How Responsible are Modern Cows for Greenhouse Gases?

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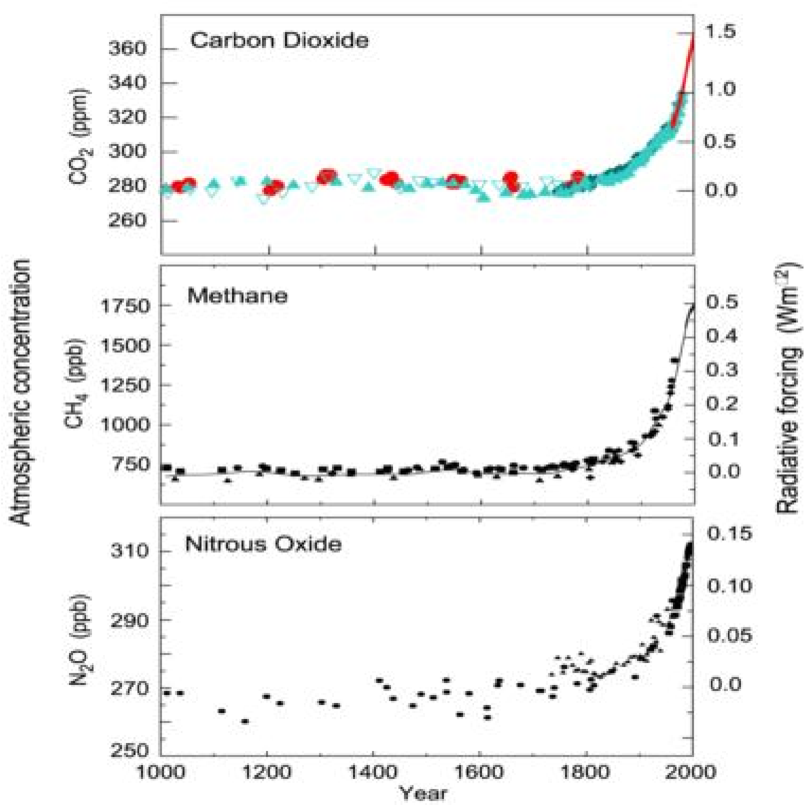
According to the Intergovernmental Panel on Climate Change the main greenhouse gases carbon dioxide, methane, and nitrous oxide started to increase around the early nineteenth century (IPCC, 2006). From then on their increase was exponential particularly during the twentieth century. Methane concentrations have more than doubled since pre-industrial times whereas carbon dioxide and nitrous oxide have increased by roughly 25 and 10%, respectively (Figure 1).

Figure 1. Atmospheric concentration of CO_2, CH_4, and N_2O since 1,000 A.D. (IPCC, 2001)



Cows produce methane from feed fermentation in the rumen part of which is absorbed by the animal and part is lost to the environment. Then again, the higher the production level of the animal (i.e. beef or dairy), the more gases are used-up as energy sources and less are eliminated to the atmosphere(Garcia and Linn. 2008).Nitrous oxide is generated from soil nitrogen by microbial action under warm, waterlogged conditions. In addition, it can also arise from cattle urine, legumes and nitrogen fertilizer. With nearly 100 million head in the U.S. between beef and dairy cattle, it is clear how the general public could perceive livestock production as significant when compared to other greenhouse gas sources.

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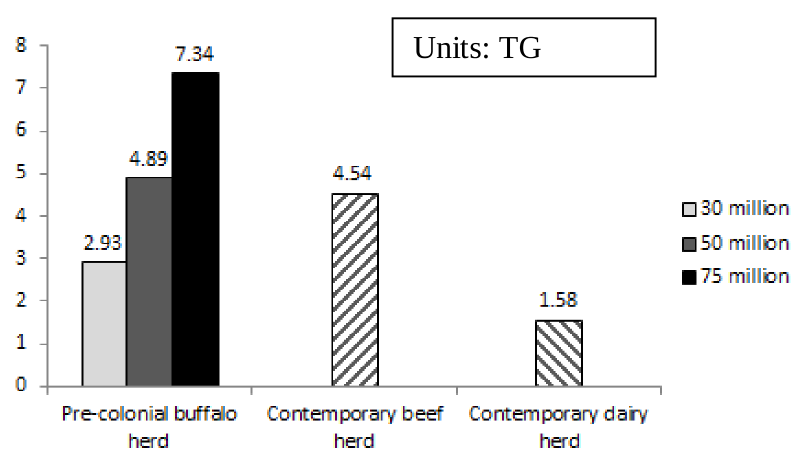
When assessing gas emissions from ruminants it is very important to take into account how much gas is emitted per unit of product yield. Cows have fixed costs of energy maintenance regardless of how much they produce (i.e. beef or milk), and they will eat to fulfill those requirements with methane and carbon dioxide being produced as a result. This is the reason why two grazed dairy cows that produce 50 pounds of milk each are more taxing to the environment than one cow producing 100 pounds. Allowing cows to manifest their genetic potential through additional feeding reduces gas emissions as the energy in them is deposited in animal products instead of being inefficiently eliminated to the atmosphere. Decades of permanently evolving best management practices have reduced these inefficiencies and allowed for a reduction in the number of animals needed to supply food for an ever growing world population.

Historic and present day greenhouse gases contribution

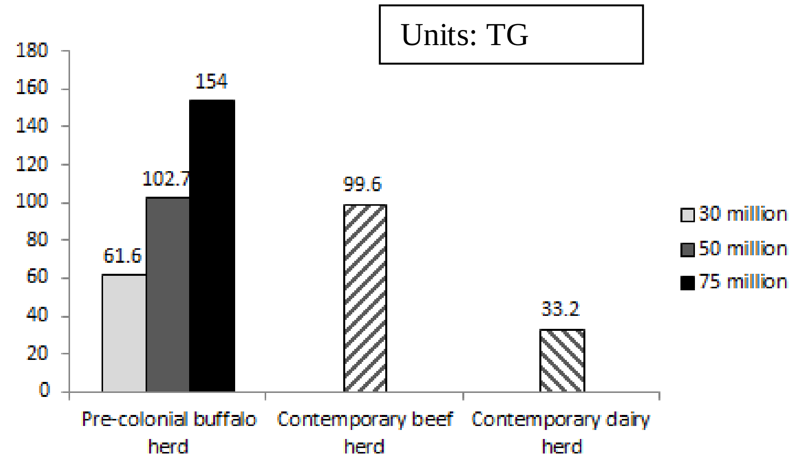
During pre-colonial times there were no domestic cattle (beef or dairy)but only wild ruminants whose methane emission can be predicted from their feed intake and compared to today's livestock. A recent article published in the Journal of Animal Science (Hristov, 2011) compared pre-colonial enteric methane emissions from all wild ruminants in the U.S. with present-day emissions from farmed ruminants (US EPA, 2011). The most significant methane-emitting group of ruminants was the bison population. Estimates of the pre-colonial bison herd are somewhere between 30 (low) and 75 million (high). In pre-colonial times, methane emissions from bison measured in Teragrams (TG) per year (one TG equals one million metric tons) were 4.89. Today's emissions are 4.74 and 1.58 TG for beef and dairy cattle, respectively (Figure 2). Carbon dioxide equivalent emissions measured in TG were 102.7 for pre-colonial bison, compared to 99.6 and 33.2TG for beef and dairy cattle during present times (Figure 3).When the average figure of the 50 million bison population was used, enteric methane emissions from bison, elk, and deer pre-colonial times were around 86% of U.S. current beef and dairy emissions. When the high figure of 75 million bison was used instead, wild ruminants in pre-colonial times emitted around 23% more methane than current domestic ruminants in the U.S.

Figure 2. Methane emissions of pre-colonial buffalo herd estimated at three population sizes and contemporary beef and dairy herds.



Modified from Hristov. 2011

Figure 3. Carbon dioxide emissions of the pre-colonial buffalo herd estimated at three population sizes and contemporary beef and dairy herds.



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South Dakota State University research (Garcia and Linn, 2008)reported that in 1924 there were 21.4 million cows in the U.S., weighing 1,000 pounds and producing 4,162 pounds of milk yearly. Conversely, during 2007 there were 9.1 million cows, weighing 1,400 pounds and producing 20,053 pounds of milk. When methane emissions were calculated for both set of data, the total cow population in 1924 produced 40% more methane than in 2007. These figures were even more contrasting per pound of milk produced, with nearly tripling the methane produced in 1924 vs. 2007. Capper et al. (2009) also reported dairy cows in 1944 produced 2.7 times as much carbon dioxide per pound of milk than in 2007.

Efficiency of carbon dioxide sequestration by plants

We often think about ruminant livestock only in terms of greenhouse gas emissions. This approach fails to acknowledge that ruminants and the plants on which they feed are part of an interphase that has been in equilibrium throughout evolution. Photosynthesis is the daytime process by which green plants synthesize sugars using carbon dioxide, water, and solar energy (captured in chlorophyll), and release oxygen to the atmosphere in the process. During the night photosynthesis gives place to respiration which consumes both oxygen and stored plant carbohydrates. Photosynthetic rates which in growing plants require carbon dioxide uptake are higher than respiration rates which uses up oxygen and results in a net increase in oxygen production and an uptake of carbon dioxide. Plants can be classified in C3 or C4 depending on the pathway used to capture this carbon dioxide (Sehtiya and Goyal,2003). In the first group carbon dioxide (one carbon) is bound to a five-carbon compound forming a six-carbon molecule. Plants from cold and temperate regions of the world such as legumes and manygrasses are members of the C3 group, which are not as efficient at capturing carbon dioxide as the C4 group. The C4 group binds carbon dioxide to a three-carbon compound instead (forming a four carbon molecule) in a much more efficient carbon-sequestration reaction. These plants originate in tropical regions of the world and include corn, sugar cane, and other tropical grasses.

Ruminant diets and carbon dioxide sequestration

Wild ruminants in the U.S. feed on legumes, grasses, and forbs depending on their foraging strategy. Bison in particular were and still are almost strict grazers feeding mostly on grasses of the Great Plains.

None of the forages of the wild ruminants in the U.S. included C3-type plants and thus their efficiency of carbon dioxide sequestration was limited when compared to C4. Of 595 dairies surveyedin 1919, a total of 62% of the farms grazed with the remainder 38% fed in confinement (Garcia and Linn, 2008). In addition, dairy cows in confinement early in the 20th century were fed mostly hay, green-chopped forages, and very limited amounts of grain or corn silage. Modern dairy cows diets on the other hand usually include large amounts of corn-derived feeds like corn silage, corn grain, high moisture corn, corn distillers grains, etc. Contemporary dairy cows eat approximately 50 pounds of dry feed daily of which 15-20 pounds could be corn silage and similar amounts of corn grain. The remainder of the diet will usually come from legume hay and/or silage, feed industry byproducts, as well as other feeds. Based on these calculations contemporary dairy cows during 305-day lactations can eat approximately 2 tons of dry corn silage and 2 tons of dried shelled corn. A conversion of these figures to wet corn plants for silage and bushels of corn for grain results in 6 tons of corn plants for silage and 36 bushels of corn grain.

According to the National Agricultural Statistical Service, the 2010 U.S. corn silage and corn grain yields per acre were 19 tons and 152 bushels, respectively. If the modern dairy cow needs 6 tons of corn plants and 36 bushels of corn grain, that would represent 0.3 acres for silage and 0.2 acres for grain. If corn is planted at 32,000 plants per acre, one cow needs 9,600 corn plants for silage and 6,400 for grain for a total of 16,000 corn plants. Recent data collected by South Dakota State University (Carlson, Personal communication. 2012) suggests that one acre of corn yielding 150 bushels captures 32,427 pounds of carbon dioxide. If corn plant density is 32,000 seeds to an acre then a corn plant absorbs one pound of CO2 per growing season. If the modern dairy cow needs 16,000 corn plants to sustain itself then it is also responsible for the removal 16,000 pounds of carbon dioxide from the atmosphere yearly. The total sequestration of carbon dioxide of 16,000 pounds is equal to 3.63 tons of carbon dioxide equivalents per cow yearly. If this figure is multiplied by the 9.15 million dairy cows in the U.S. it equals a removal of 33,232,800 tons or 33.2 Teragrams (TG) of carbon dioxide equivalents. Current total carbon dioxide emissions estimated for U.S. dairy cows are exactly 33.2 TG (EPA).It can therefore be hypothesized that carbon sequestration by the corn plants biomass can neutralize emissions if modern dairy cows are fed to match requirements for milk production and corn-derived feedstuffs are maximized in their diet.

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Current research has shown that bison in pre-colonial times produced more methane than either the modern U.S. beef or dairy herds. In addition, research does not support the contention that modern dairy cows emit more methane and carbon dioxide than cows early in the 20th century. Modern dairy milk production needs to be viewed as an animal-plant interphase where forages are required for feeding purposes and can act as a sink for carbon dioxide emitted by cows. Maximizing corn-derived feedstuffs in diets of dairy cows fed to their genetic potential will increase carbon dioxide sequestration to the point where it more than likely cancel-out the total cow's emissions for this gas.

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