May 26, 2016

Clerk of the Board
California Air Resources Board
1001 I Street
Sacramento, CA 95814
(Submitted via Internet Upload (http://www.arb.ca.gov/lispub/comm/bclist.php)

Re: Proposed Short-Lived Climate Pollutant Reduction Strategy and Draft Environmental Analysis

To Whom It May Concern:

Sequoia ForestKeeper, Wasteful Unreasonable Methane Uprising, Ara Marderosian, Todd Shuman, and Jan Dietrick submit the following comments on the Proposed Short-Lived Climate Pollutant Strategy and accompanying Draft Environmental Analysis ("Draft EA") prepared by the California Air Resources Board ("CARB").

We greatly appreciate CARB's attention to the critical task of reducing short-lived climate "superpollutants" like methane, black carbon, and flourinated gases ("HFCs"). We support many elements of the proposed Strategy, and these comments offer specific recommendations intended to strengthen its goals and enhance its effectiveness.

At the same time, we are deeply concerned that CARB's proposals for reducing black carbon emissions from wildfires—a natural occurrence in California forests—are poorly conceived, highly uncertain, inadequately supported, and likely to cause substantial adverse environmental effects that neither the Strategy nor the Draft EA adequately address. We strongly recommend that this element of the Strategy be removed so that CARB can focus on measurable, achievable reductions from the important anthropogenic sources of SLCPs identified in the Strategy. In any case, we hereby incorporate herein the May 26, 2016 comments by the Center for Biological Diversity in their entirety by reference.

Please include this letter and the references cited therein (as well as some uploaded references) in the administrative record of proceedings for this project. Detailed comments follow.

General Comment on Proposed Strategy

We strongly support the goal of seeking substantial reductions in anthropogenic SLCP emissions, and urge CARB to consider all options within (and without) the Strategy to increase the depth of reductions from *each* source and accelerate the rate of reduction or elimination of SLCP emissions from *each* source. For example, the Strategy should consider not just how to achieve reductions commensurate with rates of reduction already proposed for other GHG sources, or assumed within federal modeling. Instead, the Strategy should include options for maximal reductions and minimal timelines for achieving those reductions concerning *each* SLCP emission source.

Enteric Emissions

In this recently proposed Short-lived Climate Pollutant (SLCP) Reduction Strategy, the California Air Resources Board (CARB) has again effectively ignored the single largest methane emission source in California: enteric emissions from California livestock. No "reasonably foreseeable compliance responses associated with the methane reduction measures" are projected concerning potential enteric emission reductions from California livestock in Appendix C, pages 4-16/17, Draft EA for Proposed SLCP Reduction Strategy (April 11, 2016). Enteric emissions constitute about 30 percent of methane emissions in California in a normal year. It is unconscionable that this atmospheric methane emission source (just under a billion pounds of methane emission per year in California, as of 2013) continues to be severely neglected by CARB, when there are reasonable measures that could be enacted to dramatically reduce methane emissions from this source.

Cumulative Effects of Enteric Methane Emissions from Livestock

A billion pounds of methane emitted per year from this specific methane emission source must be considered, at the very least, a cumulative impact – or an incremental impact, which, when added to other closely-related past, present, and reasonably foreseeable global enteric emission sources, changes the environment. Cumulative enteric methane-related impacts from livestock in California result from individually minor but collectively significant methane emissions taking place over a period of time. These impacts have been, and are, contributing to a large and growing global accumulation of enteric-related atmospheric methane that has been contributing to significantly-increased global surface and ocean temperatures over the last 55 years. [See Appendix A]

A recently published analysis has provided information that now enables us to estimate much more precisely the degree to which past global enteric methane emissions have been, and will be, changing the environment of our planet.

Based upon Figure 2d in "New use of global warming potentials to compare cumulative and short-lived climate pollutants" (Myles R. Allen, Jan S. Fuglestvedt, Keith P. Shine, Andy Reisinger, Raymond T. Pierrehumbert and Piers M. Forster, Nature Climate Change, May 2, 2016), past and future global temperature change (GTC) values (in degrees Celsius) associated with the cumulative year 2011 global anthropogenic livestock and cattle-related methane emission (expressed as a pulse) are presented below:

Year	2015	2021/2022	2031/2032	2050
Livestock enteric:	0.0044	0.0061	0.0044+	0.0015
Cattle enteric:	0.0033	0.0045	0.0033+	0.0011

In short, cumulative year 2011 anthropogenic livestock-related and cattle-related methane emissions likely increased the 2015 average global temperature by 0.0044 and 0.0033 degrees C (respectively), beyond what the 2015 global average temperature would otherwise have been. The year 2011 anthropogenic livestock-related and cattle-related methane emissions can be expected to increase the 2021/2022 average global temperature by 0.0061 and 0.0045 degrees C (respectively) beyond what the 2021/2022 global average temperature would otherwise likely be. [See Appendix B]

It is undeniable that past, present, and reasonably foreseeable enteric-associated global temperature change is, in fact, a significant cumulative effect – an effect which has been partially generated by the many individually minor, but collectively significant livestock-related methane emissions taking place in California over a period of time.

The failure of CARB to take a “hard look” at the “cumulative impacts” dimension of livestock-related enteric emissions in the SLCP Reduction Strategy and the associated Draft EA currently constitutes a glaring and transparent violation of

CEQA.

Direct Enteric Emission Methane Reduction Alternatives

We propose that CARB, the legislature, and the Governor explore and consider enacting some or all of the following: measures to promote mandatory livestock herd size reduction; require that grazing cattle shall wear gas-collecting, plastic-bag-expanding backpack technology that captures emitted enteric methane, so methane can be burnt rather than belched into the atmosphere (note: google the following three links to see demonstrations of the technology: http://www.fastcoexist.com/.../these-backpacks-for-cows..., http://www.dailymail.co.uk/.../Now-THATS-wind-power-Cows... , http://grist.org/.../crazy-clip-shows-what-happens.../...); mandate to compel the development of enclosed barns-vented-to-biofilter treatment systems that capture emitted dairy-associated methane to prevent it from escaping into the atmosphere.

The failure of CARB to address direct methane reduction alternatives concerning enteric emissions in the SLCP Reduction Strategy and the associated draft EA currently constitutes another glaring and transparent violation of CEQA.

Indirect Enteric Emission Reduction Alternatives: Cap and Trade, Metrics, Mandatory Reduction Targets, and Taxes

Enteric fermentation methane emissions from *dispersed*, pasture-based livestock should also be considered for incorporation within cap and trade, with auctioned pollution permits or offset credit purchase costs based on one of the following alternatives:

- a short-term interval methane Global Warming Potential [GWP] value;
- a short-term interval Global Temperature Potential [GTP] value;
- an alternative measure based upon the radiative forcing/efficiency value of methane.[1]

Concerning the third bulleted point above, we include quoted summary language from two recent analyses by Laudner et al. (2013) and Pierrehumbert and Eshel

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1: "Based on background values of 378 ppm for CO2 and 1.75 ppm for CH4 prevailing circa 2005, the radiative efficiency of CO2 is 1.4×10^{-5} W/m2/ppb while that of CH4 is 3.7×10^{-4} W/m2/ppb, or a factor of 26 greater . . . ." (Page 349, *Short-Lived Climate Pollution*, R.T. Pierrehumbert, Annu. Rev. Earth Planet. Sci. 2014. 42:341–79.)

(2015).[2] The authors of these studies propose scientifically-derived CO2 sequestration/CH4-N2O emission ratios through which the internalization of the social and environmental costs of methane and nitrous oxide emissions might be realized through compensatory CO2 sequestration.

Laudner et al. (2013): “Using R^{eff} = 0.35, we have 1 kg CH4 per year offset by one-off uptake of 950 kg C, i.e. 3500 kg CO2” (See Lauder et al. [2013], page 426.)

Pierrehumbert and Eshel (2015):

“In the case of midwest feedlot beef, for example, the CH4 and N2O emissions associated with a sustained production of 1 kg yr−1 of beef would need to be offset by a reduction of 1460 kg in cumulative carbon from fossil fuel burning, in order to keep within an agreed climate objective.” (See page 8 and Table 2 on page 7, Pierrehumbert and Eshel [2015].)

Pierrehumbert (2014) has also proposed mechanisms (involving carbon taxes and tax credits) through which the internalization of the social and environmental costs of methane and nitrous oxide emissions might also be realized.[3] We insist that CARB consider these mechanisms as an alternative and disclose the analysis concerning these mechanisms.

For dairy-related Concentrated Animal Feed Operations (CAFOs), there should be meaningful, mandatory reduction targets established for enteric emissions from all livestock, such that a 60 percent reduction in enteric emissions, statewide, will be *required* by year 2030. We propose a mandatory 20 percent reduction target for year 2020, a 40 percent mandatory reduction target for year 2025, and a 60 percent mandatory reduction target for year 2030.

2: “[A] one-off sequestration of 1 t of carbon would offset an ongoing methane emission in the range 0.90–1.05 kg CH4 per year . . . The conversion factors are more conveniently used in terms of carbon mass, giving 1.1 t C (4.07 t CO2) offsetting 1 kg CH4 per year with R^{eff} = 0.3… Larger values of R^{eff} mean more weight is given to the effect of CO2 on radiative forcing, and so the rate of ‘equivalent’ CH4 emissions must be correspondingly higher, giving 0.95 t C (3.5 t CO2) offsetting 1 kg CH4 per year if R^{eff} is set to 0.35.” *Offsetting methane emissions — An alternative to emission equivalence metrics,* A.R. Lauder, I.G. Enting, J.O. Carter, N. Clisby, A.L. Cowie, B.K. Henry, M.R. Raupach, International Journal of Greenhouse Gas Control 12 (2013) 419–429, quotes taken from pages 419, 422. RT Pierrehumbert and G Eshel, *Climate impact of beef: an analysis considering multiple time scales and production methods without use of global warming potentials,* Environ. Res. Lett. 10 (2015) 085002. (Pierrehumbert [2014] also notes, on page 374: “Specifically, using Equation 2 we find that a permanent reduction of SLCP emission rate corresponding to 1 W/m2 is equivalent to a reduction of cumulative carbon emissions by 407 GtC, with regard to long-term radiative forcing . . .]

3: “A novel approach to multi-gas climate protection protocols, quite different from that used in the Kyoto Protocol, is required to properly deal with SLCP. In the context of a carbon tax, an emitter would pay a tax for each GtC of CO2 emitted but would be given a one-time tax credit for each Gt/year of methane emissions rate reduction, weighted according to the corresponding radiative forcing. If the emitter ever increased the methane emissions rate again, the tax credit would need to be paid back with interest . . . Related approaches to SLCP mitigation are discussed in Lauder et al. (2013).” *Short-Lived Climate Pollution,* R.T. Pierrehumbert Annu. Rev. Earth Planet. Sci. 2014. 42:341–79, page 374-375

In addition, a substantial tax should be imposed on all other sources of uncaptured, unburnt methane emitted into the atmosphere that are not included in cap and trade. A methane tax could be based on the use of a short-term interval methane GWP or GTP. Since the best scientific estimate for the *effective* lifetime of methane in the atmosphere is a little over 12 years (12.4 years, IPCC AR^{5th} 2013, Chapter 8, Table 8.7, page 714), a methane GWP of 100 should be used, as that is the approximate methane GWP associated with the 12.4 year time interval (see Figure 8.29, page 712, chapter 8, IPCC AR^{5th}). A methane tax could also be based upon analysis produced by Dr. Drew Shindell in *The social cost of atmospheric release*, Drew T. Shindell, Climatic Change (2015) 130:313–326, DOI 10.1007/s10584-015-1343-0, page 319, Table 2, Median total; declining rate. Finally, a methane tax could be based on the CO2 sequestration/CH4-N2O emission ratios that Laudner et al. (2013) or Pierrehumbert and Eshel (2016) have derived.

In any case, the findings of these rigorous analyses should be factored/incorporated into a carbon tax or cap and trade framework, so that livestock and dairy product producers would be compelled to internalize (or "absorb") into the cost of their products the social and environmental costs of CH4 and N20 emissions per kg of beef or dairy product based upon honest cumulative carbon equivalency ratio rates.[4]

The failure of CARB to address *indirect* methane reduction alternatives concerning enteric emissions in the SLCP Reduction Strategy and the associated draft EA currently constitutes another glaring and transparent violation of CEQA.

Leakage

Dairy Cares, the Environmental Defense Fund, and the CARB itself have each independently raised the issue of potential "leakage" to justify CARB inaction concerning enteric methane emissions related to livestock and dairy production in California.

The CARB stated its perspective explicitly on page 67 of the SLCP Reduction Strategy, CARB, 04/11/2016:

4: Beef and dairy product producers should also be compelled to internalize [or "absorb"] additional meat/dairy-production-related *CO2* emission costs. Such costs, as documented by Pierrehumbert and Eshel [2015], are quite dramatic for certain meat production modes [Feedlot Midwest and Pastured Midwest] that are likely similar to meat/dairy production modes in California. Soil-related carbon emission environmental costs due to livestock feed row crop production (which were not documented by Pierrehumbert and Eshel [2015]) should also be "internalized" by beef and dairy product producers.

"If regulations impose costs on the industry that cannot be recouped, a result could be emissions leakage, if some dairies relocate outside of California or herd sizes grow elsewhere. This could include places where milk production efficiencies are lower and associated enteric fermentation emissions are higher and could increase mobile source emissions from heavy duty vehicles associated with transport of dairy products to established processing facilities and distribution centers."

We believe that Dairy Cares, the Environmental Defense Fund (EDF), and the CARB have politically deployed the concept of "leakage" to ignore and/or block initiatives that would compel an "internalization" of significant enteric-emission-related environmental costs by those legally responsible for California-based enteric methane emissions. We find such arguments dubious (at best) and disingenuous (at worst).

To start, we are not aware of any studies that indicate leakage would occur, if animal-based agricultural industries were incorporated into a climate policy regime as we recommend above, and no studies concerning animal agriculture and potential leakage have been cited by CARB either.

Second, we note that it is common for industries that are being considered for inclusion in a policy like cap-and-trade to argue that the policy costs will lead to job loss and leakage. Many industries have been successful in convincing regulators that leakage would occur absent additional policy incentives. This does not necessarily mean that there actually is a significant risk of leakage – it more typically means that regulators have become swayed by the immense political power of concentrated economic interests in California. We believe such a situation is occurring now.

Third, even if some of our proposed policies above were implemented and enforced and some leakage did occur, such a result would not necessarily constitute a violation of AB 32. The state courts have applied broadly deferential review standards when CARB's policies have been challenged in the past; moreover, there is a list of eight or so objectives in AB 32 (including minimizing leakage), and the courts have basically held that CARB has discretion over how to prioritize among the competing objectives in AB 32.

Most significantly, any amount of agriculture-emissions-related leakage that might occur must be placed in historical context. A much larger type of leakage, known as resource shuffling, occurred a few years ago, and the massive leakage associated with it had a pronounced impact on carbon market prices. Yet CARB enabled and authorized such large-scale leakage, and no legal violation of AB 32 was ever recognized by either CARB or a court of law. In light of the resource shuffling that occurred, we doubt that an agricultural emissions-related climate policy that generated some leakage would be considered illegal, given the way that other problems related to leakage have been previously handled within California's system.

In short, we interpret the discourse promulgated by Dairy Cares, EDF, and CARB as an attempt to shift the economic burden of CARB's overall SLCP regulatory strategy away from the dairy industry. We do not find disclosed within this discourse a persuasive argument that CARB is effectively prohibited from meaningfully addressing livestock and dairy enteric methane emissions as a legal matter. In any case, we believe that the potential leadership and demonstration effects of compulsory inclusion of livestock-associated enteric emissions within California's GHG emission control and reduction system would outweigh any risk or actual leakage that might occur.

It is our view that the economic concept of leakage, as enshrined in AB 32, must not be used to prevent California from exerting global leadership with regard to compulsory agricultural/livestock-related business internalization of Anthropogenic Climate Disruption (ACD) pollution costs associated with livestock enteric and manure-related methane emissions. If California has to wait until every other state and nation is willing to enact similar "internalization" policies at the same time, then such internalization will probably never occur – or, if it ever does occur, it will not occur soon enough to be able to promote a meaningful reduction in the atmospheric methane concentration and associated radiative-forcing rate that is aggravating and intensifying climate disruption on our already rapidly-heating planet.

Responses to selected quotes from SLCP Reduction Strategy, 04/11/2016

A: "The long-term operational impacts associated with the Proposed Strategy would reduce emissions of black carbon, methane, and HFCs, thereby reducing GHG emissions in the State. Thus, the Proposed Strategy would result in a long-term beneficial effect and no significant cumulative effect would occur . . . Thus, short-term construction related GHG emissions impacts associated with reasonably-foreseeable compliance responses to the Proposed Strategy would be less-than-significant, when compared to the overall GHG reduction associated with implementation of the Proposed Strategy. Thus, the Proposed Strategy **would not make a considerable contribution (i.e., would be beneficial) such that a significant cumulative impact would occur** on GHG emissions." (Appendix C, 5-13/14 Draft EA for the Proposed SLCP Reduction Strategy, CARB, April 11, 2016.)

[Response: The premise underlying the Draft EA text above is fallacious. Significant cumulative effects associated with livestock-associated enteric methane emissions have already been occurring, are continuing to occur, and will likely continue to occur unless meaningful mitigation measures are adopted, enacted, and enforced to reduce SLCP emissions from *all significant* anthropogenic SLCP emission sources. Without effective mitigation of *all significant* anthropogenic SLCP emission sources, adverse global surface and ocean temperature change-related impacts are likely to continue in the future. CARB has proposed no mitigation measures concerning enteric emissions generated in California -- the single largest methane emission source in California. This failure constitutes a violation of CEQA.]

B: "California has the most dairy cows in the country and the highest aggregated dairy methane emissions. The State also has higher per-milking cow methane emissions than most of the rest of the United States, due to the widespread use of flush water lagoon systems for collecting and storing manure. Milk production feed efficiency at California dairies, however, is among the best in the world; California dairy cows produce low enteric fermentation emissions per gallon of milk. So if dairy farms in California were to manage manure in a way to further reduce methane emissions, a gallon of California milk might be the least GHG intensive in the world." Page 65, SLCP Reduction Strategy, CARB, April 11, 2016

[Response: Utilizing a conservative estimate, we note that each milking cow – no matter how efficient a milk producer it is -- still emits approximately 240 lbs. of methane into the atmosphere per year. We find the premise that low-GHG intensive milk status absolves the dairy industry from the ethical and environmental responsibility to drastically reduce enteric emissions by 2020, 2025, and 2030 to be ethically and politically reprehensible. Low GHG-intensive milk production helps generate significant global temperature change effects that are having, and will continue to have, adverse impact on native biodiversity, human populations, and the very fabric of life on this planet.]

C: “ARB and CDFA staff will establish a working group with other relevant agencies and stakeholders to focus specifically on solutions to barriers to *dairy manure projects*. The group will aim to ensure and accelerate market and institutional progress. It may cover several topics, including: project finance, permit coordination, CEQA, feed-in tariffs, simplified inter-connection procedures and contracts, credits under the LCFS, *increasing the market value of manure products*, and uniform biogas pipeline standards. This group will be coordinated with similar working group efforts related to anaerobic digestion, *composting*, energy, *healthy soils*, and water.” (*Italics added*, Page 68, SLCP Reduction Strategy, CARB, April 11, 2016.)

[Response: It takes a large quantity of cow manure (78,000 lbs) to produce the large quantity of composted manure (62,400 lbs) needed for an acre of land to achieve a net soil sequestration of atmospheric carbon (i.e. CO2) in the range of 150-990 lbs/yr/acre (converting from the original 51-333g/m2/of C results for all three years presented in Ryals and Silver, [2013]).[5] Since carbon is 27.291 percent of CO2 by mass, the amount of net atmospheric CO2 that is sequestered on this acre of land is likely in the range of 553-3627 lbs./year.

It takes 3.616 years for a beef cow to produce 78,000 lbs. of manure. Over that time, the beef cow will emit 477.3 pounds of methane (at 60 KG/yr). At GWP 34 (100 year interval, w/cc fb), that is 16,228 CO2 equivalents, at GWP 86 (20 year interval, w/cc fb), that is 41,047 equivalents. It takes a lactating dairy cow 2.6712 years to produce that much manure. Over that time, a lactating dairy cow will emit 641.1 pounds of methane (at 109 KG/yr). At GWP 34, that is 21,796 CO2 equivalents, at GWP 86, that is 55,133 CO2 equivalents.

It is going to take a number of years before the soil organic carbon sequestration levels created by the compost treatment exceed/counterbalance the CO2

5: One needs 1319.797 beef-cow-days (or 3.616 beef-cow-years) of manure production to generate 78,000 lbs of beef cow manure. Concerning dairy cows, one would need 975 (or 2.6712 dairy-cow-years) to generate 78,000 lbs of dairy cow manure. See USDA Natural Resources Conservation Service. Agricultural Waste Management Handbook (1992). See Ryals, Rebecca and Whendee L. Silver, *Effects of organic matter amendments on net primary productivity and greenhouse gas emissions in annual grasslands*, Ecological Applications, 23(1), 2013, pp. 46–59; Marcia S. DeLonge, Rebecca Ryals, and Whendee L. Silver, *A Lifecycle Model to Evaluate Carbon Sequestration Potential and Greenhouse Gas Dynamics of Managed Grasslands*, Ecosystems (2013) 16: 962–979. Note: the Ryals, Silver, and DeLonge-authored California Soil Carbon Sequestration/ Composted Manure studies form the foundation upon which the ACR composted manure carbon sequestration protocol is based.)

equivalency emissions associated with the enteric fermentation methane emissions coming from the cows, depending on the GWP used. It is not really known what the soil carbon sequestration levels will be over time, though DeLonge argues elsewhere that enhanced soil carbon sequestration levels might continue for 20 years. If one uses the GWP of 34 and the maximum number in the soil sequestration range, the equalization/counterbalanced point occurs in 4.47-6.00 years (beef cow-lactating cow). If one uses the maximum range number and the GWP of 86, the equalization point occurs in 11.32-15.20 years (beef cow-lactating cow).

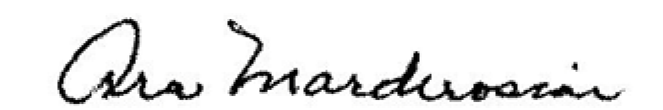
As one can see, whether application of composted manure actually generates net soil carbon sequestration over time depends on the assumptions and numbers that are used.

If the compost is plant-based, there are no complicating factors. With regard to soil carbon sequestration, plant-based compost application is indisputably beneficial.

With regard to cow-based compost, there are complicating factors. Net soil carbon sequestration may or may not occur over time relative to enteric methane emissions. It probably will not occur if one uses mean range sequestration values and the much higher methane GWPs associated with shorter-time intervals. It might occur if one uses high end range values and much lower methane GWPs associated with long-time intervals. In our view, the manure composting approach is most likely to generate meaningful net soil carbon sequestration if the sourced manure is chicken/turkey/pig-based (as there are no methane emissions due to enteric fermentation associated with these animals).

We believe that wherever there are large concentrations of manure, the manure should be composted and applied to the land. On the other hand, we do not believe that the people of California should encourage compost production associated with ruminants that emit copious amounts of methane via enteric fermentation. Cattle and sheep ranchers receiving carbon credit-related payments for creating such concentrations of ruminant manure would encourage a widespread ruminant-based manure compost production system. We are vehemently opposed to such a system, as it does not appear that such a system would generate meaningful net soil carbon sequestration over time when the countering heat-trapping effects of enteric emissions are factored into the “equation”.

Sincerely,



Ara Marderosian, Executive Director, Sequoia ForestKeeper, Kernville, CA 760.378.4574

Todd Shuman, Senior Analyst, Wasteful Unreasonable Methane Uprising, Camarillo, CA 805.987.8203

Jan Dietrick, MPH, Steering Committee, Ventura County Climate Hub, Ventura, CA 805.746.5365

Appendix A:

1: FAO Cattle-Related Statistics for 1962 and 2012

Country	Item	Element	Unit	Y1962	Y2012
World	Cattle	Emissions (CH_4) (Enteric)	Gigagrams	50,491.3724	72,289.6713

Food and Agriculture Organization of the United Nations, Statistics Division (FAOSTAT)
http://faostat3.fao.org/download/G1/GE/E

Year 1962

50,491.3724 Gg of CH4 emitted
$5.04913724 * 10^4$ Gg * $2.20462262 * 10^6$ lbs./Gg = $11.13144217 * 10^{10}$ lbs.

1.113144217 * 1011 lbs., or 111,314,421,700 lbs. of CH4, or 111.314 billion lbs. emitted

Year 2012

72,289.67 Gg of CH4 emitted
$7.228967 * 10^4$ Gg * $2.20462262 * 10^6$ lbs./Gg = $15.93714417 * 10^{10}$ lbs.

1.593714417 * 1011 lbs., or 159,371,441,700 lbs. of CH4, or 159.371 billion lbs. emitted

2: For the 1962–2012 period: +0.90/+0.67 degree Celsius rise for land/land-ocean combined

1958-1965 (1962)	1988-1995 (1992)	2008-2015 (2012)	relative to 1880-1920 (1900)
0.36/0.27	0.80/0.62	1.26/0.94	relative to 1900 land/land-ocean value of 0 degrees C

1962-1992 increase: +0.44/+0.35; 1992-2012 increase: +0.46/+0.32;
1962-2012 increase +0.90/+0.67

Source: http://data.giss.nasa.gov/gistemp/maps/. [Note: Todd Shuman consulted with Dr. Ron Miller, Deputy Chief of Lab, NASA Goddard Institute of Space Studies concerning proper parameters for input. Dr. Miller recommended "smoothing" anomalies over 7-year time frames; use Anomalies, not Trend; define Mean Period as Annual (Jan-Dec); defined base period 1880-1920 was considered reasonable. Use 1200 KM Smoothing Radius, and Robinson Map Projection. For Land: use GISS analysis; For Ocean: use ERSST v.4.]

3: "NASA recently released data showing that the planet has just seen seven straight months of not just record-breaking, but record-shattering heat. It is clear, through the space agency's data, that this year we are already well on track to see what will likely be the largest increase in global temperature a single year has ever seen. The NASA data also show that April was the hottest April ever recorded, as well as the fact that it crushed the previous April record by the largest margin of increase ever recorded. That makes it three months in a row that the monthly record has been broken, and easily at that, by the largest margin ever." Dahr Jamail, May 23, 2016, http://www.truth-out.org/news/item/36133-atmospheric-carbon-dioxide-concentration-has-passed-the-point-of-no-return

Appendix B:

The relationship between CH4 mass emission and global temperature change values in Figures 2a and 2d of Allen et al. (2016) appears to be largely linear and directly proportional (i.e. 110 Mt of CH4 generates X degrees of change, 330 Mt of CH4 generates 3X degrees of change, 1320 Mt generates 12X degrees of change, 1360 MT generates 12.36X degrees of change.) [Email communication with Dr. Myles Allen, May 15, 2016)

Todd Shuman extracted global mass emission estimates for the different anthropogenic methane emission sources and linked these values with the global temperature change (GTC) values in Figure 2d. For the mass values for the different sources, the "bottom up" methane source mass values in IPCC AR5, Chapter 6, page 507 are used. For enteric emissions for total livestock and for cattle, the Food and Agriculture Organization numbers (FAOSTAT) for year 2011 are used. Here are the numbers for the year 2011:

Enteric - 98 Mt (with the cattle subcomponent at 72 Mt)

Fossil Fuel – 96 Mt

Landfill/Waste – 75 Mt

Rice – 36 Mt

Biomass Burning – 35 Mt

From Allen et al. (2016), the total cumulative anthropogenic 2011 CH4 mass emission estimate (330 Mt, email communication with Myles Allen, May 11, 2016) is associated with a GTC value (in degrees C) of 0.015 for year 2015, 0.02066 for year 2021-2022, 0.016 for year 2031-2032, 0.005066 for year 2050, and 0.0005 for year 2100.

Todd Shuman performed some simple cross-multiplication arithmetic calculations to derive CH4-related sectoral GTC estimates below. Using the fossil fuel number as an example, here is the arithmetic method used:

For year 2015: 330/0.015=96/x=0.00436 degrees GTC; for year 2021/2022, 330/0.02066=96/x=0.006 degrees GTC; for year 2050, 330/0.005066=96/x=0.0015.

(The GTC for the total CH4 value in Year 2031/2032 is just slightly larger than for year 2015 GTC value, so Todd Shuman just added a plus sign (+) to the 2015 sectoral GTC values below to serve as the 2031/2032 sectoral GTC values.)

Below are the sectoral GTC values (in degrees Celsius) proportionally associated with the 330 Mt methane emission pulse in 2011 for years 2015, 2021/2022, 2031/2032, and 2050.

Livestock enteric: 0.0044, 0.0061, 0.0044+, and 0.0015

(Cattle enteric: 0.0033, 0.0045, 0.0033+, and 0.0011)

Fossil fuel: 0.0044, 0.006, 0.0044+, and 0.0015

Landfill waste: 0.0034, 0.0047, 0.0034+, and 0.0012

Rice: 0.0016, 0.0023, 0.0016+, and 0.00056

Biomass Burning: 0.0016, 0.0022, 0.0016+, and 0.00054

(For reference, the corresponding GTC values for the CO2 emission pulse for those years [based upon a mass of 38,000 Mt] are approximately 0.015, 0.024, 0.026, and 0.024.)

Myles R. Allen, Jan S. Fuglestvedt, Keith P. Shine, Andy Reisinger, Raymond T. Pierrehumbert and Piers M. Forster, *New use of global warming potentials to compare cumulative and short-lived climate pollutants,* Nature Climate Change, PUBLISHED ONLINE: 2 MAY 2016 | DOI: 10.1038/ NCLIMATE2998