
Letter to the Editor

Wirsenius, S. 2003. Letter to the editor responding to Bradford and Baldwin's letter regarding S. Wirsenius's (Winter 2003) "The Biomass Metabolism of the Food System: A Model-Based Survey of the Global and Regional Turnover of Food Biomass," *Journal of Industrial Ecology* 7(1): 47–80.

My article deals with the flows and use of biomass in the integrated food and agriculture system, on regional and global levels. It does not deal specifically with the physical and/or economic efficiency of livestock systems, which certainly is a very different issue. What is done in the article that has bearing on efficiency, are comparisons of one of the major service outputs, animal food (meat, milk, eggs), with one of the major resource inputs, biomass (i.e. feed). However, nowhere in the article is it claimed that the ratio between animal food output and biomass feed intake would be a sufficient description of livestock efficiency. On the contrary, in the article I stress that "...it must ... be recognized that the contribution of livestock systems to human welfare is not at all fully captured by considering only their efficiency in converting phytomass to food" (p. 74). From this statement it should be clear that I do not consider efficiency of livestock systems being a straightforward and indisputable concept – as seem to believe Bradford and Baldwin, judging from their criticism of my article.

Regarding the benefits, or outputs, of livestock systems, I do fully agree with Bradford and Baldwin that there are many more services than food that are being provided, e.g. draft power, fiber, dung, capital storage and aesthetics (grazed landscape). That these additional services should be taken into account when making wider, socio-economic efficiency comparisons between systems and regions is also recognized in my article (p. 74).

However, when it comes to the inputs and costs of livestock systems there are indeed disagreements between me and Bradford and Baldwin. They argue, implicitly, that forage, fibrous crop residues and feed from permanent grassland should not be considered as valid input in an efficiency comparison, since such materials are not edible by humans, and would not contribute to human food supply if they were not eaten by ruminants.

A fundamental assumption in that perspective is that these human-inedible materials would be wasted if not used by ruminants, i.e. they are assumed to be non-competitive resources without opportunity costs. However, in a world with 6+ billion people, and ever diminishing land areas that can be spared for nature, it is highly questionable to maintain a notion of zero opportunity cost for the use of permanent grassland and human-inedible biomass. There are several reasons to this (see also pp. 74-75 in the article):

- Today's permanent grasslands are to a large extent simply not the natural vegetation, and continuing grazing of those areas implies significant opportunity costs (e.g. lost forest, lost biodiversity)

- Grazing also of natural grasslands by domestic livestock entails significant ecosystem impacts, e.g., by changing the structure of vegetation and out-competing natural herbivores

- There exists significant regional competition for fibrous crop residues, particularly for use as fuel and for bedding in animal confinements. More importantly, over large tracts of cropland, especially in dry areas, substantial shares of crop residue production need to be left in field in order to preserve favorable soil conditions and for erosion protection.

- In addition, within the coming decades, competition for biomass and bio-productive land in general is likely to increase, due to an anticipated increasing demand for biomass energy and biomass-based materials, as replacements to energy forms and materials now based on fossil fuels.

In my view, it is evident for these reasons that all categories of land and biomass should be included in sustainability-oriented analyses of human activities that use land and biomass. In such analyses, cultivable land should be distinguished from other land categories, since cultivable land definitely is an indispensable resource for vegetable food production.

In their letter, Bradford and Baldwin state that I did not use cultivable land when comparing efficiencies or drawing conclusions in the article. Although land area numbers as such were not presented explicitly, I did include separate data on the use of cultivable-land biomass for different livestock systems, as can be seen from Figures 9-10 in the article (see also p. 76). From those figures, it is evident that in many regions the appropriation of cultivable land per food unit output for cattle meat systems is of the same order, or larger, of that for pig and chicken meat systems.

In conclusion, I think Bradford and Baldwin take an unacceptably narrow view on livestock efficiency by not including the appropriation of permanent grassland, forage and crop residues in the input side. For making relevant analyses of the sustainability of livestock systems, and their possible contributions to a sustainable global food supply, it is essential to fully take into account both natural resource appropriation (e.g. land, biomass etc) and ecosystems impacts (e.g. in terms of emissions of nitrogen and greenhouse gases) by the systems. Such a broad approach will be increasingly relevant, since the growing global population and rising per-capita demand for animal food and other biomass-based products will tend to intensify even further the pressure on Earth's ecosystems and bio-productive land areas.

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