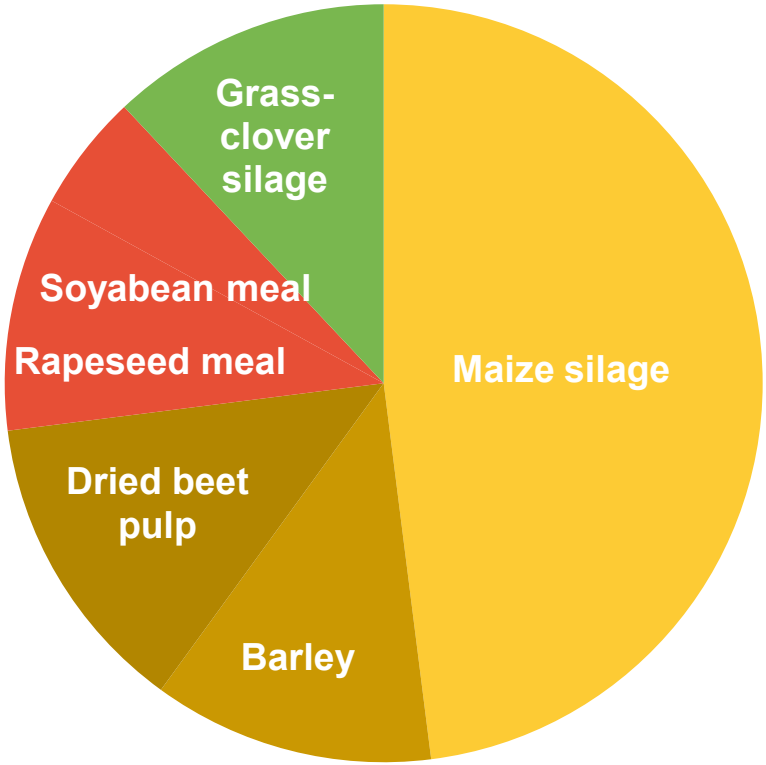
(adapted from Billen et al.,2014, Global Food Security)

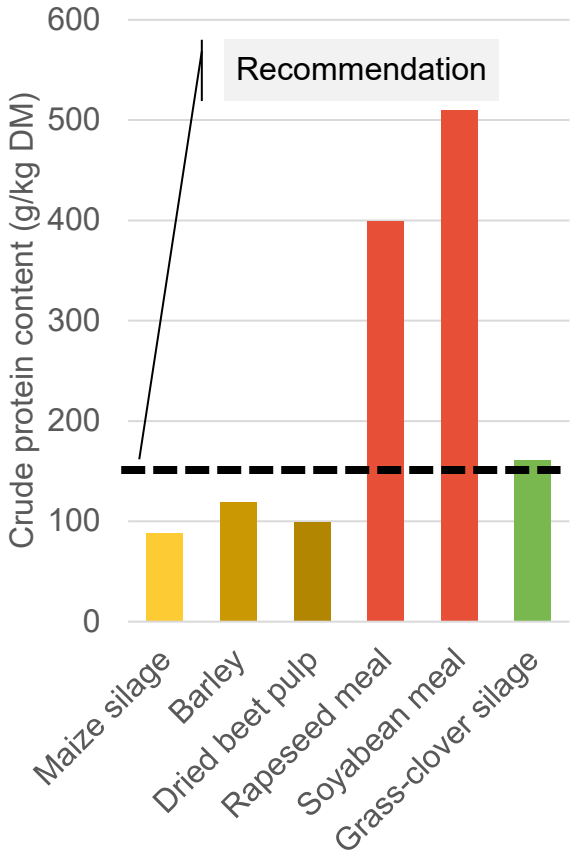


The aim of increasing protein autonomy in cattle diets is to reduce reactive nitrogen losses and promote a circular production.

Ways to increase protein autonomy in cattle diets

Ration example for high yielding dairy cows (% DM; GfE, 2023)





Ways for protein autonomy

- Reduce protein content (overfeeding)
- Increase herbage share in the diet
- Increase the protein content of herbage-based feeds in low-herbage diets
  - Prioritise fresh over preserved herbage
  - Increase grazing or earlier use
  - Optimise the share of forage legumes in leys
- Increase home-grown grain legumes
- Feed additives (amino acids)
- Heat treatment of proteins
- Selection of efficient cattle

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Low protein rations for dairy cows

	Control	Reduced	$P^{\#}$
Ration crude protein (g/kg)	148	133	
Ratio CP/NEL (g/MJ)	24	22	
Total intake (kg DM)	23.4	21.8	**
Energy corrected milk (kg ECM)	35.1	32.3	*
Milk urea (mg/dl)	20	14	***
Nitrogen use efficiency	0.33	0.34	
Urinary N excretion (g/d)	170	119	***
Methane production (g/d)	481	474	
Methane intensity (g/kg ECM)	13.7	14.8	*

*#P-value: * < 0.05, ** < 0.01, and *** < 0.001*

- Per treatment 15 mid-lactation Holstein cows
- **Control:** covers CP and APDE
  (absorbable protein at the duodenum when energy limits microbial protein synthesis in the rumen)
- **Reduced:** covers CP
- Total mixed ration:
  - Maize silage (36 %),
  - Hay (29 %),
  - Grass-clover silage (23 %),
  - Energy and protein concentrate (11 %)
  - Minerals (1 %)
- Greenfeed bait feed

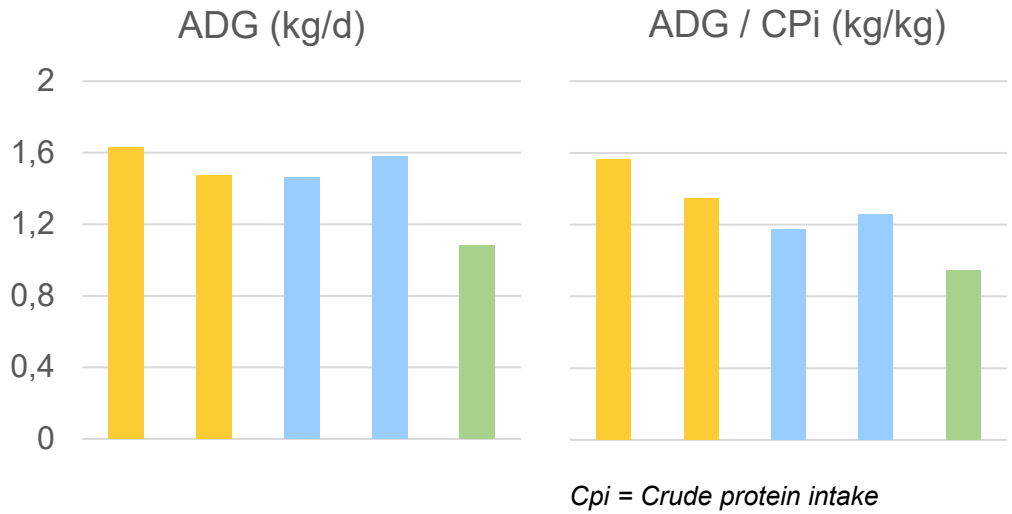
(Schori et al., in preparation)

Dairy cows needed a balanced diet according to official feeding recommendations to produce milk sustainably and to stay healthy.

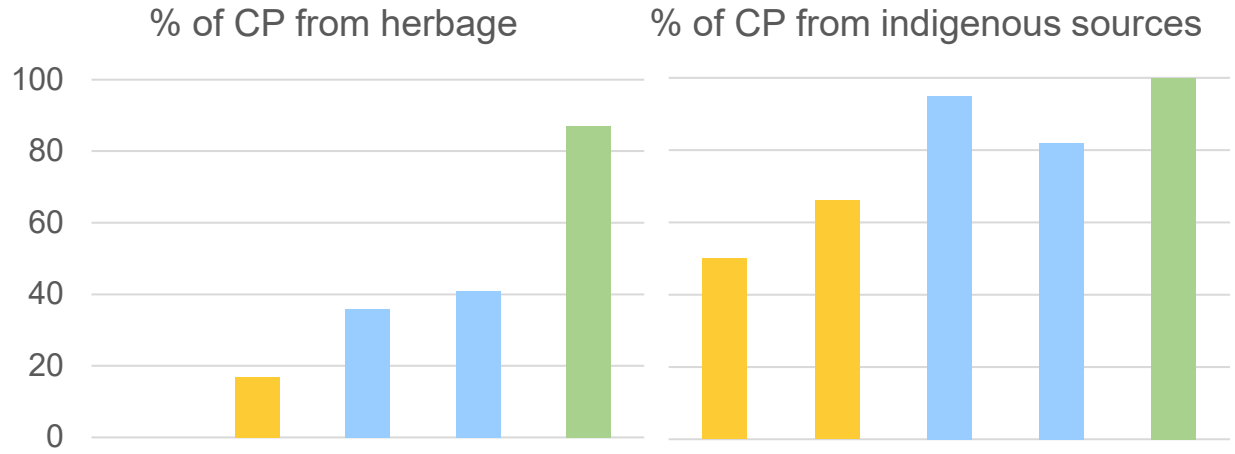
More herbage-based feeds for fattening cattle

	Maize-rich		Intermediate		Herbage-rich
Maize silage %	60 – 70		35 – 40		0 – 10
Herbage %	0 – 15		30 – 35		85 – 90
Concentrate %	20 – 30		20 – 30		0 – 5
Main CP source	Soyabean meal, maize gluten & rapeseed meal		Herbage products, peas or lupin grains		Herbage prod.
NEV & CP per DM	7.4 MJ 140 g	7.4 MJ 148 g	7.4 MJ 171 g	7.2 MJ 161 g	6.1 MJ 146 g

ADG = Average daily gain, CP = Crude protein, NEV = Net energy for meat production, Herbage = Grass silage, hay or fresh



Cpi = Crude protein intake



- Indigenous protein sources, most of which from herbage products, can cover protein requirements.
- The combined use of herbage products and grain legumes as protein sources enables high growth performances.
- The nitrogen use efficiency (ADG/CPi) decreases with an increased proportion of indigenous protein sources (protein quality).

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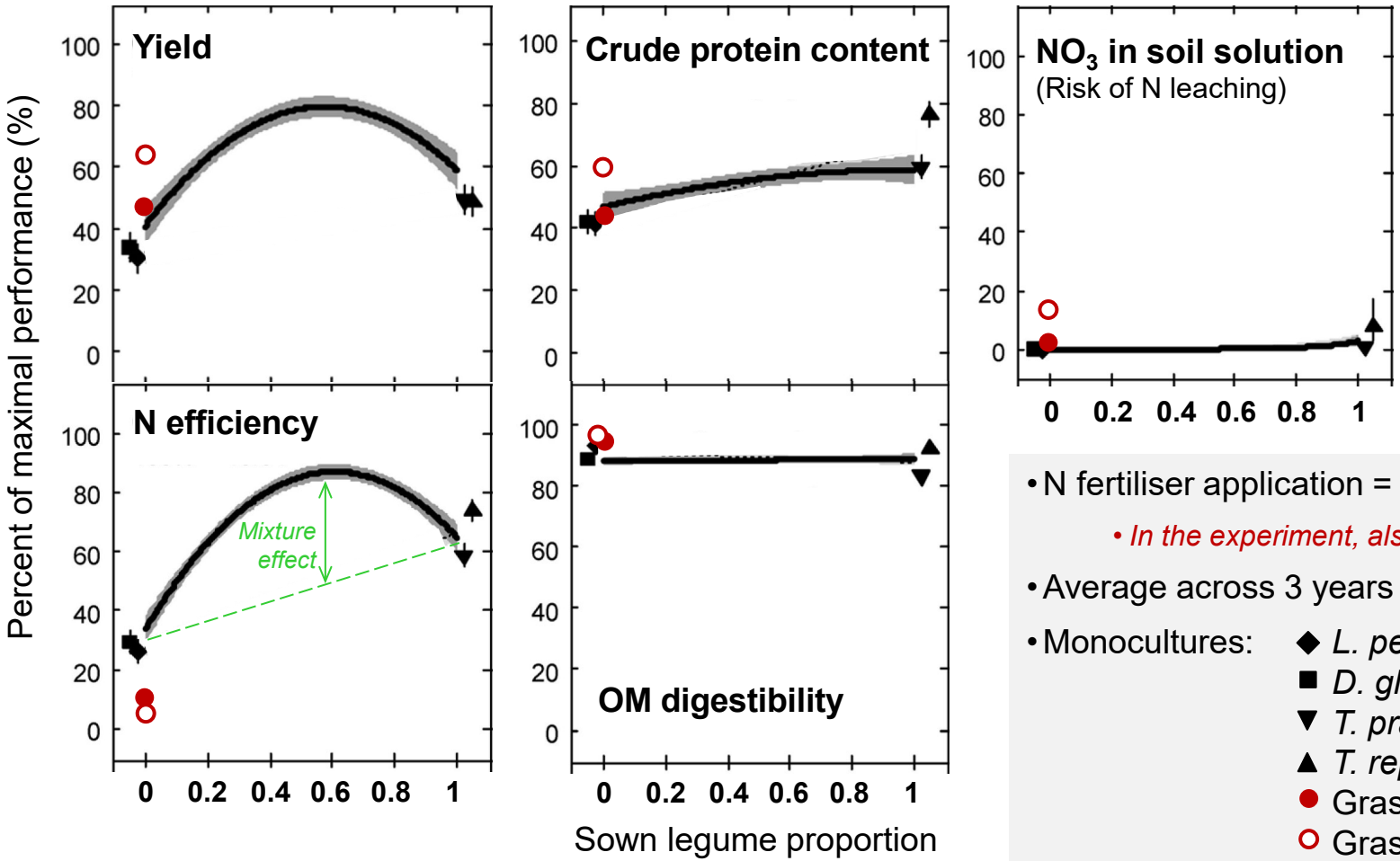
Optimise the share of forage legumes in leys



- N fertiliser application = 50 N kg ha^{-1} yr^{-1}
  - *In the experiment, also 150 and 450 kg N ha^{-1} yr^{-1}*
- Average across 3 years
- Monocultures:
  - ◆ *L. perenne*
  - ■ *D. glomerata*
  - ▼ *T. pratense*
  - ▲ *T. repens*

  } N50
  - ● Grass, N150
  - ○ Grass, N450

(Suter et al., 2021; Scientific Reports)

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Pasture management

	Low PreHM	High PreHM	*P*[#]
PreHM (kg DM/ha over 5 cm)	589	2288	***
PostHM (kg DM/ha over 5 cm)	150	200	***
Nutritive value of herbage			
Crude protein (g/kg DM)	240	184	**
Acid detergent fibre (g/kg DM)	188	218	*
Herbage NEL (MJ/kg DM)	6.6	6.3	***
Herbage intake (kg DM/d)	15.6	15.0	
Energy corrected milk (kg/d)	26.6	24.1	*
Nitrogen use efficiency[§]	0.24	0.27	-

[#]*P-value: * < 0.05, ** < 0.01 and *** < 0.001*
[§]*Calculated based on the average values per group*

- Per treatment 12 late mid-lactation Holstein cows
- **Low pre-grazing herbage mass** (low PreHM)
- **High pre-grazing herbage mass** (high PreHM)
- Similar herbage allowance 22 kg DM/d/cow.
- Full grazing, minerals and NaCl

(Rombach et al., 2023; J. Anim. Physiol. Anim. Nutr.)

Optimised grazing management can increase the protein and energy content of the herbage.

Even low protein forages can be introduced

	Pasture	Maize silage	Maize silage & protein	*P*[#]
Diet crude protein content (g/kg DM)	199	147	179	***
Herbage intake (kg DM/d)	13.3	9.9	9.6	***
Total intake (kg DM/d)	13.3	16.7	16.6	***
Energy-corrected milk (kg/d)	21.3	23.8	25.8	***
Nitrogen use efficiency	0.26	0.31	0.28	***

*[#]P-value: * < 0.05, ** < 0.01, and *** < 0.001*

- A total of 18 Holstein cows in mid-lactation
- 3 x 3 Latin square
- **Pasture**
- **Maize silage** = pasture & whole plant maize silage
- **Maize silage & protein =** pasture & whole plant maize silage (82%) & protein concentrate (18%)
- Composition of the protein concentrate: soybean meal (60 %), maize gluten (25%), potato protein (10%) and dried sugar beet pulp (5%)

(Rombach et al., 2024; J. Anim. Physiol. Anim. Nutr.)

- Even a low protein forages like maize silage can be introduced.
- For diets with maize silage: Protein in excess of requirements or protein quality may be responsible for further increases in milk yield.

Conclusions

- There are many different ways to increase or achieve protein autonomy in cattle feeding.
  - ↓ protein overfeeding
  - ↑ proportion of herbage in the diet
  - ↑ protein content in herbage (mixed swards with legumes, earlier use in low-grass diets, prioritise fresh herbage)
  - ↑ home grown grain legumes
  - feed additives (amino acids)
  - treatments of protein-rich feedstuffs (heat)
  - selection of efficient cattle
  - ...
- All these measures have different impacts on different environmental metrics, productivity, and product quality, which need to be weighed up.

Thank you for your attention!

Cows: Autonomous solution for grazing, fertilisation and milk production.

Exos (Lely): Autonomous solution for mowing, transporting, feeding and fertilising herbage.

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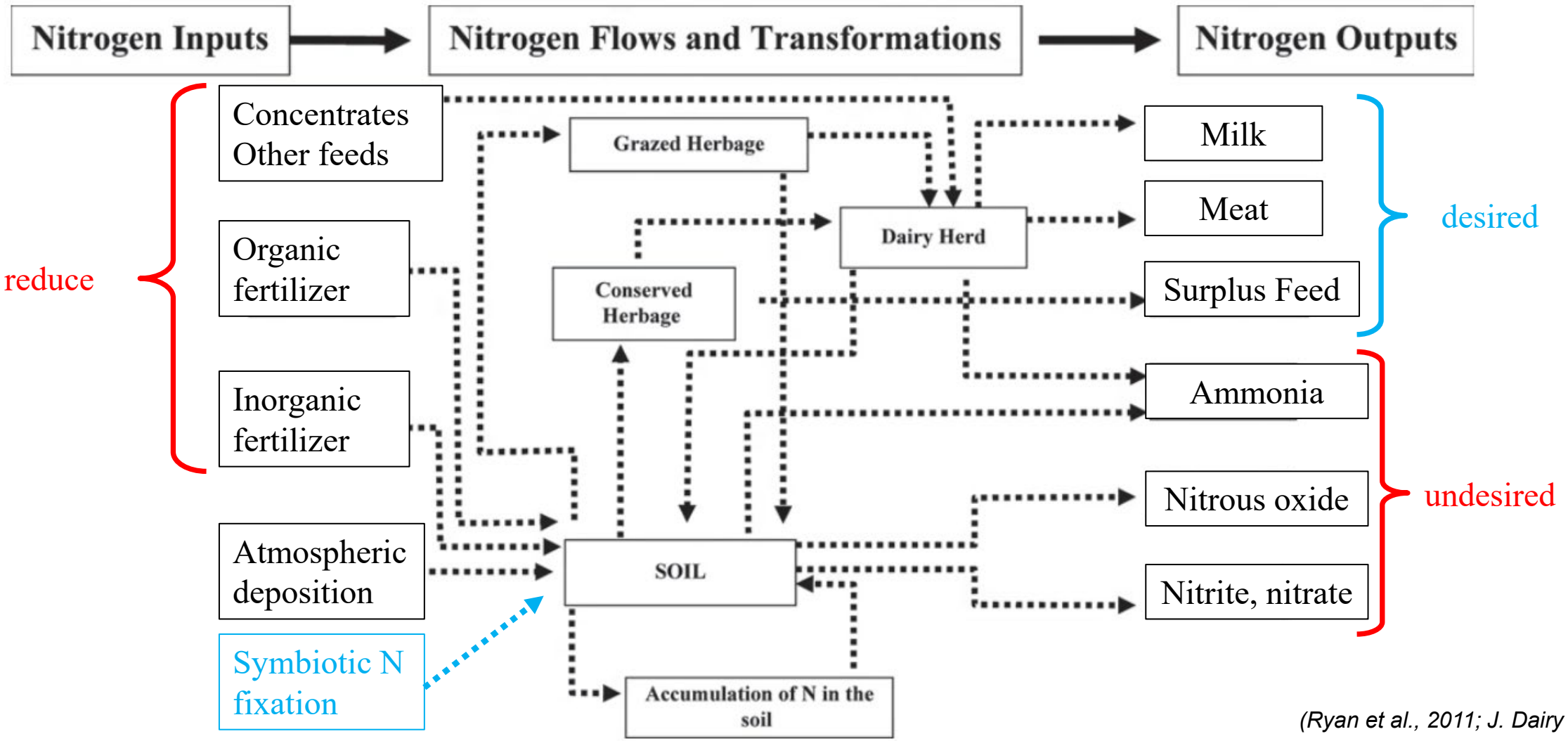
N flows within a grass-based dairy system



(Ryan et al., 2011; J. Dairy Sci.)

Yield	20.0 t ha^{-1} yr^{-1}	GraLeg N450 Yr2
N efficiency ($N_{yield}/N_{applied}$)	10.5	GraLeg N50 Yr2
Crude protein content	322 g kg^{-1} DM	Leg N450 Yr2
OM digestibility	671 g kg^{-1} DM	Gra N50 Yr2
NO3 in soil solution	75.3 mg N $liter^{-1}$	Leg N450 Yr3