Ecosystem management of pastures with grazing cattle

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Ecosystem management with grazing cattle

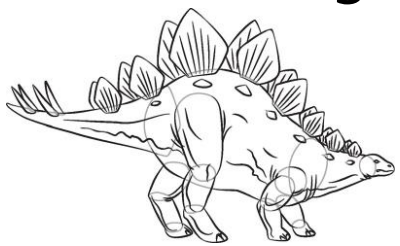
- Evolution
- Adaptation
- Perceptions
- Effects of grazing on vegetation, soil, mammals, insects, GHG and nitrogen
- Summary
- Reflections

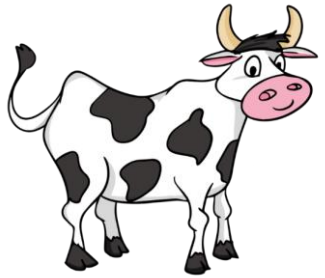
Grazers, vegetation and evolution

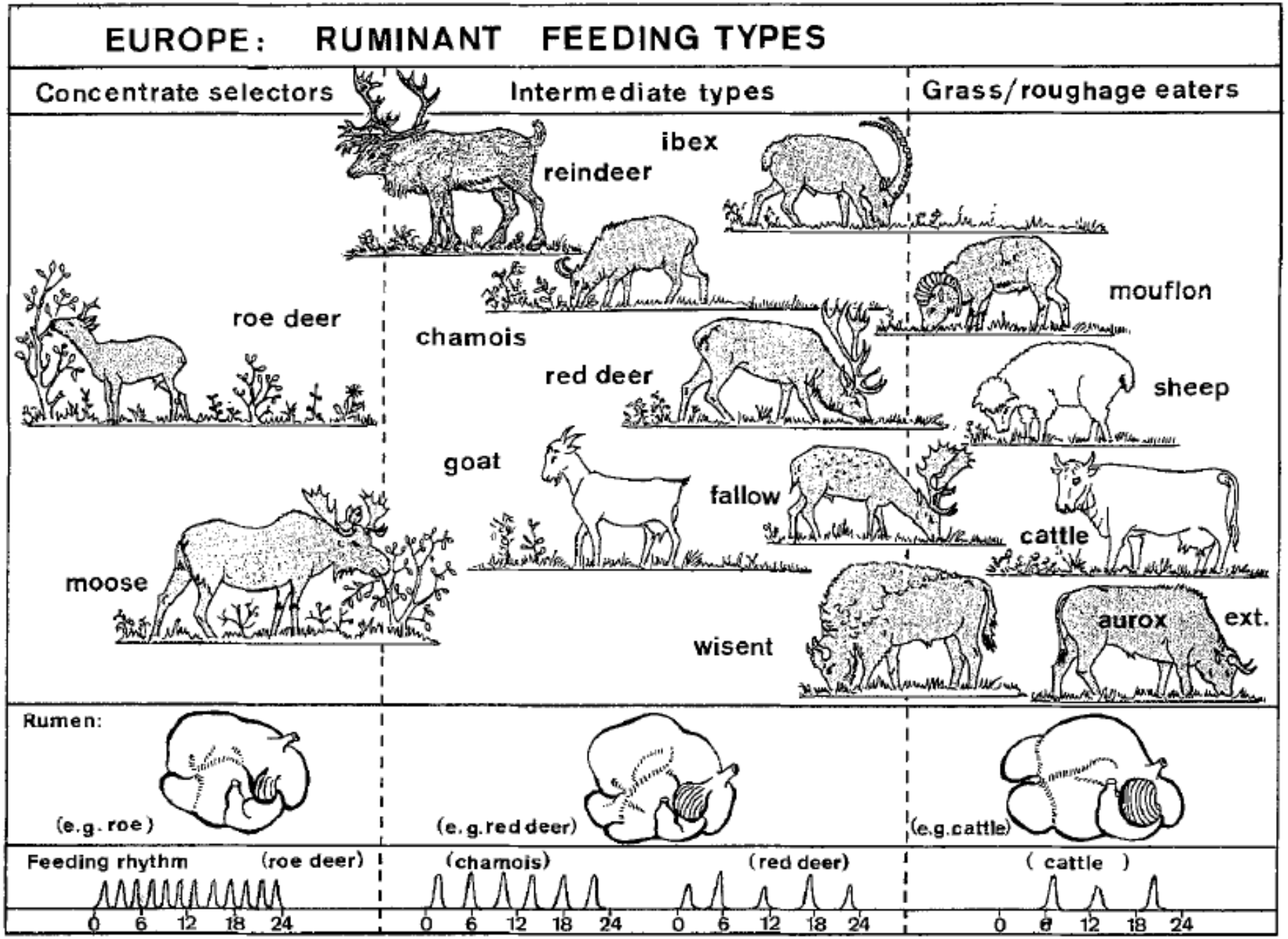
- Browse plants appear around 65 million years ago while grasses appear 26 million years ago

- Browsing herbivores (ancestors to giraffe, deer, antelope, and camels) ~38 million years ago

- All ruminant grazers (bovids) > 26 million years ago
  - Herding ~12,000 years ago







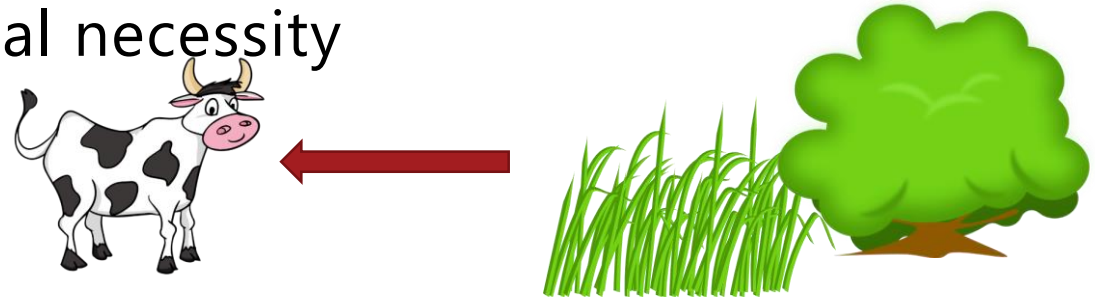
Hofmann, RR 1989.
Oecologia, 78:443-457

Grasses and browse

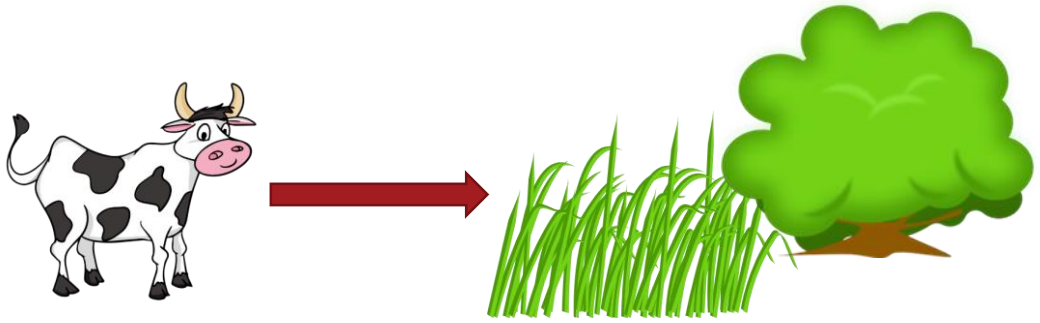
Photos H. Hansen

GRAZING

- Grazing and browsing is a nutritional necessity



- Grazing and browsing is a tool to manipulate shrub, bush and forest vegetation development (succession)
- Grazing is a tool to manage ecosystems.
- Grazing provides ecosystem services



Perceptions of Grazing on Environmental Services (ES)

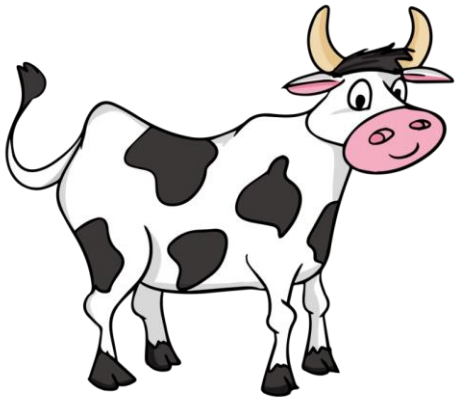
Very positive and positive perceived impacts of grazing on

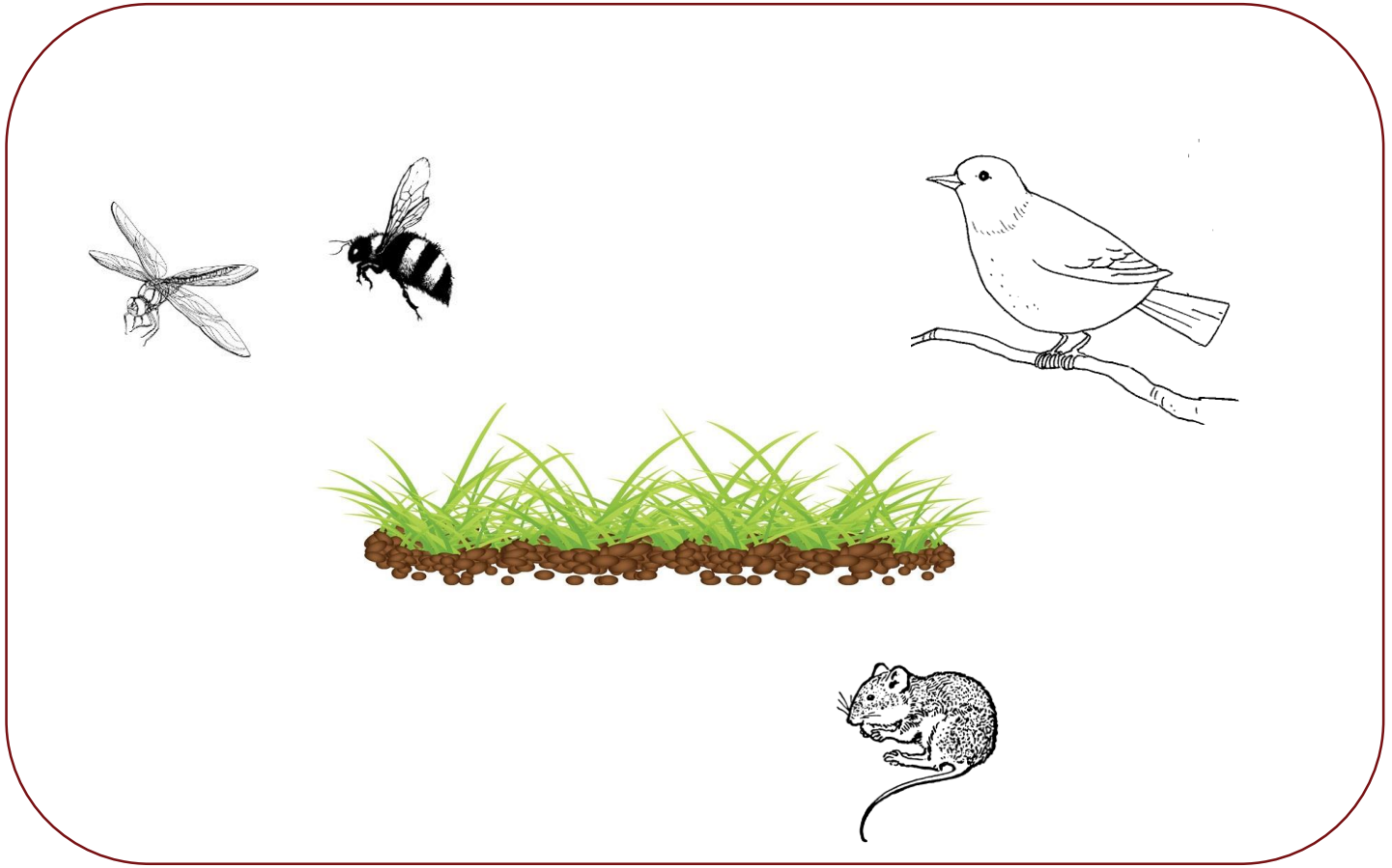
- Cultural ES
  - Knowledge systems & educational values (84%)
  - Landscape values (74%)
- Supporting ES
  - Habitat provision (66%)
  - Nutrient cycling (65%)
  - Bush encroachment control (66%)

- Only outside of Europe was grazing seen as a negative impact (<10%) on
  - Cutural ES: recreational, landscape, knowledge and educational values
  - Regulatory ES: water quality, erosion, climate (air quality) and control of crop residues/eradication of weeds
  - Supportive ES: support of primary production and habitat provision

Leroy G, Hoffmann I, From T, Hiemstra SJ, and Gandini G. "Perception of livestock ecosystem services in grazing areas." *Animal* 12.12 (2018): 2627-2638.

Knowledge of the effects of grazing





Grazing for vegetation management

Hjortholm 1920 with grazing

Figur 1. Udsnit fra den nordlige Borgbakke mod nord. Billedet er taget omkring 1920. (Foto: H. Neble). *View from the northernmost hill fortification looking north. The picture was taken around 1920.*

Hjortholm 1985 : severly reduced grazing

Figur 2. Samme udsigt som figur 1. Billedet er taget i 1985. (Foto: H. Hansen). *The same view as shown in figure 1. This picture was taken in 1985.*

Grazing and plants

	Lightly/ lenient / low intensity	Moderate grazing	Severe/ High intensisty	Ungrazed/ abandoned	Where
Plant biomass	🙂			🙁	(Norway), Finland, Africa
Plant species diversity/indicator plants	🙂	🙂			Central Europe, Cuba, Hjortholm DK
Plant species diversity	🙂		🙂		Fussingø; UK
Bird diversity	🙂				Mols Bjerg DK
Insect diversity		🙂			Hjortholm DK
Small mammal diversity	🙂				Fussingø DK
Dung beetle diversity	🙂	🙂		🙁	Brazil, Tanzania

Grazing and soils

	Management "improvement" from low to high	Where
Soil SOC	 	Europe: review; World review update
Soil organic matter, erosion, total N, soil respiration	 	Argentine Pategonia
Soil organic carbon, total N, soil microbial bioamass C, mineral N and basal respiration		Germany
Soil microbial biomass C Soil microbial activity (carbon utilization)	   	Aberdeen

Greenhouse gases

- The three most important sources of livestock-related GHGs are:
- Emissions from animals and manure (primarily methane (CH_4) and nitrous oxide (N_20)
- Direct emissions from cultivation and fertilisation of feed crops and pasture (mainly N_20 from fertilised soils and $C0_2$ from machine use)
- Land use change emissions (mainly $C0_2$ from deforestation/ grassland conversion = loss/degradation of soil carbon)
- Emissions from production of inputs (eg fertilizer), transport and processing (mainly $C0_2$)

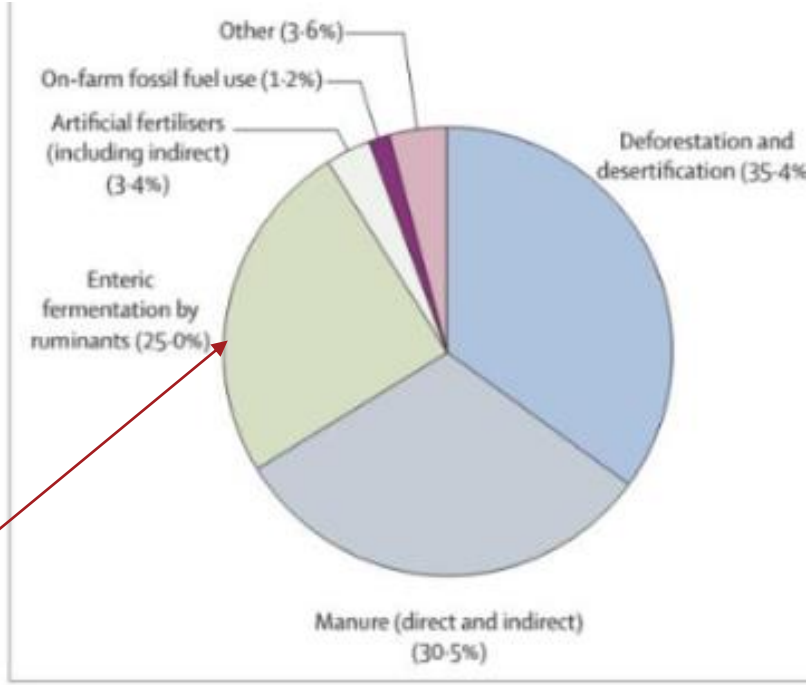
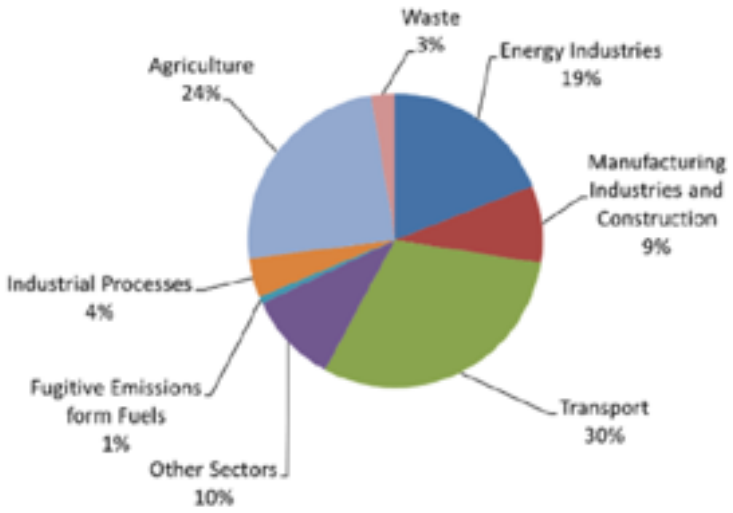


Figure 2: **Proportion of greenhouse-gas emissions from different parts of livestock production**
Adapted from FAO.[41]

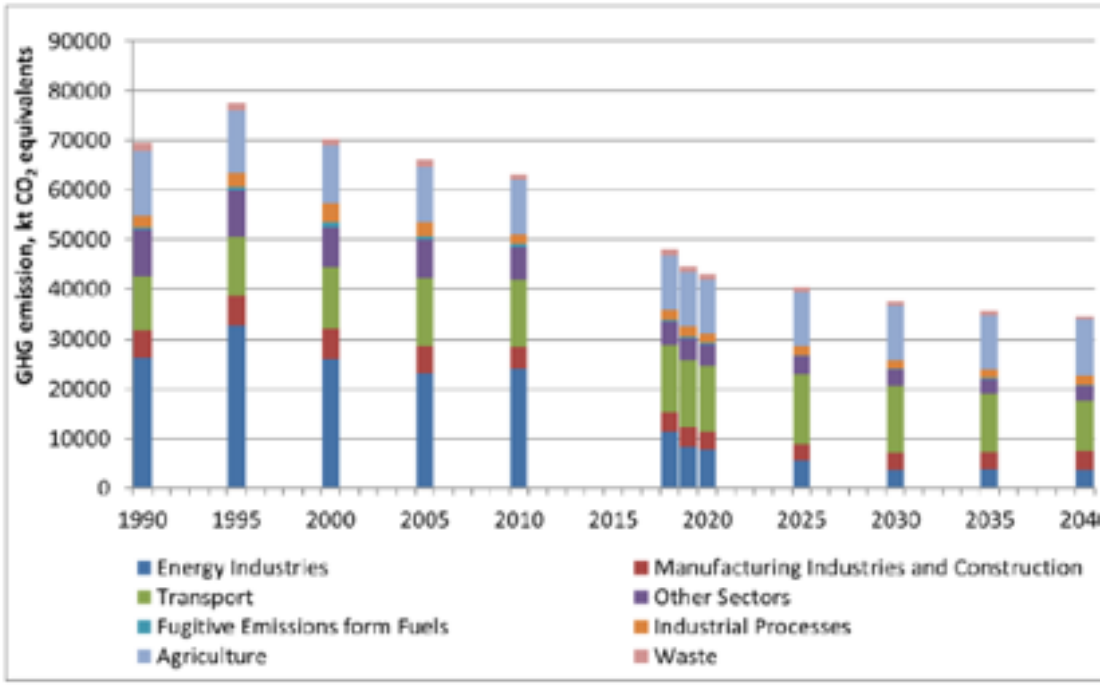
Stoumann, LS. 2021 Animals and Sustainability

Sources & trends of GHG emissions in Denmark



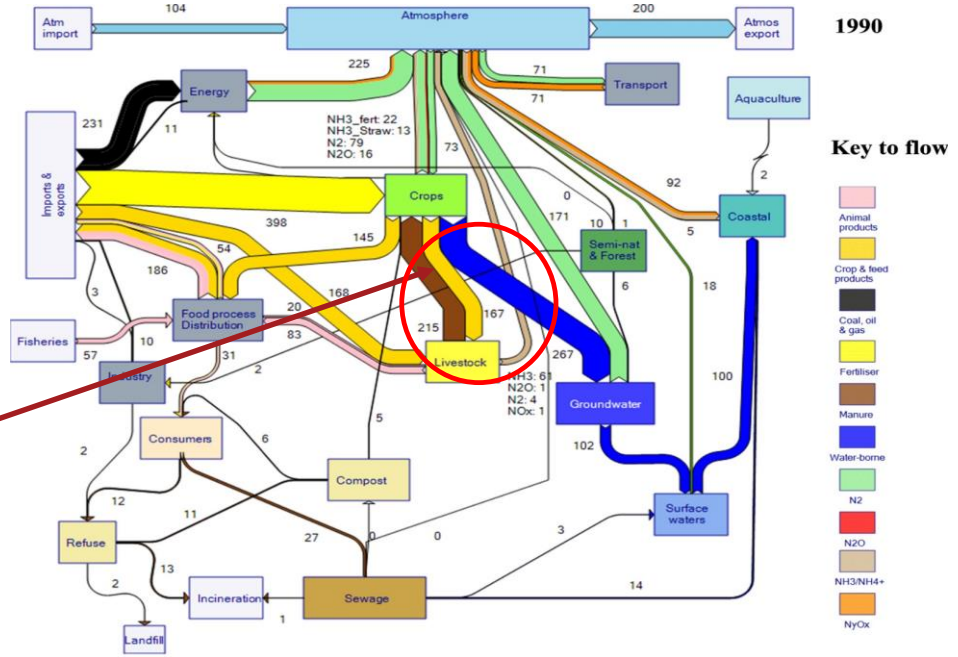
2019

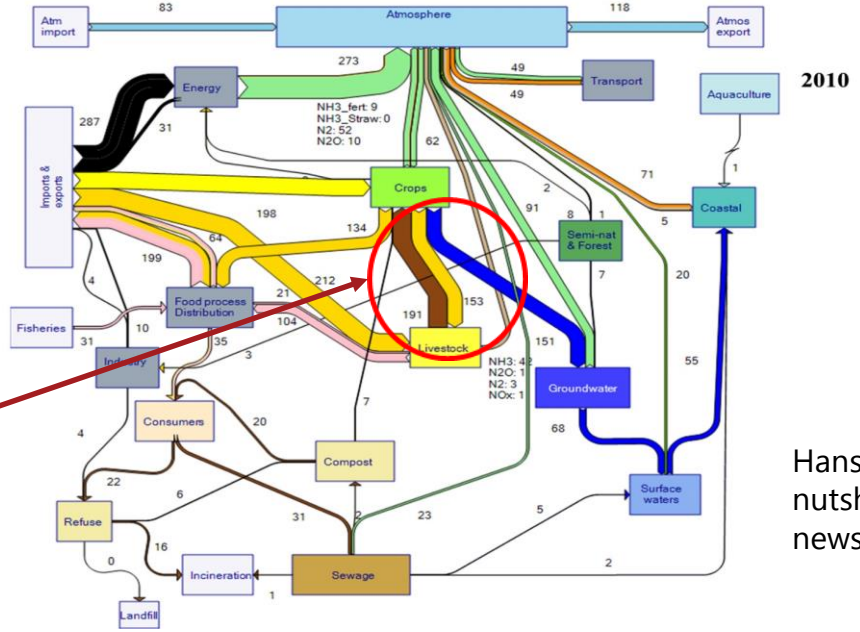
(Nielsen et al 2020)



- Total emissions in 2019: 44.6 mio t CO_2-eq. excluding and 54.8 mio t CO_2-eq. including LULUCF (Land use, land use change & forestry) + indirect CO_2
- From 1990 to 2018, the emissions decreased by 31 %.
- Projected emission in 2030 is 43.0 mio t of CO_2-eq., corresponding to a decrease since 2005 of 41 % (current political target 50%)

Stoumann, LS. 2021 Animals and Sustainability





Hansen, J. 2010. The Danish nitrogen budget in a nutshellhttps://agro.au.dk/en/current-news/news/show/artikel/nationalt-kvaelstofbudget-skaber-overblik/

Parameters that change the picture – at local levels

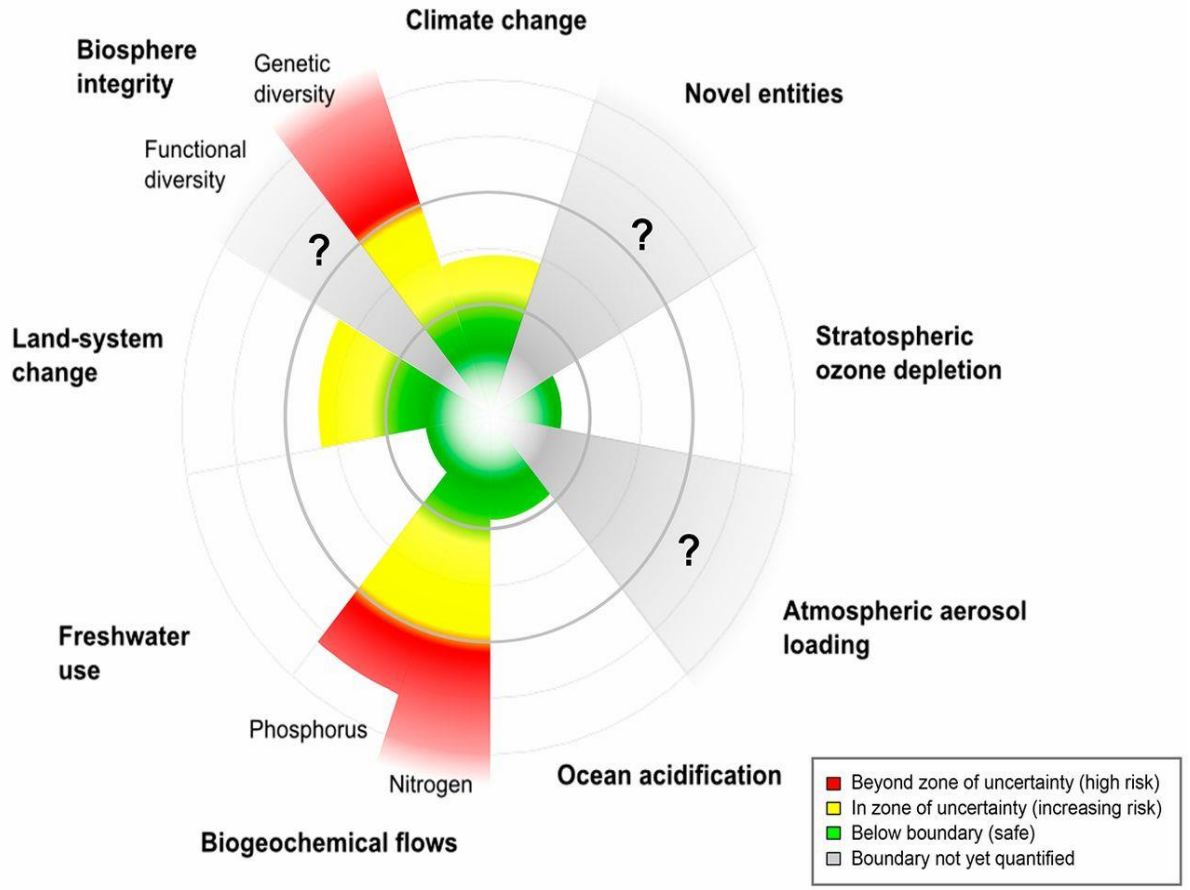
- With regards to grazing and plants, soil, insects and mammals
  - BIOMASS type and allotment (plant species, surplus or "just" sufficient)
  - FREQUENCY of grazing

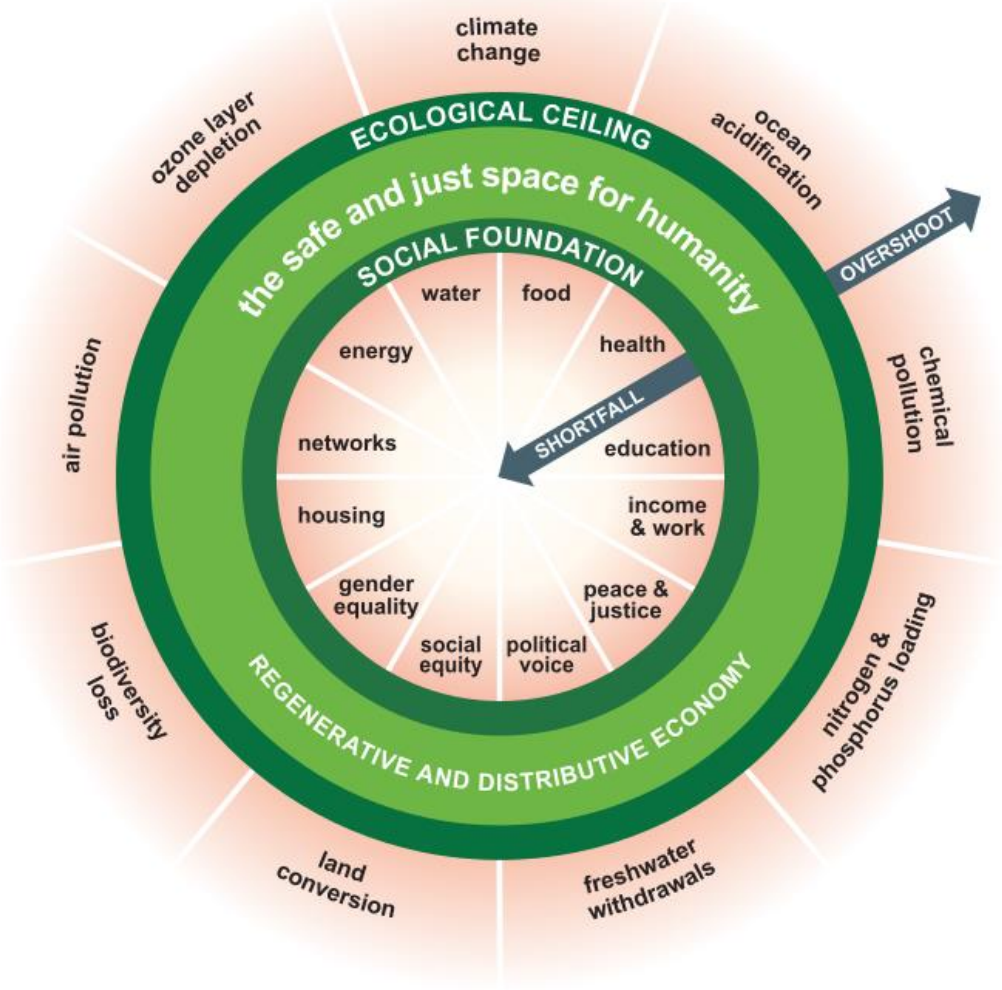
  Does the effect of 1 animal grazing for 10 days = the effect of 10 animals grazing for 1 day?
  - SEASON of grazing (plant phenology- previous season)
  - ANIMAL SELECTIVITY (eaten/available)
- With regards to CO_{2e} and N
  - Feed additives / feeding strategies
    - Agent X or Agent Y

How to summarize? Consider units and scales

- Competition between human food – animal feed needs to be minimized- How do we evaluate this?
- Per kg product: (effects measured per liter milk or meat)
- Per unit area : Organic lower C footprint
- Edible protein conversion ratio/ Land Use ratio

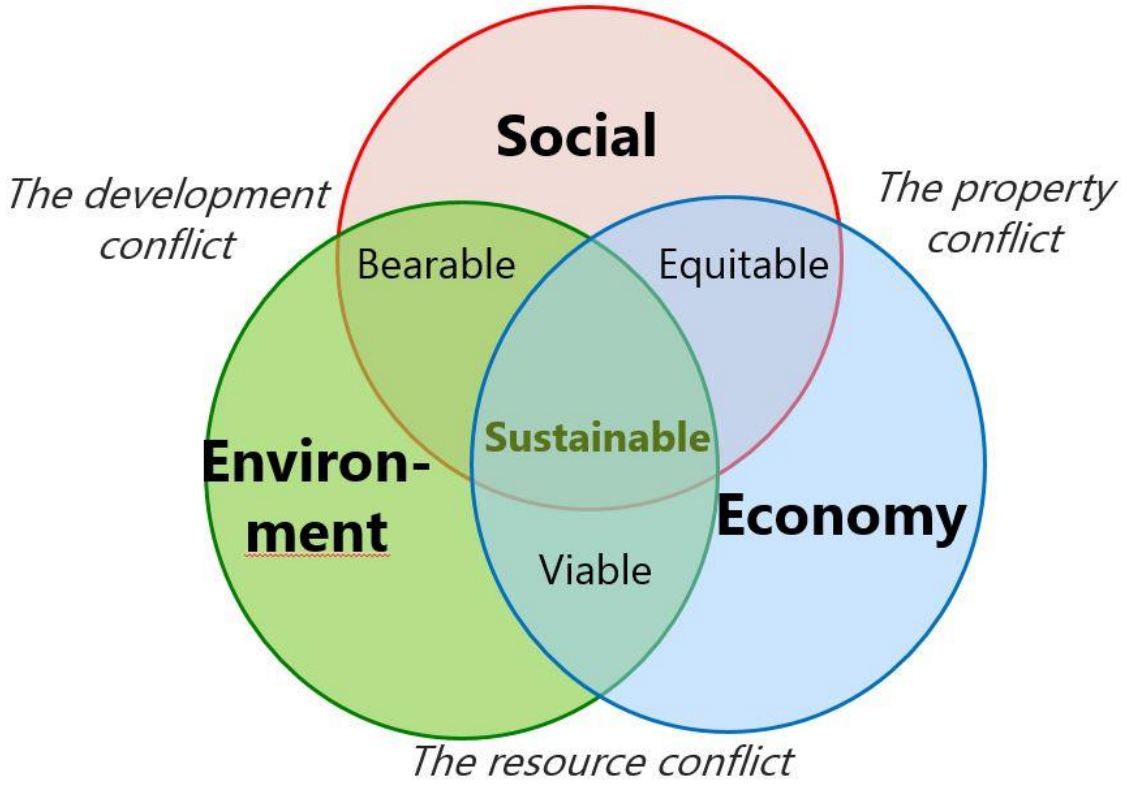
Living within boundaries- safely and justly





Steffen W, Richardson K, Rockström J, et al. 2015. *Science* 347, no. 6223 Raworth K. 2012 Oxfam Discussion Paper.

REFLECTIONS- can one size fit all?- Multicriteria decisions



- Weigh of each aspect combined with the "science" of impacts for multi-criteria decision analyses.
- -social
  - Rural development; livelihoods, working conditions
- - economy
  - Farmer profits, export income
- - environment
  - Biodiversity, nitrogen overload,GHG

Multidisciplinary efforts to make *science* based *transparent* decisions that encompass trade offs.

References:

Gerling C, Doppler T, Heyd V, Knipper C, Kuhn T, Lehmann MF, et al. (2017) High-resolution isotopic evidence of specialised cattle herding in the European Neolithic. PLoS ONE 12(7):e0180164. https://doi.org/10.1371/journal.pone.0180164
Hofmann, RR (1989). Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia, *78(4)*, 443-457. Https://10.1007/BF00378733.pdf
Shipley LA. (1999) Grazers and browsers: how digestive morphology affects diet selection. Grazing behavior of livestock and wildlife. 70:20-7
Leroy G, Hoffmann I, From T, Hiemstra SJ, and Gandini G. (2018) Perception of livestock ecosystem services in grazing areas. Animal 12: 2627-2638
Otieno S, Njoka J, Young T, Mureithi S, Ngugi R. (2009) Aboveground Net Primary Productivity in Grazed and Ungrazed pastures: Grazing Optimisation Hypothesis or Local Extinction of Vegetation Species. Nature Precedings.
Steinshamn H, Grøva L, Adler SA, Brunberg E and Lande US (2018) Effects of Grazing Abandoned Grassland on Herbage Production and Utilization, and Sheep Preference and Performance. Front. Environ. Sci. 6:33. doi: 10.3389/fenvs.2018.00033
Pykälä, J. (2003). Effects of restoration with cattle grazing on plant species composition and richness of semi-natural grasslands. Biodiversity & Conservation, 12(11), 2211-2226.
Tallowin, J. R. B., Rook, A. J., & Rutter, S. M. (2005). Impact of grazing management on biodiversity of grasslands. Animal Science, 81(2), 193-198.
Hald AB, Hoffmann CC, Nielsen L. (2003) Ekstensiv afgræsning af ferske enge. DJF rapport Markbrug 91
Buttenschøn RM. (2007) Græsning og høslæt i naturplejen. Miljøministeriet, Skov-og Naturstyrelsen
Hansen HH, Aaby B, editors. (1995) Stavns Fjord-et natur-og kulturhistorisk forskningsområde på Samsø.
Maldaner ME, Sobral-Souza T, Prasniewski VM, Vaz-de-Mello FZ. (2021) Effects of Climate Change on the Distribution of Key Native Dung Beetles in South American Grasslands. Agronomy 11, 2033. https://doi.org/10.3390/agronomy11102033
Poeplau, C. (2021) Grassland soil organic carbon stocks along management intensity and warming gradients*Grass Forage Sci.*;76:186–195.
Bjerring AT, Peri PL, Christiansen R, Vargas-Bello-Pérez E, Hansen HH. (2020) Rangeland grazing management in Argentine Patagonia. IJAB. Friends science publishers
Nüsse A, Linsler D, Kaiser M, Ebeling D, Tonn B, Isselstein J, Ludwig B. (2017) Effect of grazing intensity and soil characteristics on soil organic carbon and nitrogen stocks in a temperate long-term grassland. Archives of Agronomy and Soil Science. 63(12):1776-83
Grayston SJ, Campbell CD, Bardgett RD, Mawdsley JL, Clegg CD, Ritz K, Griffiths BS, Rodwell JS, Edwards SJ, Davies WJ, Elston DJ. (2004) Assessing shifts in microbial community structure across a range of grasslands of differing management intensity using CLPP, PLFA and community DNA techniques. Applied Soil Ecology. 1;25(1):63-84.
Heitschmidt RK, Stuth JW. (1991) Grazing management: an ecological perspective.
Halberg N. (2012) Assessment of the environmental sustainability of organic farming: Definitions, indicators and the major challenges. Canadian Journal of Plant Science. 92(6):981-96.
Hansen, J. (2010) The Danish nitrogen budget in a nutshell https://agro.au.dk/en/current-news/news/show/artikel/nationalt-kvaelstofbudget-skaber-overblik/
Hennessy DP, Shalloo L, Van Zanten HH, Schop M, De Boer IJ. (2021)The net contribution of livestock to the supply of human edible protein: the case of Ireland. The Journal of Agricultural Science. 1-9.
Steffen W, Richardson K, Rockström J, et al. (2015). Planetary boundaries: Guiding human development on a changing planet.*Science* 347, no. 6223
Raworth K. (2012) A safe and just space for humanity Oxfam Discussion Paper

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