# Environmental Sustainability, Food Security and Animal Food Production: Milk and Dairy as a Case Study

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http://barfblog.com/tags/one-health/

# Welcome Chinese Elite Cattlemen Students!

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# My Task for Today

- Sustainability of food animal production with emphasis on milk and dairy
- Environmental impact of milk and dairy production with consideration for nutrient supply for the average human
- Capability of nutrition models to help calculate the environmental impacts and role of byproducts in diets
- Role of intensification in the process of producing animal based and reduction of environmental impacts

# Role of Animal Agriculture in the Future

- Opportunities
  - Great source of essential nutrients especially for children and older adults
  - Makes use of land that is not good for other crops
  - Makes use byproducts from human food production
  - Enhance indigenous animal resources and provide fertilizer and fuel

# Role of Animal Agriculture in the Future

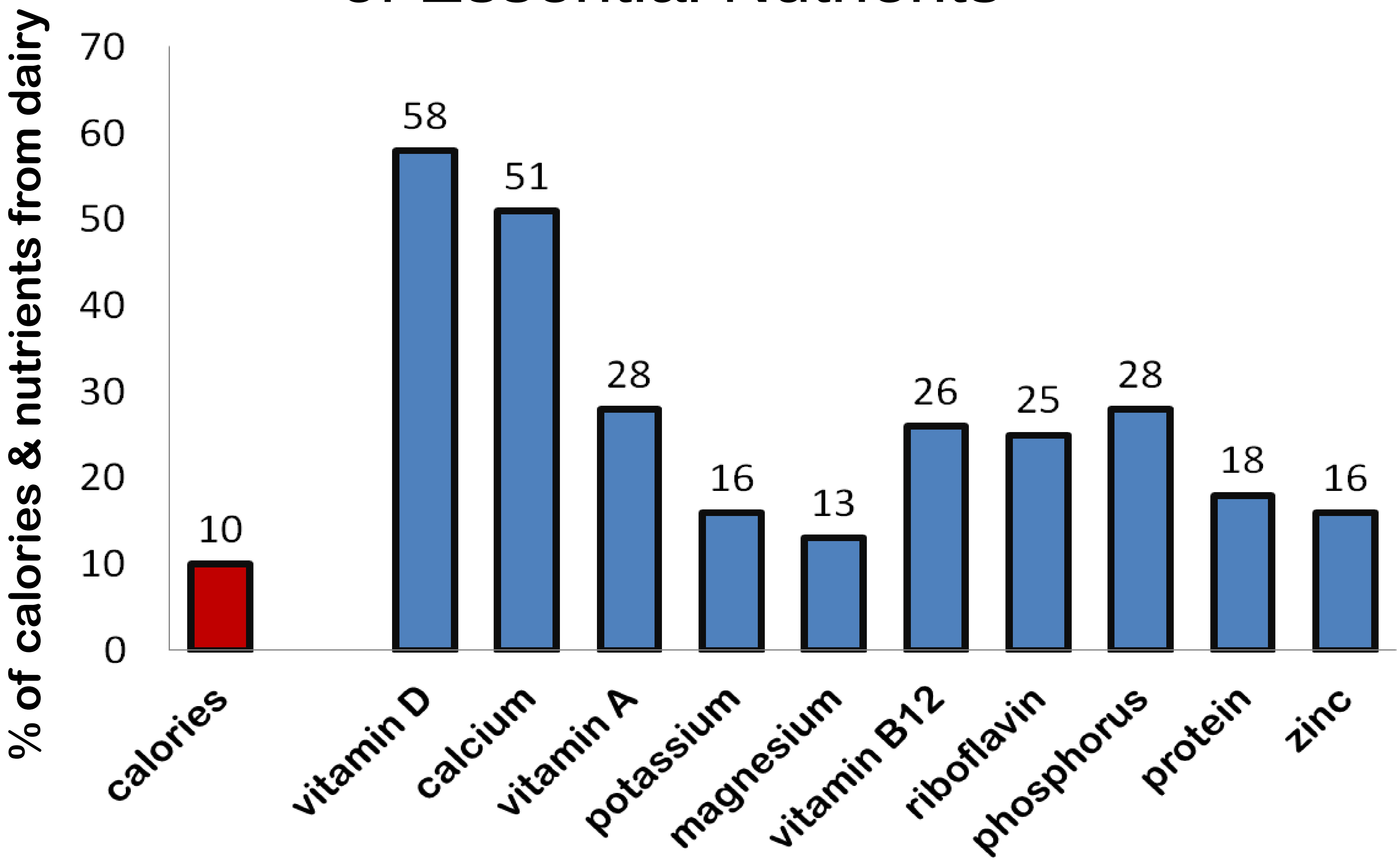
- Risks
  - Education, training, workforce
  - Resources and infrastructure – land, water, transportation, energy, (food processing and distribution), etc.
  - Failure to recognize/accept productivity as a solution and adopt technologies
  - Political stability and inability to engender appropriate working capital

# Animal Source Foods – Key components of a balanced diet

- Animal source foods are included in dietary recommendations by public health organizations around the world
- Children with little or no animal source foods have significant development problems:
  - Poor growth
  - Impaired cognitive performance
  - Neuromuscular deficits
  - High mortality rates

**Reviewed by:** Nuemann et al. (Nutrition Research 22:193) and Murphy & Allen (J. Nutrition 133:3932S)

# Dairy Products Contribution to U.S. Intake of Essential Nutrients




**NHANES 2003-2006, ages 2 years and older**

# Environmental Comparison of Human Food Sources

- Past evaluations of environmental impact have often compared foods on the basis of mass (weight) or energy (calories) or even cow/animal unit.
- Inexcusable to not consider the nutritional implications of alternative food choices.
- Comparison of foods requires a functional unit that is relevant from both a nutritional and environmental perspective

# Dietary Greenhouse Gas Emissions of Meat Eaters, Vegetarians and Vegans in UK

| Diet types | Age and Sex Adjusted Mean Dietary GHG Emissions, (kgCO2eq/d) |
|---|---|
| All meat eaters | 5.93 |
| High meat eaters (>100g/d) | 7.19 |
| Medium meat eaters (50-99 g/d) | 5.63 |
| Low meat eaters (<50g/d) | 4.67 |
| Fish eaters | 3.91 |
| Vegetarians | 3.81 |
| Vegans | 2.89 |

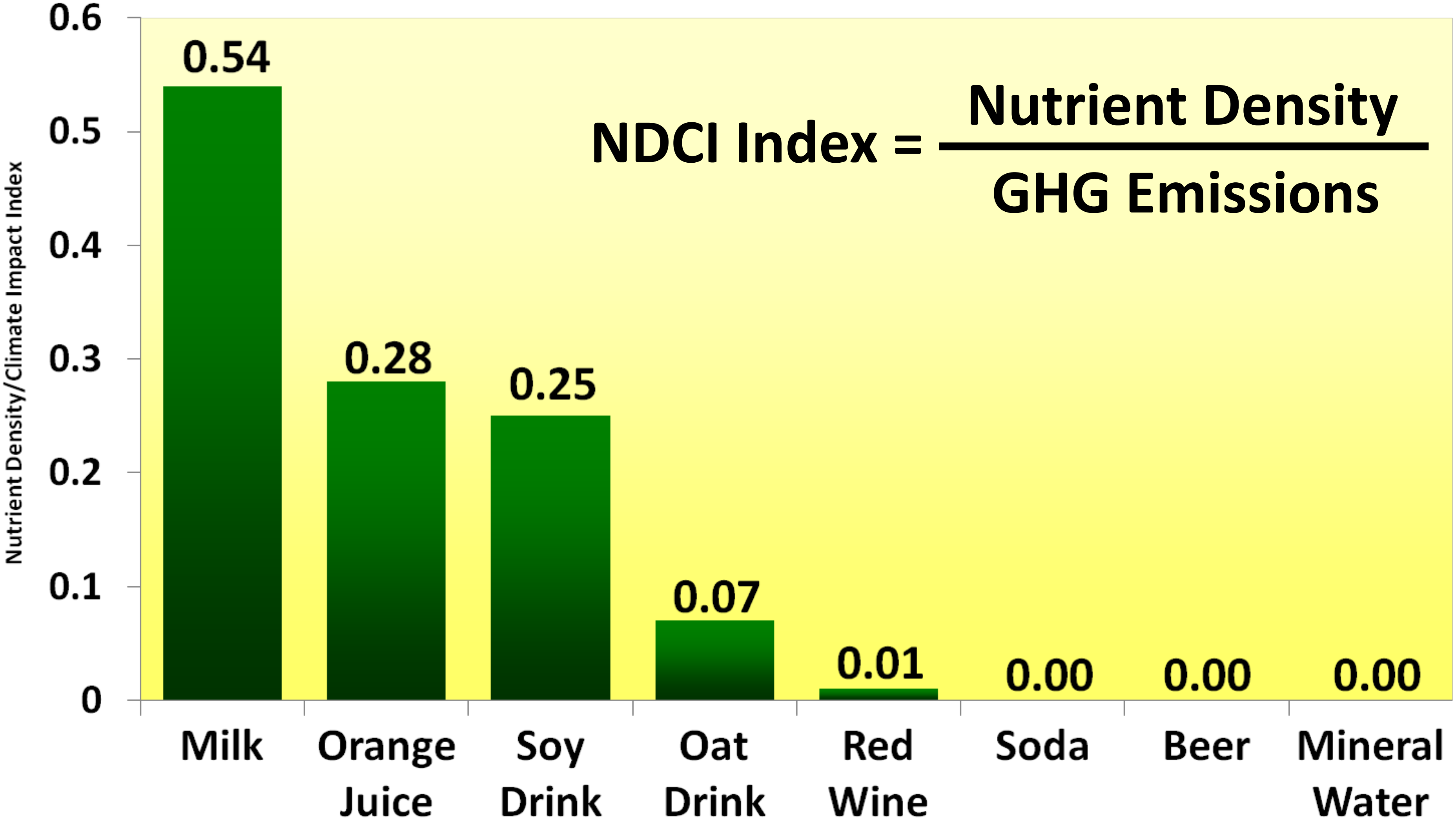
Scarborough et al., 2014; Climatic Change 125:179-192

# Beverages Vary in Nutrient Density and Greenhouse Gas Emissions

| | Nutrient Density | GHG Emissions g $CO_2$-eq/g product |
|---|---|---|
| Milk | 53.8 | 99 |
| Orange Juice | 17.2 | 61 |
| Soy Drink | 7.6 | 30 |
| Oat Drink | 1.5 | 21 |
| Red Wine | 1.2 | 204 |
| Soda | 0.0 | 109 |
| Water | 0.0 | 101 |
| Beer | 0.0 | 10 |

Source: Smedman et al. (2010). Nutrient density to climate impact (NCDI) index of beverages. Food & Nutrition Research 54:5170.

# Nutrient Density Must Be Included When Assessing Environmental Impact




Based on Smedmen et al. 2010

# Integration of Health, Environment and Nutrient Supply: Milk Example

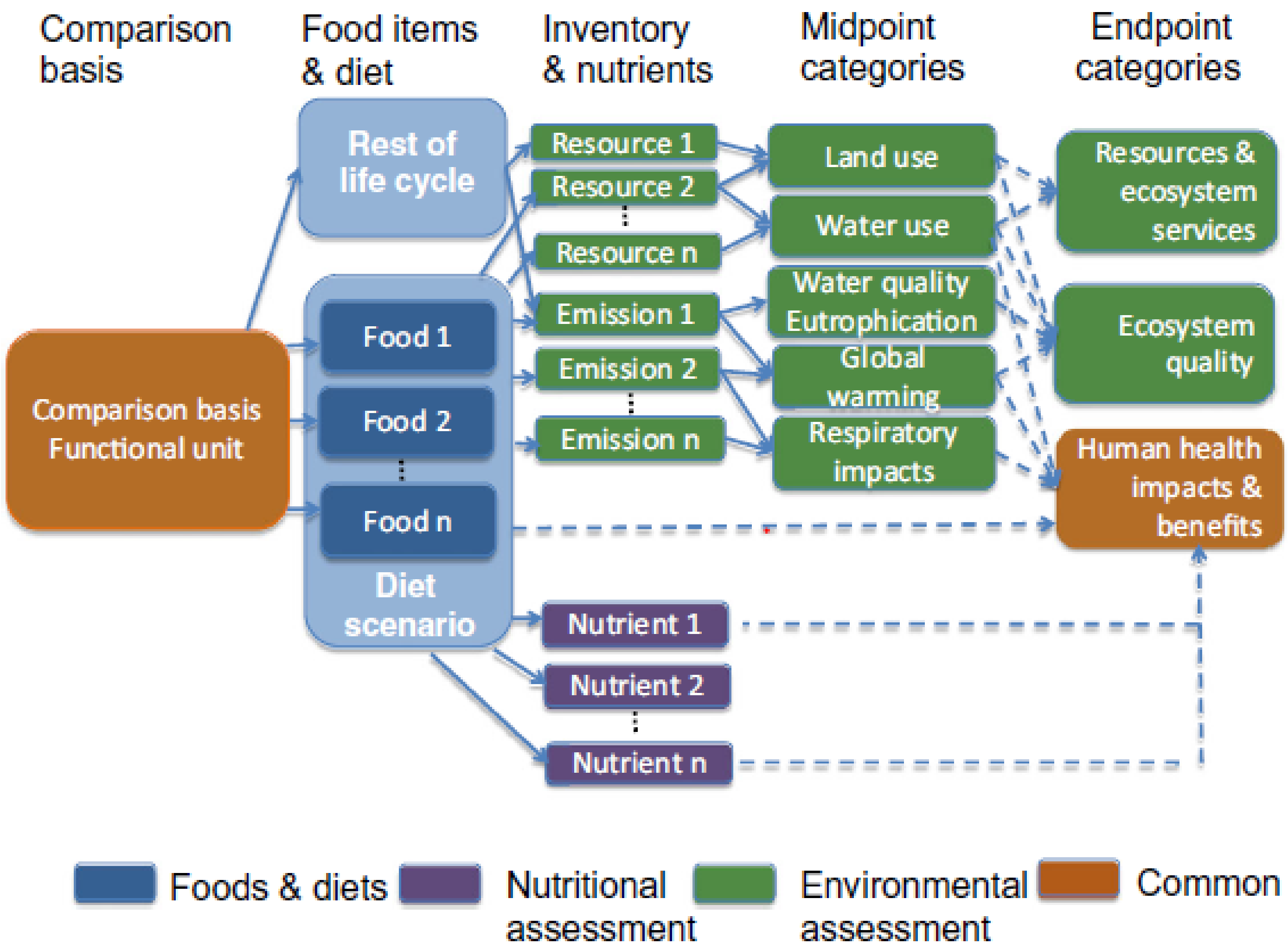



**Fig. 1** Graphical representation of the combined nutritional and environmental health impact LCA framework. *Dashed lines* represent links between midpoint and endpoint categories that are useful to interpret impact scores, but whose quantification is also associated with a high degree of uncertainty

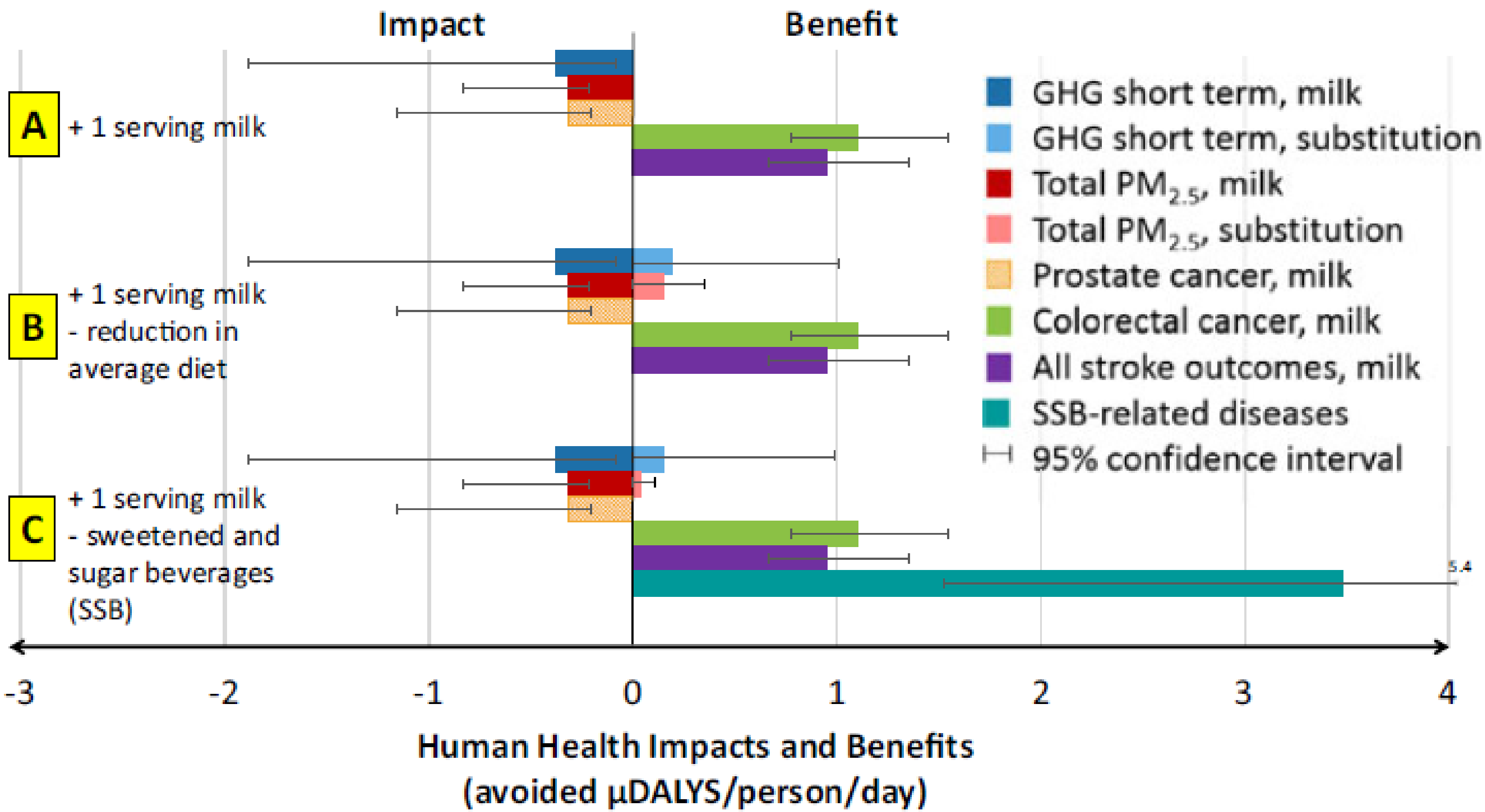
Stylianou et al. Int J Life Cycle Assess (2016) 21:734–746

# Comparison made of current U.S. diet and alternatives adding or exchanging a 119 kcal serving of milk


The width of food groups corresponds to their caloric contribution to the total average US diet

Stylianou et al. Int J Life Cycle Assess (2016) 21:734–746

# Outcomes in Health Benefits (µDALY) Compared to the Standard U.S. diet by Addition or Exchange of 1 serving Fluid Milk




DALY = Disability Adjusted Life Years – gap between current health status and ideal health status

Stylianou et al. Int J Life Cycle Assess (2016) 21:734–746

# Population growth, food for animals, concerns about intensification

- The Food and Agriculture Organization of the United Nations indicates food production will have to increase by 20-50% to meet the needs of people

- The majority of the basic food supply for humans will continue to be plant based – which means we will have more byproducts to dispose of

- Intensification of animal agriculture is considered a sustainability issue, but not well described in context of current systems (e.g. approx. 10-60% of dairy cow diets world-wide are made up of byproducts of the human food chain

# Human Food & Fiber By-product Examples

## Oil extraction
- Canola meal
- Cotton hulls
- Cotton seed meal
- Linseed meal
- Peanut meal
- Soy hulls & meal
- Sunflower hulls & meal

## Brewing & Spirits
- Brewers grains
- Brewers solubles
- Brewers yeast
- Distillers grains

## Grain milling
- Bran (corn, wheat, rice)
- Cereal fines
- Midds (corn, wheat, barley)

## Clothing
- Whole cotton seed

## Fruit/Vegetable processing
- Pomace (apple, tomato, carrot)
- Vine silage (peas & legumes)
- Corn stover
- Potato peels
- Almond hulls

## Citrus processing
- Citrus pulp

## Ethanol production
- Distillers grains (corn, milo, barley, sorghum)

## Dry corn milling for corn flour & grits
- Corn bran
- Hominy feed

## Wet corn milling for starch, sweeteners & oil
- Corn germ meal
- Corn gluten feed

## Sugar processing
- Beet pulp
- Molasses

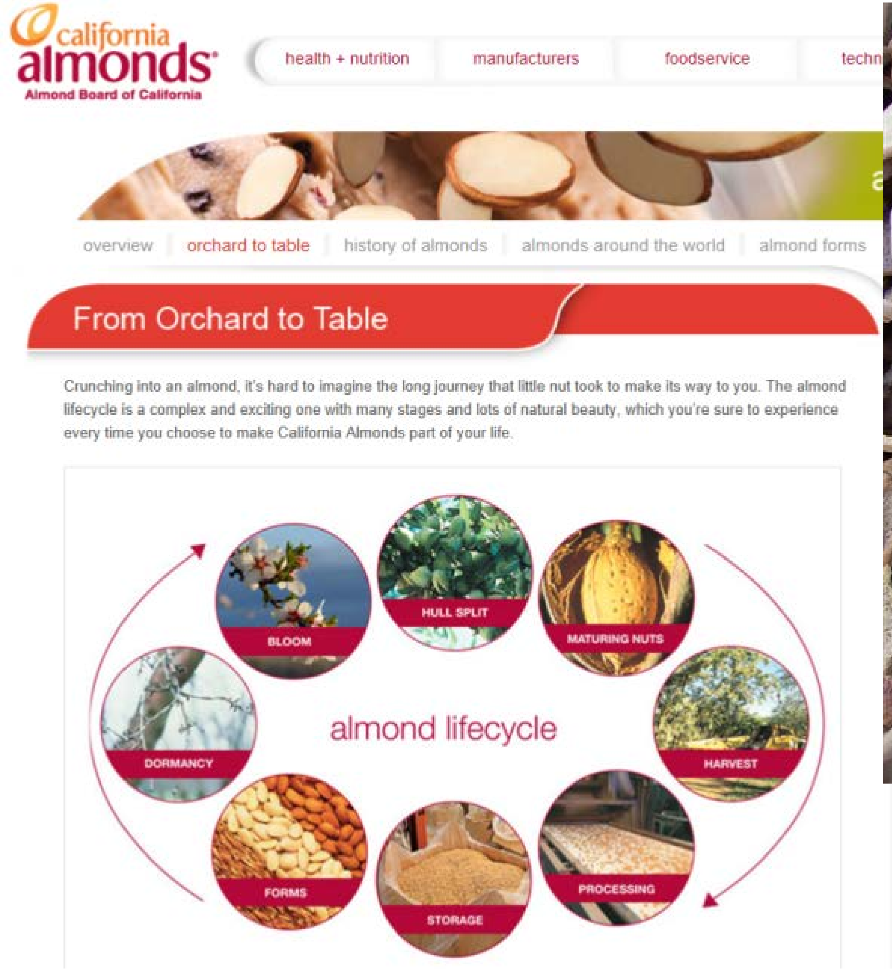
## Fish processing
- Fish meal

## Cheese manufacturing
- Whey

## Baking industry
- Bakery by-products
- Expired product

## Chocolate manufacturing
- Candy by-products
- Confectionary waste

## Human foods that fail grading
- Starches, oils
- Grains, flour
- Vegetables




Almond Growers keep good records
http://www.almondboard.com

- They produced 2.1 billion kg of almond hulls this past year - all currently disposed of through cattle

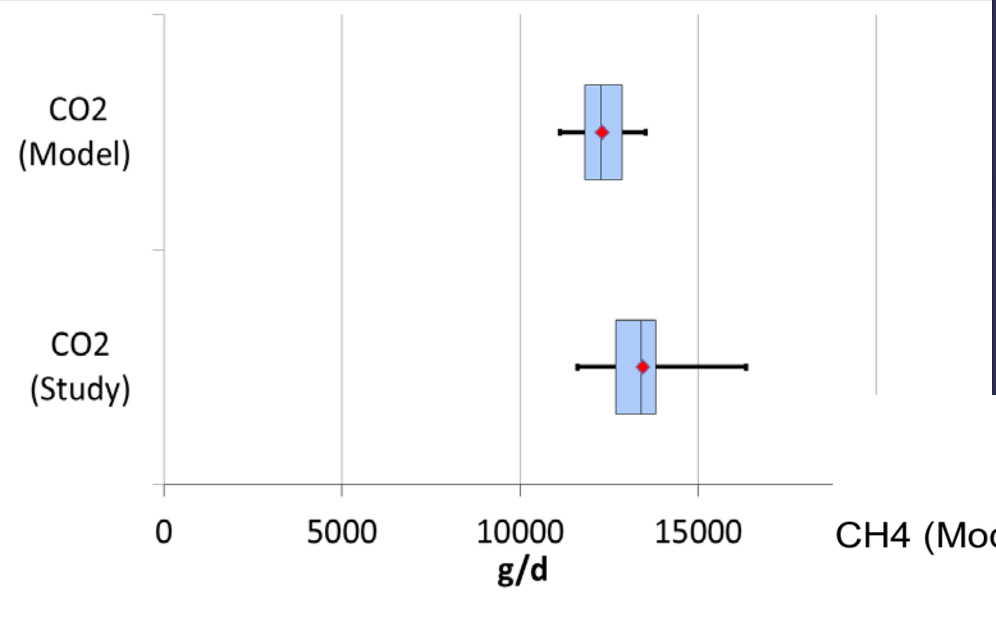
# Cornell Net Carbohydrate and Protein System (CNCPS)

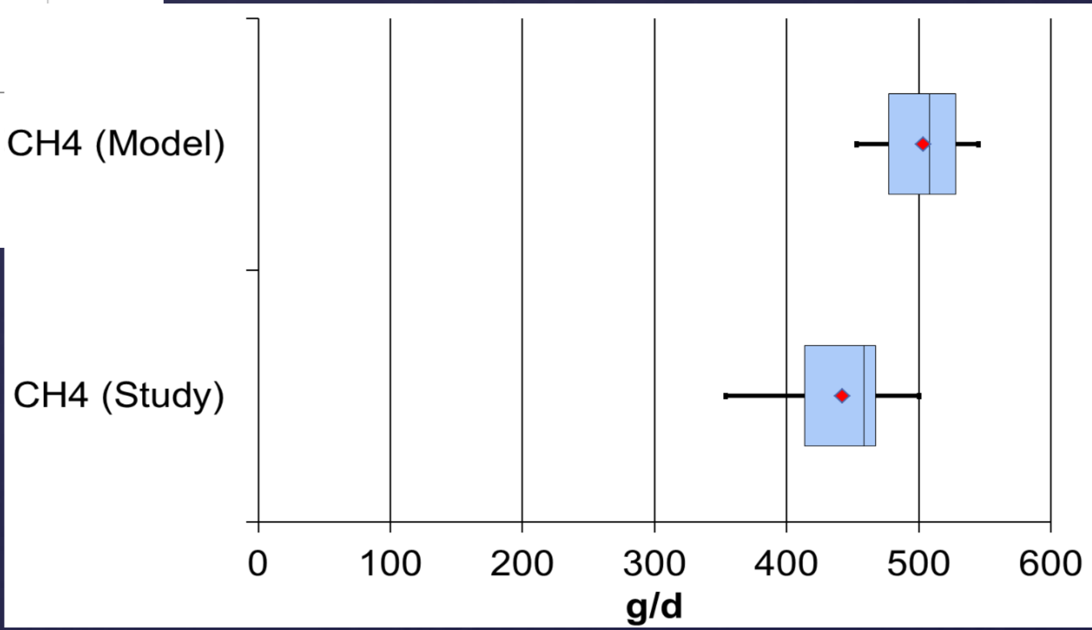
In development for over 30 yr and most published model of its type (>30 publications of the model and capability)

Used to evaluate and formulate diets for cattle, both dairy and beef - estimated to be used to formulate diets for >75% of cattle in North America and up to 15% of cattle world wide

Developed the CNCPS to predict carbon dioxide and methane emissions per cow per day and per unit of milk production

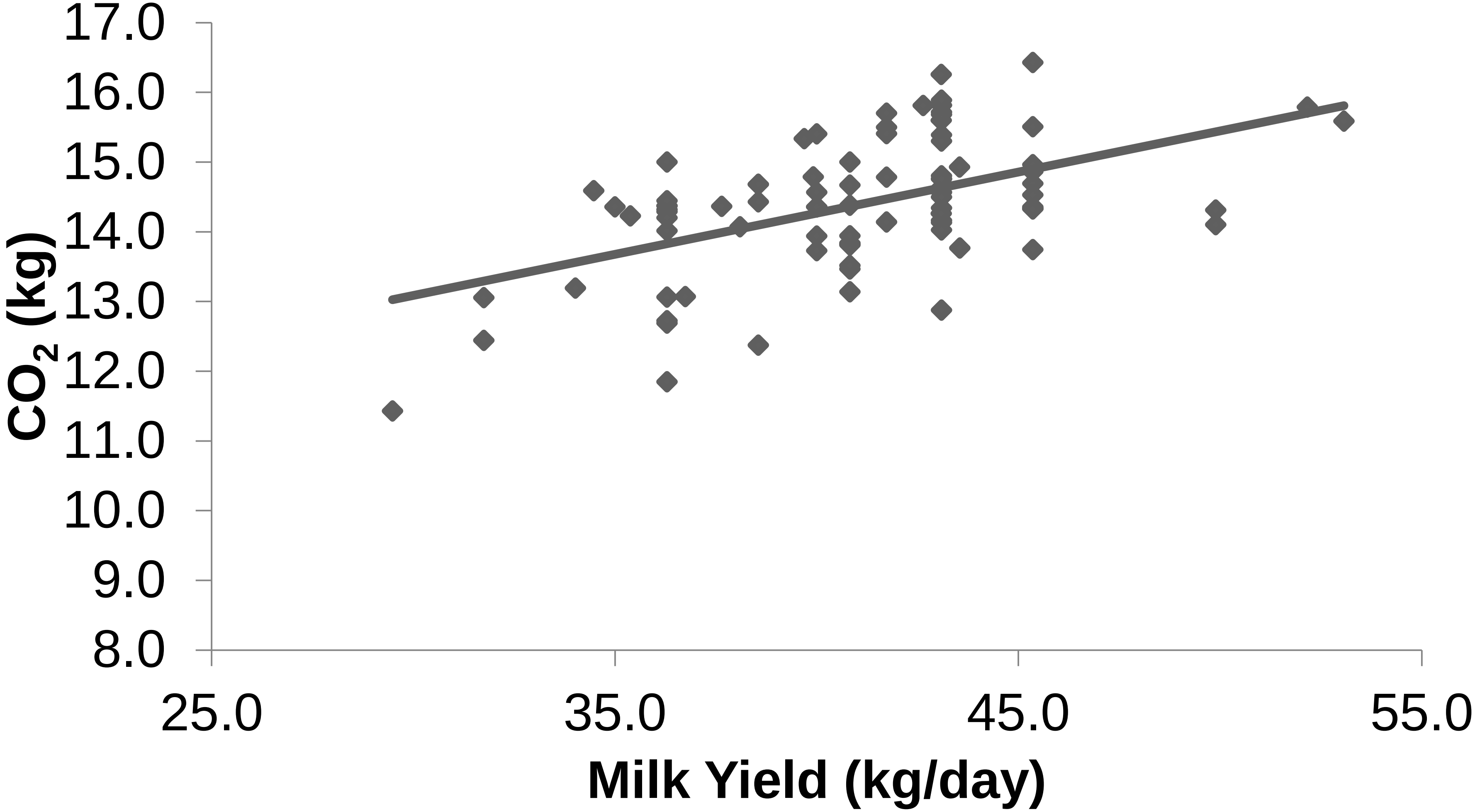
# $CO_2$ and $CH_4$ production predicted by the CNCPS compared with observed from 5 studies and 22 treatments



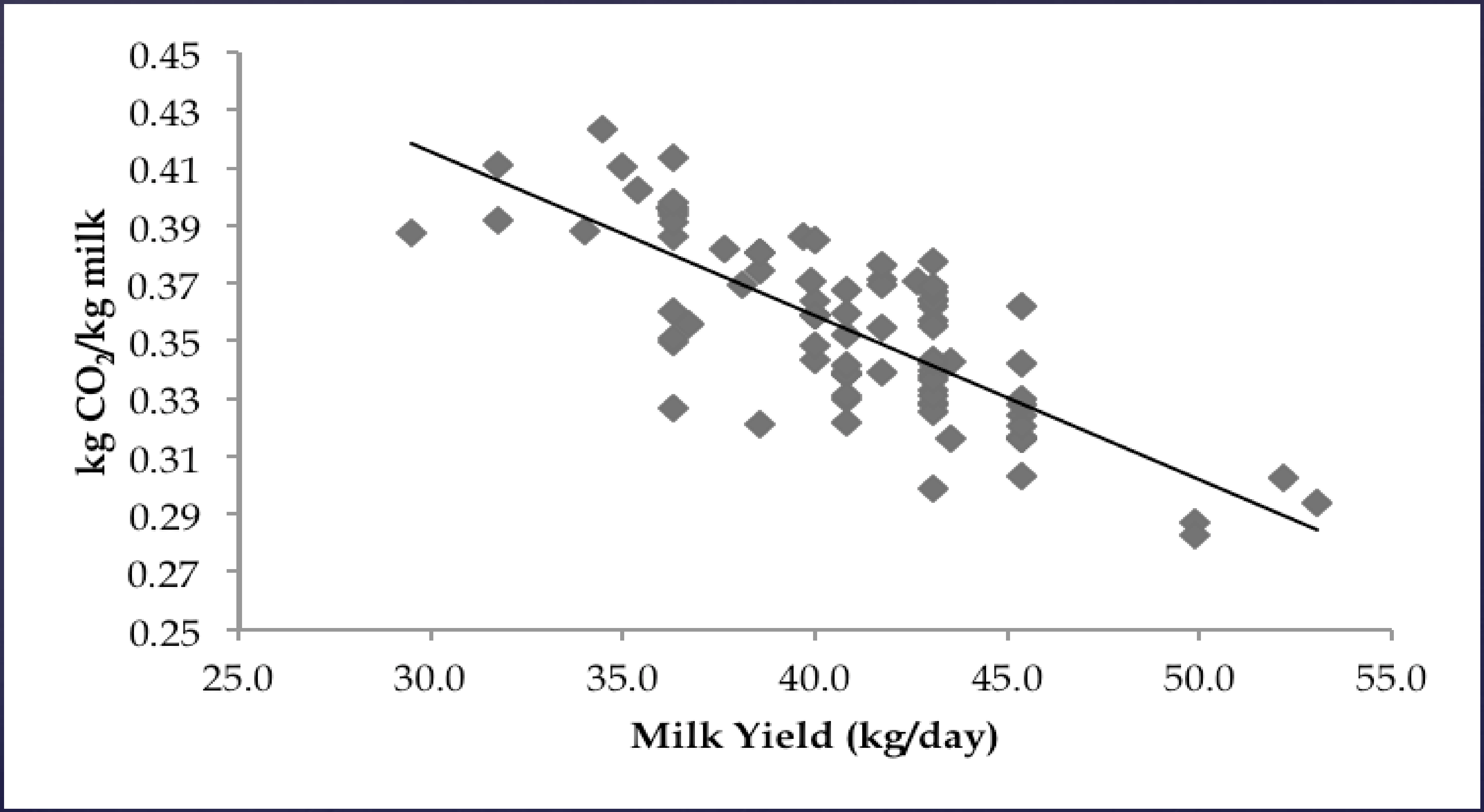

Van Amburgh et al., 2015; J. Dairy Sci

Milk yield versus predicted carbon dioxide emissions (kg/cow/d)



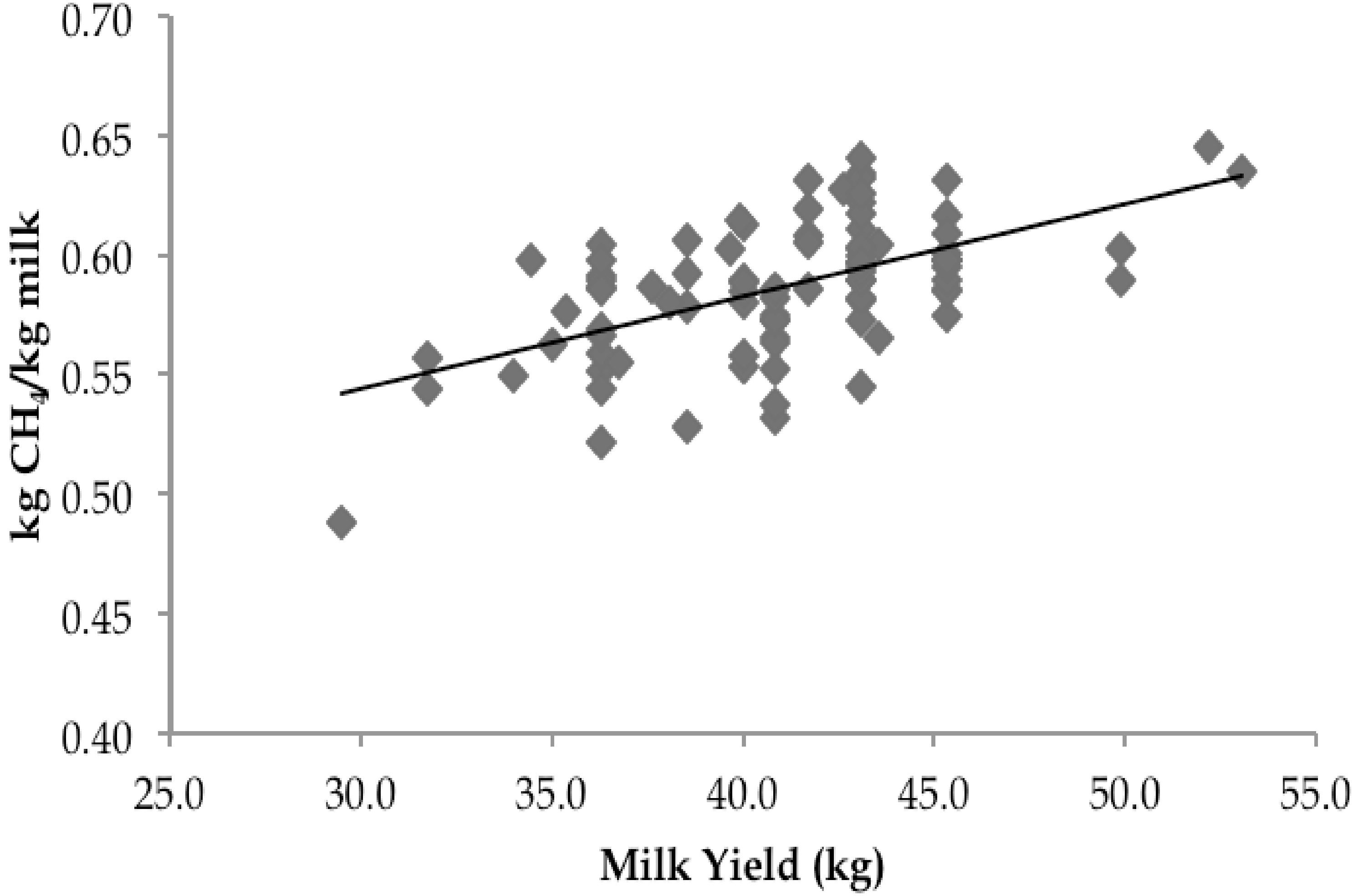

$CO_2$ (kg/d) = 0.12 × milk yield (kg/d) + 9.69 ($R^2$ = 0.69; RMSE = 0.64 kg/d)

# Predicted $CO_2$ emissions per kg of milk versus milk yield



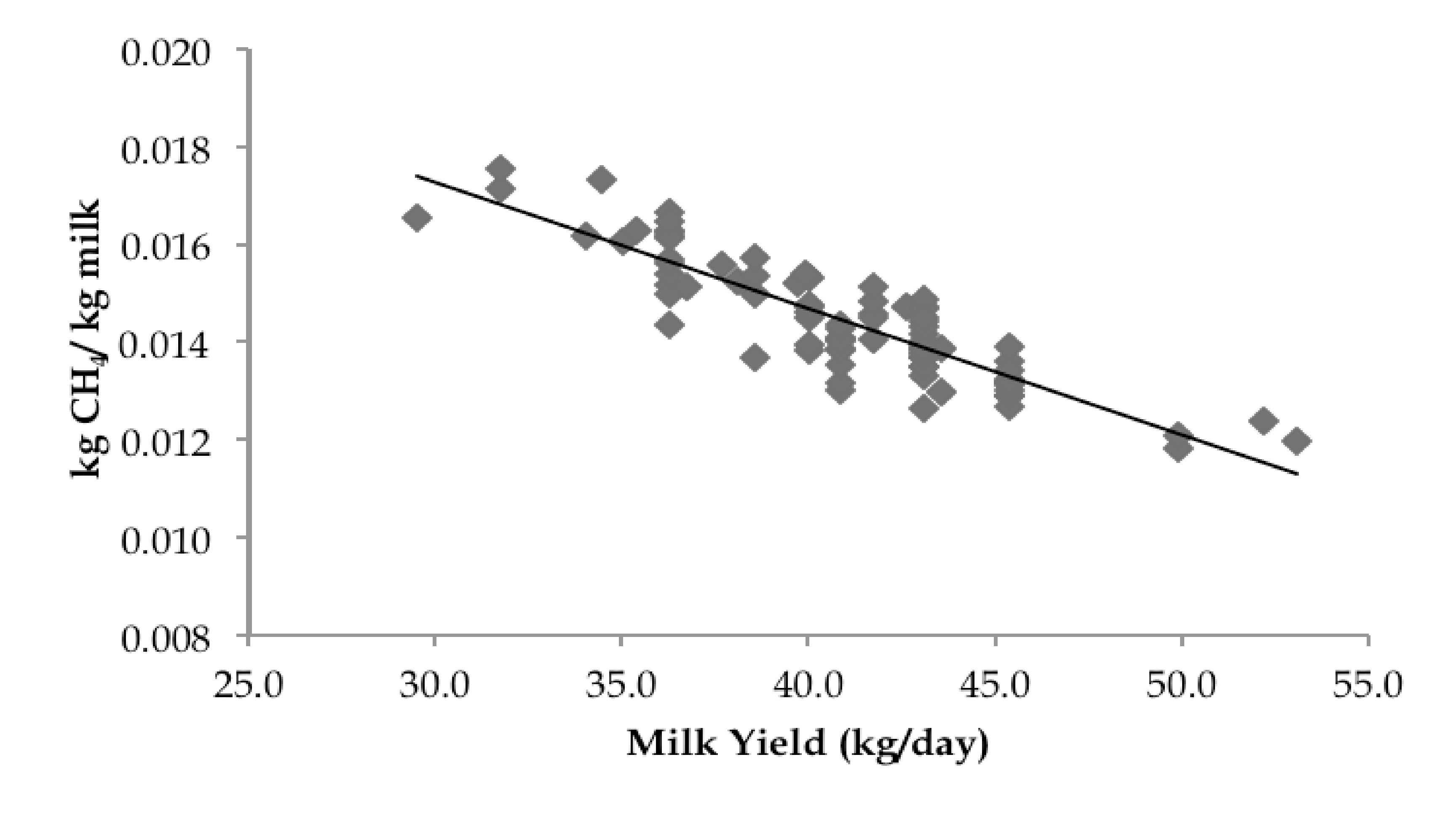

$CO_2$ Kg/kg milk = -0.006 × milk yield (kg/d) + 0.59 ($R^2$ = 0.81; RMSE = 0.02 kg $CO_2$/ kg milk.

Milk yield versus predicted methane emissions (kg/cow/d).




$CH_4$ (kg/d) = 0.004 × milk yield (kg/d) + 0.43 ($R^2$ = 0.75; RMSE = 0.02 kg/d).

# Predicted methane emissions per kg of milk versus milk yield




kg $CH_4$/Kg milk = -0.0003 × milk yield (kg/d) + 0.03
($R^2$ = 0.89; RMSE = 0.0005 kg $CH_4$/ kg milk.

Predicted carbon dioxide and methane release based on the total amount of dry matter consumed (DMI), byproduct inclusion (kg) and as a ratio of the milk yield

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| DMI | | | | |
| kg $CO_2$/kg DMI | 0.576 | 0.011 | 0.557 | 0.618 |
| kg $CH_4$/kg DMI | 0.024 | 0.001 | 0.021 | 0.027 |
| | | | | |
| Byproduct | | | | |
| kg $CO_2$/kg BP | 0.050 | 0.018 | 0.029 | 0.117 |
| kg $CH_4$/kg BP | 0.002 | 0.001 | 0.001 | 0.005 |
| | | | | |
| Milk Yield | | | | |
| kg $CO_2$/kg milk | 0.353 | 0.031 | 0.283 | 0.423 |
| kg $CH_4$/kg milk | 0.014 | 0.001 | 0.012 | 0.018 |

# Comparison of gas released from byproduct disposal between dairy cows and combustion

| Variable | Byproduct inclusion | $CO_2$ byproducts | $CH_4$ byproducts | Total gas[1] | $CO_2$ combust |
|---|---|---|---|---|---|
| | % ration DM | kg $CO_2$ Eq./cow/d | | | kg |
| Mean | 31 | 4.5 | 4.6 | 9.0 | 15.2 |
| SD | 9 | 1.4 | 1.4 | 2.8 | 4.9 |
| Min | 13 | 1.8 | 1.9 | 3.7 | 7.4 |
| Max | 57 | 7.4 | 7.9 | 15.3 | 26.7 |

[1]Total gas release = $CO_2$ (kg/d) + $CH_4$ (kg $CO_2$ Eq./d)

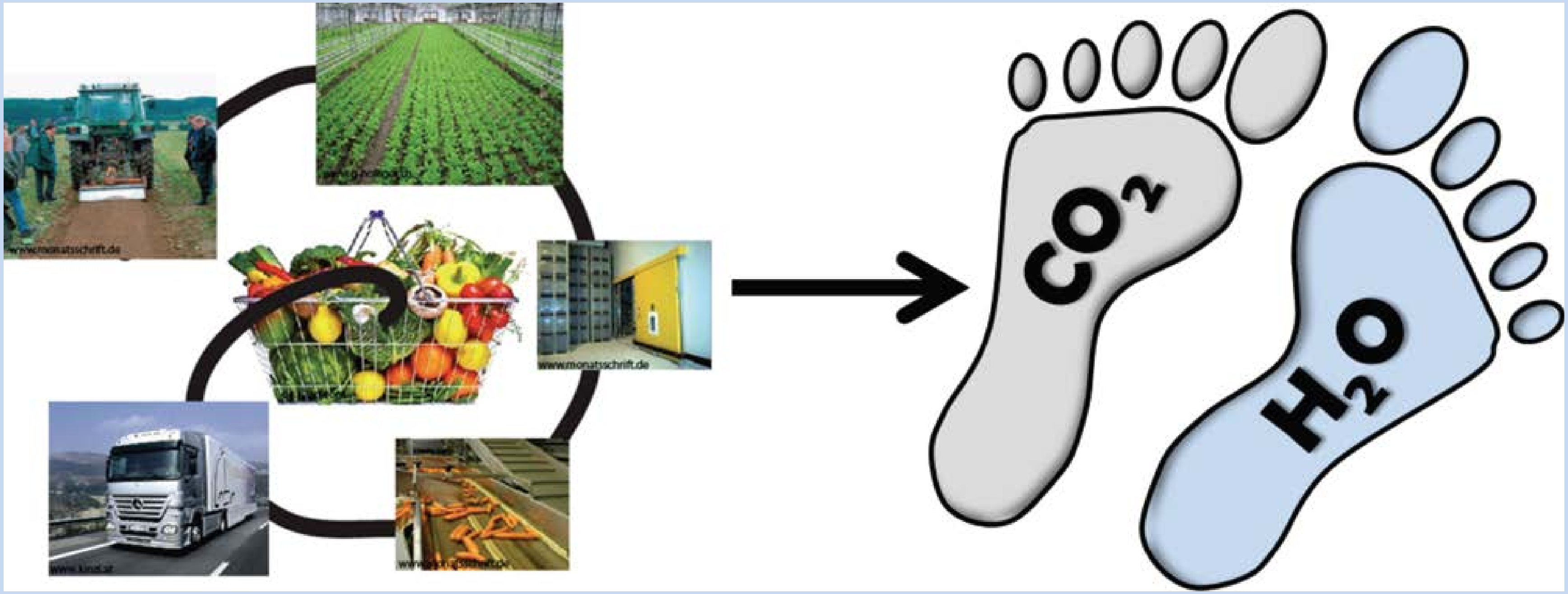
# Final Reflections

## Agriculture is about Food Production!

- All food production has an environmental impact and environmental stewardship is a critical responsibility in production agriculture.
- Essential to evaluate environmental impact per unit of output using science-based procedures.
- Productivity is a key factor in reducing the environmental impact of animal agriculture, indeed of all production agriculture.
- Sustainability comparisons among foods need to be based on supply of nutrients, especially essential nutrients.

# Agriculture is about Food Production!

- **Animal source foods are important and affordable sources of key nutrients.**
- **Essential that we understand and discuss the role of technology in food production and the environmental consequences of our choices.**



# Thank you for your attention