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The role of grasslands and nutrient circularity in animal agriculture

W. Windisch
Chair of Animal Nutrition
TUM School of Life Sciences
Technical University of Munich

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The role of livestock in utilizing agricultural biomass

Trade off between emissions, efficiency, and food competition

Alternatives ahead?

Where to go?

The availability of agricultural area is severely shrinking

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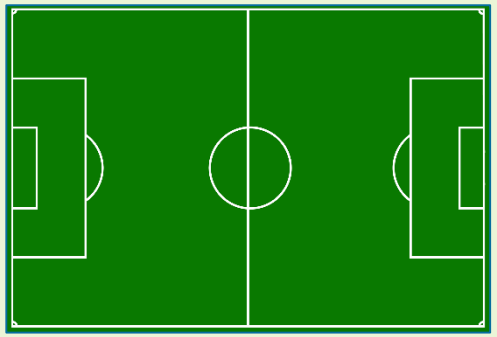
Globally available agricultural area (m²/person)

Year 1970	3800
Year 2020	2400
Year 2050	1500

(Germany, now ca. 2300 m²/person)



How many persons must feed a soccer ground (7400m²) per year

now	3 persons
by year 2050	> 5 persons

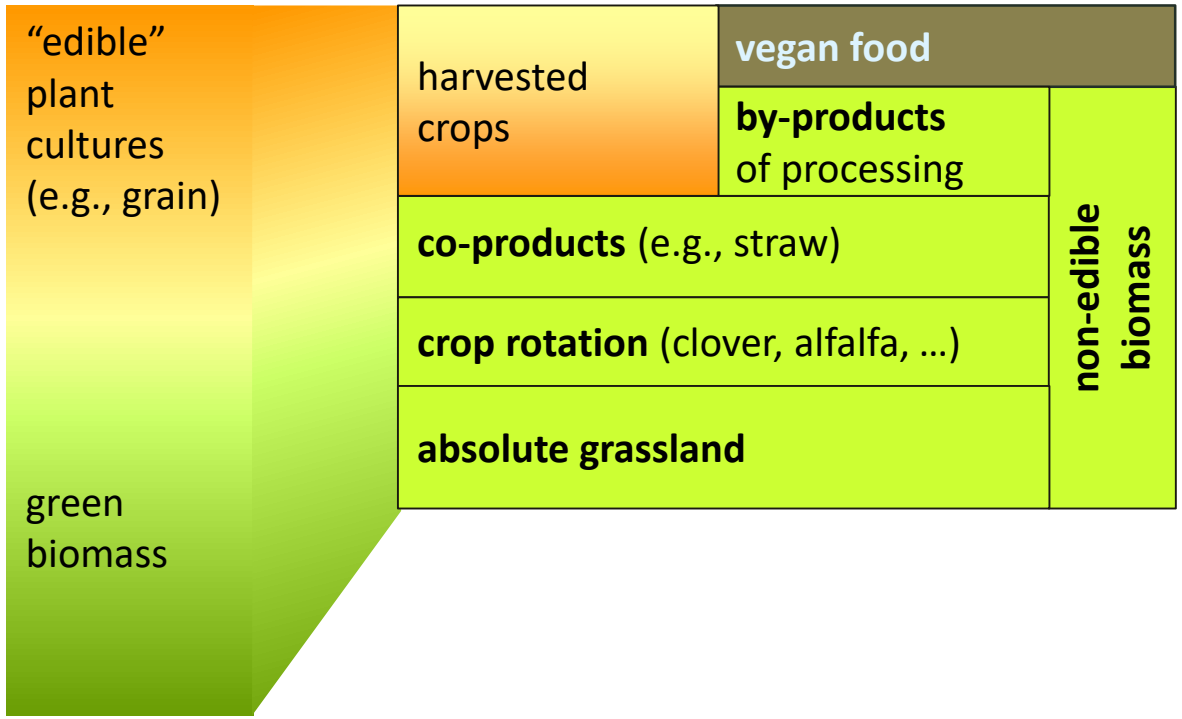
How much of visible biomass is **edible** at all?

Von Simon Koopmann - Eigenes Werk, CC BY-SA 2.0 de, https://commons.wikimedia.org/w/index.php?curid=2547740

Von Elmschrat bearbetet von VH-Halle - Eigenes Werk, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=11032439

Agriculture produces biomass, that is **non-edible** for the most part

Agriculture produces mainly **non-edible** biomass



Absolute grasslands cannot be converted into arable land producing vegan food because of

- climate (too humid/dry, short vegetation period, …)
- topography (too steep, periodically flooded, …)
- conversion would release dramatic amounts of CO_2

Absolute grassland covers major proportions of total agricultural areas, e.g.,

>70%	global agricultural area
40 – 70%	Alpine regions
ca. 30%	Central European areas with intensive plant production

Coexistence of grass with herbivores (mainly ruminants) generate highly productive habitats

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Von David Dennis from Pozuelo de Alarcón, Madrid, Spain - Zebra in the Serengeti Wildebeest Migration, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=2140044

Grassland:

quick turnover of biomass and of plat nutrients via animal dung,

high density of large animals (x20 of forest).

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Forest:

slow turnover of biomass and of plant nutrients,

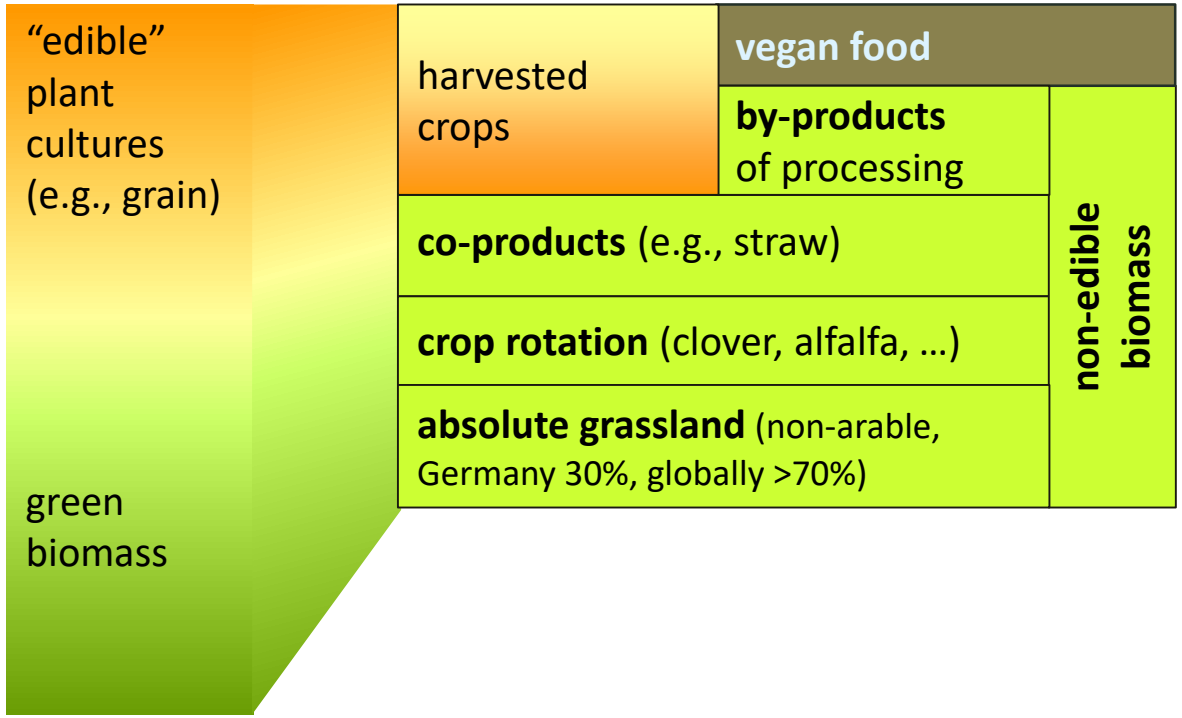
very low density of large animals (5% compared to grassland)

Livestock ruminants may generate landscapes with very high biological diversity

(quasi natural replacement of macrofauna extinguished by men during Stone Age)

Von Meloe - Eigenes Werk, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=60118715

Agriculture produces mainly **non-edible** biomass



Technology	Proportion of inevitably occurring by-products (% of dry matter input)
Milling cereals	20-30
Starch production	25-30
Sugar production	45
Oil production	55 – 60
Alcohol production (brewery, bioethanol), (1/3 of biomass is lost as CO_2 along with fermentation)	25-35

Agriculture produces mainly **non-edible** biomass

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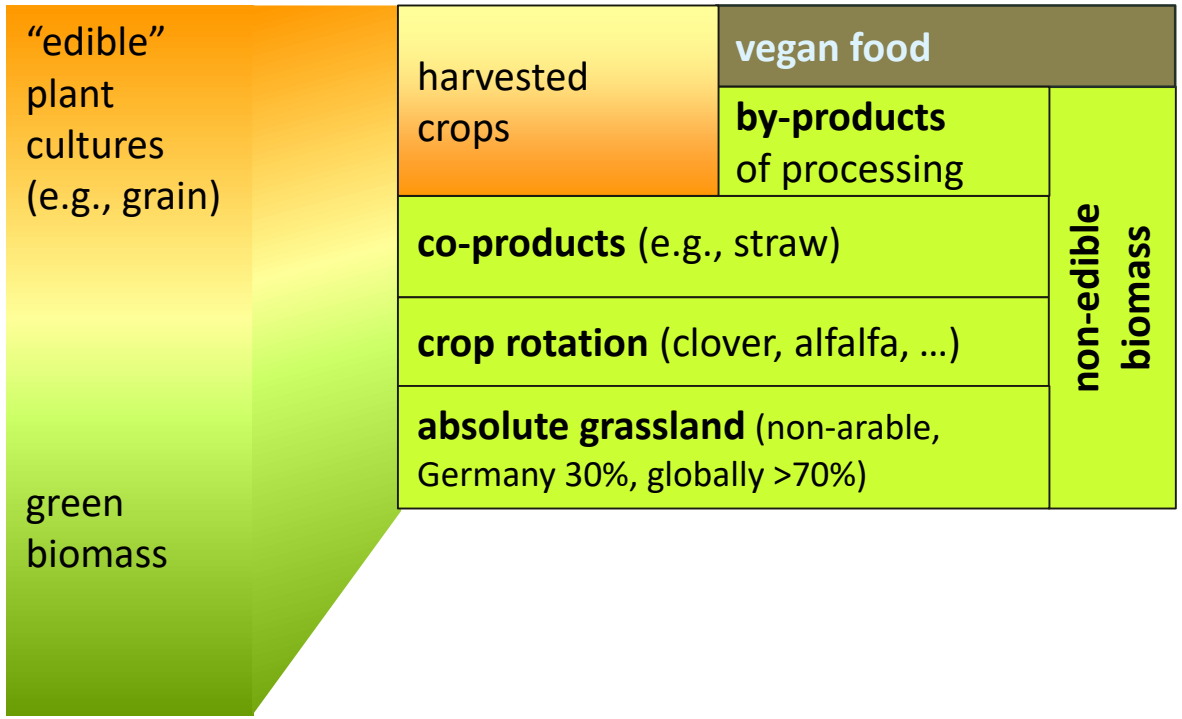
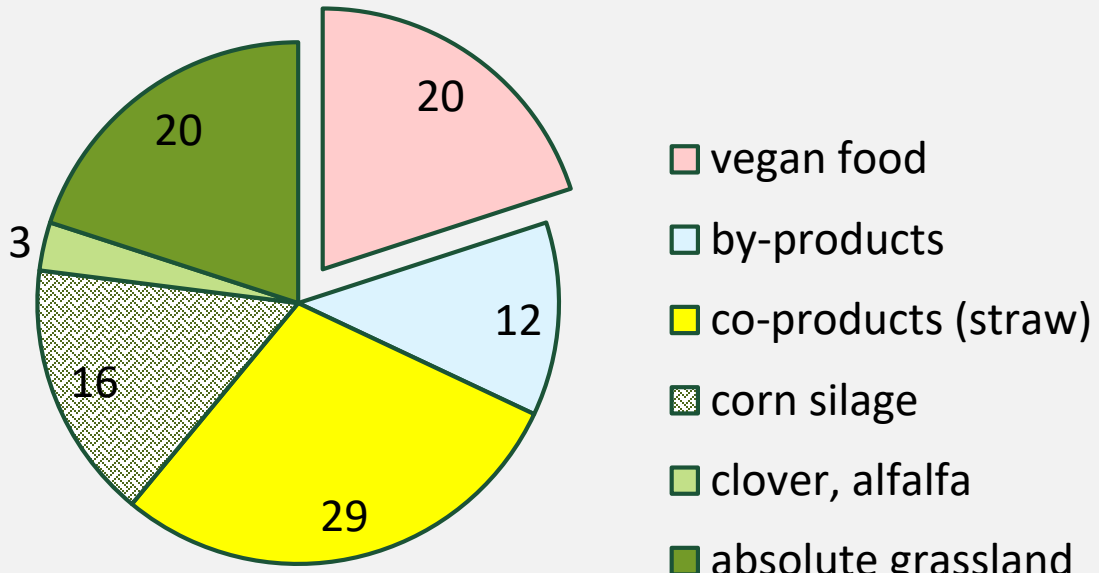
1 kg of vegan food generates at least 3 to 5kg of non-edible biomass



E.g. Germany 2020/21: Distribution of harvested biomass (DM) assuming 100% input into food industry (except corn silage)



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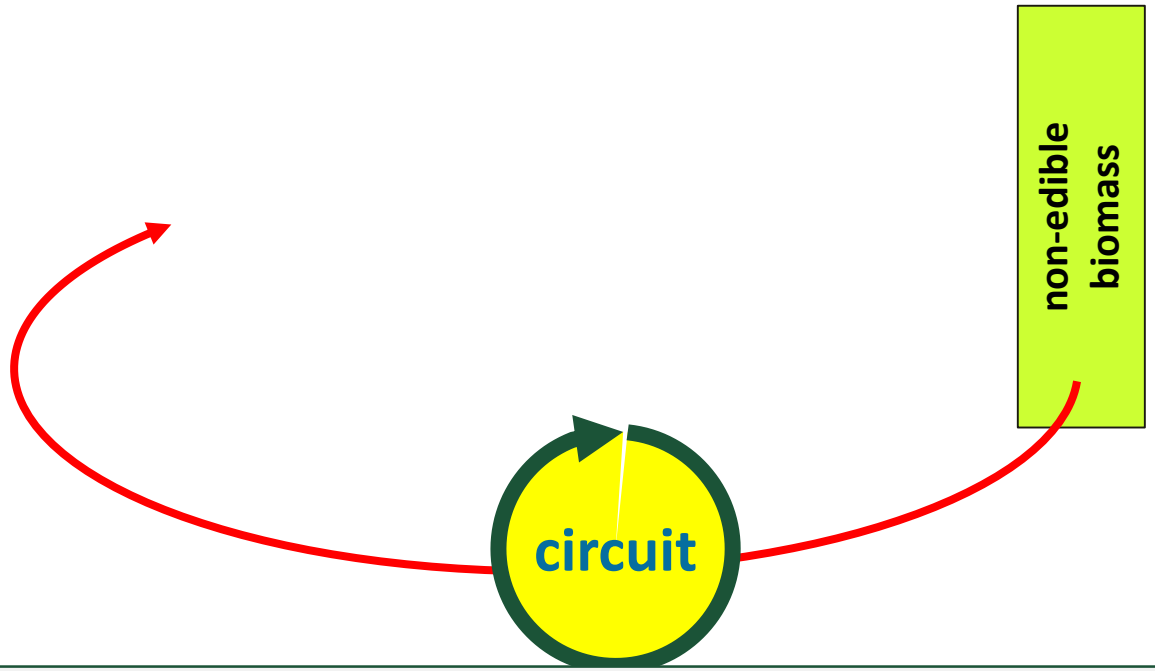

Strategies to recycle plant nutrients:

- **directly back to the soil ("vegan agriculture"):** inefficient, high emissions.
- **fermentation to biogas (CH_4):** biogas residuals are storable fertilizers; it may be applied precisely according to the plant's need.
- **feeding to livestock:** livestock dung is a storable fertilizer; it may be applied precisely according to the plant's need.

Non-edible biomass contains large amounts of plant nutrients (N, P, …)

(¾ of P withdrawal along with cereal harvest ends up in bran; 100% of P an N withdrawal along with oil seed harvest ends up in extracts)

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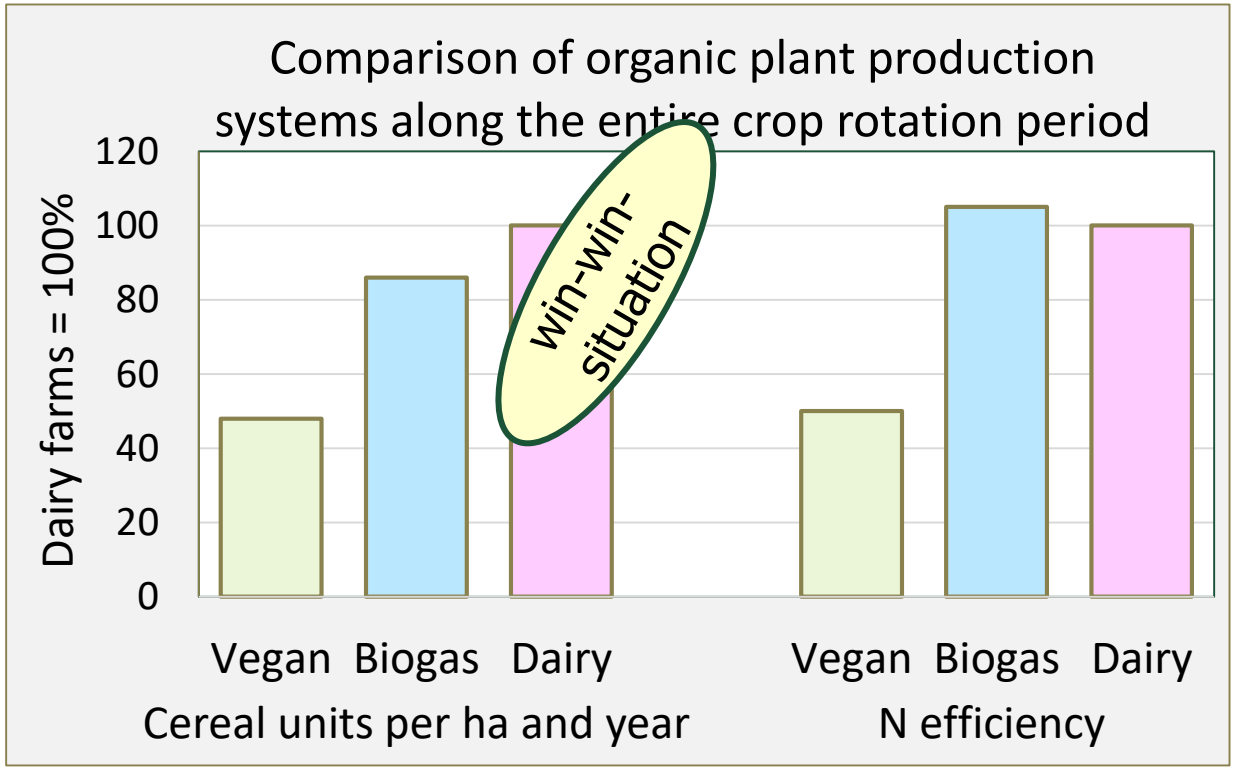

Bryzinski (2020); https://hypel.ink/bryzinski; ISBN: 979-8574395912

Livestock promotes vegan production (fertilizer) and produces food **in addition**

Feeding inevitably occurring, non-edible biomass to livestock adds up significant amounts of extra food

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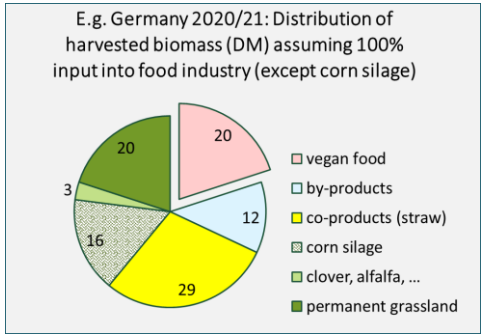
1 kg of vegan food entails at least 3 to 5kg of non-edible biomass



Net gain of food from 4kg of non-edible biomass (corrected for feed required to maintain animal herds):

- grassland and co-products fed to ruminants:
  min. 3kg milk
  min. 0.4kg meat
- By-products fed to pigs, poultry:
  min. 0.4 kg meat

Added value:
1000 to 2000 kilocalories,
100g high-quality protein

Livestock delivers high-quality food protein and kilocalories from a given agricultural area equivalent to

50 to 100% of primary vegan food

without food competition, solely from the inevitably occurring, non-edible biomass,

simultaneously delivering valuable **fertilizers** along with **circularity**.

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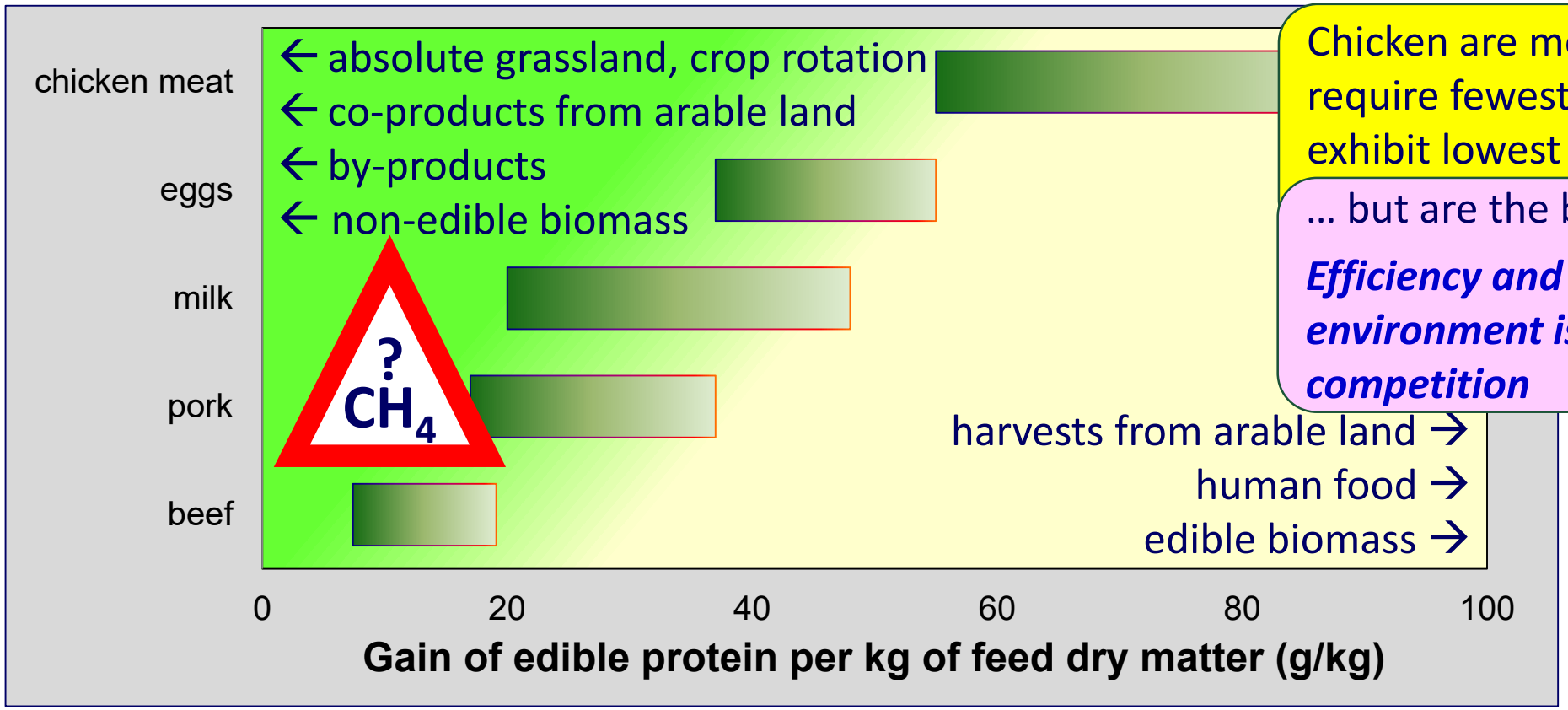
Alternatives ahead?

Where to go?

Trade off between emissions, efficiency, and **food competition**



Chicken are most efficient, require fewest resources, exhibit lowest footprints,

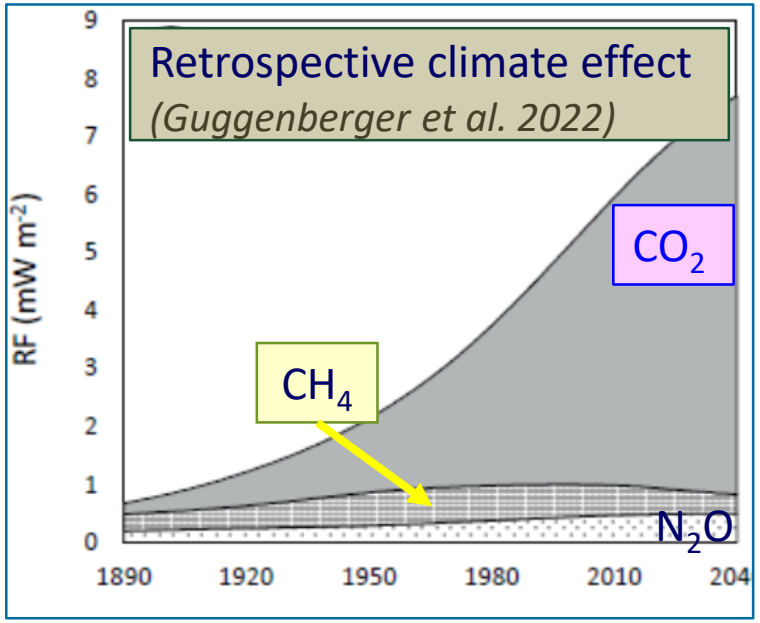
… but are the biggest food competitors.

Efficiency and protection of climate and environment is bought mainly by food competition

(Data from Flachowsky and Meyer 2008)

Feeding ruminants just seems to be inefficient and "dirty". At absence of food competition, however, it is the most efficient way to make use of it.

Climate killer cow is a misleading narrative



CH_4 production stabilizes the rumen functions (e.g. protects from formation of ethanol). Rising feeding efficiency of the total animal herd reduces the „CH_4 burden “ of meat and milk from ruminants.

CH_4 is a strong greenhouse gas (84xCO_2) but is quickly degraded (t½ 8 - 12a).
At constant animal numbers, ruminants do not increase atmospheric CH_4 concentration and hence do not additionally heat up the climate.

CO_2 is extremely stable and accumulates in the atmosphere. Current emissions from fossil energy sources heat up the climate.

→ Actions against CH_4 emissions from ruminant livestock don‘t exhibit lasting effects.
→ Stop of fossil energy use, building up CO_2 sinks = grassland, clover/alfalfa, agroforest, …
→ Maintaining ruminant production at minimized CH_4 burdens.

Feeding livestock in harmony with circularity supports environment and climate protection (1)

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1 kg of vegan food entails at least 3 to 5kg of non-edible biomass

Emissions/footprints associated to inevitably occurring, non-edible biomass are largely independent from the pathway of recycling (leave on the field vs. biogas vs. livestock).

(In the long, run CH_4 is of minor relevance).

Abstinence from feeding this biomass to livestock:

→ does not relieve the environment or climate.

→ deletes significant quantities of food that could have been produced without any food competition.

→ entails massive intensification of "vegan" food production, entailing severe rise in emissions/footprints.

Negative impacts on environment and climate occur, once additional feedstuffs are grown on arable land

Feeding livestock in harmony with circularity supports environment and climate protection (2)

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RESEARCH REVIEW

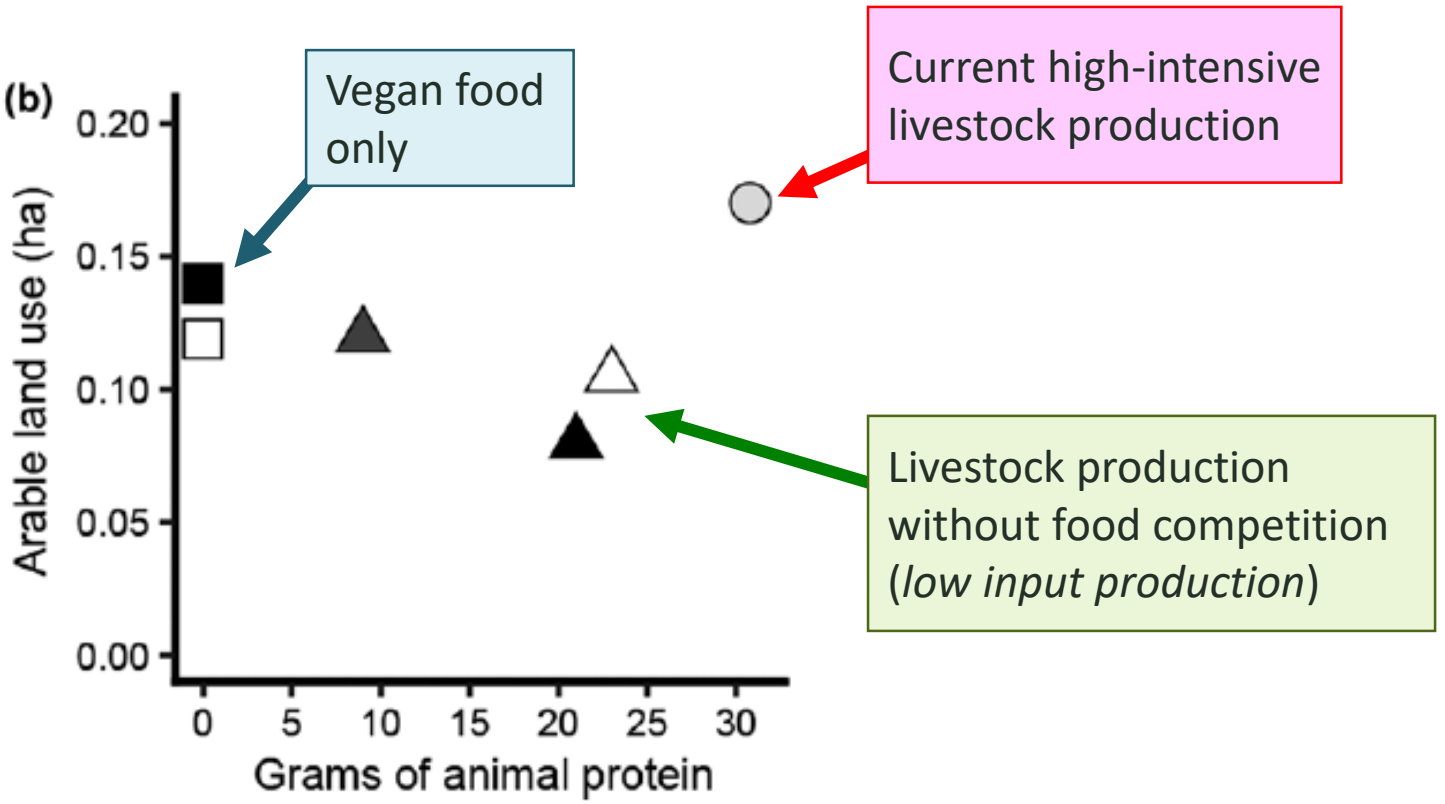
WILEY Global Change Biology

Defining a land boundary for sustainable livestock consumption

Hannah H. E. Van Zanten[1] | Mario Herrero[2] | Ollie Van Hal[1] | Elin Röös[3] | Adrian Muller[4,5] | Tara Garnett[6] | Pierre J. Gerber[1,7] | Christian Schader[4] | Imke J. M. De Boer[1]

Current high-intensive livestock production causes high footprints and emissions, but also purely vegan agriculture.

The minimum impact on environment and climate is reached only **with** livestock.



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The bottleneck of cellular meat is the culture media

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Culture media is produced from **already existing vegan food**

Cellular meat causes food competition.

Cellular meat is just another kind of livestock. It requires “feed” of highest quality (pure glucose, L-amino acids, … like parenteral nutrition).

Cellular meat must be assessed in context with circularity.

It may become a true alternative, if it may be fed with non-edible biomass (like ruminants).

Vegan food is a synergistic counterpart to livestock feeding

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1 kg oats	→	380 g in oats “milk” **+ 250 g bran + 370 g residuals**
1 kg soybean	→	200 g oil + 470 g protein **+ 80 g hulls + 250 g residuals**
1 kg lupins	→	300 g protein + **240 g hulls + 410 g residuals** + 50 g toxic oil

Production of vegan food entails large amounts of non-edible biomass.

Vegan food must be assessed in context with circularity.

Combination of vegan food with feeding non-edible by-products to livestock generates the maximum of human food from the same material (win-win-situation).

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The inevitable, non-edible biomass as fallback position of future livestock feeding entails severe consequences

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Scenario to Switzerland: solely non-edible biomass, solely organic farming (Züricher Hochschule für Agrarische Wissenschaften, zhaw, 2018).

Beef	**↓ by 40 %**
Milk (products)	**↓ by 30 %**
Pork	**↓ by 70 %**
Chicken meat	**↓ by 99 %**
Eggs	**↓ by 95 %**

The **limited quantity** of non-edible biomass restricts total production of food of animal origin.

The **limited quality** of non-edible biomass restricts pork production, and, in particular, chicken meat and eggs.

Overall effects:

- significantly less animals
- significantly less emissions
- significant drop in production of meat, milk, and eggs

Ruminants are best suited to maintain food security.

Losses in food production must be mitigated by maximizing feed efficiency of non-edible biomass.

Maximizing feed efficiency: *low input – high output*

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- Don‘t spoil feed
  - Maximize feed quality by proper harvest and preservation
  - Innovations in process technology, cascade principle, circular economy
- Precise livestock feeding (neither deficiency nor excess of nutrients)
- Supporting digestive capacity (feed additives, proper ruminant feed composition)
- Minimizing „unproductive“ feed consumption of entire livestock systems
  - Animal health and animal welfare
  - Efficient generation of robust offspring
  - Undisturbed production cycles, longevity
  - Adaptation of breeding targets to feed with limited quality (e.g., level of performance)
- Plant breeding to improve feed quality (e.g., less lignocellulose, toxins, …)

Take home message

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Don’t spoil biomass, neither edible nor non-edible. The priority is food > feed > energy.

- Maximize gain of edible “vegan” biomass from primary production until processing.
- Maximize transformation of residual non-edible biomass into human food by livestock (low input → high output).

The impact of livestock on environment and climate exhibits two steps:

I. Basal production in harmony with circularity protects environment and climate.
II. Production on top of circularity may stress environment and climate.

However, the societal demand for animal derived food may exceed basal production capacity.

The challenge: finding the acceptable balance between plant and livestock production.