Science of the Total Environment 610–611 (2018) 1207–1209

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Reducing the environmental impact of global diets

Marian Swain[a,*], Linus Blomqvist[a], James McNamara[a], William J. Ripple[b]

[a] Breakthrough Institute, 436 14th St., Suite 820, Oakland, CA 94612, USA
[b] Department of Forest Ecosystems and Society, Oregon State University, 321 Richardson Hall, Corvallis, OR 97331, USA

ARTICLE INFO

Article history:
Received 12 July 2017
Accepted 12 August 2017
Available online xxxx

Editor: D. Barcelo

ABSTRACT

It is well established in the literature that reducing the amount of meat in global diets would reduce the environmental impacts of food production. However, changes to livestock production systems also have significant potential to reduce environmental impacts from meat production, and yet are not as widely discussed in the literature. Modern, intensive livestock systems, especially for beef, offer substantially lower land requirements and greenhouse gas emissions per kilogram of meat than traditional, extensive ones. The land sparing potential of beef sector intensification is especially relevant for high priority conservation regions like the Brazilian Amazon. Leveraging livestock production systems in addition to dietary change greatly expands the opportunity to achieve conservation and climate goals in the coming decades.

Agriculture is a key driver of environmental impacts including land use change, greenhouse gas (GHG) emissions, water use, and pollution. Livestock production is responsible for a large share of these impacts, using almost one-third of global land area (Steinfeld et al., 2006) and generating 14% of all human-caused greenhouse gas emissions (Gerber et al., 2013).

Within the livestock sector, beef production plays an outsize role in environmental impacts, accounting for 41% of livestock sector emissions (Gerber et al., 2013). Cattle also have a larger land footprint than pigs or chickens due to their need for pasture area for grazing. While pasture is also used for other ruminant species, cattle represent 82% of global ruminant meat production (FAO, 2017). Pasture expansion for cattle grazing is a major driver of deforestation in high-priority conservation regions like the Brazilian Amazon (Barona et al., 2010). In addition to contributing to land use change, cattle grazing can have significant direct negative impacts on terrestrial and freshwater ecosystems (Beschta et al., 2013; Batchelor et al., 2015).

Human diets impact the global environment since they drive demand for agricultural products. The relative share of animal products in future global diets will be a key determinant of environmental outcomes, and there is extensive literature demonstrating how reducing meat consumption could lower GHG emissions and spare land (Tilman and Clark, 2014; Harwatt et al., 2017). Dietary changes like substituting poultry for beef could also improve environmental outcomes (de Vries and de Boer, 2010), as would substituting fish or dairy for terrestrial meat (Scarborough et al., 2014).

However, given the scale of livestock's environmental footprint and projected growth in meat demand, efforts to reduce consumption will not suffice on their own. Improving the environmental efficiency of production systems is also important, but has received less attention from the conservation community. Though often criticized for its higher use of inputs, more intensive livestock production systems can in fact generate significant environmental savings. Intensive livestock systems are characterized by a concentrated and carefully controlled production environment, the use of nutritionally optimized commercial feeds, and the application of advanced animal husbandry and breeding techniques, all of which serve to produce larger animals faster than in traditional extensive systems. The increased productivity also means that for key metrics including land use and GHG emissions, intensive meat production generates fewer environmental impacts per kilogram of meat, most dramatically for beef.

The environmental gains from intensification can be impressive. For beef production, the key distinguishing feature of intensive systems is the use of grain-based feeds to fatten cattle up in the last few months before slaughter (in extensive systems cattle graze only on pasture). Finishing cattle on grain significantly accelerates growth and reduces the time to slaughter, which also serves to dramatically reduce methane emissions from enteric fermentation (Pelletier et al., 2010). The result is that intensive beef production with grain-finishing produces significantly less greenhouse gas emissions per kilogram of meat than traditional grazing-only beef systems (Fig. 1).

* Corresponding author.
E-mail addresses: marianswain@gmail.com (M. Swain), linus@thebreakthrough.org (L. Blomqvist), james@thebreakthrough.org (J. McNamara), bill.ripple@oregonstate.edu (W.J. Ripple).

http://dx.doi.org/10.1016/j.scitotenv.2017.08.125
0048-9697/

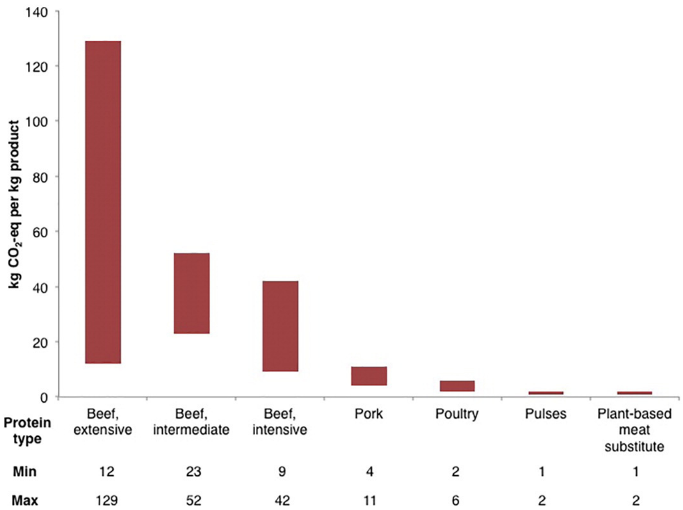

Fig. 1. Greenhouse gas emissions intensity (kg CO_2-eq per kg of product) for different animal and plant-based protein sources. Bars indicate the min/max range of results in a literature review of life cycle analysis studies (Nijdam et al., 2012).

The emissions intensity of pork and poultry are much lower than beef, and plant-based proteins outperform all meat types (Fig. 1). More intensive production of pork and poultry can also result in decreased emissions at the farm level since animals mature faster and the nutritionally-optimized feeds reduce emissions from manure (Gerber et al., 2013). However, the additional emissions from land-use change for feed production can outweigh the on-farm emissions savings if feeds are sourced from deforestation regions (Gerber et al., 2013). Intensification of pork and poultry production thus does not offer the same emissions savings as with beef, but intensive systems have already become widespread globally in response to rapidly growing demand.

In addition to GHG emissions, land use is a key environmental metric with which to compare different protein sources and production systems. Plant-based proteins have a lower land intensity than meat (Fig. 2) since they use the crop directly; meat production converts crop energy into animal protein, which involves inherent metabolic losses. As with emissions, pork and poultry perform better than beef in terms of land use per kilogram of meat (Fig. 2). Pigs and poultry do not require large grazing areas like cattle do, and as monogastric animals they are also more efficient feed converters. In all pork and poultry systems, nearly all land use is for feed crop production, rather than land for the animals themselves (de Vries and de Boer, 2010).

With beef production, feed finishing of cattle accelerates the growth process and allows more beef to be produced per unit grazing area. Even when cropland area for feed production is included, intensive systems using grain-finishing have a lower land-use intensity than extensive, pasture-only systems (Fig. 2). This result has been confirmed at the regional level in studies of the United States (Capper, 2012), Brazil (Kamali et al., 2016), and Italy (Bragaglio et al., 2017).

Intensification of beef production thus presents an important opportunity for land sparing. Beef demand is growing twice as fast in many developing countries as in developed ones (Alexandratos and Bruinsma, 2012) and in the last fifty years, pasture area expanded by one-third in Asia and by one-fifth in Latin America (FAO, 2017). Continued pressure for beef production could continue to drive land conversion and ecosystem degradation if pasture area expands further. However, meat yields (measured as the amount of meat produced per animal) remain much lower in developing countries than in the advanced livestock sectors of North America and Europe (FAO, 2017). Intensification could increase meat production in developing countries without expanding herd size or grazing areas.

In sum, the improved productivity of more intensive livestock systems can translate into important environmental savings for both emissions and land use, most notably for beef. However, highly intensive, industrial production practices also generate concerns, for example regarding the routine use of antibiotics, localized pollution from manure lagoons, and animal welfare in confined animal feeding operations (CAFOs). While trade-offs do exist between improving animal welfare, reducing environmental impacts, and increasing productivity, there are also some synergies. Finishing cattle on grain, for example, does not on its own reduce animal welfare. Intensification practices like selective breeding and modern veterinary care can dramatically improve productivity, especially in developing countries where livestock are often smaller and sicker than animals in industrialized countries. Intensive production, including in CAFOs, can be responsibly managed to

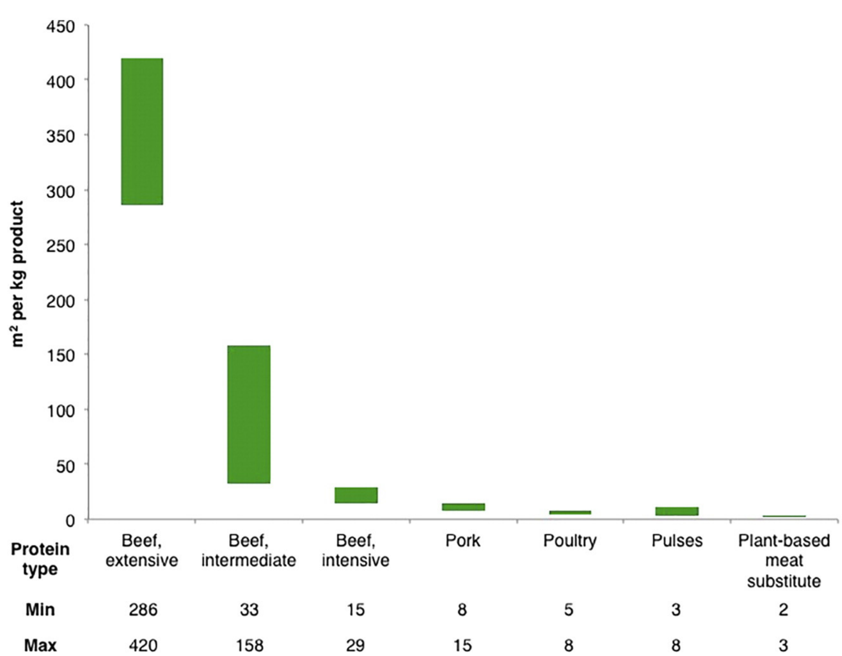

Fig. 2. Land-use intensity (m^2 per kg of product) for different animal and plant-based protein sources. Bars indicate the min/max range of results in a literature review of life cycle analysis studies (Nijdam et al., 2012).

minimize animal stress and contain environmental impacts, but policies are necessary to ensure best practice is followed.

There will be social and political barriers to reaping the benefits of livestock intensification outlined here. Technology availability, access to global markets, and capital costs all present hurdles for producers in developing countries to intensify production. Feedlot systems for cattle, for example, require high levels of initial capital investment and are unlikely to be adopted in many developing countries as long as land rents remain low and expansion is more economic than intensification (Jannasch et al., 2002). Even if intensification can successfully take place, policy supports are needed to safeguard the desired environmental outcomes. Achieving land sparing through intensification of the beef sector, for example, will require robust policies to avoid rebound, since higher livestock yields can create an incentive for further area expansion (Phalan et al., 2016). Finally, consumer and societal preferences for certain production systems and agricultural landscapes will influence how intensification plays out at the local and regional level.

Lower-meat diets have rightfully been highlighted in the literature as a means to reduce the environmental impact of food production, but these demand-side solutions must be accompanied with supply-side interventions. The gap in environmental performance between production systems has profound implications for climate and conservation outcomes this century. Modern, intensive livestock systems can reduce the land use and GHG emissions of meat production, most dramatically for beef. This offers an important opportunity to achieve land sparing and reduced emissions even with projected increases in meat demand. In the coming decades, discussions of how to reduce the environmental impacts of food production must consider both dietary changes and changes to livestock production systems as pathways to improved environmental outcomes.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Alexandratos, N., Bruinsma, J., 2012. World Agriculture Towards 2030/2050: The 2012 Revision.

Barona, E., Ramankutty, N., Hyman, G., Coomes, O.T., 2010. The role of pasture and soybean in deforestation of the Brazilian Amazon. Environ. Res. Lett. 5, 24002.

Batchelor, J.L., Ripple, W.J., Wilson, T.M., Painter, L.E., 2015. Restoration of riparian areas following the removal of cattle in the northwestern Great Basin. Environ. Manag. 55, 930–942.

Beschta, R.L., et al., 2013. Adapting to climate change on western public lands: addressing the ecological effects of domestic, wild, and feral ungulates. Environ. Manag. 51, 474–491.

Bragaglio, A., et al., 2017. Environmental impacts of Italian beef production: a comparison between different systems. J. Clean. Prod.

Capper, J.L., 2012. Is the grass always greener? Comparing the environmental impact of conventional, natural and grass-fed beef production systems. Animals 2, 127–143.

de Vries, M., de Boer, I.J.M., 2010. Comparing environmental impacts for livestock products: a review of life cycle assessments. Livest. Sci. 128, 1–11.

FAO, 2017. FAOstat database. http://www.fao.org/faostat/en/#home.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., 2013. Tackling Climate Change Through Livestock.

Harwatt, H., Sabaté, J., Eshel, G., Soret, S., Ripple, W., 2017. Substituting beans for beef as a contribution towards US climate change targets. Clim. Chang.

Jannasch, R.W., Stewart, T., Fredeen, A.H., Martin, R.C., 2002. A Comparison of Pasture-fed and Feedlot Beef. Organic Agriculture Centre of Canada.

Kamali, F.P., et al., 2016. Environmental and economic performance of beef farming systems with different feeding strategies in southern Brazil. Agric. Syst. 146, 70–79.

Nijdam, D., Rood, T., Westhoek, H., 2012. The price of protein: review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes. Food Policy 37, 760–770.

Pelletier, N., Pirog, R., Rasmussen, R., 2010. Comparative life cycle environmental impacts of three beef production strategies in the upper Midwestern United States. Agric. Syst. 103, 380–389.

Phalan, B., et al., 2016. How can higher-yield farming help to spare nature? Science 351 (80), 450–451.

Scarborough, P., et al., 2014. Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. Clim. Chang. 179–192.

Steinfeld, H., et al., 2006. Livestock's Long Shadow: Environmental Issues and Options. Food and Agriculture Organization of the United Nations.

Tilman, D., Clark, M., 2014. Global diets link environmental sustainability and human health. Nature 515, 518–522.