Life-cycle Water Use, Nutrient Cycling and Solid Waste Generation of a Large-scale Organic Dairy

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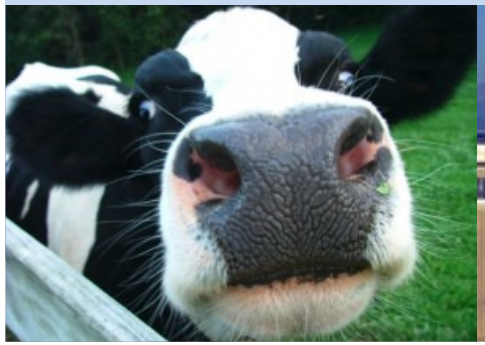
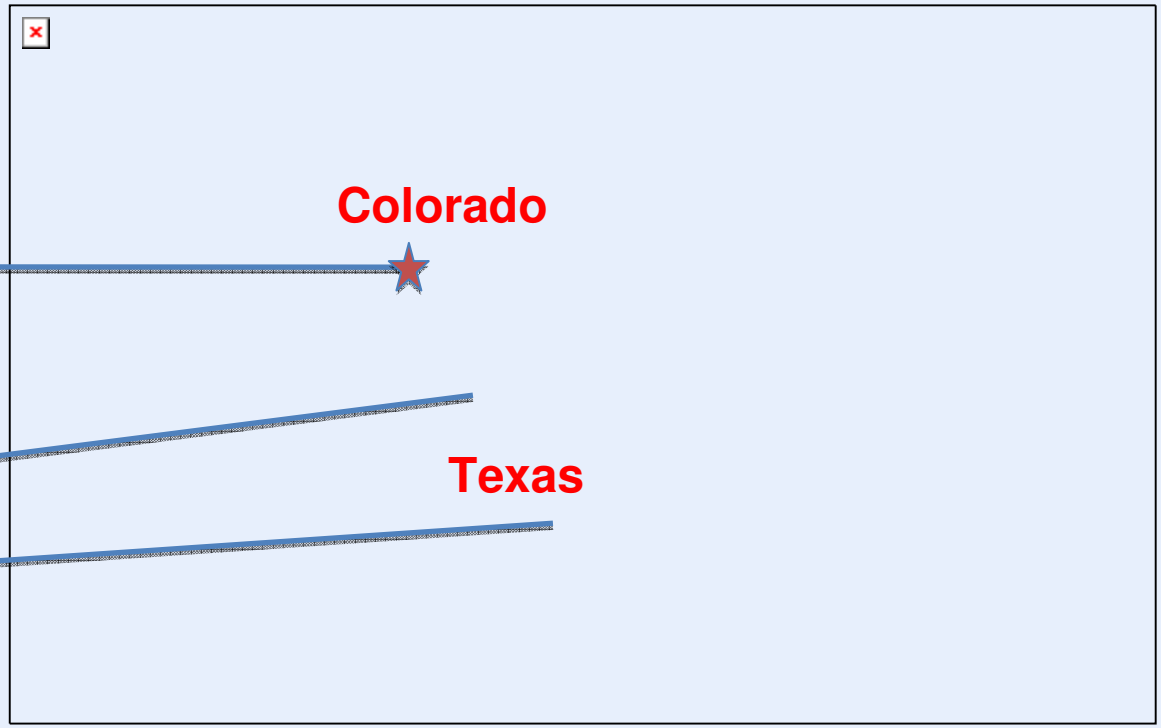



Overview of Aurora Organic Dairy

Mission: provide high quality **affordable organic** milk to customers across US

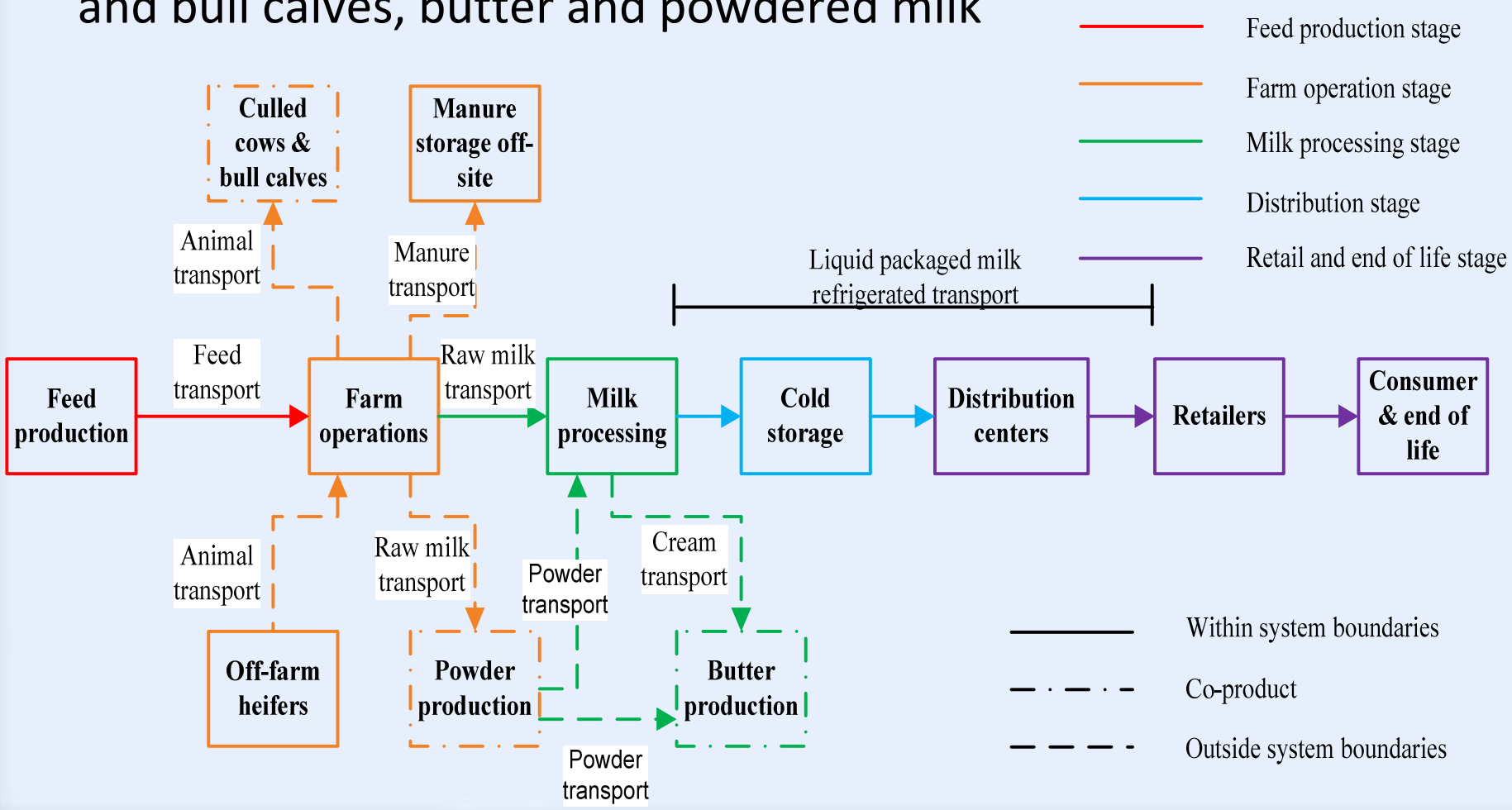
Farm	Herd Size
Platteville	892
High Plains	3672
Ray-Glo	614
Coldwater	4864
Dipple	1831



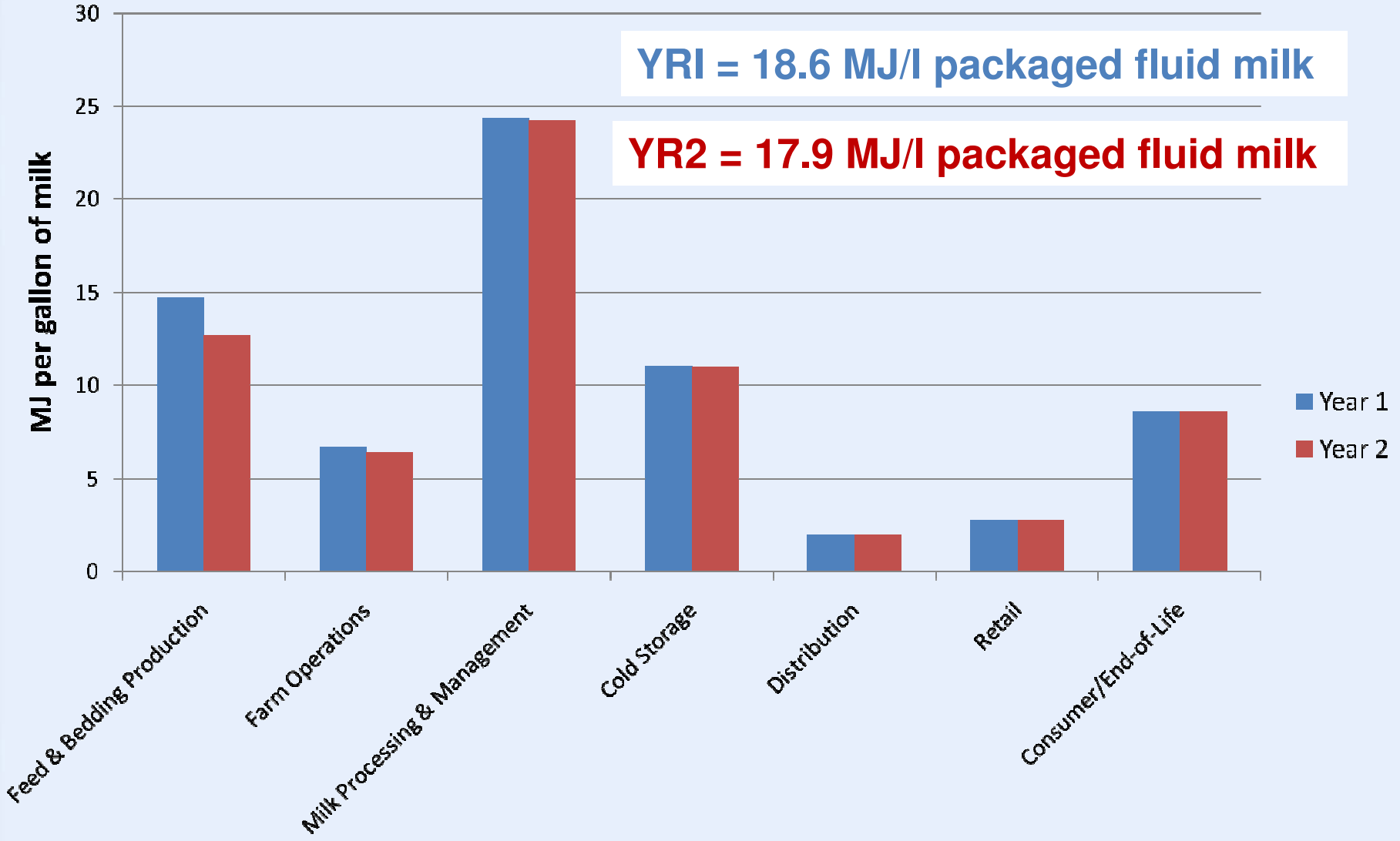
★ Milk Processing Plant

LCA System Description

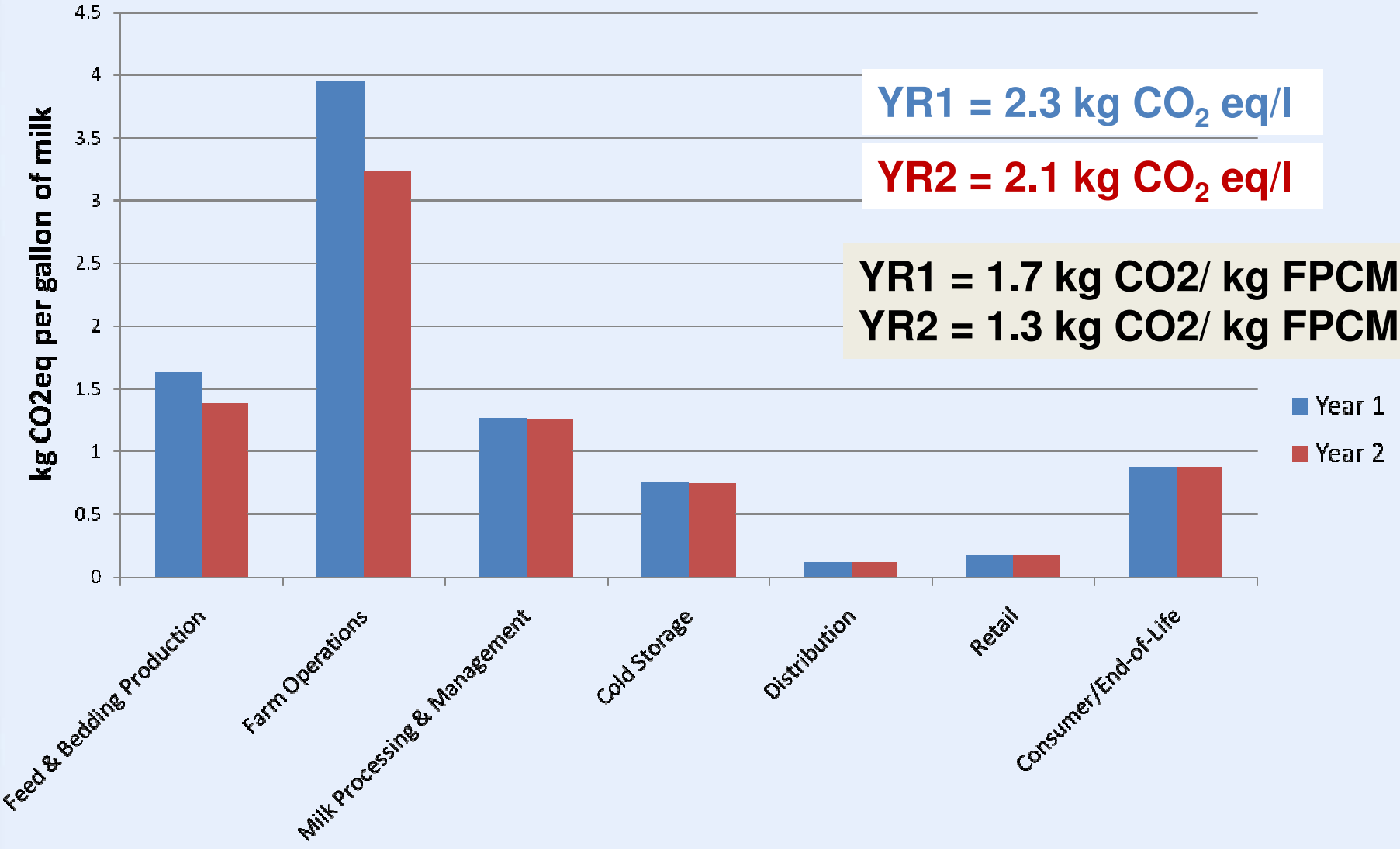
- Functional unit: One gallon (3.785 liters) of packaged liquid milk
- Impacts allocated on an energy basis to co-products: culled cows and bull calves, butter and powdered milk



Energy Use


YRI = 18.6 MJ/l packaged fluid milk
YR2 = 17.9 MJ/l packaged fluid milk
MJ per gallon of milk
30
25
20
15
10
5
0
Year 1
Year 2
Feed & Bedding Production
Farm Operations
Milk Processing & Management
Cold Storage
Distribution
Retail
Consumer/End-of-Life

Greenhouse Gas Emissions

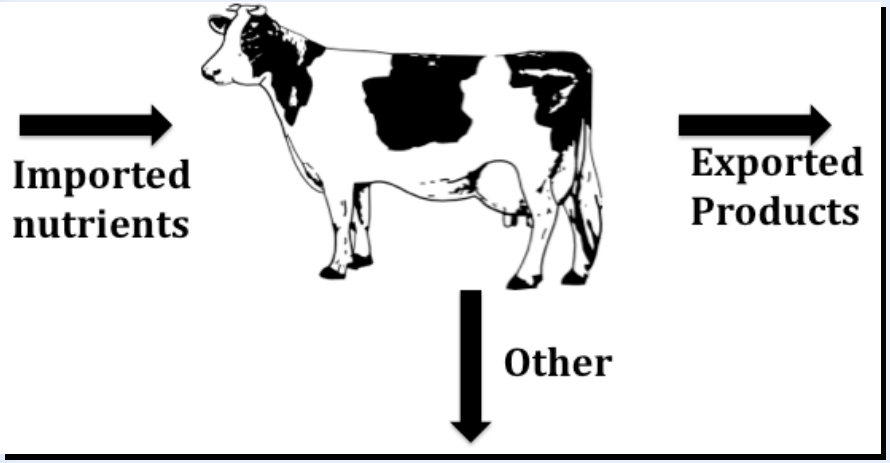


YR1 = 2.3 kg CO_2 eq/l

YR2 = 2.1 kg CO_2 eq/l

YR1 = 1.7 kg CO2/ kg FPCM
YR2 = 1.3 kg CO2/ kg FPCM

Nutrient Use Efficiency = N,P in Products/N,P in Nutrients

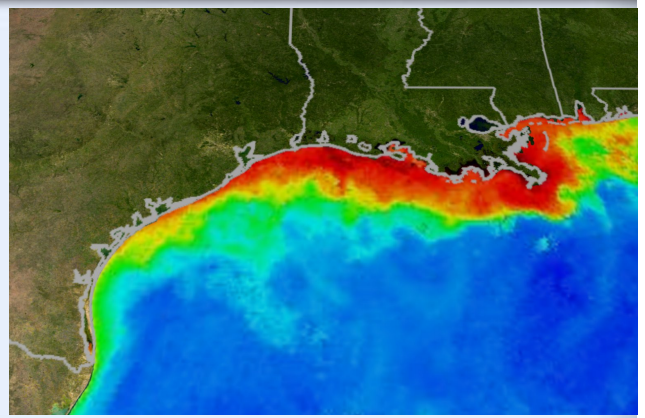


Other = excess nutrients in manure are released to the environment contributing to **acidification and eutrophication**

	AOD, all farms	AOD least efficient farm	AOD most efficient farm	Literature range*
N use efficiency	0.26	0.20	0.28	~0.18-0.35
P use efficiency	0.35	0.29	0.38	~0.30-66

* System boundaries and scope differ from this study. Cederberg and Mattsson 2000; Spears et al. 2003a,b; Kohn et al 1997; Watson 2002

Nutrient Use

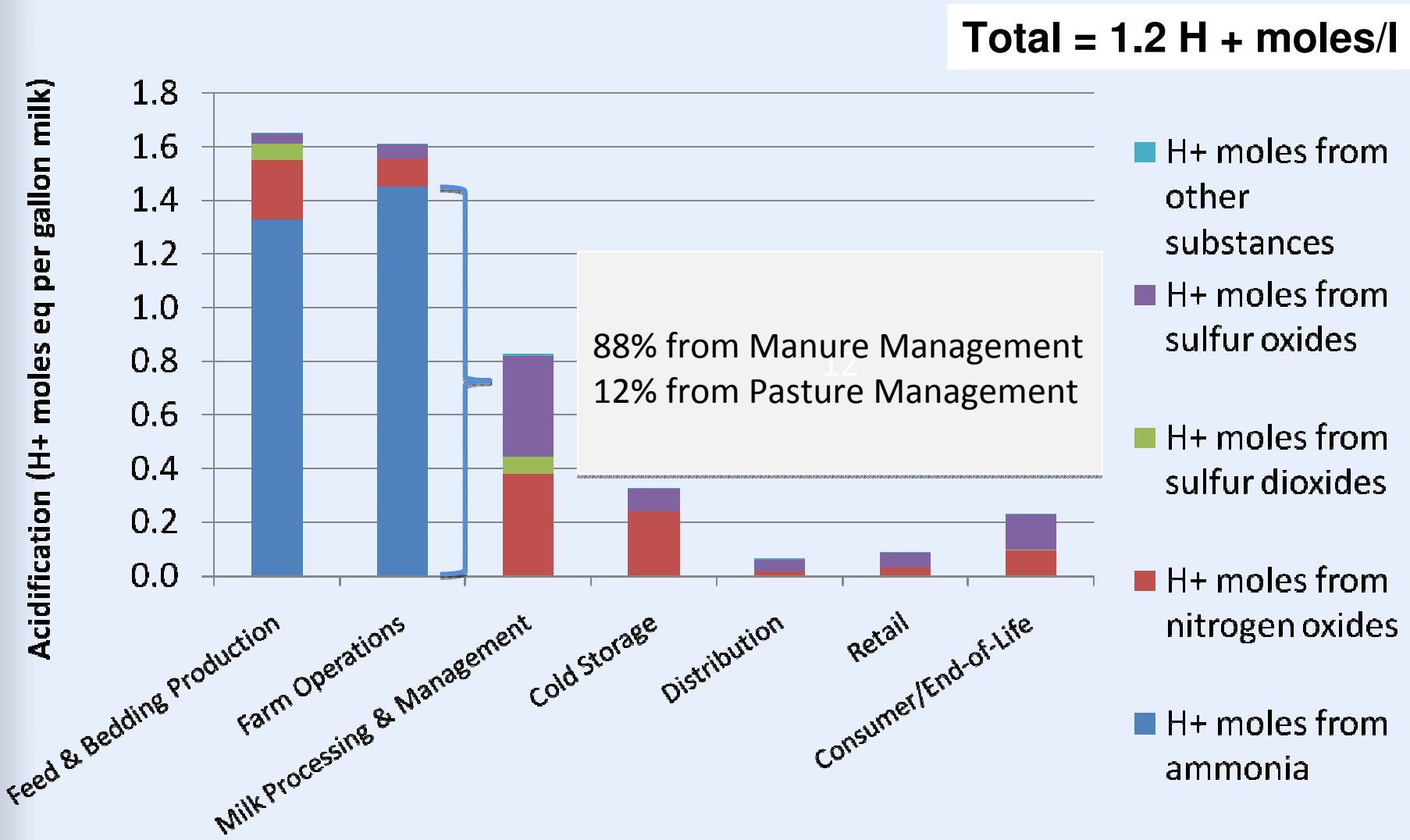


- Eutrophication and Acidification
  - The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (**TRACI**) 2 v3.0 (Bare, 2003)
- Feed and Bedding Production
  - Sources: Primary **AOD feed data and SimaPro agricultural datasets**
  - Greatest **uncertainty**: locations, management practices, **organic production data unavailable**
- Farm Operations
  - N_2O, NH_3, NO_3^-, and PO_4^{3-} releases were calculated based on AOD records using IPCC 2006, Davis 2006, NRCS 2009, Heller et al. 2009, and many other sources

Table 9. Methodology for quantifying nitrogen mass balance flows for all farm systems

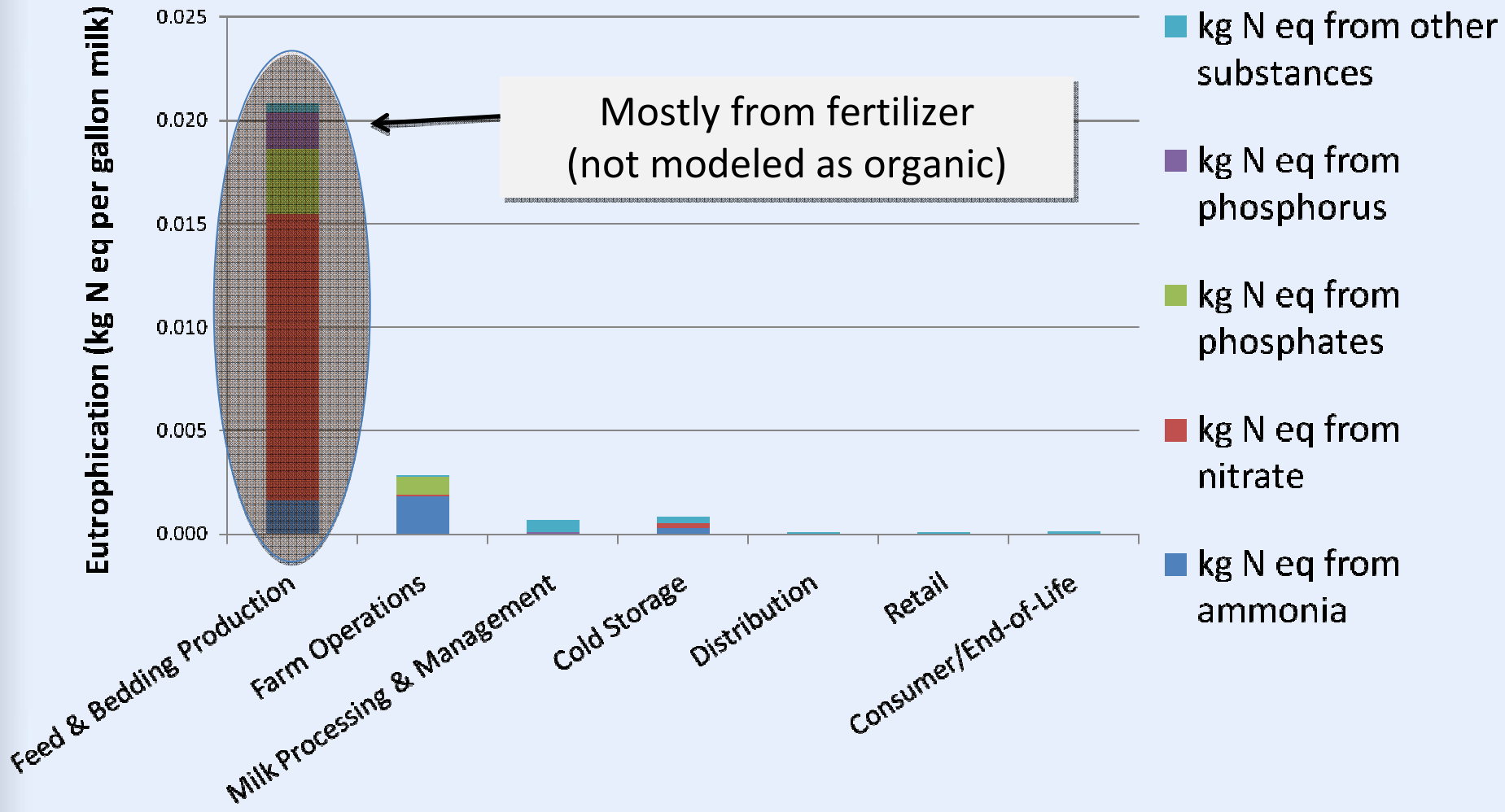
Nitrogen Farm Gate Balance		
Flow (I = input, O = output)	**Calculation formula**	**Source**
Herd I/O	# cows * N content/cow	AOD records; Dou et al., 1996
Purchased feed I	Feed mass * N content/feed	AOD records; NRCS, 2009
Bedding I	Bedding mass * N content/feed	AOD records; NRCS, 2009
Pasture forage seed I	Seed mass * N content/seed	AOD records; NRCS, 2009
Atmospheric N fixation I	Ha legume forage * N fixation/Ha	AOD records; Ledgard & Steele, 1992
Milk O	Milk mass * N content/mass	AOD records; Powell et al., 2008; confirmed with Barbano and Lynch, 1999
N_2 from manure management O	Sum over all cow populations and management systems (total gaseous N * fraction of N_2 in gaseous N)	Adapted from tables 10.32, 10.22 and 10.24 IPCC (2006)
N_2 from managed soils O	Total N to pasture * 10% Emission factor	Adapted from Brentrup, 2000; IPCC, 2006
N_2O total O	Direct N_2O from manure management + Indirect N_2O from manure management + Direct N_2O from managed soils + Indirect N_2O from manages soils	AOD records; IPCC, 2006; Heller et al., 2009
NH_3 from manure management O	Sum over all cow populations and management systems (total N volatilized as $NH_3$and NO_x - total N volatilized as N_2O from manure management)	AOD records; IPCC, 2006; confirmed with Pinder et al., 2004; assumed N_2O to total NO_x ratio of 1:3
NH_3 from pastures O	Sum over all cow populations and management systems (N deposited on pastures * 30% volatilization rate)	AOD records; IPCC, 2006; Davis, 2009
NO3- to pastures O/I	Sum over all cow populations and	AOD records; IPCC, 2006; Davis,

Life Cycle Acidification Impacts



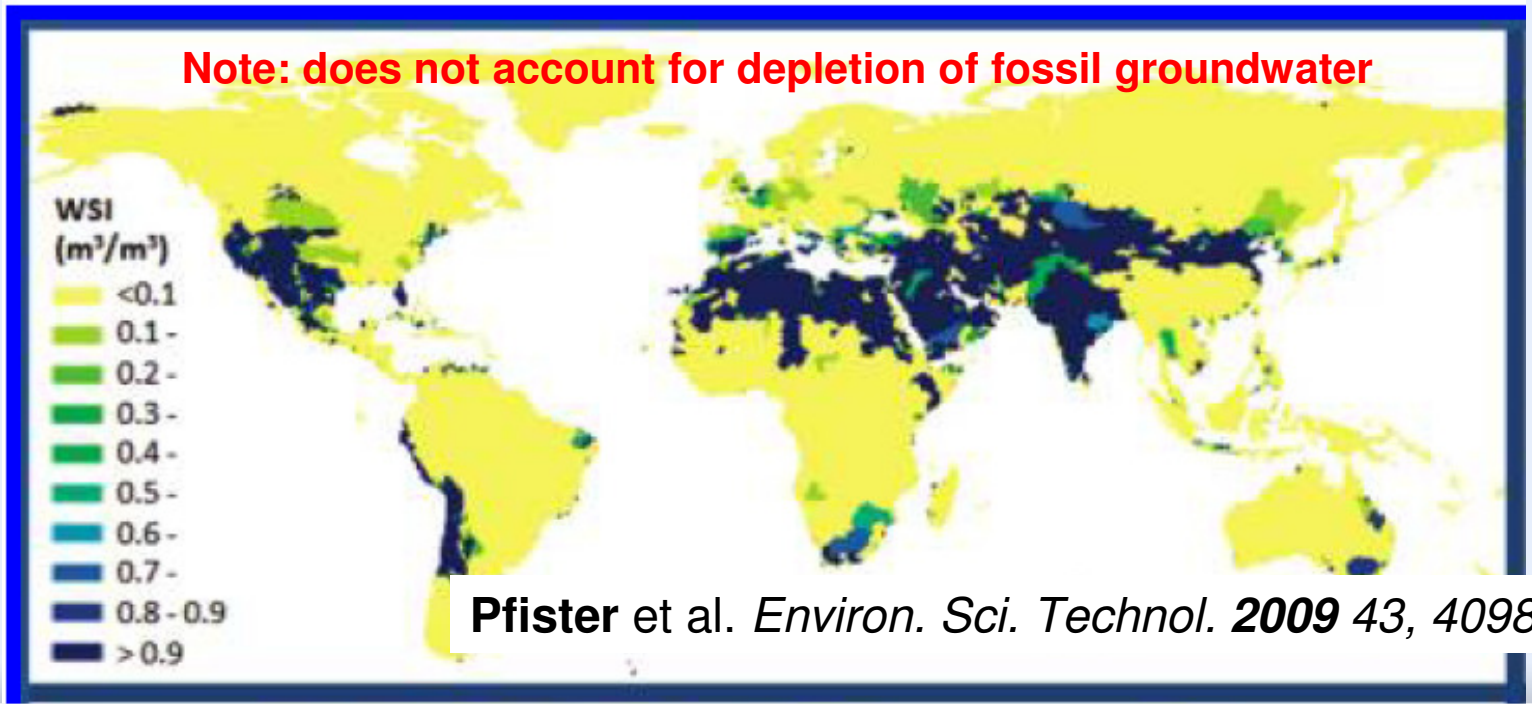
Life Cycle Eutrophication Impacts

Total = 0.0066 kg N eq/l



Water Use in the Milk Life Cycle

- Feed and Bedding Production
  - FAO's CROPWAT 8.0 and CLIMWAT 2.0, were used to determine the irrigation requirements for a given crop in a specific region
- Water Stress Index (WSI)
  - Measures the impact of consumption on the availability of

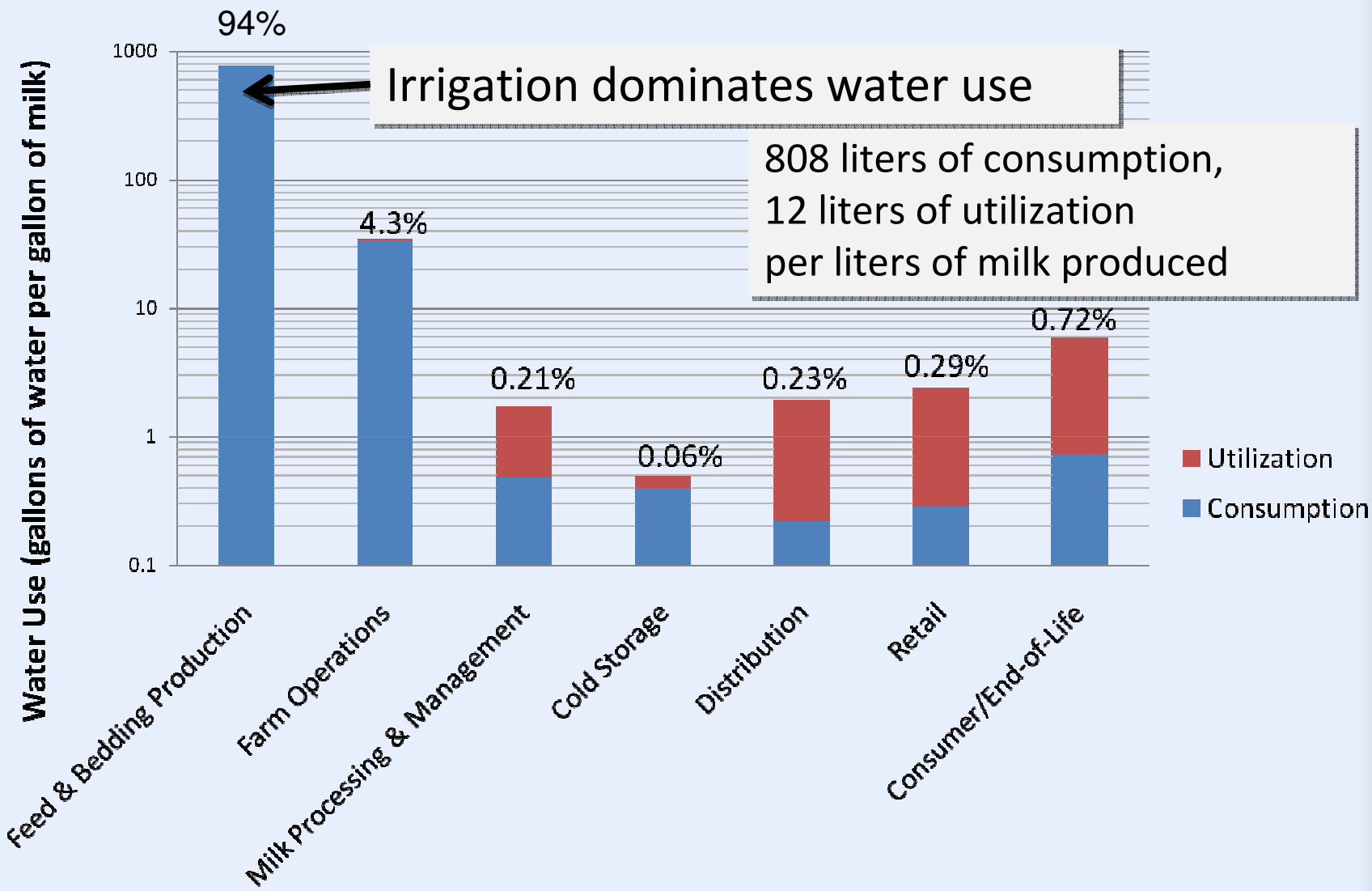


Pfister et al. *Environ. Sci. Technol.* ***2009*** *43, 4098–4104*

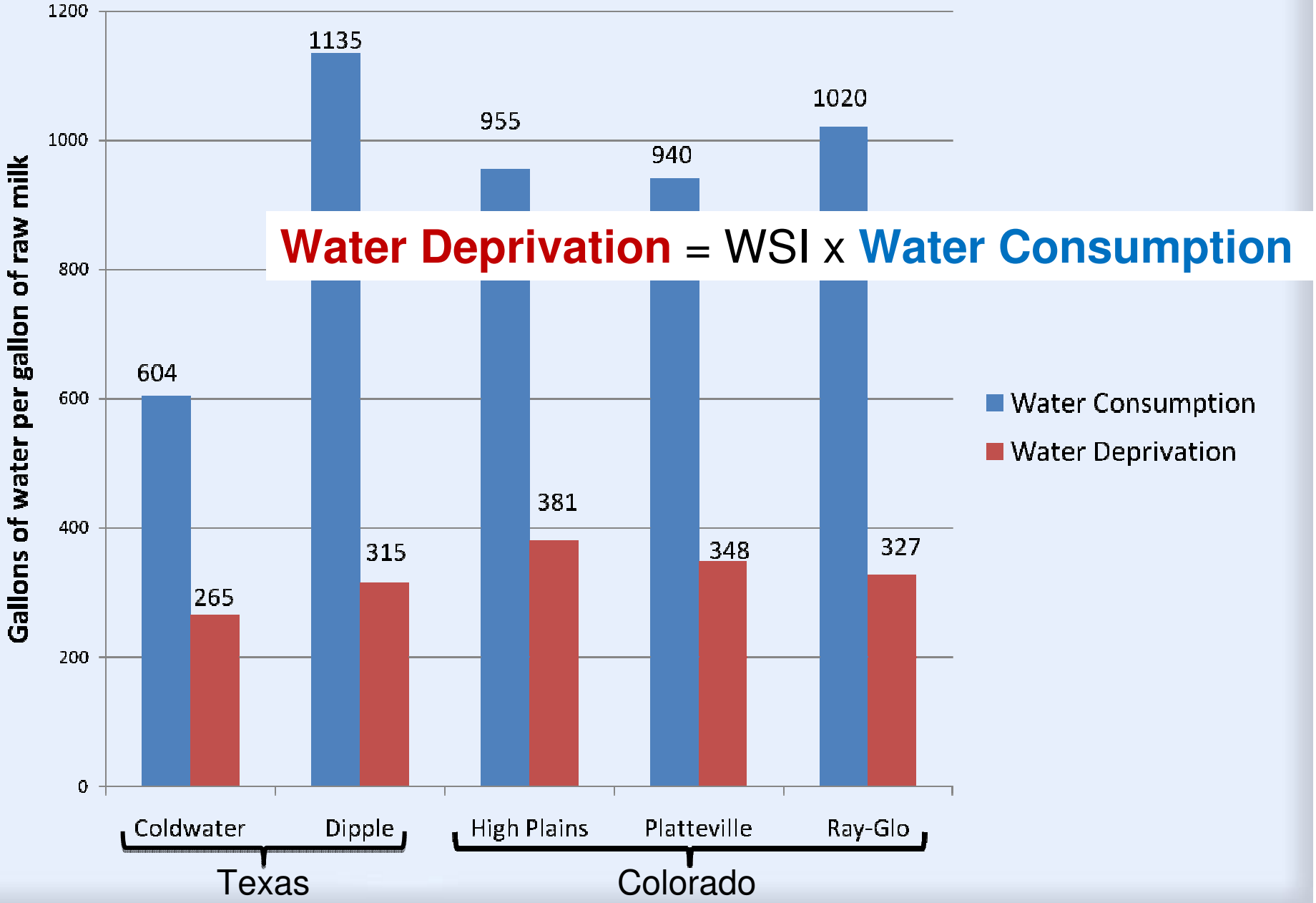
Diapositiva 10

MH8 double check, but I'm pretty sure rainwater is NOT accounted for...
Martin Heller, 14/09/2010

Results: Full Life Cycle Use



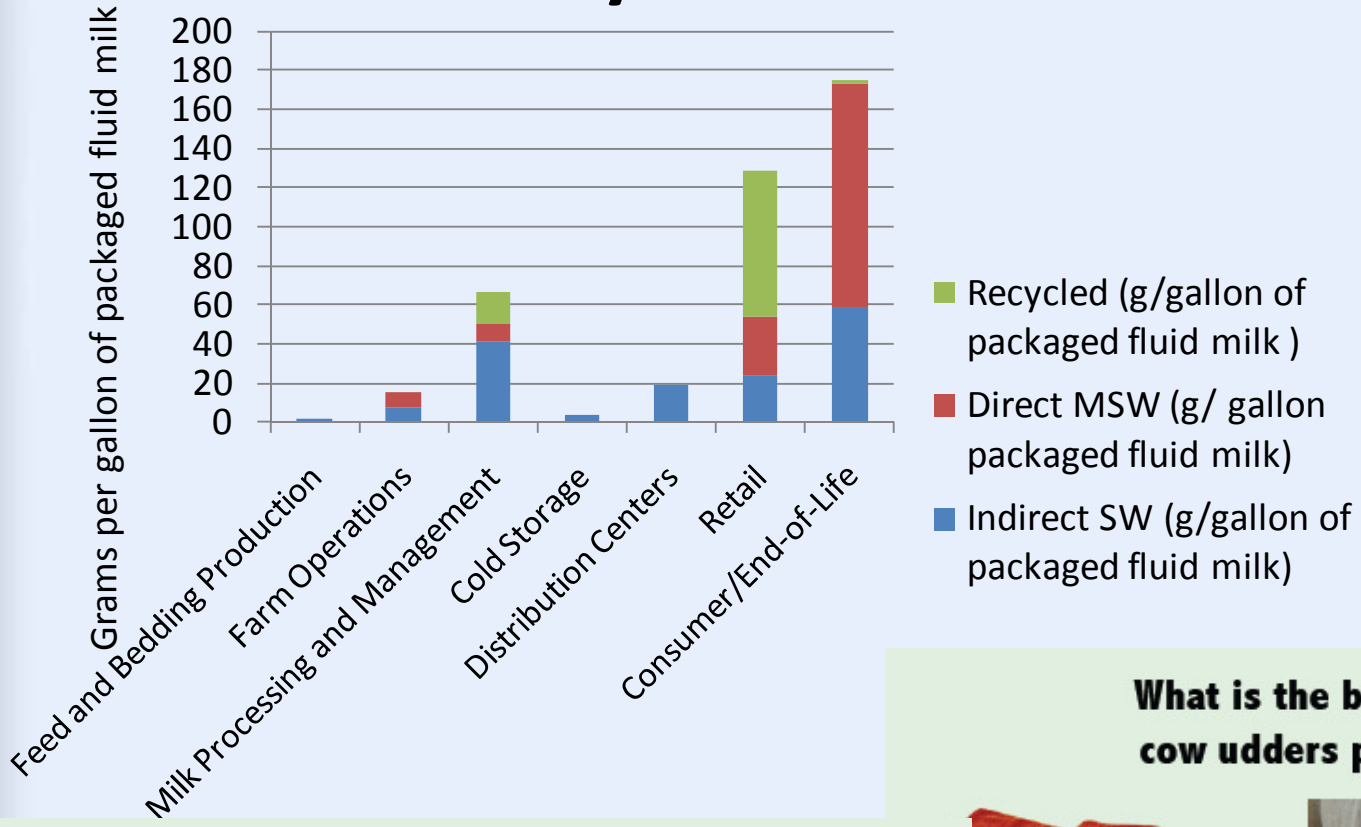
Results: Water Deprivation at Feed-growing Locations

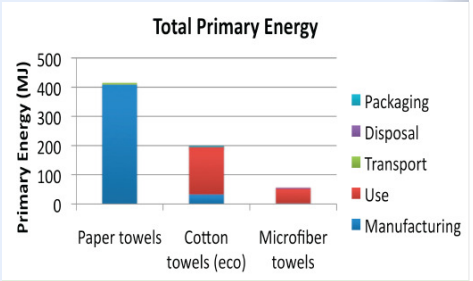


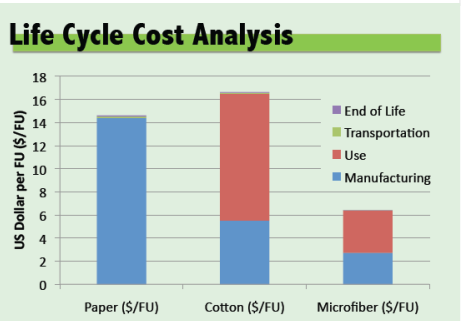
Improvement Strategies: Water Use

- Source feed from…
  - Growers with higher irrigation efficiency
  - Regions of lower water stress
- Water Energy Tradeoff?
  - Transport feed greater distances from areas of less water stress
- AOD is switching a portion of feed to forage grown on AOD pastures to meet new organic standards
  - AOD pastures, however, are in high water stress regions

Life Cycle Solid Waste Results







Current operations use disposable paper towels

13.5 million per year at all facilities

What is the best way to clean cow udders prior to milking?

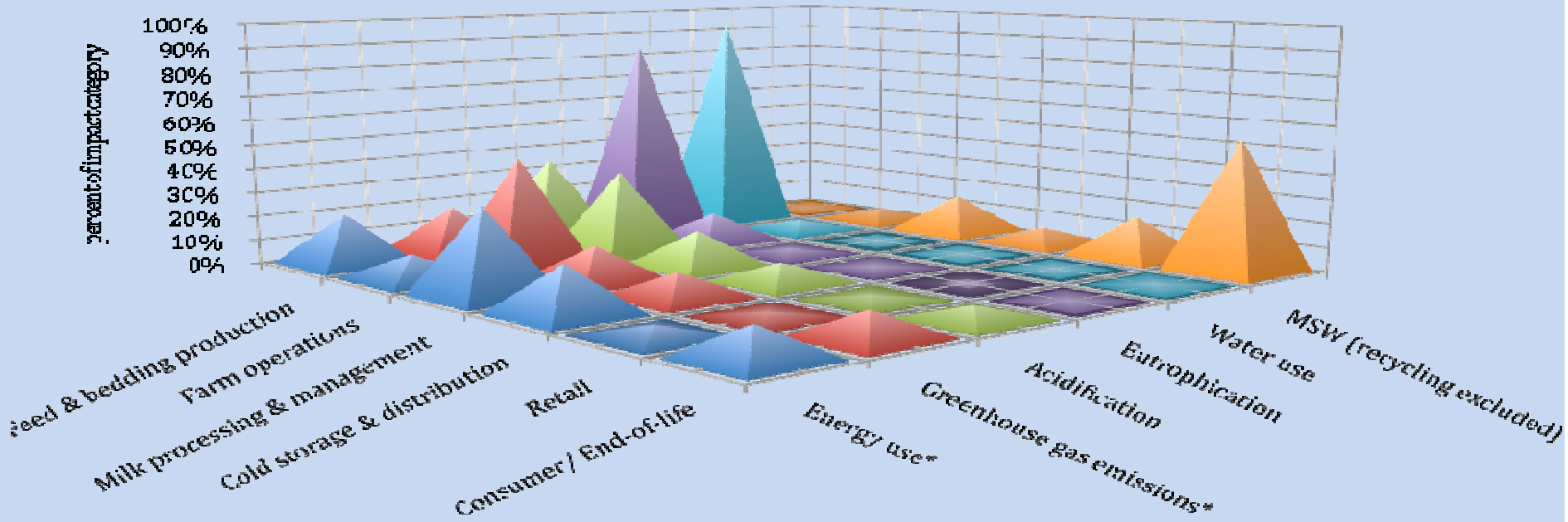


Figure 5: The emergence of an environmental impact "landscape" across the AOD fluid milk life cycle. Percentages add to 100 for each impact category. * Energy and GHG reported in Heller & Keoleian, (in review).

Local production and distribution **vs large scale and national** distribution?

Reducing feed and bedding transport to within a 161 km radius of the farms causes a **7% overall system energy reduction**

Reducing the weighted average distance to finished product distribution centers to 161 km results in a **12% reduction in system energy**

Acknowledgements

- Mark Retzloff, CEO of AOD
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- Stephan Pfister, ETH Zurich
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Questions?

http://css.snre.umich.edu