Point Blue Issue Brief

Methane Emissions from Livestock

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Introduction

The purpose of this document is to provide Point Blue staff with a summary of the state-of-the-science about a topic that is complex, globally important, and relevant to our strategic priorities: methane dynamics of livestock production systems. Because Point Blue is motivated by the need to reduce atmospheric greenhouse gas concentrations, our investments in grazing as an ecological management tool and in beef production as a regenerative agriculture practice needs to be informed by the current science on methane production by livestock. This document is subject to change as more information becomes available.

The three primary greenhouse gases responsible for climate change are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Globally, livestock (inclusive of beef and dairy cattle, swine, sheep, goats, poultry, and other domesticated ruminants) are estimated to contribute about 14% of anthropogenic greenhouse gas emissions (CO_2, CH_4, N_2O combined; Gerber et al. 2013), primarily through the release of methane and nitrous oxide. Considering only the U.S, livestock are estimated to contribute about 4% of total emissions (EPA 2017). Given that cattle contribute to, and influence, emissions of all three primary greenhouse gases, a full life-cycle understanding of all emissions associated with livestock is important to develop. However, this issue brief focuses on methane in order to provide a better understanding of how livestock systems contribute to emissions of this particular greenhouse gas. We focus on methane because it has a global warming potential 28 or 84 times greater than CO_2 over 100 or 20 years, respectively (IPCC 2013); it has a relatively short mean residence time in the atmosphere (approximately 10 years), so reductions can impact the climate system relatively quickly; and livestock emit methane enterically, making this gas relevant to livestock production systems and a possible candidate for climate change mitigation strategies within this sector (Saunois et al. 2016a).

Conclusion

Livestock produce a considerable amount of methane globally. Current evidence indicates that grass-fed cattle[1] produce more methane than conventionally-produced cattle[2]. Lifecycle analyses that consider soil carbon sequestration in different livestock production systems suggest grazing practices that build soil carbon may offset some methane emissions; however, few analyses of this kind have been conducted and further research is needed to confirm the extent to which this is possible.

We recommend that methane production be acknowledged as an intrinsic trade-off to beef production. Just as methane emissions are a consequence of managing wetlands and flooded agricultural fields, methane emission will also be a consequence of raising livestock to manage rangelands and promote desired ecosystem services,

[1] Cattle that feed on pasture or rangeland for their entire lives

[2] Cattle that spend only a portion of their life on pasture or rangeland and are otherwise fed grain

including food, soil health, biodiversity, and economic livelihoods for local communities. Creative solutions to reduce methane emissions are important to pursue.

SYNTHESIS OF INFORMATION

Measurements and estimates of methane emissions

Global and regional methane emissions are estimated in two ways: top down and bottom up. Top down methods use atmospheric models and observation of atmospheric methane concentrations to estimate the magnitude of methane emissions from the Earth's surface (Kirschke et al. 2013). Bottom up methods combine information about methane emissions from activities on the Earth's surface, including energy use, agricultural activity, and land-use change, often at a national scale (Kirschke et al. 2013). Not surprisingly, estimates from these methods do not always agree (Hristov et al. 2017). However, by acknowledging these differences and working to reconcile the two approaches, climate scientists are better able to identify the sources and magnitude of methane emissions across space and time (e.g. Miller et al. 2013, Hristov et al. 2014). Despite ongoing efforts to do so, discrepancies between and within the different measurement approaches still exist and have led to debate over the causes of rising methane emissions over the last decade. Fossil fuel production, wetland ecosystem dynamics, livestock, and changes in biomass burning have all been invoked as possible explanations (Howarth 2015, Saunois et al. 2016a).

These uncertainties notwithstanding, there is strong agreement that livestock are a significant source of methane emissions. This agreement comes from an extensive body of research that has quantified livestock methane emissions at various scales from individual animals to groups of animals. Measurements from individual cattle have been criticized because they often rely on techniques to capture methane emissions in a confined environment rather than a natural setting. However, methods also exist to quantify methane emissions in the field (Johnson and Johnson 1995, Lassey 2007, Bhatta et al. 2007). These field-scale methods allow methane production to be measured from groups of animals in a natural setting (Harper et al. 1999, Desjardins et al. 2004), making it possible to compare grain foraging and pasture foraging animals in conditions that include interactions with soil microbes and environmental conditions.

The contribution of livestock to the global methane budget

Methane is produced naturally and anthropogenically, with current estimates putting the former at 40% and the latter at 60% of global methane emissions (Saunois et al. 2016a, b). Major anthropogenic sources of methane include fossil fuel production and use, agriculture and livestock, landfills/waste, and biomass burning (Figure 1). Livestock produce 20-30% of global anthropogenic emissions (Saunois et al. 2016b, Wolf et al. 2017).

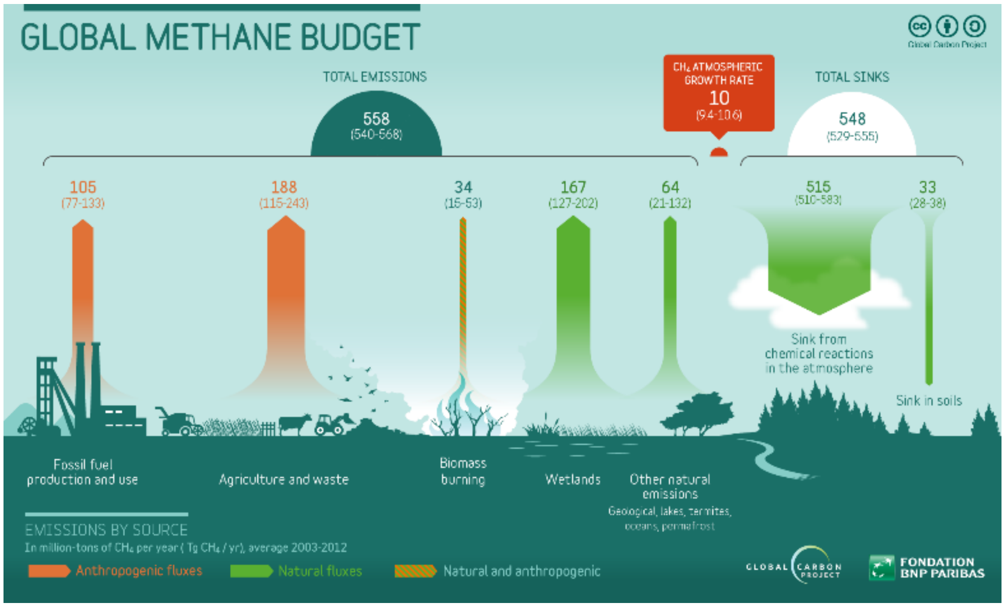

Figure 1. Methane budget for 2016 from the Global Carbon Project.

There are two primary sources of methane from livestock: enteric methane and manure methane. Enteric methane, which accounts for the majority of methane emissions from livestock, is produced from the digestion process and released primarily as burps (Saunois et al. 2016b). Manure methane, which contributes relatively little to methane emissions from livestock, is produced in the greatest amounts when liquid manure is stored or treated in low oxygen environments, including lagoons, ponds, tanks, or pits. When manure is deposited as a solid on rangelands, its contribution to the methane footprint of beef production is limited (Saunois et al. 2016b, Slade et al. 2016). Since methane emissions from manure are negligible on extensively managed rangelands (i.e., grass-based systems; Herrero et al. 2016, Slade et al. 2016), there is probably little opportunity for emissions reductions through this pathway.

Just as sources are the processes that produce methane, sinks are the processes that break methane down. The biggest methane sink is in the atmosphere; here, chemical reactions occur that break down methane into carbon dioxide. Bacteria in (non-wetland) soils typical of many rangelands can also act as a small methane sink (~4% of the total sink; Kirschke et al. 2013; Figure 1). Healthy soils are larger methane sinks than soils that are compacted and degraded (Smith et al. 2000). However, the amount of methane consumed by bacteria in soil is small relative to the amount produced enterically by livestock (Saunois et al. 2016b). In addition, the methane that is burped by cattle will not be immediately consumed by soil microbes; on average, one methane molecule released into the atmosphere stays there for 10 years before being broken down by atmospheric or bacterial processes (Saunois et al. 2016b).

Comparing methane emissions from grass-fed and grain-fed cattle

Current evidence suggests that grass-fed cattle produce more methane than conventionally-produced cattle. These differences, which can be considerable (35-70%; Harper et al. 1999, Peters et al. 2010, Lupo et al. 2013; Stanley et al. 2018), are attributed to the high nutrient diets and associated reduction in finishing time associated with conventionally-produced, grain-fed livestock. For example, Harper et al. (1999) demonstrated that cattle feeding on grass generated about four times more methane than their feedlot counterparts within a four day period. Similar conclusions were drawn by Pelletier et al. (2010), who took into account the full production cycle using a life-cycle analysis and found that grass-fed beef is more greenhouse gas intensive than conventionally-produced beef when viewed on an equal live-weight production basis (Pelletier et al. 2010).

The picture is less clear when comparing methane emissions within grass-fed management strategies. If grass-fed management strategies rely on distinct cattle breeds (Roehe et al. 2016), different stocking rates (Dumortier et al. 2017), or promote varying levels of forage quality (Richmond et al. 2015, Ruviaro 2015), it's reasonable to think that they might differ in overall methane dynamics. However, not enough evidence exists to draw a relationship between different grass-fed management strategies (e.g., rotation frequency), and the mechanisms that may affect livestock methane production.

Importantly, management practices that increase on-ranch carbon capture may help to offset the methane emissions of grass-fed cattle. Indeed, a number of recent life-cycle analyses show that increasing soil carbon of grass-fed beef operations can offset some (~15%) or even all of the enteric methane that is produced by livestock, depending on the magnitude and duration of carbon gain (Pelletier et al. 2010, Lupo et al. 2013, Rowntree et al. 2016, Tichenor et al. 2017; Stanley et al. 2018). These values derive from estimated rates of carbon sequestration due to improved grazing, the magnitude of which is still subject to much debate and requires additional study. Other on-ranch practices like composting or riparian restoration can be used to sequester even more above and below-ground carbon, providing another means of off-setting greenhouse gas emissions of cattle.

The current and historical methane emissions of wild ruminants

Wild ruminants (e.g., deer, elk, and bison) also produce methane. Prior to European settlement in the United States, enteric methane came primarily from bison, and emissions from these and other wild ruminants were much greater than they are today (12 to 28 times greater; Hristov 2012). With the loss of bison and introduction of domesticated livestock, the main source of enteric methane in the United States shifted from wild to domesticated sources. Today, wild ruminants produce approximately 5% of total enteric methane emissions, and it is estimated that in the United States livestock currently produce ~14% more enteric methane than wild ruminants did before European settlement (Hristov 2012).

RECOMMENDED NEXT STEPS

We recommend that methane production be acknowledged as an intrinsic trade-off to livestock production. To reduce the methane emissions of livestock, we will need to look toward creative and collaborative solutions, which may include changing grazing practices, providing food supplements, breeding for animals that produce less methane, and reducing the total number of livestock. For the time being, we recommend focusing actions to maximize soil carbon sequestration and net greenhouse gas reductions throughout the livestock production life cycle and across the ranch to help offset methane emissions and maximize other ecosystem services.

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