

**World Food Day Colloquium, Hohenheim, 16. October 2015**

**Ecological footprint of grassland-based ruminant systems**

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**Current knowledge and future challenges**

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**Animal Nutrition and Rangeland Management  
in the Tropics and Subtropics**

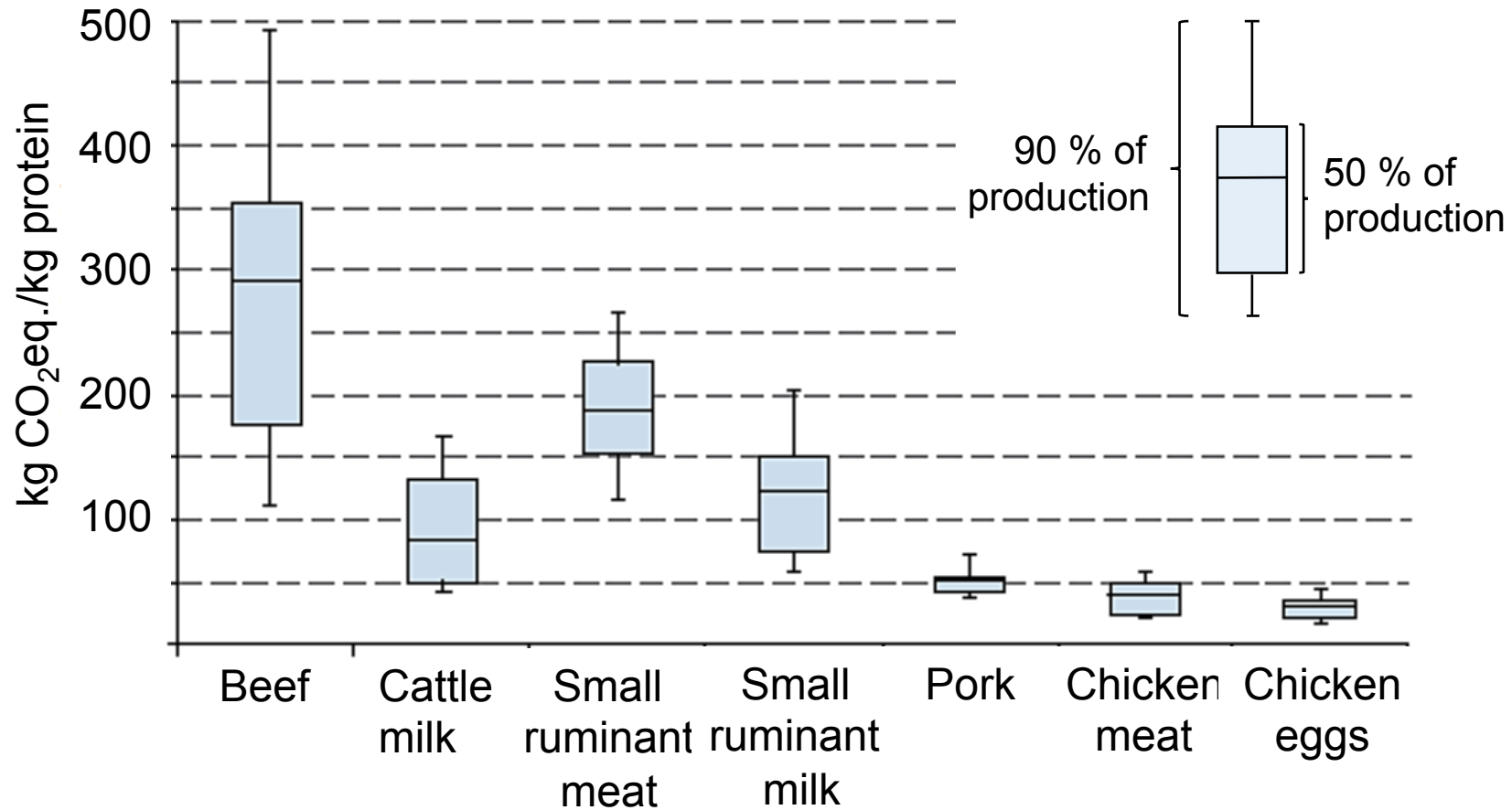


## Introduction

- Significant contribution of grassland-based ruminant husbandry to global food supply (*e.g.*, 25% of beef and sheep meat and 12% of milk produced globally; 2001-2003 data; FAO 2012)
- Great proportions of the worlds' grasslands and ruminant stocks in developing countries



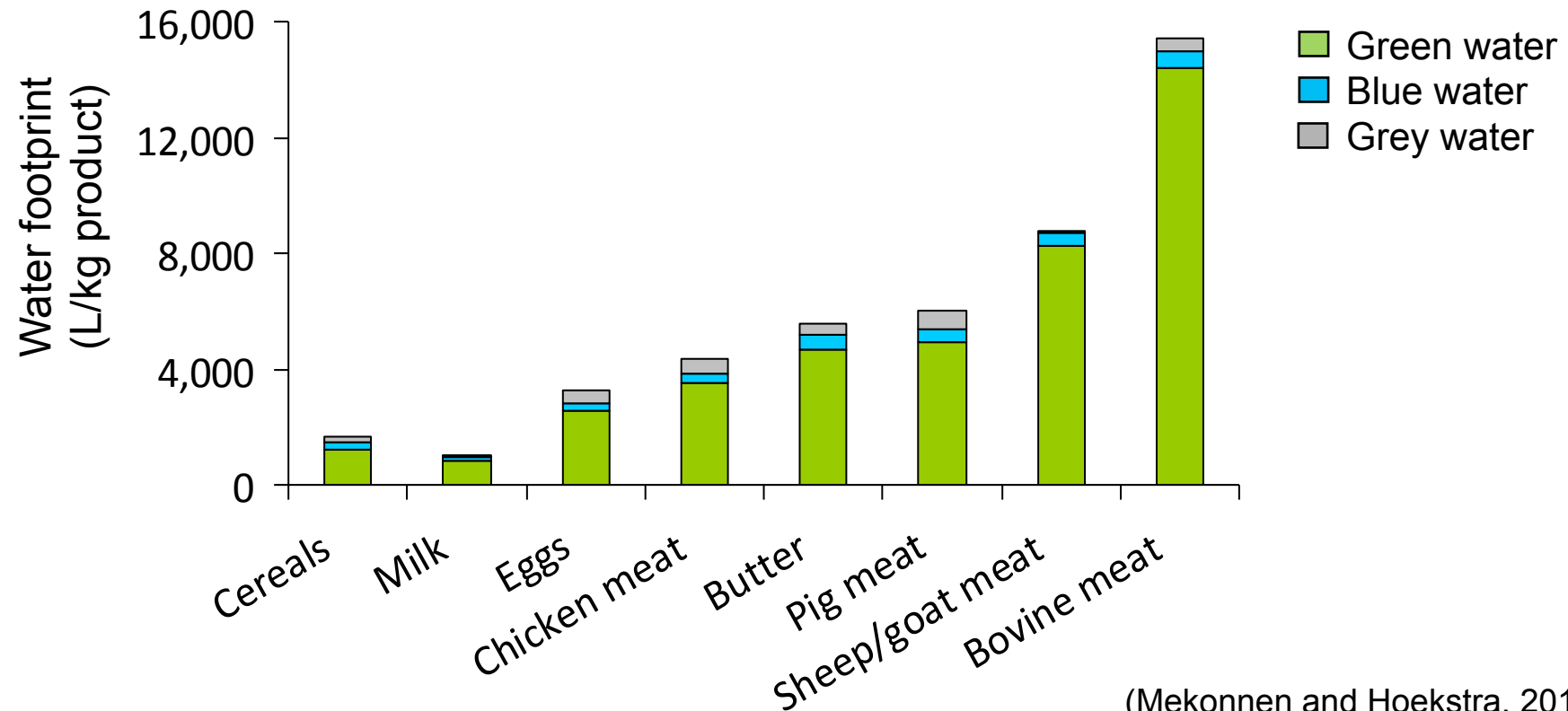
# Ecological footprints of ruminant systems



(Gerber *et al.* 2013; Tackling climate change ..., FAO)

## Ecological footprints of ruminant systems

- Global water footprint of animal production: 2,422 billion m<sup>3</sup>/yr
- Appr. 98% related to feed supply, 1% to drinking water, and 1% to service water



(Mekonnen and Hoekstra, 2010)



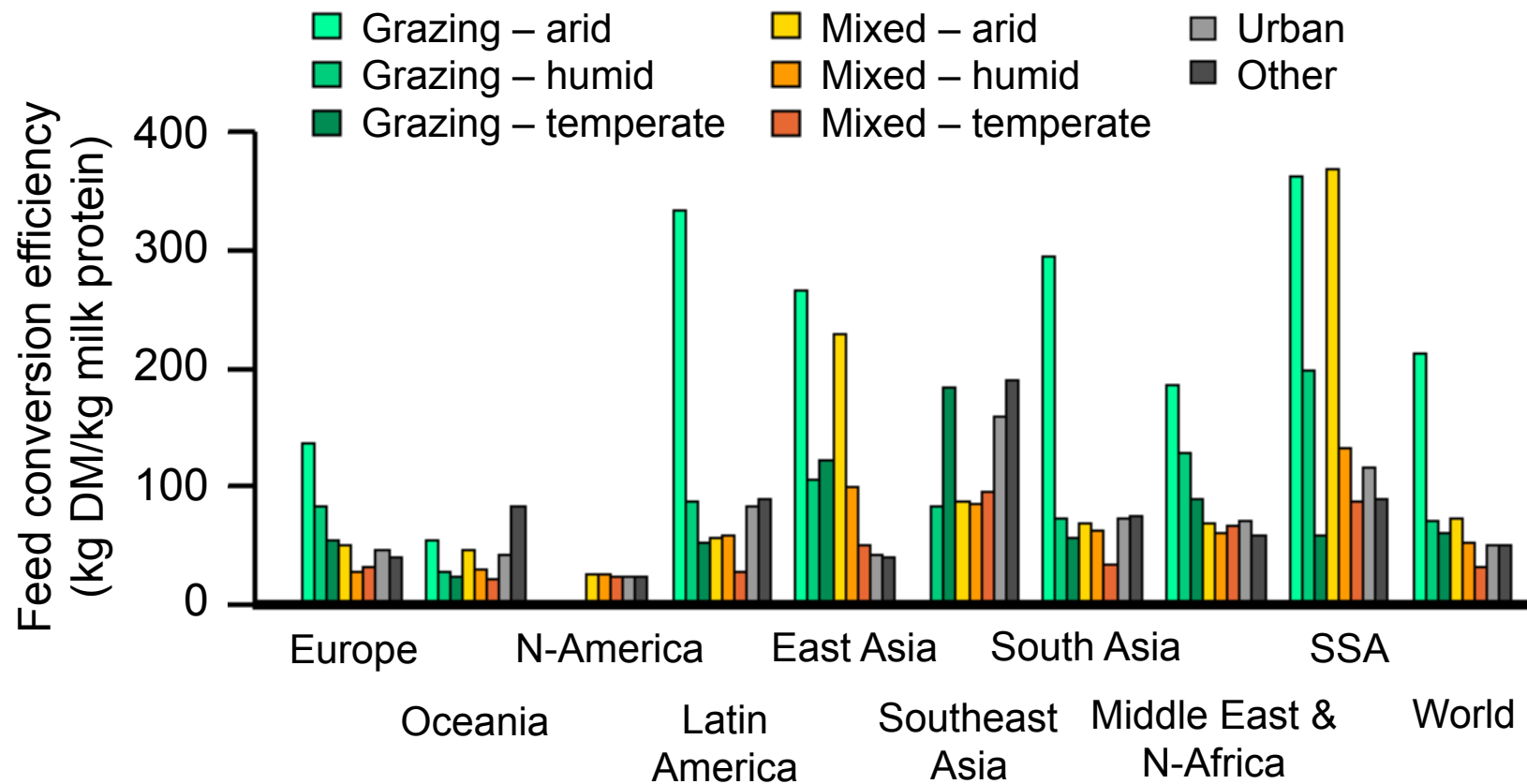
## Introduction

- Significant contribution of grassland-based ruminant husbandry to global food supply (*e.g.*, 25% of beef and sheep meat and 12% of milk produced globally; 2001-2003 data; FAO 2012)
- Great proportion of the worlds' grasslands and ruminant stocks in developing countries
- Ruminant production is major source of global GHG emissions and consumer of natural resources
- Adverse impacts on environment through forage consumption, trampling, feces/urine excretion, and GHG emissions (Steinfeld *et al.* 1996, FAO)
- About 20% of the worlds' grasslands degraded to some extent (Suttie *et al.* 2005)



# Ecological footprints of ruminant systems

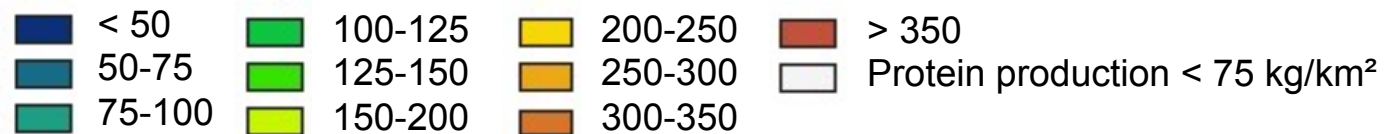
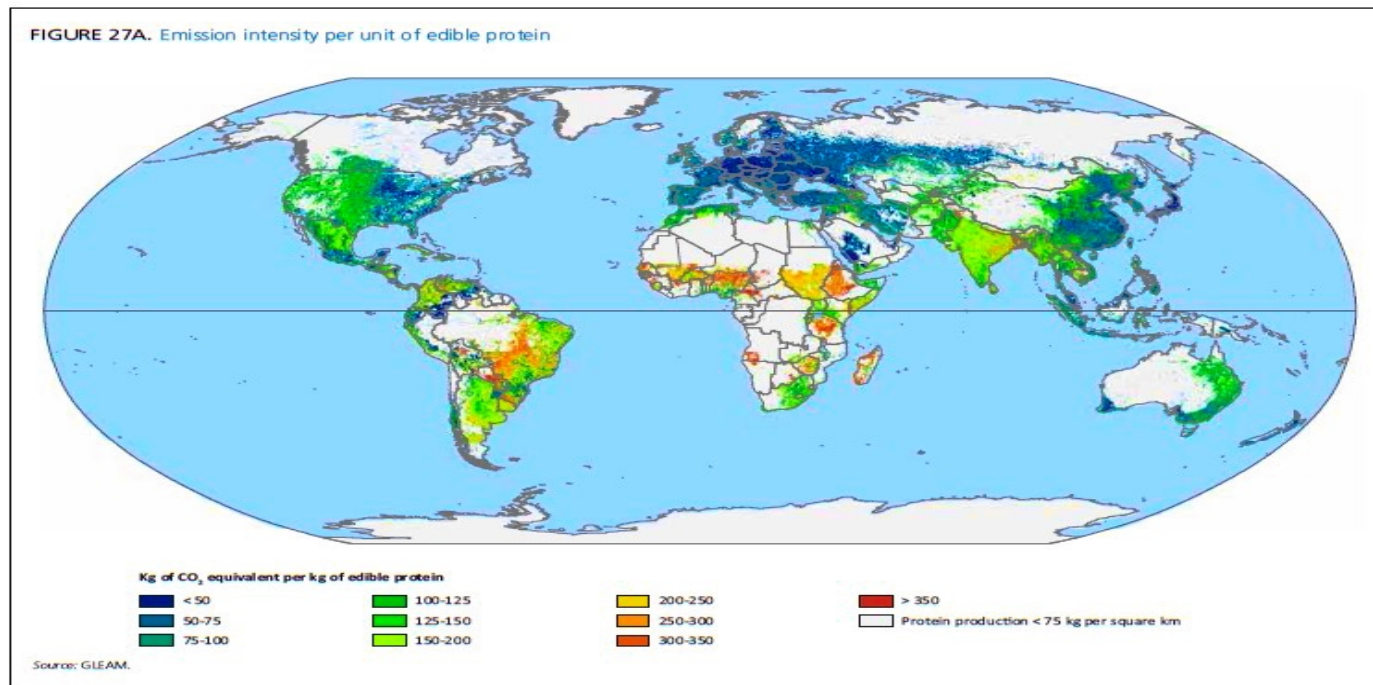
## Feed conversion efficiency of dairy cattle systems



(Herrero *et al.* 2013; PNAS 110, 20888-20893)

# Ecological footprints of ruminant systems

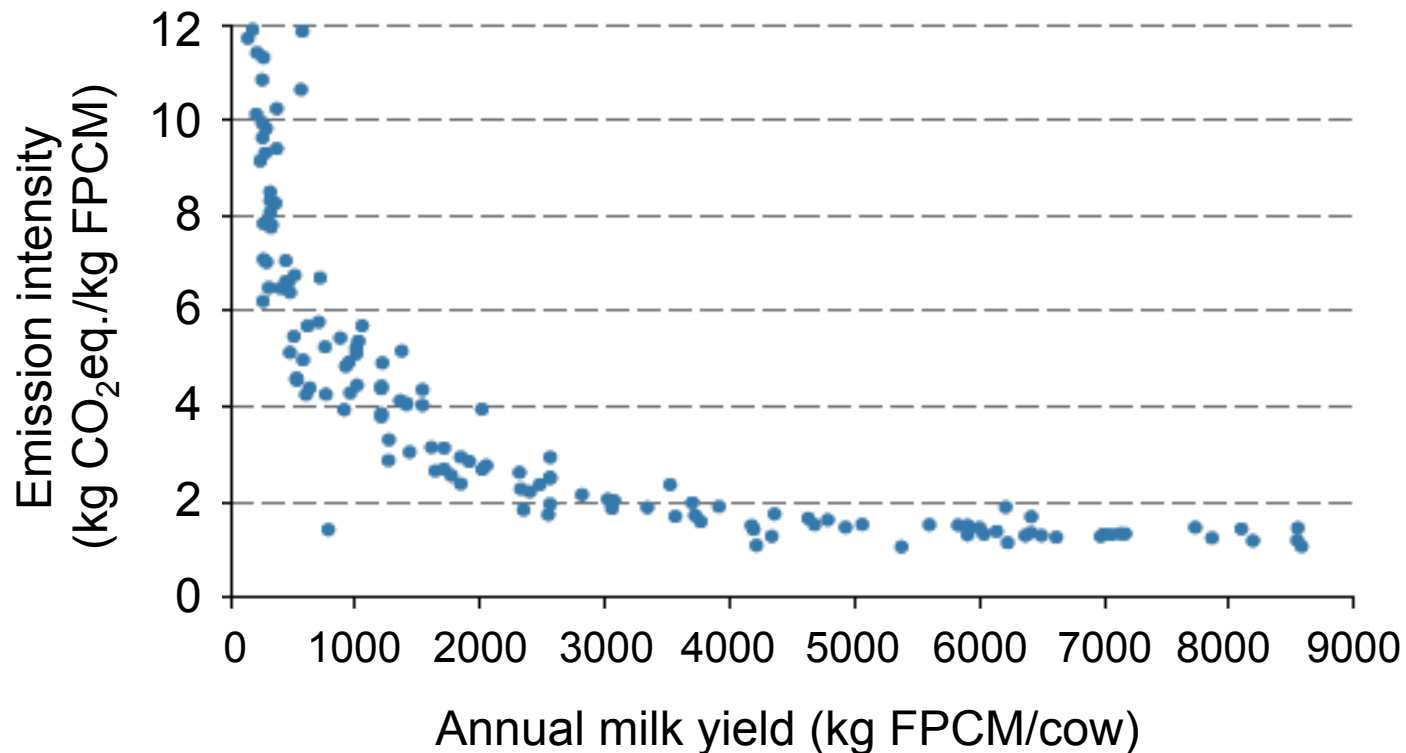
## Emission intensity (kg CO<sub>2</sub>eq./kg edible protein)



(Gerber *et al.* 2013; Tackling climate change ..., FAO)

## Ecological footprints of ruminant systems

### Efficacy of improving individual animal performance



(Gerber et al. 2011; in Gerber *et al.* 2013; Tackling climate change ..., FAO)





## Strategies to improve ecological footprint

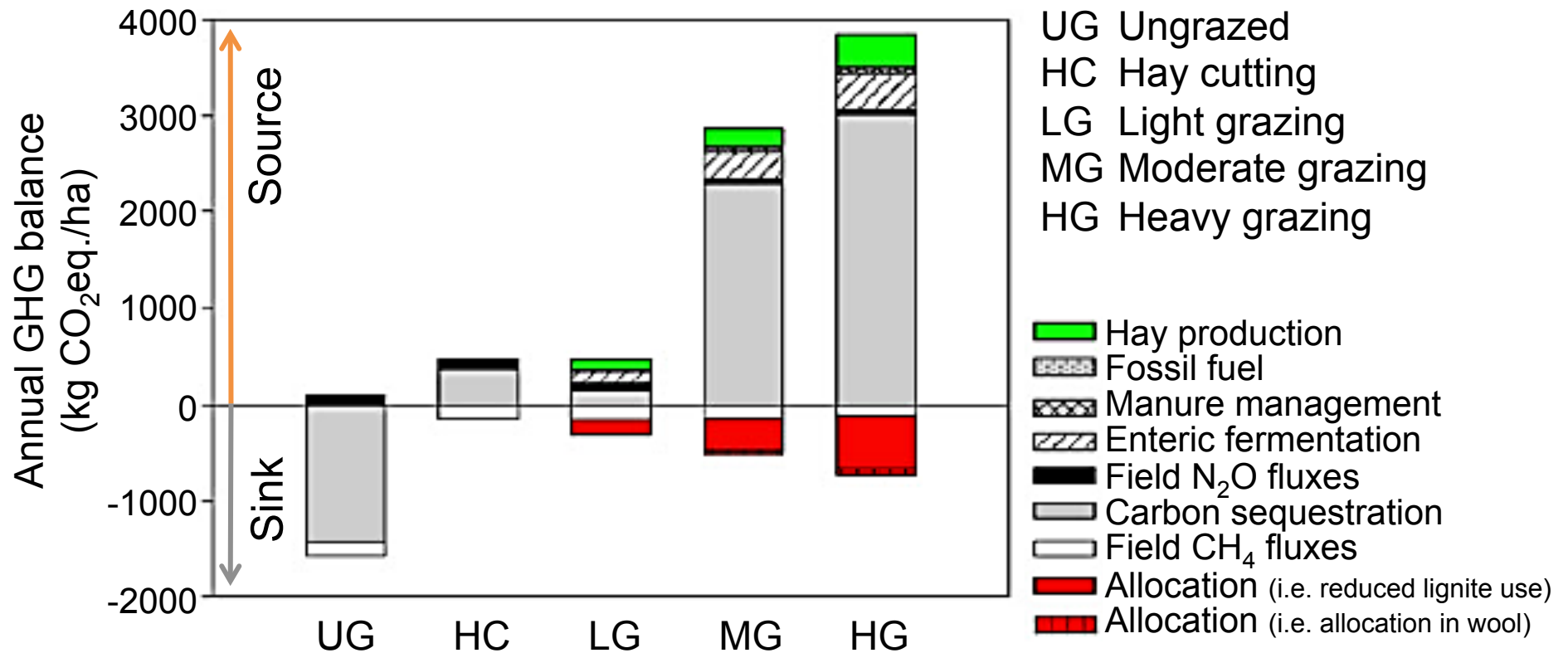
- Grassland management
  - Choice of forage crops
  - Fertilization, irrigation, or other improvement measures
- Grazing management
  - **Stocking rate/forage allowance**
  - **Grazing system** (e.g., rotational, deferred, strip)
  - Mixed species grazing
- Feeding management
  - **Supplemental feeding** (e.g., concentrate, forage, nutrient/mineral blocks)
  - Dietary additives (e.g., phytochemicals)
- Herd and farm management
  - Breeding (Genotypic/phenotypic variation)
  - Hygiene and health care
  - Manure handling
  - Integrated vs. pure livestock systems

(e.g., Boval and Dixon, 2012; Animal 6, 748-762)



# Grazing management

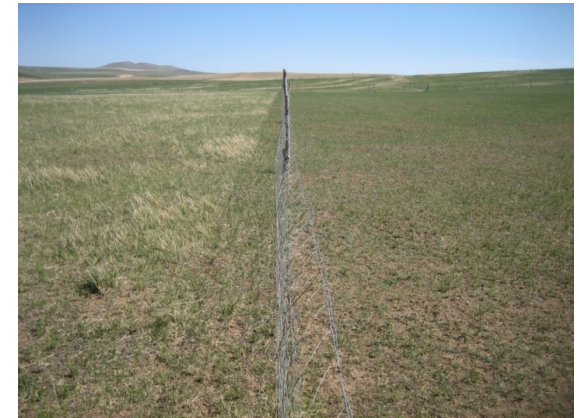
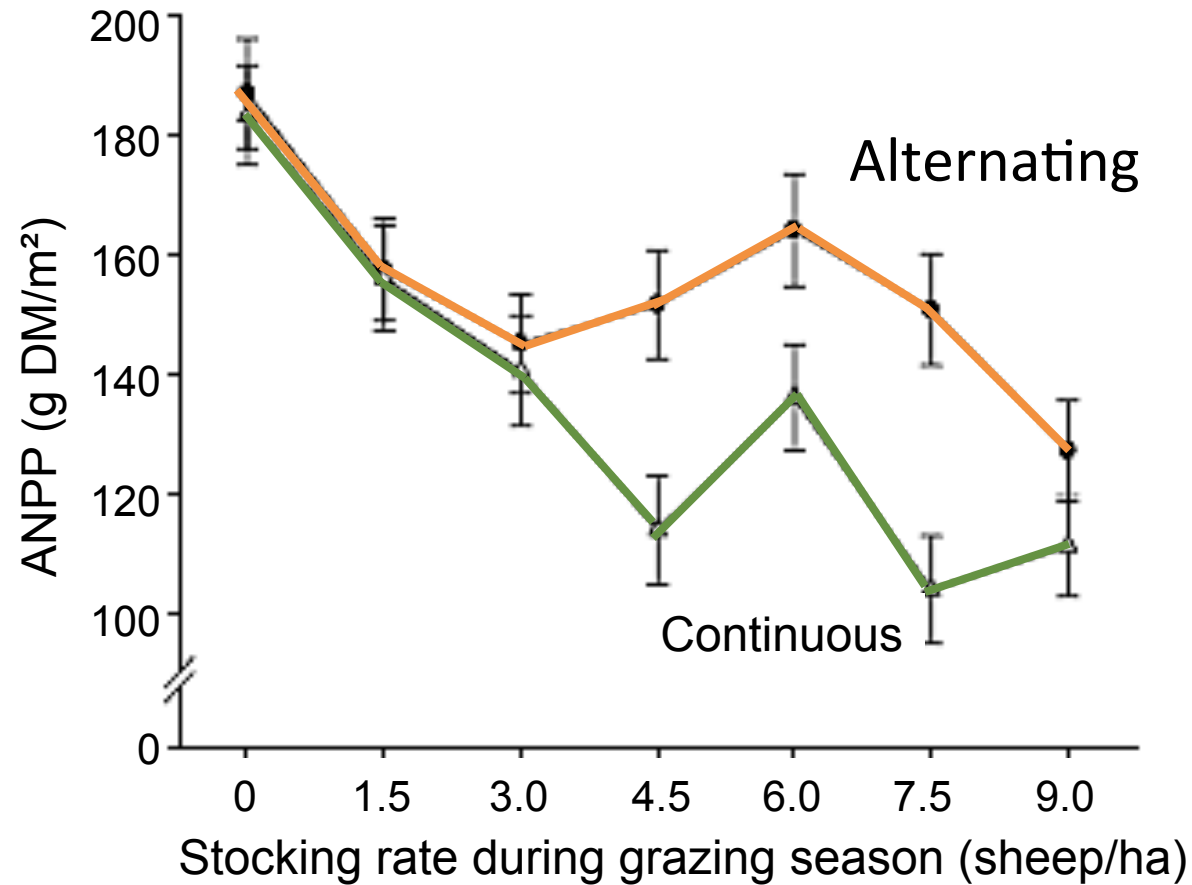
## Effect of grazing on annual carbon balances in a semi-arid steppe



(Schönbach *et al.* 2012; *Nutr. Cycl. Agroecosyst.* 93, 357-371)

## Grazing management

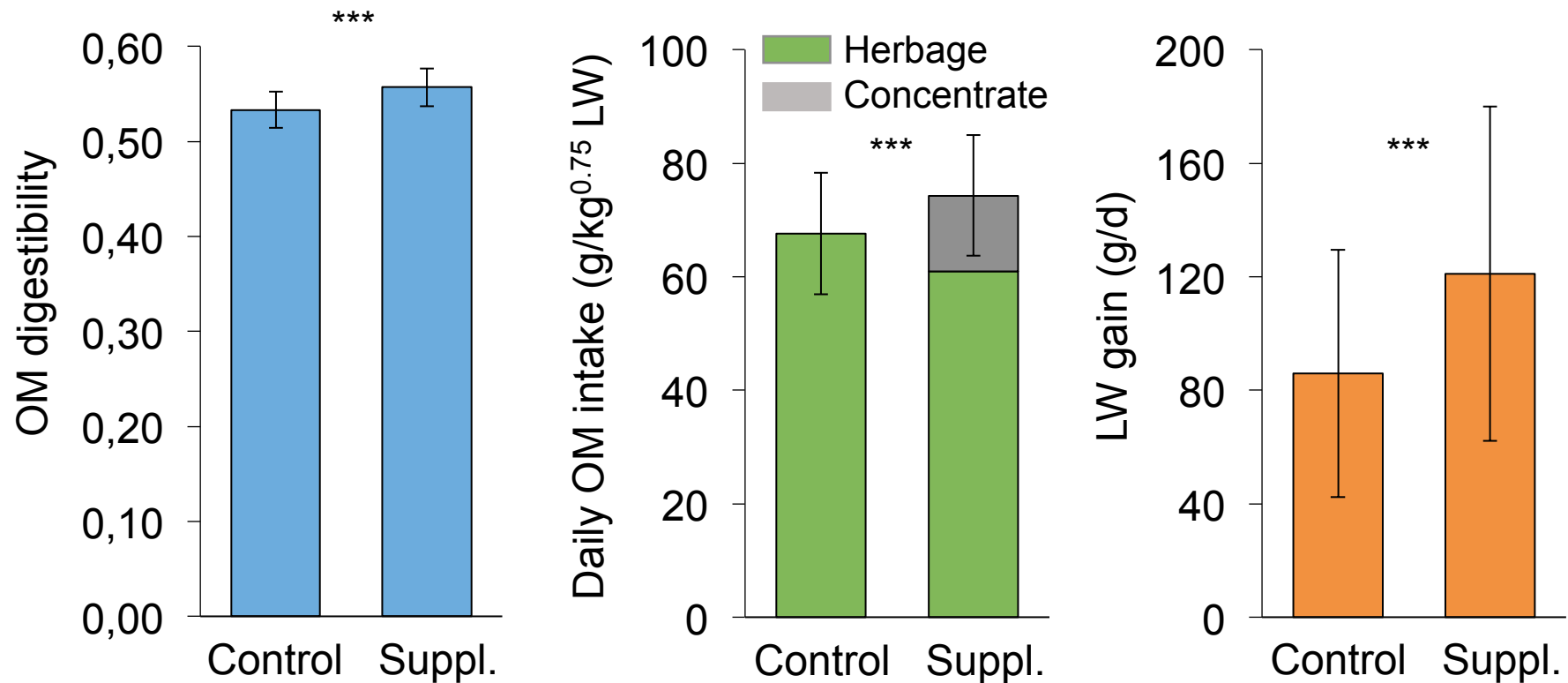
### Above-ground net primary production of a grazed semi-arid steppe



(Schönbach *et al.* 2011; Plant Soil 340,103-115)

## Feeding management

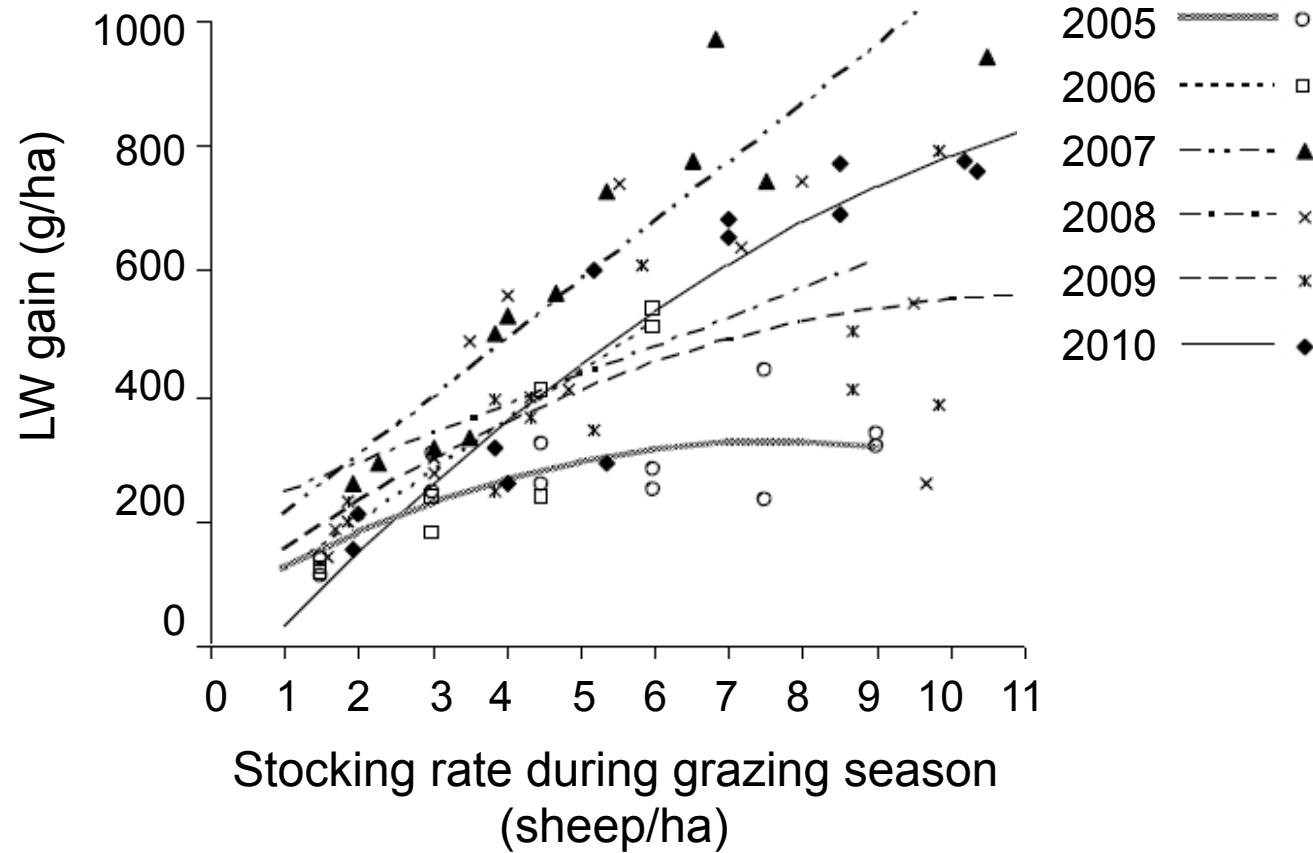
### Supplement feeding of grazing sheep (n=72) in a semi-arid steppe



(Boesing *et al.* 2014; *Livest. Sci.* 165, 157-166)

# Challenges

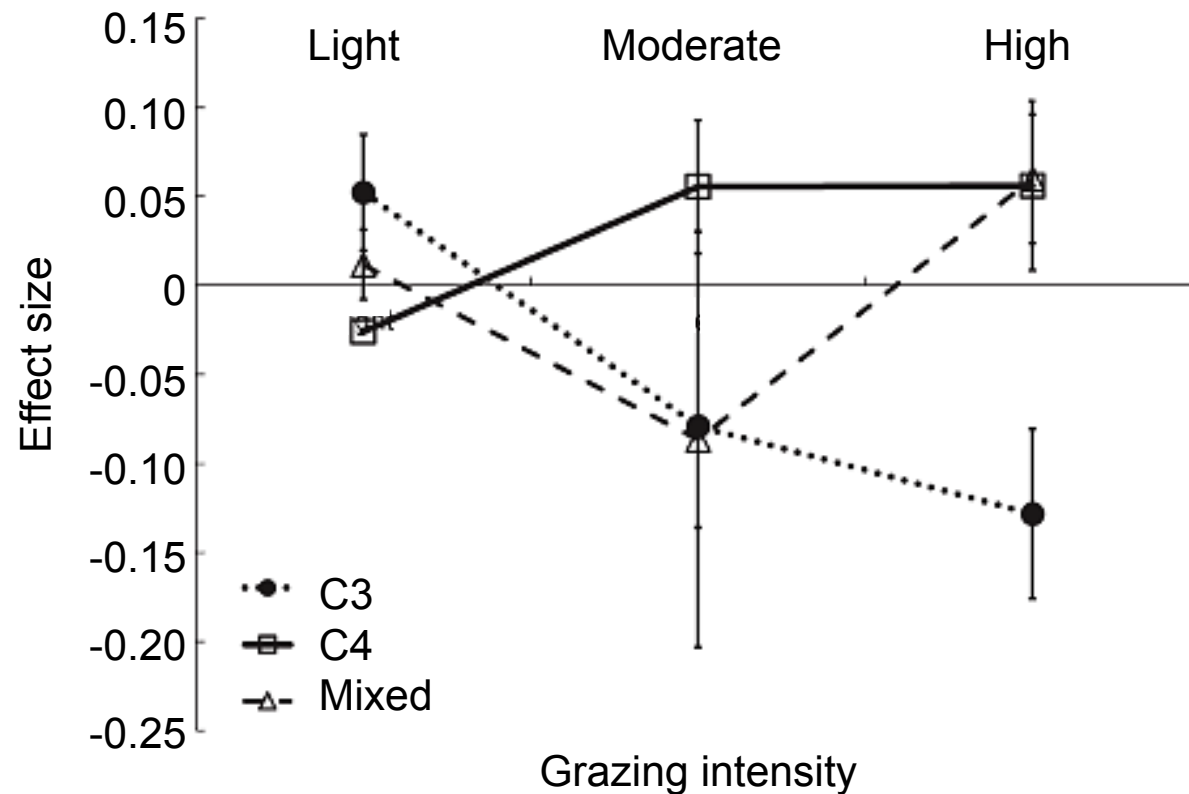
## Grazing intensity effects on LW gain of sheep in different years



(Pictures: Müller, 2007)

# Challenges

## Grazing intensity effects on soil organic carbon stocks in grasslands



(McSherry and Ripley 2013; Glob. Change Biol. 19, 1347-1357)



## Summary & Outlook I

- Limited feed conversion increases ecological footprints of ruminant products from (extensive) grassland-based systems
- Considerable scope of improving productivity and feed use efficiency in grassland-based ruminant systems
  - Grassland and grazing management
  - Feeding and improved herd management
  - Adoption of integrated farming systems
- Sophisticated management to minimize environmental costs and to enhance ecosystem productivity and functioning



## Summary & Outlook II

- Refined methodological approaches to evaluate intensity of environmental impacts across the diverse ruminant systems
  - Multiple outputs of livestock keeping
  - Integrated farming systems
  - Origin and source of inputs
- Basic data for ecological footprint estimates in particular for (sub)tropical systems
  - Composition and quality of ruminant diets
  - Enteric CH<sub>4</sub> emissions
  - Feed conversion efficiency
  - Carbon sequestration potential
- Cross-regional and interdisciplinary analyses to account for differences in agroecological settings and to enhance the understanding of interactions between environment, grassland ecosystem components, and grazing animals





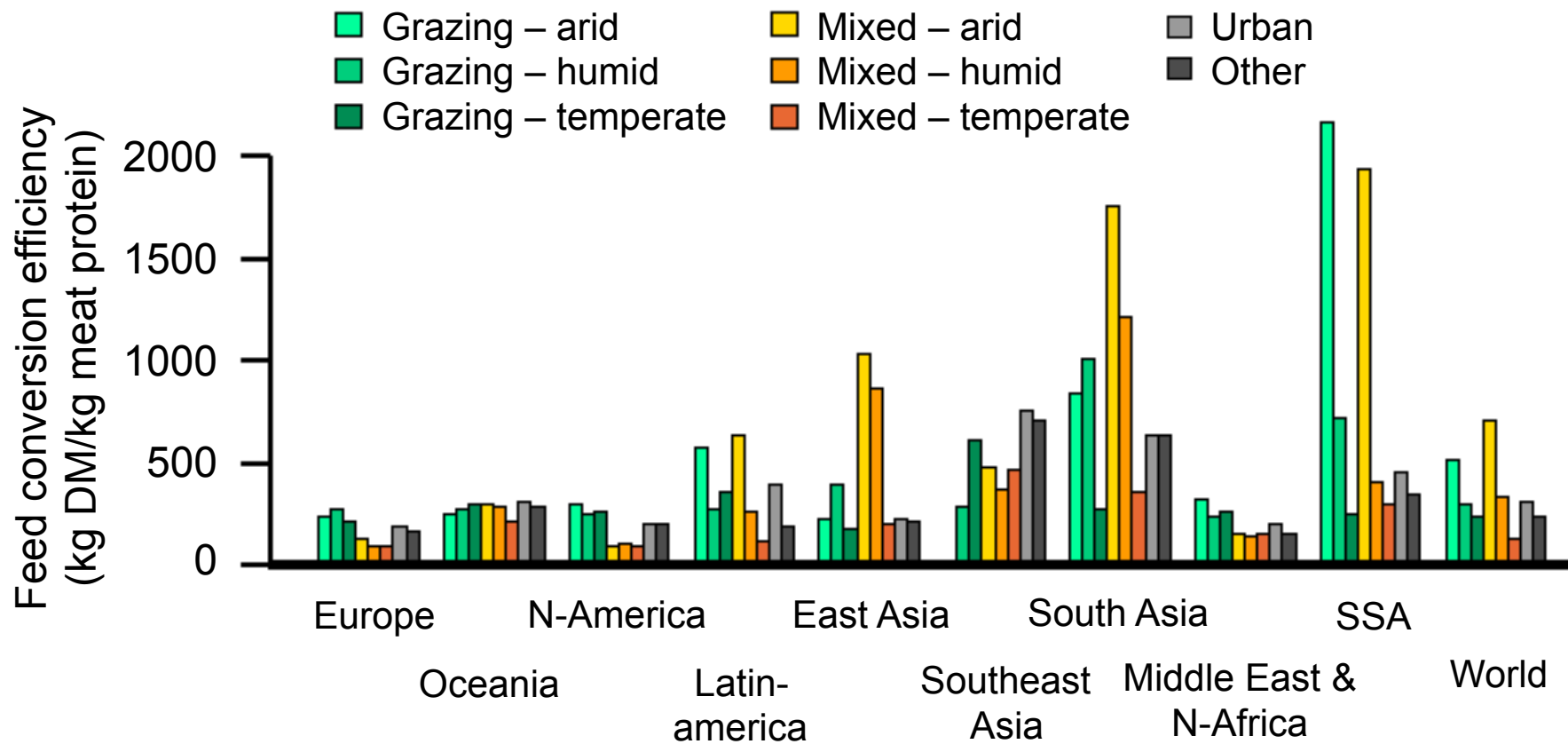






# Ecological footprints of ruminant systems

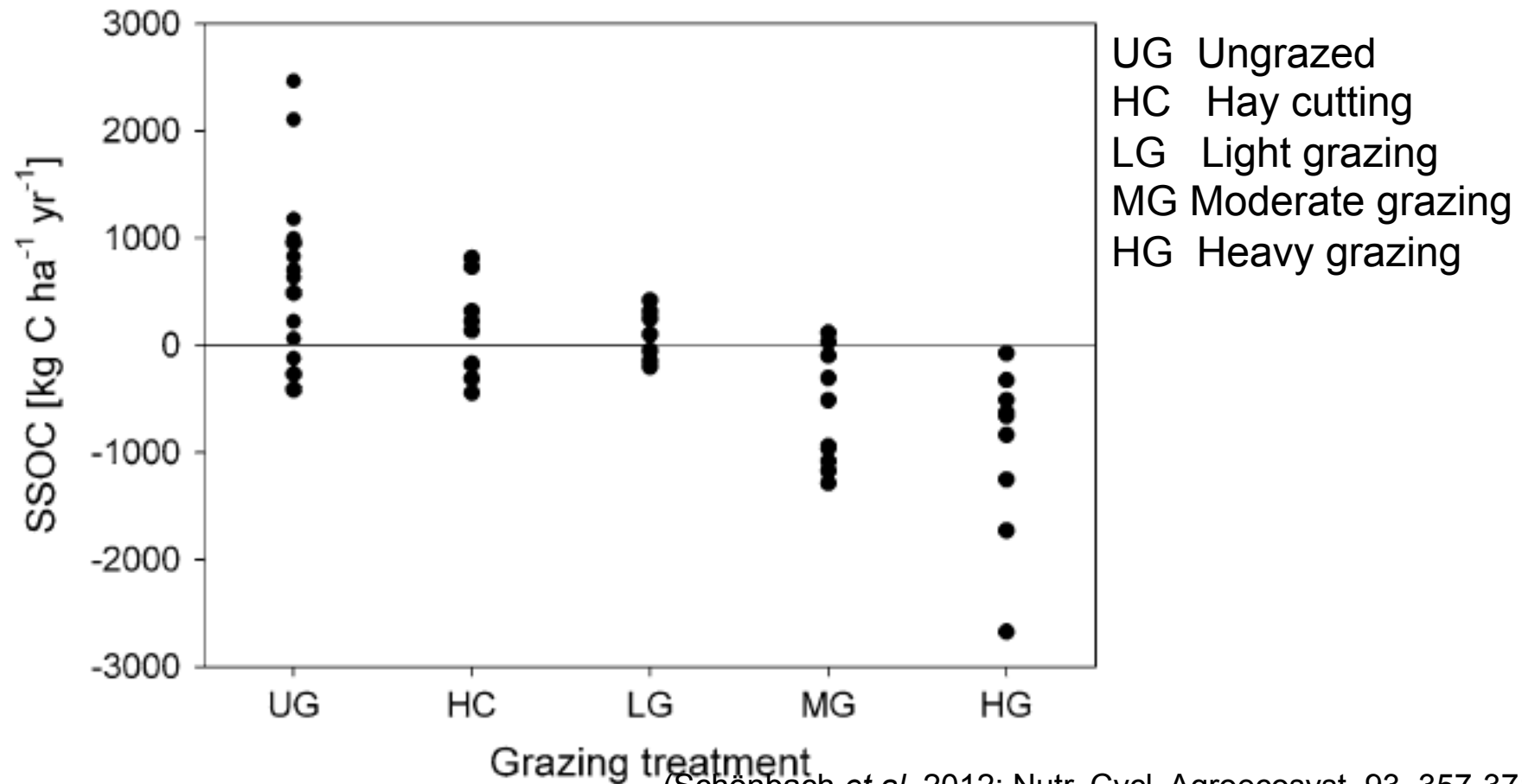
## Feed conversion efficiency



(Herrero *et al.* 2013; PNAS 110, 20888-20893)

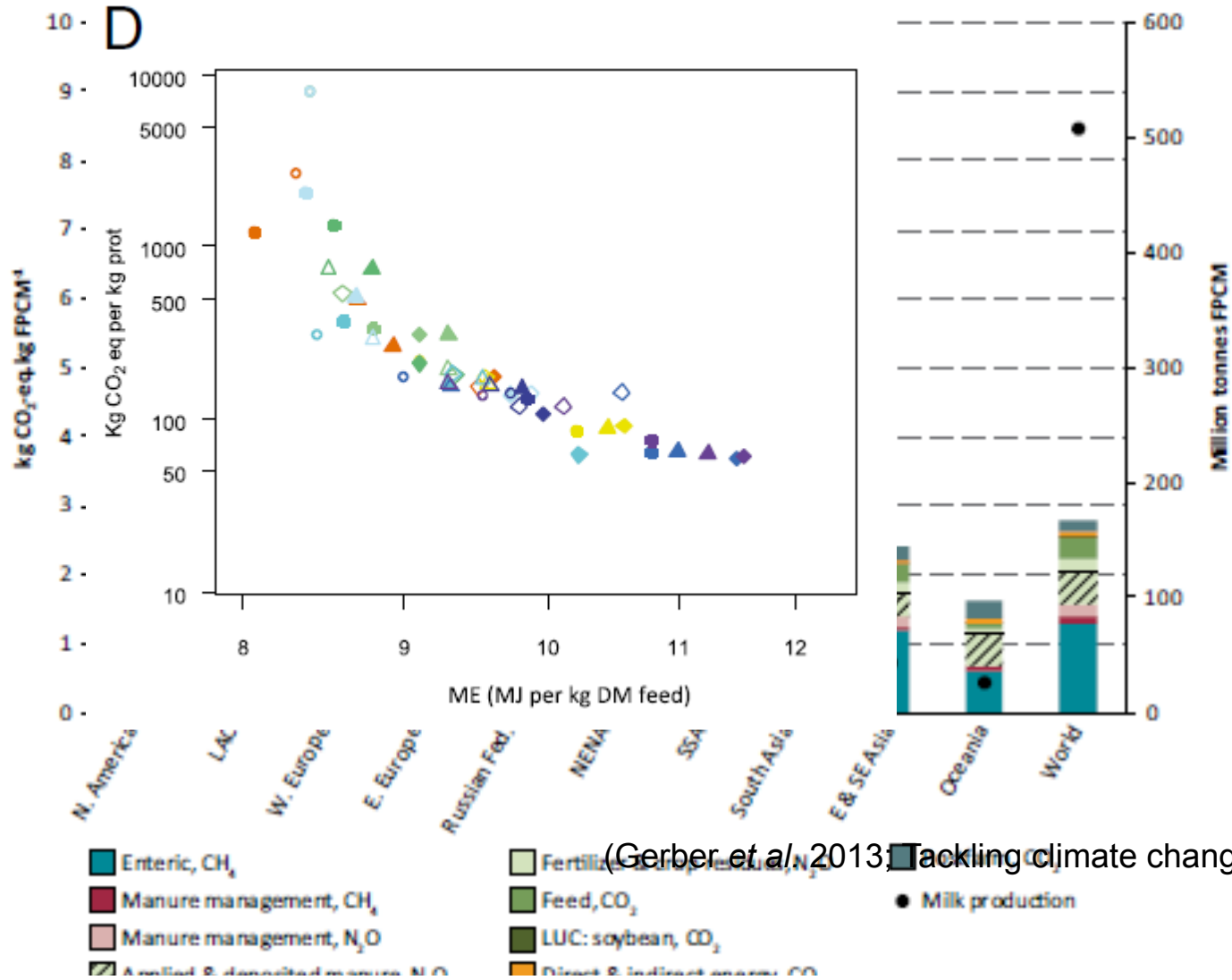
## Ecological footprints of ruminant systems

### Effect of stocking density on sequestration of soil organic carbon (SSOC)

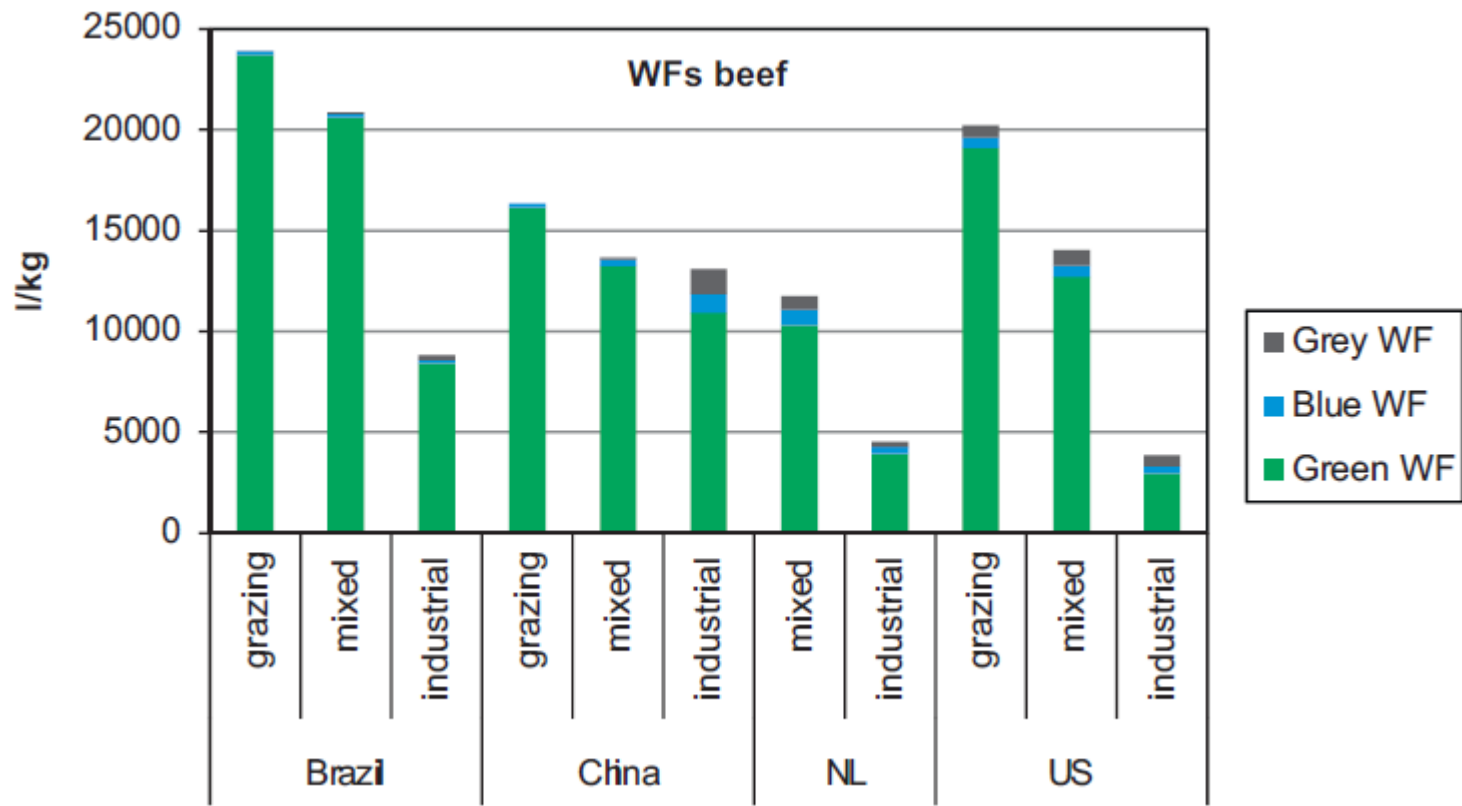




# Ecological footprints of ruminant systems

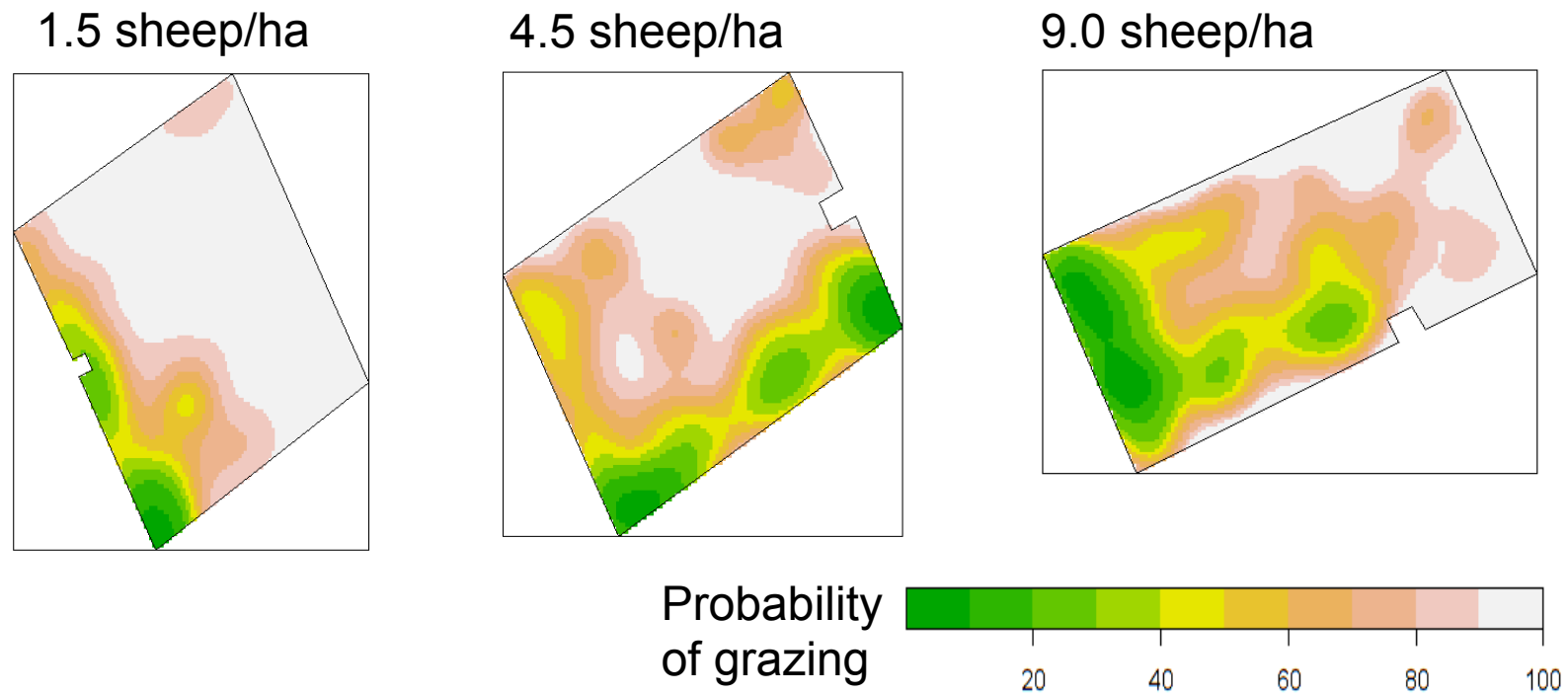


(Gerber et al, 2013, Tackling climate change ..., FAO)



## Challenges

### Spatial distribution of grazing in 2-ha-plots grazed at different stocking rates





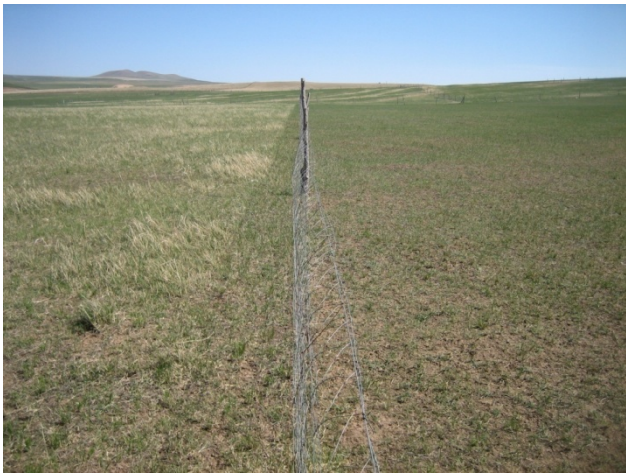
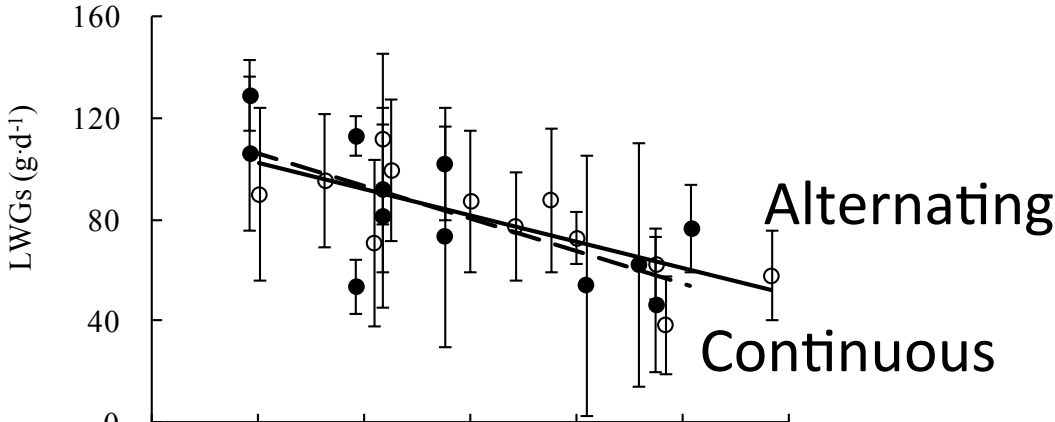


# Ecological aspects of livestock feeding in pastoral systems

2009 a

$y = -5.17x + 113 \quad R^2 = 0.52 \text{ (CON)**}$

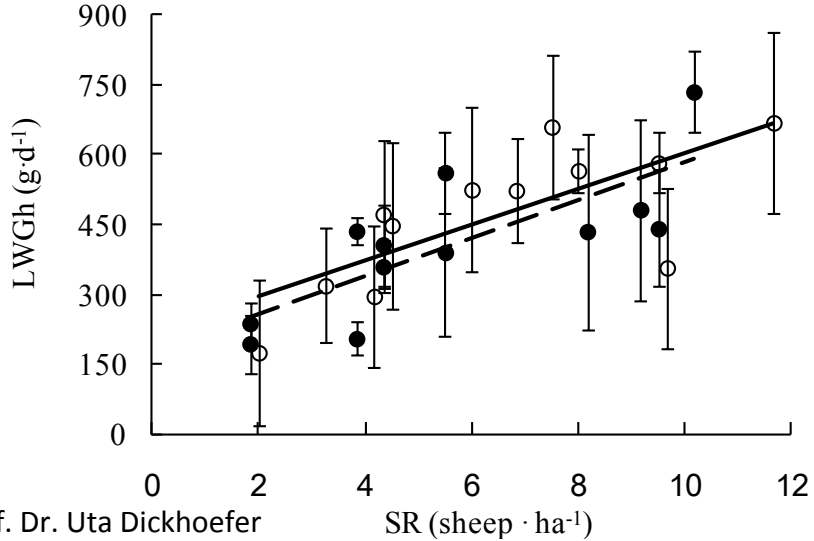
$y = -6.30x + 119 \quad R^2 = 0.44 \text{ (ALT)**}$



2009 b

$y = 38.2x + 220 \quad R^2 = 0.49 \text{ (CON)***}$

$y = 40.4x + 178 \quad R^2 = 0.55 \text{ (ALT)***}$





## Ecological footprint

- Ecological footprint is a measure of

*„the area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth the land and water is located”.* (Wackernagel und Rees 1996)

- Land footprint, Water footprint, Carbon footprint .....
- Comparing resource use and environmental impacts of different societies, activities, production systems, products etc.
- Identifying important sources and critical points for system’s optimization
- Deriving management and policy recommendations